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John Wesley Powell worked actively for public land system reform while a director of geographical and geological surveys in the West from 1869 to 1894. Although this has won him acclaim as a conservationist, the basis of Powell's linkage of reform with scientific work is poorly understood.

A study of the intellectual aspects of Powell's survey work to about 1884 shows his linkage of science and reform had both practical and philosophical foundations. While working in the West Powell found applications of his geological and ethnological studies useful in treating problems that had arisen for settlement in the region. Powell's study of Indian culture reflected ethnologist Lewis Henry Morgan's emphasis on social organization. It taught Powell that the government's approach to Indian problems was ineffective because it misunderstood their social organization and their institutions.

Powell emphasized physical aspects of the geological problems he studied. He focused on structure, on processes of upheaval and erosion, and on the historical record those agencies left in

topography. Powell found this work provided geographical and other physical information useful in planning the large-scale irrigation systems that he believed were necessary for continued growth in the West. He also found his survey's work valuable for administrative and policy-making needs in the General Land Office. Powell's _Report on the Lands of the Arid Region_ in 1878 reflected his advocacy of better and more systematic methods in classifying and surveying the public lands. It also keynoted his involvement in efforts to abolish the government's contract land survey system and replace it with a permanent system of geographical and geological surveys.

Philosophical foundations for Powell's involvement in reform are revealed in his ideas on evolution. These combined L. H. Morgan's appreciation of cooperative social institutions with Herbert Spencer's view of evolution as an increasing differentiation and integration of matter. Human evolution for Powell was multi-dimensional and included intellectual, industrial, and institutional elements.

Powell believed his survey's work for science and for land system reform was consistent with his evolutionary scheme. His intellectual heritage shows that he was acting out the commitment of nineteenth-century positivism to the empirical methods of science and to their use in achieving social progress.

John Wesley Powell:

Science and Reform in a Positive Context

by

John Joseph Zernel

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Typed by Leona M. Nicholson for John Joseph Zernel

In Memory

of

JAMES F. LAHEY

Scientist

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The dissertation presented here is both the culmination of an academic program and a milepost in a longer-running attempt to move beyond the limitations of a first-chosen career. That anything has been accomplished in either sense is due in very large measure to the efforts of Dr. Robert J. Morris, Jr. and Dr. Paul L. Farber, faculty in the Department of General Science at Oregon State University, who introduced me to the history and philosophy of science. In so doing, these gentlemen presented me the means to extricate myself from certain conceptual problems related to the function and value of science in society and to move ahead with my career objectives. Moreover, whatever I have been able to accomplish in outgrowing the limitations of an earlier, narrowly technical education is largely a result of the breadth of interests, critical thinking, and patience these men brought to their teaching.

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I have been fortunate to have in Dr. Morris a research advisor who combined patience and a willingness to provide free rein, both of which I needed to distill a manageable research problem out of a complex of suspicions and dimly perceived ideas. Moreover, to whatever extent this dissertation represents clear thought, clear expression, and critical thinking, it does so at a considerably higher level than it would have without the standards set by Dr. Morris.

Other members of my committee have also helped to make this thesis something more than it otherwise might have been. Drs. Paul Farber and J. Brookes Spencer in the Department of General Science, William G. Robbins in the Department of History, Robert E. Frenkel in the Department of Geography, Wilbur A. Davis in the Department of Anthropology, and William W. Chilcote in the Department of Botany and Plant Pathology all helped to save me from ambiguity and error. Dr. Farber deserves special mention for helping me with nineteenth-century evolution theory and social philosophy, and both he and Dr. Spencer helped me to refine and sharpen my thesis arguments. I am also specially indebted to Dr. Robbins for preventing me from straying into deep water in the history of the public domain.

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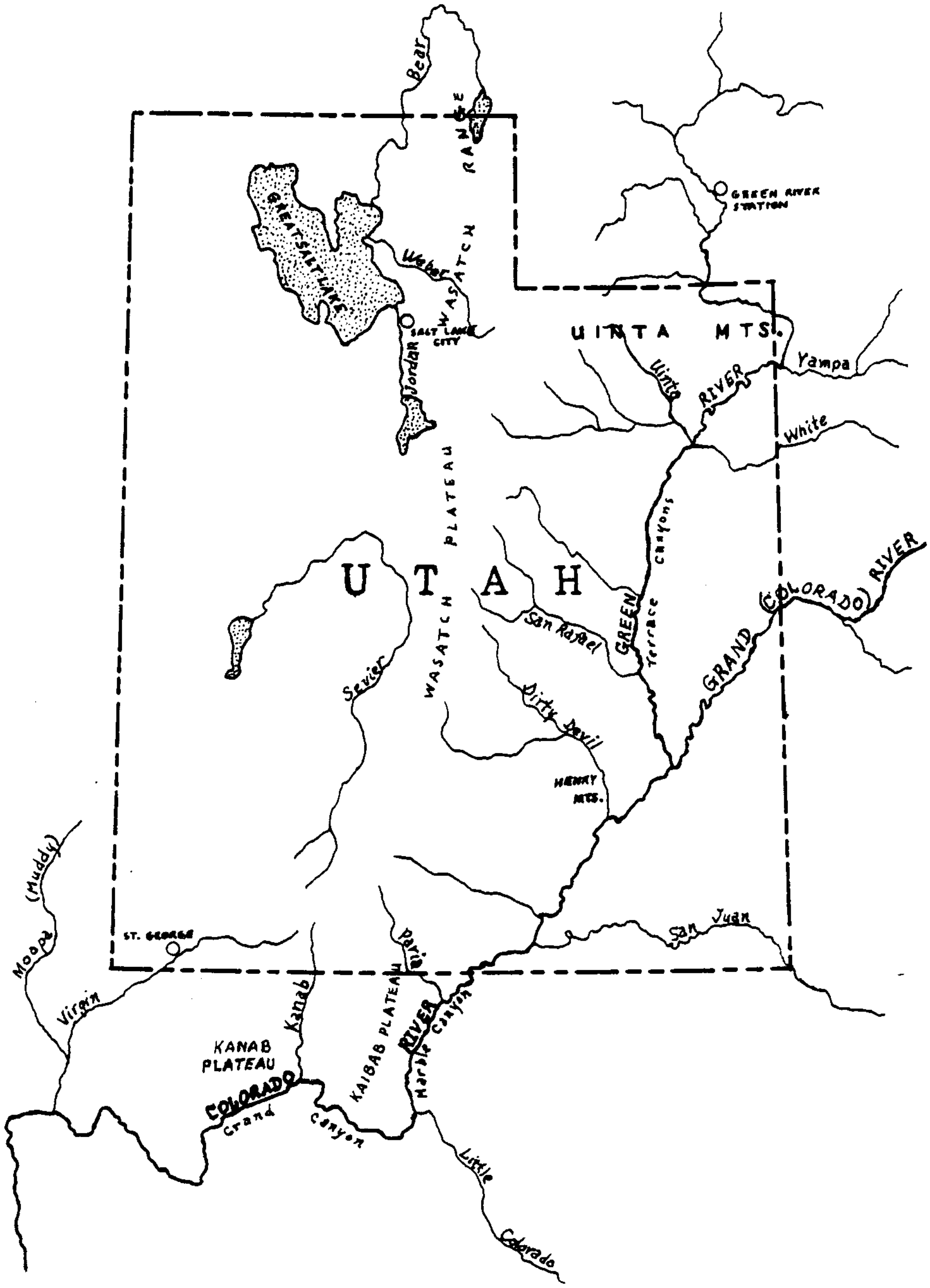

MAP. Scene of survey operations by John Wesley Powell, 1869-1879.

JOHN WESLEY POWELL: SCIENCE AND REFORM IN A POSITIVE CONTEXT

CHAPTER ONE

J. W. POWELL: REFORMER AND SCIENTIST

John Wesley Powell (1834-1902) has become a familiar figure in American history through his role in shaping the early structure and operations of the United States Geological Survey and particularly for his involvement in the great land system reform efforts that began early in the 1870s and spanned nearly twenty years. In 1878 as head of the Geographical and Geological Survey of the Rocky Mountain Region, Powell published the Report on the Lands of the Arid Region of the United States, his seminal description of the physical geography of the western public lands and the problems their distinctive characteristics posed for the existing land disposal system.[1] Soon afterward to help provide a foundation for a proper land system, Powell worked actively and prominently to establish a permanent geographical and geological survey of the public lands, the result being the establishment of the United States Geological Survey in 1879.

As its second director from 1881 to 1894 Powell initiated the survey's broad and continuing economic assessment of the nation's lands and resources as part of a program of national geological and topographical mapping. In 1888 these efforts were expanded with the

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[1] U. S. Congress, House, Report on the Lands of the Arid Region of the United States, with a More Detailed Account of the Lands of Utah, by J. W. Powell, Ex. Dec. 73, 45th Cong., 2nd sess., 1878.

authorization of the Irrigation Survey. Caught up in controversies of land system reform, the Irrigation Survey was terminated by Congress in 1890, and Powell was driven from office. The work left a legacy of men and ideas, nevertheless, that soon bore fruit in the Progressive conservation movement. This movement was spear headed not only by forest management advocate Gifford Pinchot and by Theodore Roosevelt, but also by men Powell brought to the Geological Survey: among others Frederick H. Newell who became first head of the Reclamation Service; W. J. McGee, chief theorist behind the multiple-purpose river system development proposals produced by the Inland Waterways Commission; and farther in the background Charles D. Walcott, head of the Geological Survey after Powell.[2]

The literature on Powell as a pioneer of natural resource conservation dates to the 1931 classic, The Great Plains. In this, Walter Prescott Webb highlighted Powell's contention that the dry-lands of the West were ill-suited to institutions created to fit the moist, forested regions of the East. Henry Nash Smith's Virgin Land (1950) placed Powell's work in a larger context of America's attitudes toward land and resource development and set the tone for

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[2]On the conservation movement see John T. Ganoe, "Origin of a National Reclamation Policy," Mississippi Valley Historical Review, 1931-32, 18:35-37; A. Hunter Dupree, Science in the Federal Government. A History of Policies and Activities to 1940 (Cambridge: Belknap Press of Harvard University Press, 1957), pp. 195-214, 232-51; and Samuel P. Hays, Conservation and the Gospel of Efficiency. The Progressive Conservation Movement 1890-1920 (Cambridge: Harvard University Press, 1959; reprint ed., New York: Atheneum, 1975), pp. 6-8, 22-26, 102-109. William John McGee preferred to be known by his initials--without punctuation. I have chosen to indulge only the first preference to minimize confusion.

mid-century interest in Powell. Two modern biographical efforts have provided a more or less comprehensive understanding of Powell's career as a public servant and advocate of land policy reform: William C. Darrah, Powell of the Colorado (1951), is conventionally biographical, whereas Wallace Stegner's Pulitzer Prize winning Beyond the Hundredth Meridian is focused more narrowly on Powell's career as a survey administrator and land policy visionary. These books are further supplemented by works focusing on the early history of the Geological Survey and on the controversial irrigation survey undertaken by Powell.[3]

On the other hand the more narrowly scientific side of Powell's career--eclipsed rather quickly by growing administrative responsibilities--has not been so comprehensively studied. Except in narrow areas it has not been probed to any depth, and the resulting picture of Powell as a scientist is fragmented and incomplete. The treatments by Powell's biographers are cursory and do not provide more than a dim portrait. In geology where his reputation is linked to theories of land form development, Powell is remembered for pointing out the significance of subaerial erosion as a geological process and for contributing certain important concepts to the theory of river system development. Other aspects of his work are passed over,

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[3]Walter Prescott Webb, The Great Plains (Boston: Ginn and Co., 1931), pp. 353-56, 419-22; Henry Nash Smith, Virgin Land. The American West as Symbol and Myth (Cambridge: Harvard University Press, 1950; Harvard Paperback, 1973), pp. 196-200; William Culp Darrah, Powell of the Colorado (Princeton: Princeton University Press, 1951); Wallace Stegner, Beyond the Hundredth Meridian. John Wesley Powell and the Second Opening of the West (Cambridge, Mass.: Riverside Press, 1954; c. 1953, 1954), pp. 351-67.

however, and the basic framework of Powell's approach to geology is missed.[4]

Anthropologists know Powell somewhat negatively as a participant in the discredited nineteenth-century school of cultural evolutionists. He is also recognized for his work in promoting linguistic and other anthropological studies of American Indian culture as head of the Smithsonian Institution's Bureau of Ethnology from its inception in 1879 until his death in 1902. However, no detailed study of his theoretical ideas on society and social evolution has appeared.[5]

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[4]Darrah, Powell, pp. 148-50, 214-18; Stegner, Hundredth Meridian, pp. 146-55. Richard J. Chorley, Antony J. Dunn, and Robert P. Beckinsale, The History of the Study of Landforms, or the Development of Geomorphology, vol. 1: Geomorphology before Davis (London: Methuen and Co., John Wiley and Sons, 1964), pp. 501-505, 515-45 gives the current assessment of Powell's geology. A treatment by a younger contemporary of Powell is useful, W. M. Davis, "Biographical Memoir of John Wesley Powell, 1834-1902," National Academy of Sciences, Biographical Memoirs, vol. 8 (Washington, D.C.: National Academy of Sciences, 1915), pp. 15-38.

[5]Powell is portrayed as a cultural evolutionist in John S. Haller, Outcasts of Evolution. Scientific Attitudes of Racial Inferiority, 1859-1900 (Urbana: University of Illinois Press, 1971), pp. 107-110; George W. Stocking, Jr., Race, Culture, and Evolution. Essays in the History of Anthropology (New York: The Free Press, 1968), pp. 123-29, 278; idem, "Some Problems in the Understanding of Nineteenth-Century Cultural Evolutionism," in Readings in the History of Anthropology, ed. Regna Darnell (New York: Harper and Row, 1974), p. 423; Regna Darnell, "Professionalization of Anthropology," in Readings, ed. Darnell, p. 174; and Fred W. Voget, A History of Ethnology (New York: Holt, Rinehart, and Winston, 1975), pp. 190-91. Powell's organizational efforts for ethnological research are discussed in Curtis M. Hinsley, Jr., Savages and Scientists. The Smithsonian Institution and the Development of American Anthropology 1846-1910 (Washington, D.C.: Smithsonian Institution Press, 1981), pp. 125-82. Don D. Fowler and Catherine S. Fowler, "John Wesley Powell, Anthropologist," Utah Historical Quarterly, 1969, 37:152-72, Stegner, Hundredth Meridian, pp. 251-69, and Darrah, Powell, pp. 255-69 also discuss Powell's work in ethnology.

This incomplete picture of Powell's scientific life no doubt has contributed to the apparent consternation and confusion surrounding Powell's connection of science with land system reform. The tacit sense of scientific mission Powell brought to his reform efforts cannot be missed by anyone reading, let us say, his Report on the Lands of the Arid Region. It is this sense of mission that Wallace Stegner captured as a central theme for his account of Powell's career in Beyond the Hundredth Meridian. Here, Powell's reform involvement is portrayed as an effort to take public lands policy out of the realm of self-interest politics and place it on an uncorrupt foundation of science.

Yet, a satisfying intellectual linkage between these efforts and Powell's more properly scientific work has not been established. Some of the explanations offered more or less off-handedly illustrate best the attitude that elements unrelated to science account for Powell's reform involvement. Stephen Pyne, biographer of Powell's brilliant colleague in geology Grove Karl Gilbert, suggests Powell had inherited his minister-father's "evangelical zeal"; and Wallace Stegner in Beyond the Hundredth Meridian at one point called some of Powell's land policy ideas relict manifestations of "Brook Farm" utopianism.[6]

Other explanations appeal only slightly less to an unscientific

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[6] Stephen J. Pyne, Grove Karl Gilbert. A Great Engine of Research (Austin: University of Texas Press, 1980), pp. 73-74; Stegner, Hundredth Meridian, p. 316.

side of Powell's character. Both Darrah and Stegner have drawn attention to the reform-minded social philosophy of Lester F. Ward as a probable influence on Powell. Powell and Ward met first in the mid-1870s through Ward's interest in botany; they grew close, for in the early 1880s Powell helped Ward publish his Dynamic Sociology and made a place for him in the Geological Survey as a paleobotanist. Darrah and Stegner imply that because Powell shared Ward's rejection of laissez faire social doctrines, his broad view of the responsibilities of government, and his evolutionism, Powell probably also partook of Ward's activism.[7]

As it happens, there are distinct differences in the thought of the two men. Moreover, intellectual forces motivating both have been overlooked. This is an important point, one which I will discuss further in the closing chapters. But that matter aside, the role of any social philosophy in motivating Powell's involvement in reform has not been probed deeply enough to show any science-related foundation for his actions.

This lack of understanding about Powell's reform efforts is evident in recent criticism of some of Powell's survey programs. Stephen Pyne, for example, refers to Powell's topographic mapping as an "obsession" and a "monomania." In a recent history of the Geological Survey, Minerals, Lands, and Geology for the Common

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[7]Darrah, Powell, pp. 280-81; Stegner, Hundredth Meridian, pp. 117, 333. Lester F. Ward, Dynamic Sociology, or Applied Social Science, 2 vols. (New York: D. Appleton and Co., 1883).

Defence and General Welfare, Mary C. Rabbitt is less extreme but still dismisses Powell's land policy initiatives as personal whims. In a suggestive contrast she faults Powell severely for failing to serve properly the needs of those she sees as the survey's natural symbiotic partners, the mining and mineral industries.[8]

These various characterizations elicited by Powell's involvement with public lands policy are difficult to reconcile with his sense of scientific mission. Unreconciled, they undermine our view that the Geological Survey's contribution to principles of natural resource utilization was in some sense a scientific one. Moreover, they muddle our understanding of the part science has played in the making of the American nation.

Convinced that the political and scientific dimensions of Powell's career were not without meaningful connections, I have undertaken in this thesis a more thorough study of the intellectual aspects of Powell's career. Rather than assessing his place in the history of the growth of scientific ideas, this study of Powell's geological, ethnological and social thought, and his views on the public domain and its administration seeks to uncover the foundations of his sense of scientific mission--the basis of his involvement of science with social reform. It encompasses the period from the beginning of his systematic survey of the Colorado River region in about 1871 to the prime of his intellectual development in the

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[8]U. S. Geological Survey, Minerals, Lands, and Geology for the Common Defence and General Welfare, by Mary C. Rabbitt, 2 vols., Washington, D.C.: 1979-80, vol. 2: 1879-1904, pp. 238-39; Pyne, Gilbert, pp. 62, 117.

early 1880s. This was the primary period of his intellectual growth, and the period in which the framework of his thought fully developed.

Two key ingredients are revealed bridging the scientific and activist dimensions of Powell's career. First, in the course of pursuing his survey's basic scientific objectives, Powell found much of his survey's science also useful for serving the needs of western settlement. Sensitive to the role irrigation and other great engineering works would have to play in making available the West's resources for agricultural development, and aware as well of the role surveying played in the planning of such works, Powell saw great potential utility for the topographic investigations and mapping produced in his surveys. Moreover, a scientific understanding of the natural processes responsible for producing the resources of the West offered insights that could not be overlooked if policies or resource development and settlement were to serve intended purposes. Consequently Powell viewed his survey's work as a great practical asset for the General Land Office in its increasingly difficult work of administering settlement in the West.

To develop this particular ingredient of the connection between the scientific and reform aspects of Powell's career, it will be necessary to discuss Powell's scientific work and his evolving concerns for problems obstructing settlement in the West. These are recounted in chapters Two through Six. Chapter Two treats Powell's geology and chapter Three his ethnological work. Chapter Four introduces irrigation as an engineering and also an institutional problem for the West, and chapter Five illustrates Powell's approach to this and similar problems confronting development of the public lands. Chapter Six then discusses Powell's opinions on the proper structure and role of the government's scientific survey work, as revealed through his participation in the Interior Department's attempts to restructure the General Land Office's survey system.

A second key dimension of the connection between the scientific and reform aspects presented in Powell's career is intellectual, and can be found in his thought on man and society. These views developed to maturity in the early 1880s out of his cumulative experience in science and as a spectator of westward expansion. Powell's evolutionary views of man and society provided an intellectual framework that allowed him to justify his conception of survey responsibilities. Unconciously, Powell viewed his conception of proper survey responsibilities--and the Geological Survey, to the extent it approached his ideal--as a simple institutional innovation, a natural and progressive step in the course of human social evolution.

Moreover, Powell's thought on man and society places him in the mainstream of an intellectual current that except perhaps in the domain of sociology has gone unrecognized in the history of American science. This was nineteenth-century positivism, which was as much committed to the twin gospels of science and social reform in the less severe British strains of the second half of the century as it was earlier in the original context of Auguste Comte's Positive Philosophy. Nineteenth-century positivism provided Powell the broad intellectual foundation necessary for dedicating his survey to public land system reform.[9]

Powell's thought on man and society was early conditioned by the evolutionary views of ethnologist Lewis Henry Morgan, an influence which is outlined in chapter Three. However, Powell was also strongly influenced by Herbert Spencer's concept of evolution. In chapter Seven Spencer's evolutionism is reviewed along with its criticism by the American sociologist Lester F. Ward; this is followed by a description of Powell's theoretical views on evolution, man, and society. Chapter Eight is a concluding discussion of the interrelations among Powell's evolutionism, his positivism, and his actions as survey head.

It will be helpful to review briefly Powell's background, the historical setting of his survey, and highlights of his career before

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[9]The reader should not confuse positivism in the sense of its use here with logical positivism, the empiricist approach to strictly epistemological problems prominent later in twentieth-century philosophy. Neither should one equate positivism narrowly with the Positive Philosophy of Comte. Application of the term positivism to philosophies other than that of Comte and his doctrinaire disciples has drawn the objection of W. M. Simon, European Positivism in the Nineteenth Century (Ithaca, N.Y.: Cornell University Press, 1963), pp. 3-4. However, Simon's recommended alternative of "scientism" for the variant philosophies, if one is to judge by one prominent example of its use, is too broad--not to mention pejorative and anachronistic--to be of much value in minimizing confusion (see Harold I. Sharlin, Joseph F. Wall, and David A. Hollinger, "Spencer, Scientism, and American Constitutional Law," Annals of Science, 1976, 33:457-80). The formal designation "Positive Philosophy" or the modifier "Comtean" will be used here to narrow the meaning when necessary.

probing more deeply into the intellectual dimensions of his work.[10] Powell was born in upper New York state in 1834, the son of an English farmer, tailor, and Methodist preacher. Powell was educated in haphazard frontier fashion as his father moved westward through New York, into southern Ohio, then to Illinois and to southern Wisconsin, ever searching for a good circuit ministry. While in Jackson, Ohio in his early teens, Powell was tutored in natural history by a local part-time pedagogue who occasionally assisted Ohio state geologist William Mather in his survey work. Young Powell accompanied these men from time to time and became interested in a career in science. He left home at seventeen to teach school and educate himself in science as best he could. He enrolled for limited stays in several small schools in Illinois and Ohio (the last was Oberlin College) but never found the curricula suitably scientific. He continued to teach school, becoming superintendent of schools in Hennepin, Illinois in 1860. He spent his summers taking trips along the Ohio, Illinois, and Mississippi rivers collecting molluscs, minerals, and other objects of natural history, and he joined the

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[10] Biographical details in this account are drawn from Darrah's _Powell of the Colorado_. Other accounts are Elmo Scott Watson, ed., _The Professor Goes West_ (Bloomington, Ill.: Illinois Wesleyan University Press, 1954), and Leonard Wibberly, _Wes Powell: Conqueror of the Grand Canyon_ (New York: Farrar, Straus, and Cudahy, 1958). Memorials by contemporaries are W. M. Davis, "Biographical Memoir," and G. K. Gilbert, ed., _John Wesley Powell: A Memorial to an American Explorer and Scholar_ (Chicago: Open Court, 1903). A descriptive bibliography of Powell's writings is found in P. C. Warman, "Catalogue of the Published Writings of John Wesley Powell," _Proceedings of the Washington Academy of Sciences_, 1903, 5:113-87, although Darrah, _Powell_, p. 412 advises that it is not complete.

Illinois State Natural History Society in 1858 at the age of 24. Later he served as secretary and he became the resident head of conchology in 1861.

From 1861 to 1865 Powell served in the Union Army. He tutored himself in engineering, and consequently was given responsibility for defensive works and other battle field construction needs as an artillery officer under Fremont, Grant, and Sherman--experience that may account for his later appreciation of engineering needs in irrigation and flood control. He was wounded in 1862 at Shiloh, losing his right arm above the elbow. This injury caused him recurring pain throughout his life. Powell returned to active duty in 1863, and saw heavy action at Vicksburg. He served at Nashville in 1864, and was mustered out as a major and chief of artillery for the Seventh Army Corps at the conclusion of the war.

Soon afterwards Powell returned to Illinois to take a position as professor of geology at Illinois Wesleyan University at Bloomington. In 1866 he also began teaching courses at nearby Illinois State Normal University where the state Natural History Society collections were housed. In that year and the following Powell as secretary of the society lobbied the state legislature to set up a museum for the collections. He was successful, and was appointed museum curator in March 1867.

Powell immediately undertook plans to enrich the society's collections by taking a summer expedition to the Pike's Peak country of Colorado. The venture was early evidence of Powell's organizational energies, for it was undertaken with free passes, solicited from railroads, military rations arranged through General Grant, instruments loaned from the Smithsonian Institution, and funding from several local institutions (and Powell's own pocketbook as well!). The party consisted of Powell, his wife, and ten local amateur scientists and students.

The expedition was a great adventure that included an ascent of Pike's Peak. Its success encouraged Powell to organize similar ventures in 1868 and 1869. These trips focused more on the region around the Colorado river headwaters and its little-known geology. They were still exciting adventures, however: the 1868 trip brought the first ascent of Long's Peak in Colorado's Front Range, and that of 1869 was an exceedingly dangerous float down through the unknown chasms of the Colorado River. Owing in part to false rumors of disaster and the killing of three of the party by Indians, this latter expedition brought Powell nationwide fame.[11] It also allowed him to go to Washington in 1870 and, with the help of Smithsonian Institution head Joseph Henry, win a $10,000 appropriation to carry on a more rigorous scientific exploration of the region and its geology. Thus was born the Exploration of the Colorado River of the West--known after 1874 as the U. S. Geological and Geographical Survey of the Territories, and after 1876 as the U. S. Geographical and Geological Survey of the Rocky Mountain Region--one of the four great

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[11]Full accounts of the canyon voyage of 1869 are provided by Darrah, Powell, pp. 108-143, and by Stegner, Hundredth Meridian, pp. 42-115. A more concise account is found in William H. Goetzmann, Exploration and Empire. The Explorer and the Scientist in the Winning of the American West (New York: Alfred A. Knopf, 1966), pp. 541-53.

post-Civil War geographical and geological surveys that would be consolidated to form the United States Geological Survey in 1879.

The great western surveys Powell joined in 1870 grew out of a national appetite for geographical knowledge[12] that had inspired surveys of a more or less scientific character beginning in 1804 with the Lewis and Clark Expedition. The War Department became actively involved in exploration of the poorly known territory beyond the frontier, with its first notable involvement being the exploration by Major Stephen Long into the plains and east slope of the Rocky Mountains (the so-called Great American Desert) in 1819.[13]

Science gained an established place in these explorations through the Army's West Point-trained officers, men who early saw the value of scientific skills in mapping and engineering, and as a result placed a premium on cultivation of science.[14] An elite corps of Topographical Engineers provided the foundation for the most prominent military explorations of the West from the time of their establishment as an independent department in 1838 until war-time demands caused them to be reabsorbed into the Engineer Department

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[12]Nathan Reingold is of the opinion that geographical concerns dominated American scientific efforts until about 1870. See Nathan Reingold, ed., Science in Nineteenth-Century America. A Documentary History (New York: Hill and Wang, 1964), pp. 59-62.

[13]See Dupree, Science in the Federal Government, pp. 29-33, 51-61, 95-105.

[14]The following discussion of antebellum exploration by the War Department is derived from William H. Goetzmann, Army Exploration in American West 1803-1863 (New Haven: Yale University Press, 1959). See also idem, Exploration and Empire, pp. 57-64, 231-352.

during the Civil War years. Explorations involving the officers of the Topographical Engineers included the John C. Fremont expeditions of 1842-1845; Lieutenant William H. Emory's 1846 Mexican War reconnaissance of the Southwest, and the subsequent Mexican Boundary Survey; the great Pacific Railroad Surveys of the 1850s; and a series of territorial reconnaissances in the late 1850s in the northern plains and the Great Basin by Ives, Macomb, Simpson, Warren, and others. These expeditions were typically accompanied by civilian botanists, zoologists, and geologists, often attached to the military parties through the offices of the Smithsonian Institution. Among the notables were the botanists John Torrey, Asa Gray, and C. C. Parry; zoologists Charles Girard and Spencer Baird; and geologists Jules Marcou, John Strong Newberry, and Ferdinand V. Hayden.

The Civil War interrupted military exploration, but with the end of hostilities westward expansion surged ahead, and the War Department attempted to renew its involvement. This resulted in the establishment of the United States Geographical Surveys West of the One Hundredth Meridian under the command of Lieutenant George M. Wheeler. Born in Massachusetts in 1842, Wheeler was an 1866 graduate of West Point. His survey's work began in 1869 when the newly promoted lieutenant led his first independent reconnaissance into eastern Nevada. Subsequently the survey worked in that state and in western Utah, Arizona, and New Mexico. Its function particularly in its earlier years was primarily military: it focused on topography and geography of the forbidding Apache and Paiute desert country in order to help the War Department carry out its responsibilities for the protection of settlements. As in the earlier military expeditions, science was brought along in an adjunct capacity. The early 1870s, for example, found the geologists Archibald Marvine and Grove Karl Gilbert attached to Wheeler's parties. Wheeler sought to move beyond the ad hoc nature of the earlier explorations, however, and in about 1872 he began a systematic mapping he hoped would be extended to all the western territories.[15]

Professional scientists who had enjoyed success in conducting state geological surveys during the mid-nineteenth century or who had been involved in earlier War Department exploration also turned their attention to exploring the western territories. One was geologist Ferdinand V. Hayden, who led the United States Geological Survey of the Territories under the auspices of the Interior Department. Hayden, born in Massachusetts in 1829, had a scientific background very similar to Powell's. He was a graduate of Oberlin College, and took an M.D. degree from Albany Medical College in 1853, but his

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[15] Goetzmann, Exploration and Empire, pp. 467-88; Geological Survey, Minerals, Lands, and Geology, vol. 1: Before 1879, p. 200. The four predecessor surveys to the U. S. Geological Survey are reviewed in Goetzmann's Exploration and Empire, pp. 430-576; see also Great Surveys of the American West (Norman: University of Oklahoma Press, 1962). A shorter treatment is to be found in the history of the U. S. Geological Survey by Thomas G. Manning, Government in Science. The U. S. Geological Survey 1867-1894 (n.p.: University of Kentucky Press, 1967), pp. 1-33. An account of these surveys' activities is usefully woven into the Geological Survey's Minerals, Lands, and Geology, vol. 1, pp. 161-288. Access to the major publications of these surveys may be attained via their formal institutional titles as presented in the ensuing account; access to all of the several hundred volumes of their publications, including annual progress reports is to be found in U. S. Geological Survey, Catalogue and Index of the Hayden, King, Powell, and Wheeler Surveys, by L. F. Schmeckebier, Geological Survey Bulletin No. 222 (Washington, D.C.: 1904).

interests were in natural history. While at Oberlin he studied geology with the young John Strong Newberry, and at Albany he studied under New York's state geologist James Hall. He began a free-lance geological career in the West during the period of the Pacific Railroad Surveys. He associated himself with paleontologist Fielding B. Meek, and together they established the West's first standard stratigraphic column. After the war, Hayden's free-lancing brought him to Nebraska where in 1867 he carried out a survey in the state under General Land Office auspices with some unexpended territorial funds. Hayden's enthusiasm for western development led him to highlight the region's economic resources, and helped him win new appropriations for surveys in the territories further west.

Hayden's Geological and Geographical Survey of the Territories operated largely in Colorado, Wyoming, and Montana. Housed in the Interior Department, its operations began to assume significant proportions in 1869, and its field party included an entomologist, a zoologist, and a mining engineer. Thereafter it continued to grow into a larger and larger miscellaneous scientific enterprise that included a large contingent of topographers (among them Henry Gannett, trained on the California Geological Survey, and later to become chief geographer of the U. S. Geological Survey) and such subsequent well-knowns as the artist, topographer, and anthropologist William H. Holmes; ornithologist C. Hart Merriam; mineralogist A. C. Peale; and paleontologist Edward Drinker Cope. Hayden was a self-confessed apostle of western progress and development, and his survey enjoyed broad support among western politicians and economic interests.[16]

A third survey operating in the western territories was the United States Geological Exploration of the Fortieth Parallel under Clarence King. Born in Rhode Island in 1842, he was a graduate of Yale's Sheffield Scientific School. He received his introduction to field work in geology under Josiah D. Whitney in the California State Geological Survey during 1864-1866. He was influenced by Whitney's vision of a survey over the entire Great Basin, and in 1867 King struck out on his own with the backing and endorsement of the War Department. The Fortieth Parallel survey covered a belt approximately one hundred miles wide across the northern Great Basin and Rocky Mountains, through the West's great California and Colorado mining regions along the route of the Union Pacific and Central Pacific Railroads.

It was a scientific enterprise of the highest credentials, patterned along the lines of the survey Whitney had conducted in California. Topographic mapping was prominent, and its economic geology reflected the enthusiasm for growth of the mineral industries. The mapping was conducted by James T. Gardner, another graduate of the Whitney survey. For the geological work King assembled a staff in keeping with his interests and educational background. Three positions in geology were filled by the brothers James D. and Arnold Hague, and by Samuel F. Emmons, each educated in the scientific

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[16]Goetzmann, Exploration and Empire, pp. 489-529.

schools at Harvard or Yale, and in Europe at Freiburg's Royal School of Mines.[17]

It was these three great surveys conducted by Wheeler, Hayden, and King that Powell joined and competed with in his survey of the Colorado. Over the first few years of the 1870s Powell's survey progressively grew out of its amateur beginnings into a more rigorous scientific effort. Careful topographic mapping of the Colorado River region was begun and ably executed by Powell's brother-in-law and former teacher in Bloomington, Almon H. Thompson. Triangulation methods similar to those used by the Coast Survey and by Clarence King were used. Powell took responsibility for the geology, but he soon recognized valuable assets in Wheeler survey geologist Grove Karl Gilbert and in a Washington-based Army officer, Clarence E. Dutton. Gilbert and Dutton joined the survey in 1875; after 1876 as the survey began to extend its operations into central Utah, they took charge of all the new geological work. Powell in the meantime was increasingly interested in ethnological studies of the region's Indian population, and he turned his primary attention to this area beginning in 1876. This work, which included study of the materials collected from various sources by the Smithsonian Institution,

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[17]Goetzmann, Exploration and Empire, pp. 430-66. See also Thurman Wilkins, Clarence King. A Biography (New York: MacMillan, 1958), pp. 93-116. Mary Rabbitt informatively works the growth of the mining and mineral industry into her account of the federal surveys as background, Geological Survey, Minerals, Lands, and Geology, vol. 1, pp. 139-204, and passim.

eventually led to the establishment of a separate Bureau of Ethnology in the Smithsonian in 1879.[18]

All the geographical and geological surveys were inclined to enlarge their fields of operation. Competing ambitions caused disputes that twice led Congress to consider consolidation of the surveys. Hayden and Wheeler were the chief antagonists, but Powell each time managed to use the Congressional forum to showcase his survey operations. In the first inquiry in 1874 he drew attention to needs for accurate topography and land classification. Subsequently he was transferred to the administration of the Interior Department, where in tandem with the Hayden survey he began a program systematically mapping the territories.

Powell became more involved in public lands issues in his Interior Department setting, and in 1878 completed his Report on the Lands of the Arid Region of the United States. The same year consolidation of the surveys again came before Congress, and at that time Powell and Clarence King threw their support to a wholesale consolidation and reorganization of the Coast Survey, the public land surveys, and the four geographical and geological surveys. Congress was amenable only to the consolidation of the latter, and in 1879 the U. S. Geological Survey was established under Clarence King.

Powell moved to the Smithsonian Institution to continue his ethnological work, but he returned to direct the Geological Survey in

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[18]The overview of the highlights of Powell's career in this and following paragraphs is drawn from information contined in Goetzmann, Exploration and Empire, pp. 551-601; Darrah's, Powell of the Colorado; and Manning, Government in Science.

1881 after King left to pursue business ventures. King's program had focused largely on geology to serve the mining and mineral industries. Powell reduced this emphasis, undertaking more general geological pursuits. Paleontological work was prominent, as was a program for a national geological map. This expanded program weathered some harsh criticism from a laissez faire Democratic administration in 1886 and continued to grow through the end of the decade. In 1888, however, Powell took an opportunity to expand his land classification and land law reform efforts through an Irrigation Survey sought by interests in the West. This effort, unfortunately, ran afoul of a strong disagreement in Congress over a policy on land laws pertaining to irrigation. Powell's leadership of the Irrigation Survey was repudiated in 1890, and the survey terminated. Bitterness in the West over the outcome of the Irrigation Survey brought a vindictive alliance with conservative Democrats in 1892, with the result that Powell suffered a major political defeat and Geological Survey budgets were slashed. Powell informally began to relinquish control of the survey afterward, and he retired from the directorship in 1894. He was replaced by Charles D. Walcott, a paleontologist in the survey who for several years had headed the division of geology under Powell.

Powell continued to direct the Smithsonian Institution's Bureau of Ethnology, but progressively turned the bureau administration over to long-time colleague W. J. McGee. He renewed development of philosophical ideas he first broached early in the 1880s, but with undistinguished results.[19] Powell's health began to deteriorate rapidly in 1901, and he died in 1902.

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[19] His major effort was an overly ambitious synthesis of his thoughts on mind and epistemology, J. W. Powell, Truth and Error. Or the Science of Intellection (Chicago: Open Court Publishing, 1898).

CHAPTER TWO

PHYSIOGRAPHICAL GEOLOGY

In the last half of the nineteenth century the Rocky Mountain and Great Basin region of the West presented a grand field of research for American geologists. Its sparse cover of vegetation and deep canyons laid open the anatomy of the earth's crust over a vast area, stimulating fresh geological approaches to questions on structure, on the form of the land surface, and on the dynamic processes everywhere at work. John Wesley Powell has long been recognized as a major figure in the geological developments spawned in the region, both as an individual and as a leader of a staff that included Grove Karl Gilbert and Clarence E. Dutton.[1]

Geology thus represents a key aspect of Powell's work, and it is appropriate that an attempt to understand the inner workings of the man begin here. Indeed, Powell used the knowledge he gained through his geological studies, and even the broad philosophical perspective he applied in his work, to tackle land system problems as well.

Powell's reputation in geology rests primarily on his

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[1]The significance of the American West as a field of geological study was noted by Karl Alfred von Zittel, History of Geology and Paleontology to the End of the Nineteenth Century, trans. Maria M. Olgivie-Gordon (London: Walter Scott 1901. New York: Charles Scribner's Sons, 1901), pp. 184, 207. For a more complete discussion see Richard J. Chorley, Antony J. Dunn, and Robert P. Beckinsale, The History of the Study of Landforms, or the Development of Geomorphology, vol. 1: Geomorphology Before Davis (London: Methuen and Co., John Wiley and Sons, 1964), pp. 469, 591-98. This volume includes an extensive section (pp. 469-648) on geomorphological contributions by the geologists of the western surveys.

theoretical contributions to fluvial geomorphology--his analysis of erosion processes and his exposition of the power of rivers in cutting valleys and degrading the surface of the land. Others before Powell recognized the large part stream erosion played in western geology, but to Powell goes the credit for the first systematic treatment of the problem grounded in field studies. Powell identified the two great unconformities below the Cambrian in the Grand Canyon rock series and recognized their significance as evidence of the great denudational power of erosion. He developed a clear conception of the phenomenon of antecedence as a determinant of a river course, and thus originated the modern developmental classification of streams as consequent, antecedent, or superimposed. Finally, Powell formulated the concept of a base level of erosion which, as the hypothetical surface of denudation resulting after erosion has proceeded to its limit, was the antecedent of William Morris Davis's idea of the peneplain.[2]

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[2]Chorley, Dunn, and Beckinsale, _Geomorphology_, pp. 501-505, 515-545 gives the modern assessment of Powell's theoretical work as a geomorphologist. W. M. Davis, "Biographical Memoir of John Wesley Powell, 1834-1902," National Academy of Sciences, _Biographical Memoirs_, vol. 8 (Washington, D.C.: National Academy of Sciences, 1915), pp. 15-38 is still valuable, however. See also G. K. Gilbert's contribution in "John Wesley Powell, Proceedings of a Meeting Commemorative of his Distinguished Services," _Proceedings of the Washington Academy of Science_, 1903, 5:113-17. Comments on the present status of Powell's geological interpretations are given in U. S., Geological Survey, _The Colorado Region and John Wesley Powell_, Mary C. Rabbitt, et al., Professional Paper 669, Washington, D.C.: 1969. Brief assessments also appear in Wallace Stegner, _Beyond the Hundredth Meridian. John Wesley Powell and the Second Opening of the West_ (Cambridge, Mass.: Riverside Press, 1954), pp. 146-55, and William H. Goetzmann, _Exploration and Empire. The Explorer and the Scientist in the Winning of the American West_ (New York: Alfred A. Knopf, 1966), pp. 562-66.

Fluvial geomorphology represents but one dimension of Powell's work, however. Although Powell's focus on erosion as a dynamic agency in geology was prominent, it was nevertheless subordinate to his broader interest in the structure of the earth's crust and in the history of its development. In the Plateau Province Powell found a region with striking structural features. Its geology was the result of predominantly vertical movements in the earth's crust acting on a vast geographical scale. Powell sought to describe the structure of the region, and to show the role of upheaval in its development.

Topography was important in this work, to a large extent because it gave evidence of the importance of erosion as a geological agency. But for Powell topography was also important as a result and reflection of geological structure. Topographic information for Powell represented a new class of physical evidence that provided insights both into geological structure, and, where the control of structure was violated, into erosion and its role in the past history of the earth.

Zittel writing late in the nineteenth century included Powell's work under the head of "physiographical geology." To Zittel this was a loosely defined branch of study allied both with geography in its emphasis on the physical qualities and features of the earth's surface, and with geology through its concern for understanding the causes.[3] The term suggests more an approach in doing geology than a discrete field in the discipline, but it seems apt for

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[3]Zittel, History of Geology, p. 172.

the description of Powell's work. It admits the wide range of geological interests that comprised Powell's geological efforts and it draws attention to a physical approach in geology that is characteristic of much of Powell's work.

Powell authored only a few reports before he ended his active research efforts in geology in about 1876. His Exploration of the Colorado River of the West, and its Tributaries, published in 1875 was intended more as a narrative of the river expeditions and a description of the region for general audiences, although it contained some valuable material on drainage development and on the geological structure of the Grand Canyon area.[4] The Report on the Geology of the Eastern Portion of the Uinta Mountains published the following year was rigorously geological, with material on stratigraphy, structure, and dynamic processes including erosion and upheaval.[5]

In addition to these major treatises, Powell prepared three shorter progress reports for Joseph Henry, Secretary of the

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[4] J. W. Powell, Exploration of the Colorado River of the West, and its Tributaries, Explored in 1869, 1870, 1871, and 1872, under the Direction of the Secretary of the Smithsonian Institution (Washington, D.C.: Government Printing Office, 1875). The geological material is found in the second part of the report, "On the Physical Features of the Valley of the Colorado." The narrative of the first part reads as an account of the 1869 voyage, but draws on some materials from the second voyage without remark; see Darrah, Powell, pp. 120, 215, and Goetzmann, Exploration and Empire, p. 550. The third part of the report is an unrelated zoological paper on the mammalian family Geomyidae by Elliott Coues.

[5] Idem, Report on the Geology of the Eastern Portion of the Uinta Mountains, and a Region of Country Adjacent Thereto, with Atlas, U. S. Geological and Geographical Survey of the Territories, Second Division, Washington, D.C.: 1876.

Smithsonian Institution, who had charge of his survey work until 1874. The first preliminary report covered the initial two years work under a regular federal appropriation, 1870-71 and 1871-72. The second and third preliminary reports covered subsequent one-year intervals. These progress reports reveal much about Powell's work in geology.[6]

Other geological reports were published under Powell Survey auspices after 1876, but as Powell had changed his field of research to ethnology, they were the work of others (primarily G. K. Gilbert and C. E. Dutton).

In first undertaking the canyon voyage of 1869, Powell seems to have been primarily occupied with the potential of the canyon-cut Colorado River region for providing an extensive stratigraphical section--"the best geological section on the continent." This was noted in his later account of his overland travels in the region in 1868-69.[7] When Powell returned from the 1869 voyage, however, his horizons had expanded--he was impressed with the magnitude of stream erosion he had seen, and with the region's varied geological structure

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[6]U. S., Congress, House, "Survey of the Colorado River of the West," Misc. Doc. 173, 42nd Cong., 2nd sess., 1872 (hereafter cited as Powell Report, 1872); idem, "Report of the Survey of the Colorado of the West," Misc. Doc. 76, 42nd Cong., 3rd sess., 1873 (hereafter cited as Powell Report, 1873); idem, "Professor Powell's Report on the Survey of the Colorado of the West," Misc. Doc. 265, 43rd Cong., 1st sess., 1874 (hereafter cited as Powel Report, 1874).

[7]U. S. Congress, Letter of J. W. Powell, Congressional Globe, 40th Cong., 2nd sess., 25 May 1868, pt. 3:2564; Powell, Uinta Mountains, p. iv.

as well. Canyons had lateral canyons, Powell found, and these had laterals of their own, and even higher orders, cutting the country "into a labyrinth of cañons" often thousands of feet deep. He noted extensive folding and, in general, a "constant change in geological structure" that produced a continual change of scenery.[8]

But the first canyon voyage was longer on adventure than geology. The trip was more hazardous than anticipated, and survival often took precedence over scientific aims. "On starting we expected to devote ten months to the work," Powell explained in 1874, "But meeting with some disasters, by which our store of rations was greatly reduced, we were compelled to hasten the work, so that but three months were given to it."[9]

Afterwards Powell decided to undertake a better organized and more fully provisioned survey, with the small boats being re-supplied at intermediate points along the river's course. This would also extend beyond the river canyons to the northwest, covering the unexplored plateau country between the Colorado River and the Mormon settlements strung out along the valleys of the Sevier and Virgin rivers. For this effort, Powell sought and obtained his first federal monetary appropriation ($12,000 for 1870-71).[10]

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[8] J. W. Powell, "Major J. W. Powell's Report on His Exploration of the Rio Colorado in 1869," ed. William Culp Darrah, Utah Historical Quarterly, 1947, 15:22, 26. This document is a reprint of a report published as an appendix in New Tracks in North America, W. A. Bell, 2nd ed. (London: 1870).

[9] Powell Report, 1874, p. 3.

[10] Ibid., pp. 3, 27.

The Powell survey, as an entity comparable in objectives and in means of support to the other western geological and geographical surveys, was now under way. During the 1870 field season Powell and a small party traversed the plateaus north of the Grand Canyon investigating the region's geology and exploring for routes by which boats could be reached with supplies. In the meantime Powell's brother-in-law, chief lieutenant, and topographer Almon H. Thompson collected equipment and compiled maps and other available geographical information in preparation for a systematic mapping effort.[11]

In the spring of 1871 the second river exploration began. It was completed over a period of two years. From late May to late November, Powell and Thompson and a few assistants descended the Green and Colorado rivers between the Union Pacific railroad line above Flaming Gorge in Wyoming on the north and the mouth of Glen Canyon in southern Utah on the south. Overland trips were taken by Powell into the plateau country west of the river courses and also to the south around Kanab, north of the Grand Canyon. The following summer saw the survey extended downstream into Grand Canyon. At this time the plateaus north of the Grand Canyon received special attention, with land parties examining eruptive features and faulted structures.[12]

The topographic work undertaken for the systematic surveys begun after 1870 was much more precise and extensive than that done on the

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[11]Powell Report, 1872, pp. 2-5.

[12]Powell Report, 1873, pp. 3-6.

first expedition.[13] Then the base for maps had been the meandered river course, with salient points along the channel connected by compass bearings and estimated distances. The base was adjusted with astronomical observations for latitude and longitude (the latter by the method of lunar distances) taken at intervals of approximately 50 miles. Altitudes were taken by barometer and referenced to tri-daily barometric readings at the river surface.

For the new effort two methods were used. In the plateau region north and east of the Grand Canyon, extending into the vicinity of the Fremont (Powell's "Dirty Devil") River, the meandered baseline of the river was abandoned in favor of a precisely measured 48,009.4 ft. baseline laid out in the Kanab valley north of the Grand Canyon.[14] From this line mapping was carried out using triangulation to establish a network of datum points throughout the region. This was in accordance with the regular practices of the Coast Survey, and comparable to the methods settled on by King's Fortieth Parallel Survey to the north in its quest for mapping methods accurate enough

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[13] Powell outlined his topographical work in Powell Report, 1872, pp. 6, 10-12, and in Powell Report, 1874, pp. 306. They were also reviewed in U. S., Congress, House Committee on Public Lands, "Geographical and Geological Surveys West of the Mississippi," H. Rpt. 612, 43rd Cong., 1st sess., 1874, p. 51.

[14] The line was measured using a set of wooden, metal-tipped rods leveled on trestles, and also using a steel tape, Powell Report, 1874, pp. 4-5. The region surveyed from this line was conspicuously unexplored and unmapped at the time, ibid., p. 6.

for geological needs.[15]

Powell hoped eventually to extend the instrumental survey to the north, embracing the plateaus lying west of the Green River and connecting with King's work. Immediate purposes in that area, however, were served by mapping along the Green and Colorado river courses above Marble Canyon and over a 25-50 mile belt of adjacent country. For this work a less precise form of triangulation was used. A baseline was run along the meandered river course and defined astronomically--a method similar to that used on the first voyage, but more refined. The initial point at Green River Station in Wyoming was telegraphically linked to the longitude of a Coast Survey point established in Salt Lake City, and the river course meandered using two independent observers. Elevations were determined both by barometer referenced to the river surface and by triangulation.[16]

The greater part of the plateau district had been traversed instrumentally and geologically by the close of 1872, and in the course of this work a picture of the geology of the province began to come into focus. Powell paid close attention to the exposed strata he encountered on all of his overland trips, preparing horizontal sections and collecting fossils. "In this region of naked rocks, towering cliffs, and cañon walls," he observed, "the geologist may read the rock-leafed record as he runs"! Powell was not a skilled

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[15]Hayden and Wheeler adopted similar methods in their surveys, but not until 1873. On the topographical practices of the western surveys see "Geographical and Geological Surveys," H. Rpt. 612, 1874, passim, and especially pp. 50-51, 56-58.

[16]Powell Report, 1873, pp. 3-4.

paleontologist, however, and, as appropriation levels did not allow the employment of a specialist, the stratigraphical work was pursued less systematically than it otherwise could have been. An early affiliation with F. B. Meek, who handled the Hayden survey's paleontology, proved unsatisfactory.[17]

Nevertheless, Powell attempted early to correlate the strata he found with formations recognized in the East. He soon found that the fossil fauna and flora were quite different from those exhibited elsewhere and began constructing an independent series with local formation names. This he found difficult because it was necessary to coordinate observations taken from widely scattered sites.
By Powell's own comments, it appears that he felt very tentative about his groupings and wished for more extended study. No significant stratigraphical results were published in Powell's 1875 report on the Colorado River explorations. Only in 1876 after securing the assistance of paleontologist Charles A. White, were results finally published.[18]

The Report on the Geology of the Eastern Position of the Uinta Mountains of that year contained a description of twenty-three formations and their fossils found in the region from the Grand Canyon to the vicinity of the Uinta Mountains. Powell discussed the structural

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[17] Ibid., p. 14; Powell Report, 1874, pp. 12-15, 18-19; U. S. Congress, House, "Geographical and Geological Surveys," Ex. Dec. 80, 45th Cong., 2nd sess., 1878, p. 9 notes the Meek affiliation; quoted material, Powel Report, 1872, p. 4.

[18] Powell, Uinta Mountains, pp. v-vi, 38, 71.

relations of the strata and their correlation with formations identified by other geologists in neighboring areas. He also provided a geological map of the Uinta Mountains and surrounding area where formations were exposed. All together Powell presented a series of more than 45,000 feet of sedimentary and metamorphic rocks extending back to the Eozoic (Pre-Cambrian) period, fulfilling his early objective of providing "the best geological section on the continent."[19]

A picture of the structural geology of the plateau region to the south began to emerge by early 1872 after the first field season of the second canyon voyage. In contrast, most probably, to the predominant contemporary view of mountain structure as crustal corrugations caused by simple compressional folding (as in the case of the Appalachians), the plateau character of the province was beginning to make an impression on Powell.

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[19] Charles A. White prepared one chapter of this report on the "Invetebrate Paleontology of the Plateau Province."

In assigning the Bitter Creek formation to the Tertiary rather than to the Cretaceous, through recognition of an unconformity due to subaerial erosion, Powell entered into the lignitic or "Laramie" question. In doing so he took a stand against both F. V. Hayden's view that all coal-bearing strata represented a continuous record of Cretaceous-Tertiary age, and Clarence King's claim that they were Cretaceous age. Ibid., pp. 64-66, 71-72. On "The Laramie Question" see George P. Merrill, The First One Hundred Years of American Geology (New Haven: Yale University Press, 1924; facsimile ed., New York: Hafner Publishing Co., 1969), pp. 579-93. Powell's contribution to the issues is not mentioned by Merrill, although C. A. White's role beginning in 1877 is treated.

> After . . . reaching the head-waters of the San Rafael, I ascended the mountains to the west. I found them composed of cretaceous and tertiary strata, nearly horizontal, and the summit was a vast and almost level plain. Perhaps this should have been called a plateau rather than a mountain range.[20]

Major structural features of the region were becoming apparent. Powell saw the province as a system of several great anticlinal folds oriented generally east and west, complicated by another, lesser system of transverse folds oriented north and south. The whole complex was seen to have been slowly uplifted and subjected to thousands of feet of denudation by the drainage system. Powell's classification of stream valleys as they related to structure was also complete at this time although not perfect in its terminology, and its tacit theoretical consequences--that the relation of drainage patterns to structural geometry recorded the history of erosion and upheaval--had already helped Powell conclude that the rate of uplift in the region had been comparatively slow.

> . . . The elevation of the folds above the sea proceeded but little faster than their denudation by rains and rivers. And it is not probable that the summit of the mountains were ever much higher than at present.

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[20]Powell Report, 1872, p. 8. Powell explicitly rejected the applicability of the Appalachian model in the Colorado plateau region later, Uinta Mountains, p. 9. The prominence of the Appalachian ranges as a model for theories of mountain building during the middle and later years of the nineteenth century is reviewed by Joseph Barrell, "The Growth of Knowledge of Earth Structure," in A Century of Science in America, with Special Reference to the American Journal of Science 1818-1918, ed. by Edward Salisbury Dana (New Haven: Yale University Press, 1918), pp. 170-88. See also Zittel, History of Geology, pp. 304-307.

Powell also judged that upheaval had affected the province progressively, moving both northward and westward into the region.[21]

The field work of the next season on the plateaus north of the Grand Canyon added two new dimensions to these outlines. First, Powell recognized a "great system of faults, unparalleled in geological annals," running generally transverse to the northward-dipping strata of this region. The dislocations showed themselves in a variety of forms, including flexures as well as simple fractures with escarpments, and generally added to the complexity of the plateau surface north of the Grand Canyon.[22]

Often associated with this faulting were certain eruptive features. Basalt flows were common, producing table lands and filled valleys. Cinder cones were also present. These features would receive more careful study the following year, in 1873. One particular feature, the Henry Mountains, would later receive close study of G. K. Gilbert, and provide the model for his concept of laccolithic intrusions.[23]

Powell's appreciation of the effects of erosion on these faulted, folded, and eruptive structures also grew during this season. A series of five bold, east- and west-trending cliffs flanking the Grand

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[21] J. W. Powell, "Remarks on the Structural Geology of the Valley of the Colorado of the West," Bulletin of the Philosophical Society of Washington, 1871-74, 1:48-51 [in Smithsonian Miscellaneous Collections, Smithsonian Institution, vol. 20 (Washington, D.C.: Smithsonian Institution, 1881)]; quoted material from p. 51.

[22] Powell Report, 1873, p. 12.

[23] Ibid., pp. 9, 13.

Canyon on the north were recognized as products of erosion acting on the exposed edges of formations dipping gently to the north. Extensive step-like terraces resulted, which were complicated by canyoning and by the transverse system of faults. Erosion working on the more ancient basaltic masses produced residual mountain masses that stood starkly amid valleys or atop plateaus.[24]

By the closing of the 1872 season, then, Powell's picture of the geology of the region was complete in its bolder outlines. The report for the following year, in exhibiting Powell's penchant for systematic if not always instructive categorization, suggests that results were being organized for presentation; and indeed there is very little in the later Colorado River and Uinta Mountains reports relating to structural geology or the agency of erosion that was not expressed or implied in outline form by 1873.

The Grand Canyon area and the Colorado plateaus immediately north of the canyon provided important insights for the structural geology of the Plateau Province. The system of faults that Powell observed there highlighted the predominantly vertical character of the tectonic forces operating on the region, breaking the area up into a complex of large blocks uplifted without significant tilting and bounded on their east and west edges by fault escarpments or abrupt monoclinal flexures. Powell saw this structure as a

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[24] Ibid., pp. 9-13.

distinctive type,[25] which he termed the Kaibab structure, after the plateau on the north rim of the Grand Canyon east of Kanab Creek. It became the characteristic--although not the exclusive--structural type representative of the Plateau Province. The vertical character of the deformation, together with its generally north and south lineaments, shifted Powell's attention from the idea of great, east-west crustal folds he had first conceived; eventually it provided a new framework on which he could see a broad similarity of structure from the Rocky Mountains on the east, across the Plateau Province, and through the Great Basin ranges on the west.[26]

These insights make it fitting that Powell and the Grand Canyon region should have become so closely linked in the historical literature. It was the Uinta Mountains region, however, that brought out Powell's most comprehensive geological work. As the part of the Plateau Province Powell first visited, it provided a full range of stratigraphical information on the region from Pre-Cambrian age

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[25]"Type" for Powell had no absolute ontological significance. As he remarked on the classification of valleys in Exploration of the Colorado, p. 161, "Species are not found in structural geology . . . ; that is, there are no definite 'hard and fast' lines of demarkation . . . , and the classification rests solely on typical examples."

[26]Powell provided an extended discussion of faults and their various manifestations in the structure of the Kaibab and adjacent plateaus, ibid., pp. 182-90. He identified the Kaibab structure as the predominant structural type of the Plateau Province, and compared it with structural types in surrounding provinces in Uinta Mountains, Chapter I: "Three Geological Provinces."

through the present. It offered Powell early evidence of the vertical forces operating on a large scale throughout the province, and its stream-cut valleys provided fundamental insights into erosion and its topographic effects. The Uinta Mountains area provided the basis for Powell's formulation of a larger region's developmental history, and conclusions reached for the Uinta area became a point of departure for interpretation of other areas.

Powell saw the Uinta Mountains as a great east- and west-trending flexure about 150 miles long and 50 miles wide, the flexure along its axis representing an upheaval of about 25,000 feet above the general level of the country. Zones of maximum flexure were localized along the north and south flanks in monoclinal flexures or, in places, simple faults. These accounted for most of the displacement, giving the warp the character of an upheaved block with its top surface gently arched. The uplift was greatly eroded, stripping formations through the Paleozoic from the arched upper surface, and leaving a broad, irregular, table-like mass 8000-10,000 feet in elevation.[27]

In his report on the Exploration of the Colorado Powell observed that the mountain mass had been cut through by the Green River. It entered transverse to the arch on the north flank, then turned sharply east and flowed through Red Canyon and Brown's Park almost longitudinally along the flexure, receiving several tributary streams. At Lodore Canyon the river turned abruptly south, running transverse to the uplift for many miles before turning back

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[27]Ibid, pp. 176-79 and plates.

toward the southwest and leaving the mountain.

Powell recognized that the course taken by the river was generally in opposition to the larger structural lines, and out of this observation grew a systematic classification of valleys. Powell noted that as the river entered on the north flank of the anticlinal uplift it was running directly counter to the northward dip of the beds--a course he termed anaclinal. As it turned and ran through Brown's Park, the Green River was nearly atop and running longitudinally along the axis of the fold in a manner Powell called anticlinal. Through Lodore Canyon, after crossing the axis and flowing transversely but with the dip through the formations on the uplift's south flank, the course was cataclinal.

Summit Valley, tributary to Lodore Canyon from the west along the summit, ran parallel to the anticlinal axis along the flank with southward-dipping beds. This type of valley, which Powell called monoclinal, was typified on one flank by the erosion-cut, upturned edges of a formation and on the other flank by a more gentle dip-slope formed in one of the softer, more easily eroded beds. Monoclinal drainage was common on the upturned edges of the formations exposed on both the north and south flanks of the Uinta upheaval. There the ridges often were very prominent, forming "hog-backs" that were quite obstructive to travel.

Two other tributaries of the Green just to the south of the Uintas ran along the axis of a syncline paralleling the Uinta fold. These streams followed the structural depressions, and were called synclinal streams.

On the very largest scale, the Green River was seen to have cut completely across the axis of a fold. Powell called such a stream diaclinal, recognizing that it was a compound, separable on smaller scales into anaclinal and cataclinal sections.[28]

Powell organized all six categories of valleys into two orders, those paralleling or longitudinal to an axis of a fold, and those transverse to it. This system of categorization was essentially descriptive, as critics have noted.[29] Nevertheless the classification was an important step in theory building. "The study of the structural characteristics of valleys and cañons," Powell pointed out, "teaches us, in no obscure way, the relation between the progress of upheaval and that of erosion and corrasion."[30] From this foundation Powell inferred the antecedent origin of the drainage system across the Uinta uplift and eventually developed his respected classification of streams as consequent, antecedent, or superimposed.

The Green River's course posed a clear contradiction of the presumably normal state of affairs for a "consequent" stream, where the structural highs and lows guide a stream's course.

> To a person studying the physical geography of this country, without a knowledge of its geology, it would seem very strange that the river should cut through the mountains, when apparently, it might have passed around them to the east, . . . where the mountains are degraded to hills. . . .
> . . . Why did not the stream turn around this great obstruction, rather than pass through it? The answer is that

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[28] Exploration of the Colorado, pp. 157-62, and fig. 53-58.

[29] Davis, "Memoir of Powell," p. 31; Chorley, Dunn, and Beckinsale, Geomorphology, p. 533.

[30] Exploration of the Colorado, p. 162.

> the river had the right of way; in other words, it was running ere the mountains were formed; not before the rocks of which the mountains are composed, were deposited, but before the formations were folded.

The river was thus "antecedent" to the deformation.[31]

"The direction of the streams," Powell maintained, provided "indubitable evidence that the elevation of the fold was so slow as to not divert the streams" flowing over the region.[32] In forming this conclusion Powell had considered alternatives. The structural geology of the uplift offered no evidence of a fracture or fissure dictating the Green River's course; the canyons were clearly cut by corrasion. They might conceivably have been cut, Powell hypothesized, by being incised from a later, stratigraphically higher formation down into the earlier, warped and buried beds. Such superimposed drainage patterns, as he termed them, had been observed in the Park (Rocky Mountain) Province; but although Powell concurred with this explanation there, he did not feel it fit the facts in the case of the Uinta Mountains. In the Uintas many of the streams were monoclinal tributaries to the Green, which Powell did not feel could have developed by superimposition.

> Recurring again to the valleys of the Uinta Mountains, it may be well to remark here that, coming from the Rocky Mountains to the study of the Uinta Mountains, I at first supposed that the valleys of this region also were superimposed upon the rocks now seen, but gradually, on a more thorough study, the hypothesis was found to be not only inadequate to the explanation of the facts, but to be entirely inconsistent with them . . . .

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[31] Ibid., p. 152.

[32] Ibid., p. 162.

> A brief reference to the character of this evidence may not be out of place here. . . . If the valleys were superimposed on the present rocks, they must be consequent to rocks which have been carried away; but the valleys consequent upon the corrugation, which was one of the conditions of the origin of the Uinta Mountains, could not have taken the direction observed in this system; they would have all been cataclinal, as they ran down from the mountains, and turned into synclinal valleys at the foot, forming a very different system from that which now obtains.

In addition, Powell noted an absence of stratigraphically higher beds sufficiently extensive for superimposition to have occurred.[33]

The river, then, must have cut its way into the fold as it was slowly upheaved.

> The contracting or shriveling of the earth causes the rocks near the surface to wrinkle or fold, and such a fold was started athwart the course of the river. Had it been suddenly formed, it would have been an obstruction sufficient to turn the water in a new course to the east, beyond the extension of the wrinkle; but the emergence of the fold above the general surface of the country was little or no faster than the progress of the corrasion of the channel. We may say, then, that the river did not cut its way <u>down</u> through the mountains, from a height of many thousand feet above its present site, but, having an elevation differing but little, perhaps, from what it now has, as the fold was lifted, it cleared away the obstruction by cutting a canon, and the walls were thus elevated on either side. The river preserved its level, but the mountains were lifted up, as the saw revolves on a fixed pivot, while the log through which it cuts is moved along. The river was the saw which cut the mountains in two.[34]

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[33]Ibid., pp. 152, 163-66; quoted material from p. 166. Others argued that superimposition was the better explanation according to Davis, "Memoir of Powell," p. 26. For modern interpretations of Colorado River development see Charles B. Hunt's "Geologic History of the Colorado River" in Colorado Region and John Wesley Powell, Geological Survey, pp. 59-127. Typically, both superimposition and antecedence are cited to explain the Colorado drainage, where Powell pointed to antecedence alone. The Green River through the Uintas is now seen to have resulted from superimposition alone.

[34]Exploration of the Colorado, p. 153.

Powell used the insights into drainage development and its structural relations gained in the Uinta Mountains to interpret the geology elsewhere in the region. In the Uintas, for example, the monoclinal valleys often had been found to produce hog-back ridges, especially along the flanks of an upwarp where the up-turned edges of the formations were exposed. The slope of the cut edges of the strata facing the axis of the warp was typically steep, and the slope away from the mountain side was more gentle to greater or lesser degrees, conforming to the dip of the strata. The valleys were cut into the softer, more easily eroded strata, and often their level had been degraded even below that of the surrounding country away from the folds (the main drainage channels being themselves incised still lower in their canyons).[35]

Powell saw that a similar process of erosion on similarly inclined structures elsewhere produced a cliff and terrace landscape. On leaving the Uinta uplift the Green River first flowed into and across a gentle, east-west synclinal fold marked by the Uinta and White rivers. From there roughly to the confluence with the Colorado (Powell's Grand River) the Green traveled against the gentle dip of the strata through an area Powell called the "Terrace Cañons." These canyons "cut through three great inclined plateaus" forming "a great stairway" of terraces marked by three cliffs. Leaving the valley of the White River toward the south by land, one had to climb "gradually, almost imperceptibly," ascending perhaps 3000 feet over

[35] Ibid., pp. 158-62.

40 or 50 miles. Then the brink of a cliff was reached, followed by an abrupt descent to a second, lower terrace. Farther on was a similar long, gradual descent, and a second cliff; then a third terrace terminated by a third cliff. The river course cut through these steps in a series of three corresponding canyons.[36]

Powell explained these cliffs and terraces as analogs of monoclinal valleys and hog-back ridges:

> It will be remembered that in the description of the country lying to the north of Red Cañon and Brown's Park, it was explained that ridges were formed by the unequal progress of erosion through the upturned edges of the formations lying on the flank of the fold.
>
> Thus ridges are seen where the dip of the rocks is at a high angle--often twenty to forty five degrees; but where the dip is at a low angle--from one to five degrees--such ridges are not found.

Instead, the upper surface of rock unit forms the gently-inclined terrace, and the cut edges form cliffs. Imagination and close instrumental work, Powell observed, show the operation of like causes in both cases.

> Expand a fold like that of the Unita Mountains, where the rocks dip from ten to ninety degrees, to a more gentle curve, where the rocks dip at a much smaller angle, so that the inclination is scarcely perceptible to the eye, and can only be determined by an extended leveling and tracing of the strata, and the hog-backs are thrown farther apart. The escarpments of these hog-backs, facing the axis of the fold, are still lines of cliffs; but the slopes on the opposite sides are so gently inclined as not, at once, to be apparent, and the streams heading near the brink of the cliffs, and running down the gentle slope away from this line, excavate their own valleys and cañons, and so break up the plane of this slope that its inclination is not at once observed; in fact, it can only be discovered as a generalization from a careful study.[37]

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[36] Ibid., pp. 167-68.

[37] Ibid., pp. 169.

Similarly, Powell used monoclinal drainage to explain the prominent cliff lines of the plateaus north of the Grand Canyon. There the system of faults complicated interpretations considerably, however, and examples are less instructive. The east-west cliff lines deriving from a structure similar to the Terrace Cañons Powell termed cliffs of erosion; but where faulting operated and tilting was more pronounced, he saw monoclinal ridges equivalent to the hog-backs of the Uinta uplift.[38]

Another extension of the monoclinal drainage and monoclinal ridge concept was in Powell's interpretation of Great Basin geological history, offered in his report on Uinta Mountains geology. Powell judged monoclinal ridges to be the primary structural type in the Great Basin Province; and in observing that the ridge lines in province had not been carried back by erosion from the places of faulting to any significant extent, Powell inferred that upheaval there as in the Plateau Province had been slow and comparatively continuous.[39]

With such interpretations to complement stratigraphic evidence, Powell arrived at an outline of the geological history of the Plateau Province and the Park and Great Basin provinces contiguous with it. In late Mesozoic times, Powell supposed, the Great Basin

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[38] Ibid., pp. 190-93, 205; Uinta Mountains, pp. 11-14. See also Powell Report, 1873, pp. 9-11, 13.

[39] Uinta Mountains, pp. 16, 33. Powell also included a summary of the results of G. K. Gilbert's classic analysis of Great Basin structure (pp. 23-25). Gilbert found about two-thirds of the Great Basin ridges were the faulted monoclinals that Powell chose as the region's characteristic structural form.

region on the west was a dry lowland denuded by erosion. The Plateau Province to the east was a shallow sea, and the Park Province an open sea with a chain of islands extending to the south. The series of upheavals that produced modern topographic features through their continuing action were judged to have begun with the Cenozoic era. Upheaval was least to the west in the Great Basin, where erosion very nearly kept pace with elevation, and the general elevation of the land surface above the level of the sea remained about the same as it had been when the movements commenced. Upheaval was progressively greater toward the east, with upheaval in the Park Province reaching 30,000 feet. Denudation was less able to keep pace with upheaval in these provinces, with the result being that the present plateaus and mountains came into being. The Plateau Province was the last to emerge from the Mesozoic sea, in consequence of its depressed initial condition and moderate rate of upheaval; thus the drainage between the Great Basin and Plateau provinces, Powell concluded, was necessarily reversed in the late Tertiary.[40]

Because drainage development and degradation processes generally offered so much insight into the history of the earth, Powell made erosion "a subject of much study."[41] Ground had already been broken in the area at about mid-century by the outstanding American geologist James Dwight Dana through his work with the United States Exploring Expedition in the Pacific in 1838-43. Dana demonstrated that valleys

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[40]Ibid., pp. 32-36.

[41]Powell Report, 1874, p. 17.

typically were landscape features excavated by streams. He observed how valley cross-sections changed from narrow V-shapes to vertical-sided gorges and then to broad valleys, and how the stream profile changed at the same time from very steep to gentle. He accounted for these changes by explaining that the excavating power of a stream depended on the velocity and volume of the flow, and by showing that the former decreased and the latter increased from the headwaters down stream.[42]

Powell moved beyond this, showing how erosion in its relations to factors of climate, geological structure, and lithology worked to produce a great variety of landscape features. He demonstrated the incredible magnitude of general surface degradation that erosion accomplished since the Pre-Cambrian period, and he undertook a more extended physical analysis of erosion processes in a search for a better understanding of the factors affecting the rate of degradation.

On this last score Powell's analyses were neither as incisive nor as comprehensive as the classic studies presented soon afterwards by his assistant G. K. Gilbert.[43] Gilbert was better able to

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[42]For a discussion of Dana's work see Chorley, Dunn, and Beckinsale, Geomorphology, pp. 357-70.

[43]U. S. Geographical and Geological Survey of the Rocky Mountain Region, Report on the Geology of the Henry Mountains, by G. K. Gilbert, Washington, D.C.: 1876, pp. 99-144. For an assessment of Gilbert's work see Chorley, Dunn, and Beckinsale, Geomorphology, pp. 550-67. Powell and Gilbert met in 1872 in Utah, each independently having already developed significant interests in structural geology and in erosion as a geological agency. Stephen J. Pyne, Grove Karl Gilbert. A Great Engine of Research (Austin: University

distinguish consistently between the power of flowing water to erode and the actual work accomplished in degrading the surface of the land (the latter being dependent on the volume as well as the velocity of the flow). Gilbert also made more effective use of the river conceptually, as the fundamental physical system around which the erosion process acts. And finally Gilbert in his concept of grade--that a river profile in its various reaches is a dynamic response to the resistance of the bed material and the erosive power of the flow which tends toward an equilibrium gradient displaying neither corrasion nor deposition--grasped a simple but powerful idea that was far more useful in explaining a wide variety of erosion phenomena than anything Powell had at his disposal.

But if Powell's analysis had neither the incisiveness nor scope of Gilbert's, it still helped add to his understanding of the erosion process and its effects in the landscape. The great power of erosion evident on every hand in the Plateau Province made a great impression on Powell. It was apparent in every stream channel, canyon, and mountain form, which collectively represented a considerable degree of erosion. That total, however, could not compare with the general degradation of the surface over the entire region.

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of Texas Press, 1980), pp. 72, 77, tells us that the two men quickly became close friends; that along with Clarence Dutton they freely exchanged ideas of all kinds; and that consequently, it is not clear in many cases which man broke ground for the other. This is such a case, and it is most probable that Powell and Gilbert developed their ideas on the erosion process conjointly, the differences in their ideas representing not so much stages of development as personal differences in intellectual priorities and analytical skills.

> But the carving of the cañons and mountains is insignificant, when compared with the denudation of the whole area, as evidenced in the cliffs of erosion. Beds hundreds of feet in thickness and hundreds of thousands of square miles in extent, beds of granite and beds of schist, beds of marble and beds of sandstone, crumbling shales and adamantine lavas have slowly yielded to the silent and unseen powers of the air, and crumbled into dust and been washed away by the rains and carried into the sea by the rivers.[44]

Below the surface in the stratigraphic record was even more impressive evidence. In an unconformity in the Paleozoic strata of the Uinta Mountains more than 3000 feet of rock had been stripped away before the Carboniferous deposition commenced; and in the Grand Canyon during the same period of erosion nearly 10,000 feet were removed. In areas where upheaval was greatest, as along the axial ridge of the Uintas, Powell's stratigraphic studies showed more than 25,000 feet of rock were disintegrated and carried away. Over the entire region of the Uinta uplift embracing more than 2800 square miles, Powell calculated that "about 8300 cubic miles of rock" had been carried away, giving "a mean degradation of about three cubic miles to the square mile."[45]

Powell addressed himself to denudation and the factors affecting its rate beginning with his first report, the Exploration of the Colorado River of the West. The durability of rock material was one very recognizable consideration. Powell noted that where there were broad regional differences in the lithological character of the

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[44] Exploration of the Colorado, p. 208.

[45] Uinta Mountains, pp. 70, 181.

rocks, districts composed of softer rocks were rapidly excavated to form valleys and plains while the more resistant districts endured to form hills and mountains. On the other hand where stratified rocks were encountered the effect of harder and softer beds was to produce cliffs and hog-back ridges.[46]

Another obvious factor to consider was precipitation in its effect on stream volumes. In districts bordering highland areas where larger stream volumes could be expected because of the greater precipitation in the mountains, Powell thought erosion was more rapid.[47] But greater precipitation also increased the growth of vegetative cover that protected against erosion, and so Powell concluded that precipitation levels probably had more effect on the form of surface features in the region than on overall surface erosion.

> . . . Erosion does not increase in ratio to the increase of the precipitation of moisture, caeteris paribus, as might be supposed; for, with the increase of rains there will be an increase of vegetation, which serves as a protection to the rocks, and distributes erosion more evenly, and it may be that a great increase of rains in this region would only produce a different series of topographic outlines, without greatly increasing the general degradation of the Valley of the Colorado.[48]

Cliffs and hog-back ridges, for example, were probably typical only of arid climates.

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[46] Exploration of the Colorado, p. 204.

[47] Ibid., pp. 162-63.

[48] Ibid., p. 209.

> Where there is a great amount of rain-fall, the water penetrates and permeates the rocks, and breaks them up, or rots them, to use an expression which has been employed with this meaning; and the difference between the durability of the harder beds and that of the softer, is, to some extent, compensated for by this agency.

Ridges and cliffs were produced in humid regions, but they were typically more muted; hills and mountains were produced rather than plateaus and ridges with escarpments. In the case of streams, the humid regions produced valleys rather than steep-sided canyons.[49]

Another factor was elevation. This had visibly affected the general degradation of the Colorado region, Powell believed. In part it acted through increased rainfall; more importantly and directly, it acted through greater inclination of the stream channels.[50] This increased the velocity of flows, and in turn increased the power of running water to transport materials and corrade channels. Hence, Powell concluded, "degradation of rocks increases with the inclination of the slopes."[51]

The degradation problem to Powell was one of both altitude and inclination; and in an attempt to represent the effects of elevation more clearly, Powell introduced the concept of base level. Acting regionally or locally, the base level was the ultimate level to which an area could degrade.

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[49] Ibid., pp. 204-205.

[50] Unlike G. K. Gilbert with his law of divides, which linked the increase of slopes as watershed divides were approached to the increased discharge of streams, Powell never gave a satisfactory physical explanation to this phenomenon. He treated it more or less as an empirical rule.

[51] Exploration of the Colorado, p. 203.

> Let me state this in another way. We may consider the level of the sea to be a grand base level, below which the dry lands cannot be eroded; but we may also have, for local and temporary purposes, other base levels of erosion, which are the levels of the beds of the principal streams which carry away the products of erosion. . . . Where such a stream crosses a series of rocks in its course, some of which are hard, and others soft, the harder beds form a series of temporary dams, above which the corrasion of the channel through the softer beds is checked, and thus we may have a series of base levels of erosion, below which the rocks on either side of the river, though exceedingly friable, cannot be degraded.

Powell acknowledged that a base level was not a surface strictly speaking, for

> the action of a running stream in wearing its channel ceases, for all practical purposes, before its bed has quite reached the level of the lower end of the stream. What I have called the base level would, in fact, be an imaginary surface, inclining slightly in all its parts toward the lower end of the principal stream draining the area . . . , or having the inclination of its parts varied in direction as determined by tributary streams.[52]

This notion of an inclined surface shows that, like G. K. Gilbert, Powell recognized an equilibrium condition for streams in which they neither corraded nor deposited, but simply transported the received load. Powell's use of the idea was much more limited than Gilbert's, however. Powell was only looking for a frame of reference on which to gauge denudation rates. With the base level concept Powell was able to combine his statements concerning elevation and inclination into a single expression, "That the more elevated any district of the country is, above its base level of denudation, the more rapidly it is degraded by rains and rivers."[53]

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[52] Ibid., pp. 203-204.

[53] Ibid.

Powell never made use of the base level idea in any quantitative fashion. Typically he relied on the simple qualitative linkage of higher elevations with greater rates of degradation.[54]

In an attempt to establish this rule more firmly and to use the rule in his assessment of upheaval rates in the Plateau Province, Powell returned to the study of degradation in his Report on the Geology of the Eastern Portion of the Uinta Mountains. Powell undertook a physical analysis of the process of erosion, and began by drawing a distinction between the initial disintegration of rock from its parent strata and its subsequent transportation as detritus. In disintegration Powell identified the principal operating forces as gravity in breaking rock away from ledges, fracturing it in falls, and abrading it in the course of transportation by flowing water; expansion and contraction through temperature changes; crystallogenic expansion when water freezes in cracks and pores; and chemical reactions.[55]

In the transportation of debris Powell distinguished carefully among dissolved materials; materials that had particle sizes and specific gravities small enough for "flotation" (suspension) by the flow; and the larger and heavier materials that maintained contact with the stream bed. The first group encountered negligible

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[54] He did use the physical idea of a base level, however, to explain the sequence of canyons and valleys presented by the Green and Colorado rivers: the valleys were produced as a consequence of resistant strata causing local base levels at their lower reaches. Ibid., pp. 206-207.

[55] Uinta Mountains, pp. 181-84.

frictional resistance and behaved as fluids flowing under the action of gravity. They flowed, as he put it, by "rock power": water was merely a vehicle, and gravity acting on the rock material supplied the motive force of transportation. In the second group some of the energy of the flowing water was required for maintaining flotation; but again the flow was not required to drive the debris after it was suspended. In the third instance driving power from the flowing water was required constantly in order to overcome friction of the material along its bed.[56]

As Powell proceeded in his analysis he pointed out that the suspended portion of the load accounted for the great bulk of transported material. Consequently the amount of material carried under a given discharge rate depended on the fineness of particle size.

> Comminution promotes flotation. If this comminution is great, approaching complete or molecular comminution, the velocity of the water . . . becomes a small factor, and the amount of transportation chiefly depends on the containing capacity of the water; but as comminution is less and the size of the particles larger, some force must intervene to promote flotation, and this is derived from the water power; and to sustain the same amount of flotation more of this force must be utilized as the size of the particles increase.[57]

Powell noted that flotation increased with the velocity of the flow, and in turn with the declivity or gradient. The suspended load was thus a function of slope. Moreover he reached the same conclusion for the remaining components of the load: the load driven

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[56]Ibid., pp. 184-87.

[57]Ibid., p. 186.

along the bed depended on water power, and thus the slope; and the dissolved portion of the load moving under the direct influence of gravity obviously depended on slope. In transportation, Powell concluded, "the rate is determined by declivity."[58]

Powell then used the results of this analysis of disintegration and transportation to examine the various modes of degradation. He identified the fundamental modes as surface degradation, or "erosion proper"; corrasion by streams transporting debris; and sapping (i.e., undermining) of cliffs, ledges, and stream banks.[59]

In each mode Powell contended that degradation was especially affected by the rate of transport of detritus. In surface degradation and sapping, transportation deficiencies protected the parent material from attack by disintegration processes. In corrasion, the transportation process made river-borne debris the instrument of stream bed disintegration. The force applied was dependent on rock power and water power--the same as transportation in general--and so the rates of all modes of degradation were dependent on slope or declivity.[60]

Indeed, slope affected degradation in geometric proportion as it increased, Powell reasoned. Greater slopes increased corrasion, but in so doing added to stream loads and increased downstream corrasion even more. Overall, Powell suggested, this led to a further increase

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[58] Ibid., p. 187.

[59] Ibid., pp. 188-96.

[60] Ibid., p. 189.

in gradient, which accelerated surface erosion above the streams and then again added to stream corrasion, consequently increasing the gradient even more.

> Rapid corrasion increases the declivity of erosion, and hence increases erosion; and this increased erosion augments the instrument of corrasion, hence, increases corrasion; and declivity by the two methods of degradation enters the general problem of degradation as a factor with a rapidly increasing value.[61]

Powell's logic was faulty here, we note, because in the absence of any discussion of loading in excess of the capacity of the stream or of a limit caused through operation of a base level, his arguments lead to the false corollary that slopes increase down stream! But we will allow that Powell recognized, if in a somewhat awkward fashion, that disintegration and transportation were interdependent parts of the degradation process and that there were conditions in which changes in one process led to disproportionate changes in the system as a whole.

Powell also saw the sapping process increased via the synergistic effects of slope and corrasion. Thus he concluded that slope was the keystone to the entire problem of degradation rate.

> Having considered all the modifying conditions of climate and petrology, it yet remains that degradation increases with declivity through the combined forces of water power and rock power in a rapidly-multiplying rate from that low degree of declivity which permits the transportation of finely-comminuted load to that high degree of declivity which permits the load to be moved by its own gravity, when the effect of declivity is again multiplied at a still higher rate until verticality

[61] Ibid., p. 190.

> is reached and undermining begins and another multiplication of the effect of declivity ensues.

"The higher the mountain, the more rapid its degradation," Powell concluded. "Mountains cannot remain long as mountains; they are ephemeral topographic forms."[62]

With this rule more firmly in hand Powell could return to more fundamental problems in geology. In an apparent test of uniformitarian principles, he asked whether the rate of upheaval in the Uinta uplift was slow and uniform, or perhaps episodic with periods of rapid upheaval separated by long periods of calm.

Powell first considered the case of a single, cataclysmic episode of upheaval, comparing the theoretical topography to that which actually was found in the Uintas.

> Its steep flanks would then have been regions of great declivity, while its axial region would have comparatively gentle slopes, and as the first streams heading along the axis ran toward the flanks, these streams would not only have had channels suddenly increasing in declivity at the flanks, but the amount of water carried by the streams would have steadily increased from axis to flanks, and hence corrasion on the flanks would have proceeded at a rate determined by these multiplied causes. As the main channels were thus corraded all the lateral channels would in like manner have been rapidly corraded; . . . the degradation along the flanks would have far exceeded degradation along the axis, and this would have resulted in the production of an ever narrowing axial ridge. An examination of the map reveals the fact that these are not the topographic characteristics of the Uinta Mountains.[63]

The Uintas' mass, it will be remembered, presented itself as an irregular tableland.

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[62]Ibid., pp. 195-96.

[63]Ibid., p. 197.

Powell then contemplated the gradual and episodic cases.

> Let us further consider . . . two hypotheses, one of which must be true. If elevation was constant but slow, the axial region was first attacked by degradation, and as it was slowly uplifted, degradation kept this axial region down so that an axial ridge was not produced. If elevation was intermittent it might have been fast for a time, and then ceased until the region was planed down to a general level now represented only by the summits of the highest peaks, and then a new upheaval carried it to its present elevation. But the rate of this last uplift must have been slow or the axial ridge would have been more pronounced, and hence we may infer that the elevation was either slow by continuous motion, or what would be its equivalent, slow through intermission of movement, with the last epoch of elevation slow.[64]

This was a verdict for uniformitarian principles in geology. Powell did not hammer the point home as emphatically here as he had the previous year in his report on the Exploration of the Colorado River of the West, however.

> . . . The study of the structural characteristics of the valleys and canons teaches us, in no obscure way, the relation between the progress of upheaval and that of erosion and corrasion, showing that these latter were *pari passu* with the former, and that the agencies of nature produce great results--results no less than the carving of a mountain range out of a much larger block lifted from beneath the sea; not by an extravagant and violent use of power, but by the slow agencies which may be observed generally throughout the world, still acting in the same slow, patient manner.[65]

Powell's report on the geology of the Uinta Mountains in 1876 marked the end of his career in active geological research. His interest in Indian culture was increasing, and Powell was ready to commit himself more heavily to ethnological studies. At the same

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[64] Ibid., pp. 197-98.

[65] Exploration of the Colorado, p. 162.

time Powell had come to feel confident about turning over the geological work to the assistants he had enlisted the previous year.

Powell found in Grove Karl Gilbert a geologist who in his work with the Wheeler survey demonstrated not only exceptional analytical skill, but also a sensitivity to the structural problems presented in the region. Moreover, in his earlier work with the State Geological Survey of Ohio in the glaciated region near Lake Erie, he had learned to appreciate the geological insights to be gained from a study of topographical features. Gilbert continued his excellent work with Powell, and later in the U. S. Geological Survey as well. In addition to the erosion studies already mentioned, he studied structural deformations caused by volcanic intrusions that resulted in the concept of the laccolith; he worked out the geological history of the Pleistocene lake in the Great Basins known as Lake Bonneville; and he studied the problem of hydraulic mining debris that was choking river channels and flooding agricultural land in California.[66]

In Army Ordnance officer Clarence E. Dutton, Powell found another who shared his interests. While stationed in Washington, D. C. early in the 1870s, Dutton had frequented local scientific societies and produced several papers on crustal contraction and other theories

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[66]See the biography by Stephen J. Pyne, Grove Karl Gilbert. A Great Engine of Research (Austin: University of Texas Press, 1980); W. M. Davis, "Biographical Memoir of Grove Karl Gilbert," Biographical Memoirs, National Academy of Sciences, vol. 21, no. 2 (Washington, D.C.: National Academy of Sciences, 1926); and Chorley, Dunn, and Beckinsale, Geomorphology, pp. 546-72.

accounting for the structure and deformation of the earth's crust. Dutton's geological studies in fifteen years service with Powell covered the same broad range as his mentor's in stratigraphy, structure, and landform studies. His most important contributions, however, reflected his training in physics and chemistry and his interest in the physics and evolution of the earth's crust. He became the nation's foremost authority on volcanism and earthquakes; he introduced the concept of isostacy to explain vertical movements of the crust; and he was a major participant in the lengthy struggle to reconcile geological and geophysical views of the history of the earth.[67]

Through Powell's efforts a comprehensive picture of the structure, stratigraphy and developmental history of the upper Colorado River basin was first revealed, a picture that contributed much to our present understanding of the regional geology and geomorphological history. On a theoretical level Powell brought the phenomenon of vertical movements of the earth's crust into prominent focus. He demonstrated the prominent part erosion has played in the past history of the earth and in sculpturing its topographic forms, and he broke new ground in studying the physical factors involved in fluvial erosion process.

Certain distinctive and interrelated qualities of Powell's work underlay these scientific contributions. First, Powell's geological

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[67]Ibid., pp. 573-86; Pyne, Gilbert, pp. 79-82.

study of the history of the earth was predominantly an exercise in physical science.[68] There are descriptive aspects to Powell's work, as in his classifications of stream valleys and mountain structure, and others like G. K. Gilbert doubtless were more thorough and proficient practitioners of the physical approach. Nevertheless, in Powell's view the important geological processes deforming the earth's crust and shaping its topographical features were to be understood in terms of the principles of physics--as substances related in space and time, and subject to the fundamental laws of motion.

Secondly--and this is thoroughly consistent with his mechanical perspective--the geological phenomena that most held Powell's attention were those related to structure and topography. "The geological report which has no reference to geological structure is dreary reading," Powell observed in 1876 near the end of his active geological career, "and less interesting as a recreation than a table of logarithms." At least the logarithmic table, he pointed out, had meaning and purpose. Geological structure for Powell bore directly on fundamental geological problems presented in the earth's crust. Structure, Powell had learned, "revealed the great facts of

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[68]This physical approach to problems of geological structure and to the study of geological processes has been frequently overlooked. Goetzmann, for example, labels both the Colorado River and Uinta Mountains reports as "in the realm of descriptive geology" (Exploration and Empire, p. 563); and Pyne seems to consider Powell a product of morphology and evolution as practiced by paleontologists like J. S. Newberry (Gilbert, pp. 74-75).

geology relating to displacement, degradation, sedimentation, metamorphism, and extravastion."[69]

As an aid to the study of structure in geology, Powell found topography indispensable. "Geology is revealed in topography," he contended, for topography reflected structure. "It is impossible to understand a discussion of the geological structure of a region," Powell claimed, "without first fully grasping the character and magnitude of its geographic features."[70] This was the lesson taught by the Uinta uplift and the Grand Canyon plateaus.

Moreover, subtle contrasts between land form and structure--like those offered in the stream-carved valleys of the Uinta Mountains--provided insights into the history of the earth. Consequently, the geographical work of his survey always meant more to Powell than simply constructing maps: topography played an important part in geological theory and explanation.

These interrelated characteristics of Powell's geology--his physical science approach, and his emphasis on geological structure and topography--together gave his work the distinctive stamp Zittel called physiographical geology. In subsequent chapters we shall see how this work lent itself easily to serving certain needs arising on the public lands.

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[69]J. W. Powell, "A Biographical Notice of Robert Archibald Marvine," Bulletin of the Philosophical Society of Washington, 1874-78, vol. 2, Appendix X, pp. ii, vi, [in Smithsonian Miscellaneous Collections, vol. 20, Smithsonian Institution (Washington, D.C.: Smithsonian Institution, 1881)].

[70]Ibid., pp. iv-v.

CHAPTER THREE

ETHNOLOGY: A SCIENCE OF MAN

When Powell took to the field to investigate the geology of the Plateau Province he also studied the Indians found in the region. This was not unusual, for the geographical and geological surveys cut a broad swath in the study of natural history. Indian ethnology was a visible part of the efforts by Wheeler and Hayden as well.[1] Powell became more deeply involved in the work than either Hayden or Wheeler, however.

Powell was strongly influenced in the later 1870s by Lewis Henry Morgan's ideas on Indian social organization and culture evolution, finding in Morgan's views a fruitful theoretical framework for explaining Indian society. Powell redefined Morgan's theory in more objective terms and used this viewpoint in organizing research at the Smithsonian's Bureau of Ethnology. But though Indian ethnology interested Powell as an intellectual exercise, he also found the study had important practical bearings on the government's handling of Indian problems caused by the westward push of settlement. Thus, ethnology provided Powell an early lesson on the value of his survey's basic scientific work for problems arising in the government's administration of the public lands.

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[1] William H. Goetzmann, Exploration and Empire. The Explorer and the Scientist in the Winning of the American West (New York: Alfred A. Knopf, 1966), pp. 485-87, 513, 525-26.

Powell developed an interest in Indian culture early, having been introduced to the Indian mounds in southern Ohio while still a youth. His frontier upbringing sustained that interest, bringing him constantly into contact with Indian tribes. Even at Shiloh, during the Civil War's quiet periods, Powell was moved to probe local Indian grave sites. When Powell began his Colorado River explorations he was further encouraged by Joseph Henry, Secretary of the Smithsonian Institution and long-time promoter of anthropological research. Powell's early base of operations in the Mormon settlements of Utah put him in close contact with the Ute and Paiute tribes of the Great Basin, and during his geological explorations Powell missed few opportunities to study life among the local tribes. But one hand washed the other, and much of Powell's early geological knowledge of the plateau region on the north flank of the Little Colorado in northern Arizona was gleaned on an overland trip in 1870 to the Hopi villages at Oraibi.[2]

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[2]William Culp Darrah, Powell of the Colorado (Princeton: Princeton University Press, 1951), pp. 255-69, describes Powell's early development in ethnology and its growth into a serious study.

For Joseph Henry's role in promoting anthropological studies see Curtis M. Hinsley, Jr., Savages and Scientists. The Smithsonian Institution and the Development of American Anthropology 1846-1910 (Washington, D.C.: Smithsonian Institution Press, 1981), pp. 34-40.

Powell's ethnological studies consisted primarily of collecting data on subsistence practices, political and social organization, religious practices, mythology, and language--the entire spectrum of cultural characteristics of Indian peoples.[3] His primary concern was linguistics, however, for he was quickly convinced that a knowledge of languages was essential in ethnological studies. Nothing of value could be accomplished, he believed, "without a thorough knowledge of languages" to help probe into the conceptions, opinions, and motivations of Indian peoples.[4] Indeed in Powell's published work in ethnology--and there was little of this, in part because of the need for generating data and in part because of administrative demands--the subject of linguistics predominated.[5] Powell took pains to learn the languages of all the tribes he encountered in the West, and perhaps because of his success in doing so he enjoyed friendly relations with the tribes and traveled freely among them.

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[3] U. S. Congress, House, "Survey of the Colorado River of the West," Misc. Doc. 173, 42nd Cong., 2nd sess., 1872, pp. 4, 11.

[4] U. S. Congress, House, "Surveys of the Territories," Misc. Doc. 5, 45th Cong., 3rd sess., 1878, p. 26.

[5] These included J. W. Powell, "Linguistics," in _Tribes of California_ by Stephen Powers, _Contributions to North American Ethnology_, vol. 3, U. S. Geographical and Geological Survey of the Rocky Mountain Region, Washington, D.C.: 1877, pp. 439-613; idem, _Introduction to the Study of Indian Languages, with Words, Phrases, and Sentences to Be Collected_ (Washington, D.C.: Government Printing Office, 1877), a guide for field work; idem, "On the Evolution of Language," in _First Annual Report, 1879-80_, Smithsonian Institution, Bureau of Ethnology (Washington, D.C.: Government Printing Office, 1881), pp. 1-16; idem, "Indian Linguistic Families of America North of Mexico," in _Seventh Annual Report, 1885-86_, Smithsonian Institution, Bureau of Ethnology (Washington, D.C.: Government Printing Office, 1891), pp. 1-142.

Powell's familiarity with the tribes of southern Utah brought him to the attention of Paiute Indian agent George W. Ingalls late in 1872. Ingalls was disturbed at the poor conditions of the Indians in his area and hoped to find a solution. He enlisted Powell to serve temporarily as an interpreter and consultant. A quick review of the conditions suggested that establishing land in the area for exclusive Indian use was a practicable solution, but only if the several tribes involved could agree to live together amicably. Ingalls and Powell then worked for an appropriation to investigate the matter.[6]

This was accomplished, and Powell and Ingalls spent much of the summer and fall of 1873 studying the Ute, Paiute, and Shoshone tribes in Utah and adjacent areas of the Great Basin. Powell made the most of this opportunity to study Indian culture in the region. The result was a thorough census of the tribes, and a description of their conditions of existence. The report[7] by Ingalls and Powell recommended that the tribes be provided with tools and animals and that they be relocated on reservation grounds adequate to sustain their numbers.

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[6]Powell's involvement in this matter is recounted in Darrah, Powell, pp. 194-204.

[7]J. W. Powell and G. W. Ingalls, "Report of J. W. Powell and G. W. Ingalls," in Report of the Secretary, 1873, U. S. Interior Department, Washington, D.C.: 1873, pp. 409-38.

Only the recommendation providing three reservation sites[8] for the separate location of the Utes, Paiutes, and Shoshone was meaningfully carried out by the government, so the results of this effort to improve the condition of the tribes was limited. It was this work, however, that biographer William C. Darrah believes transformed Powell into an ethnologist.[9]

Indeed, it was approximately at the time of this work with Ingalls during the winter of 1872-73 that Powell began to take a more systematic approach to his ethnological work. He began to appreciate Indian mythology as a key to understanding the culture, for it provided "their explanation of the origin of things, their authority for habits and customs, and their common or unwritten law."[10] Powell's first paper on mythology was offered about three years later before the American Geographical Society of New York, "Outlines of the Philosophy of the North American Indians."[11]

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[8]Two of these were the area of Powell's Colorado River exploration, the Uintah [sic] and Ouray Indian Reservation in the Uinta valley of northeastern Utah, and the Moapa Indian Reservation in Nevada northeast of Las Vegas on a tributary of the Virgin River. The third reservation was at Fort Hall in Idaho.

[9]Darrah, Powell, p. 204.

[10]U. S. Congress, House, "Report of the Survey of the Colorado of the West," Misc. Doc. 76, 42nd Cong., 3rd sess., 1873, p. 6.

[11]J. W. Powell, "Outlines of the Philosophy of the North American Indians," Journal of the American Geographical Society of New York, 1878, 8:251-68. Powell's most substantive effort in this area was "Sketch of the Mythology of the North American Indians," in First Annual Report, 1879-80, Smithsonian Institution, Bureau of Ethnology (Washington, D.C.: Government Printing Office, 1881), pp. 19-56.

Powell's interest in the political organization of the various tribes also became prominent about the same time, and he displayed a continuing awareness of its value to the government in their administration of Indian policy. Substantive information about the various tribes was so scarce that great confusion surrounded even the identification of tribes by name or by territories frequented.[12]

After Powell completed his geological reports on the Colorado River survey, he seems to have turned his personal research interests exclusively to ethnology. In 1876, the same year that the volume on the geology of the Uinta Mountains appeared, Powell arranged with Joseph Henry to take responsibility for work on the ethnological collections accumulating in the Smithsonian Institution. This was the germ that developed into the Bureau of Ethnology in 1879. Powell funded a position for an assistant to help with the linguistic studies in 1877, and in the same year the Survey of the Rocky Mountain Region began publication of its ethnological series, the *Contributions to North American Ethnology*.[13]

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[12]U. S. Congress, House, "Professor Powell's Report on the Survey of the Colorado of the West," Misc. Doc. 265, 43rd Cong., 1st sess., 1874, pp. 20-21; report on the Powel Survey in *Annual Report of the Board of Regents, 1876*, Smithsonian Institution (Washington, D.C.: Government Printing Office, 1877), p. 62.

[13]Smithsonian Institution, *Annual Report of the Board of Regents, 1877* (Washington, D.C.: Government Printing Office, 1878), pp. 82-86; idem, *Annual Report, 1876*, pp. 62-63. Powell's assistant was a Swiss immigrant and student of linguistics, Albert S. Gatschet (1832-1907). Gatschet was instrumental in carrying out the linguistic studies of the Bureau of Ethnology for Powell, and became well known in his own right. A fine history of ethnology on the Smithsonian and its Bureau of Ethnology is found in Hinsley's *Savages and Scientists*.

A theoretical dimension began to develop in Powell's work in the lake 1870s, an evolutionary viewpoint that, as we shall see in chapters Seven and Eight, expressed itself in social theory and spilled over into Powell's everyday administration of survey work. This was derived from the evolutionary ideas of American ethnologist Lewis H. Morgan.

Lewis Henry Morgan (1818-1881) was by profession a laywer. His practice in Rochester, New York, catered to railroad and mining ventures and provided him the time and means to study American Indian society. His interest in Indian culture began before his practice was established when he organized a secret fraternal society, the Grand Order of the Iroquois. Casual interest in the local tribes occasioned by the secret order's Indian rites became more serious by the mid-1840s as Morgan witnessed abuses to local Indians and visible disintegration of their culture. The study of Indian social organization then became a lifetime avocation for him. Morgan is credited with inaugurating the study of kinship relations in ethnology in his first major work, System of Consanguinity and Affinity of the Human Family, in 1871. But his best known work was an outgrowth of the former published six years later, Ancient Society, or Researches in the Lines of Human Progress from Savagery through Barbarism to Civilization.[14]

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[14]Smithsonian Institution, System of Consanguinity and Affinity of the Human Family, by Lewis H. Morgan, Contributions to Knowledge, vol. 17 (Washington, D.C.: Smithsonian Institution, 1871); Lewis H. Morgan, Ancient Society, or Researches in the lines of Human Progress from Savagery through Barbarism to Civilization,

Ancient Society offered a theory of cultural evolution maintaining that from a common biological endowment and set of needs in the state of earliest savagery all human societies evolved along similar lines of progress, passing through similar stages of culture toward civilization. Expressed in material appurtenances but more importantly in certain fundamental institutions, mankind developed from a life of subsistence and a social organization based on personal relations to a life of property and a social organization based on territory and property relations. Differences in the progress of various races and societies were laid to fortuitous

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(New York: Henry Holt, 1877). For biographical information see Carl Resek, Lewis Henry Morgan, American Scholar (Chicago: University of Chicago Press, 1960), and Bernhard J. Stern, Lewis Henry Morgan: Social Evolutionist (Chicago: University of Chicago Press, 1931). Estimates of Morgan's place in the history of anthropology are given in Stern, Morgan, passim; idem, "Lewis Henry Morgan Today. An appraisal of his Scientific Contributions," Science and Society, 1946, 10:172-76. In addition there are treatments by Robert H. Lowie, The History of Ethnological Theory (New York: Holt, Rinehart, and Winston, 1960; c. 1937), pp. 54-67; by Leslie A. White, ed., "Introduction," in Ancient Society, by Lewis Henry Morgan (Cambridge: Belknap Press of Harvard University Press, 1964; reprint ed. from 2nd printing, New York: Henry Holt, 1878), pp. xxiv-xlii; and similarly by Eleanor Burke Leacock, ed., "Introduction," in Ancient Society by Lewis Henry Morgan (Gloucester, Mass.: Peter Smith, 1974; c. 1963), Pt. I, pp. xiii-xx. Shorter comments on Morgan's contributions also appear in Marvin Harris, The Rise of Anthropological Theory. A History of Theories of Culture (New York: Thomas Y. Crowell, 1968), pp. 177-88; George W. Stocking, Jr., Race, Culture and Evolution. Essays in the History of Anthropology (New York: The Free Press, 1968), pp. 116-20; Fred W. Voget, A History of Ethnology (New York: Holt, Rinehart, and Winston, 1975), pp. 188-89, 292-95.

advantages in the endowments of the environment which were compounded by an accelerating rate of progress that accentuated the progress of the more advanced groups.[15]

Morgan's theory was the result of an early inspiration that kinship terminologies were relics of actual familial relations and of his desire to establish an Old World origin of the American Indian. Through a comparative study of kinship systems, Morgan in his Systems of Consanguinity and Affinity, arrived at the outlines of a complete evolutionary scheme for the development of the monogamous human family out of earlier stages of communal marriage. In working this out Morgan saw that other institutional developments were related to the evolution of the family, and in his Ancient Society he presented human evolution in much more comprehensive terms.[16]

Morgan gave the evolutionary scheme of Ancient Society a chronological structure by organizing human progress into a sequence of cultural stages. Three periods of savagery and three periods of barbarism were recognized as antecedents of the civilized era. Criteria from the historical record of "inventions and discoveries" and its material expressions of the growth of human intellect were proposed to mark the breaks between the various levels of culture. The use of pottery--presupposing a village style of life--separated

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[15]Morgan, Ancient Society (1964), pp. 1-15, 38-45. As for many anthropologists of the day, European civilization for Morgan represented the cutting edge of cultural evolution.

[16]White, "Introduction," pp. xvi-xvii.

savagery from the lower stage of barbarism, for example. Middle barbarism commenced in the New World with irrigated grain cultivation, and in the Old World with domestication of animals. Iron smelting brought the upper status of barbarism. The development of a phonetic alphabet and written language was the culminating achievement of the barbaric period, and it marked the beginning of civilization.[17]

This record of industrial progress was but one way to order human progress for Morgan. Another that he followed more energetically and systematically was "the growth of certain ideas and passions . . . from few primary germs of thought," as expressed in the development of "domestic institutions." Both avenues provided a record of human progress for Morgan, and together with the concommitant growth of the mind in its mental and moral powers through experience, they comprised the whole of human evolution. But it was to the growth of primary institutions--a complex of institutions, social and civil--that the bulk of *Ancient Society* was devoted.[18]

Morgan identified seven ideas expressed in social and civil institutions as prominent elements of cultural progress. Four of these he treated in *Ancient Society*. The first was the institution of the family, the history of which Morgan traced based on the kinship systems earlier developed in *Systems of Consanguinity and Affinity*. The most primitive system recognized by Morgan--no longer

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[17]Morgan, *Ancient Society* (1964), pp. 11-12, 16-22.

[18]Ibid., pp. 11-12.

extant, and inferred strictly from kinship terminology--was the consanguine family, characterized by group intermarriage among near and remote blood relations of a common age class. A second form of group-marriage family, in which separate blood lines were represented in the sexes, was recognized by Morgan as the Punaluan family. This he held to be coincident in middle savagery with incipient social organization into matrilineal clans. A third significant form of the family was the monogamanian, which derived from the advantages of pairing found under the more localized subsistence systems of lower barbarism. It owed its permanent establishment, however, to the growing importance of property in the upper status of barbarism, and the desire to restrict its ownership.[19]

Another major idea treated by Morgan was subsistence and its related arts. This, as will be evident, was closely related to his record of progress in inventions and discoveries through the growth of intellect. It was an area of the most fundamental importance, for upon human subsistence skills depended the whole question of human supremacy on the earth.

> Mankind are the only beings who may be said to have gained an absolute control over the production of food; which at the outset they did not possess above other animals. Without enlarging the basis of subsistence, mankind could not have propagated themselves into other areas not possessing the same kinds of food, and ultimately over the whole surface of the earth; and lastly, without obtaining an absolute control over both its variety and

[19] Ibid., pp. 325-30, 359-60, 366-67, 390, 396-98.

> amount, they could not have multiplied into populous nations. It is accordingly probable that the great epochs of human progress have been identified, more or less directly, with the enlargement of the sources of subsistence.[20]

Indeed, Morgan believed that a complete scheme of periodization might be founded on subsistence arts, if it were not that they were as yet so poorly known. His treatment of subsistence consisted of little more than its identification, as suggested above, with the "great epochs" of progress. Morgan identified a "natural subsistence" on fruits and roots, and a fish subsistence as typical in savagery. Cereal grain subsistence, and a meat and milk subsistence were the earliest to promise an abundance of food, and on these systems barbaric culture was initiated. Later, in the modern era with the invention of the plow, field agriculture hearlded a new age of unlimited subsistence and great population growth.[21]

A third institutional idea given very extensive treatment by Morgan was <u>government</u>. Although Morgan identified a very primitive social organization based on sex alone, it was savagery's social organization based on the clans or <u>gens</u> that he identified as the period's most noteworthy achievement.[22]

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[20]Ibid., p. 24. This emphasis on the importance of the means of subsistence in human progress, together with the emphasis on the role of property to be discussed below, attracted Karl Marx and Friedrich Engles. As a result, <u>Ancient Society</u> was adopted as a Marxist classic. See White, "Introduction," pp. xxxiii-xxxix.

[21]Ibid., pp. 24-30.

[22]Ibid., pp. 49-50, 60-61.

The gens was a basic social unit defined on kinship or blood relations, traced typically along the female line. Morgan first identified clan organization in the Iroquois social order, but he soon recognized it as the basis of ancient Greek and Roman gentile organization as well.[23] Affiliation with the gens conferred basic social rights and obligations to its members, among them the election of chiefs and a voice in all gens arbitration and decision-making. In these rights Morgan saw the birth of democracy. Also provided through the gens organization were rights to inheritance of property on a mutual basis, religious rites, obligations to marry outside the gens, and to assist in the common needs of the gens.[24]

The <u>tribe</u> was an association of contiguous gentes, whose members intermarried and spoke the same dialect. It was a naturally evolving association, Morgan believed, developing out of the expansion of population from a single locale. Inevitably, with time and increasing isolation from the originating locale, dialects and territories became distinct, and tribes multiplied. Occasionally, the tribes were loosely re-integrated into a <u>confederacy</u> for broad defensive concerns.

Tribal government, which Morgan identified with the lower status of barbarism, consisted of a <u>council of chiefs</u> of the gentes, a representative democracy, in essence, that ruled over matters of

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[23] White, "Introduction," p. xxx.

[24] Ibid., pp. 60-80.

common interest to the tribe. A similar but separate elected council operated where a confederacy was established. Out of the council of chiefs over the course of the remaining barbaric period, Morgan saw the evolution of a separate office of military commander, a popular assembly to ratify council decisions, and an antecedent of the modern judge. Morgan traced these developments in detail in Greek and Roman culture, establishing his view that basic elements of democratic government were differentiated out of ancient gens and tribal governmental organization.[25]

The fourth major institutional idea, that of property, Morgan found closely related to the idea of government. In savagery, even in its highest state, the production of property was inconsiderable; it was inherited upon death by the gens communally or among the nearer matrilineal kin. But beginning in lower barbarism with the development of more sophisticated subsistence arts and early forms of the distinctly paired human family, property became more substantial and its inheritance a more serious concern. Early in the barbaric period property belonging to husband and wife was kept distinct, and the gens to which each was affiliated inherited their property separately. But later, as land-based subsistence systems developed more fully, exchangeable property (including slaves) became more considerable; coupled with the rise of the monogamous patrilineal family, exclusive inheritance by the children of the deceased became the established rule. With this rule the

[25] Ibid., pp. 93-114.

coincidence of both wealth and official position became possible, which often antagonized democratic principles and led to the advent and abuses of aristocracy.[26]

Even more importantly for Morgan the increased importance of property and propertied classes, together with the growth of military classes and their special concerns, created needs that the ancient kinship-based governmental organizations could not serve. In Greece civilization was fully inaugurated for Morgan by the transformation of democratic institutions from the basis in the gens and blood ties to a basis in territory and property--by a transformation from the ancient <u>social</u> to the modern <u>political</u> organization.

> They substituted a series of territorial aggregates in the place of an ascending series of aggregates of persons. As a plan of government it rested upon territory which was necessarily permanent, and upon property which was more or less localized; and it dealt with its citizens, now localized in demes through their territorial relations. To be a citizen of the state it was necessary to be a citizen of a deme. The person voted and was taxed in his deme. In like manner he was called by election into the senate, and to the command of a division of the army or navy from the larger district of his local tribe. His relations to a gens or phratry ceased to govern his duties as a citizen.

A similar transformation occurred later in Rome, although in that case propertied classes grew to hold supreme controlling power.[27]

Three other important domestic institutions were identified by Morgan but were not treated in <u>Ancient Society</u>. Human language he thought far too large a subject for him to undertake, and religion

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[26] Ibid., pp. 445-68.

[27] Ibid., pp. 221-37, 276-91; quoted material from pp. 233-34.

he thought intractable. House life and architecture he found closely related to the growth of the family, but he deferred a systematic treatment of it.[28]

Powell found Morgan's evolutionary ideas a revelation for the insights they provided into the organization of Indian society and valuable in a practical sense in their implications for government policy on the Indians in the West. Powell was corresponding with Morgan in 1876 when he took over responsibility for working up results from the Smithsonian's ethnological collections. He was aware of Morgan's on-going work with Indian society, and he was looking forward to the completion of Ancient Society so that he could use it in interpreting his own materials.[29]

On receiving Ancient Society in late spring of 1877 Powell was not disappointed. "I believe you have discovered the true system of social and governmental organization among the Indians," he wrote Morgan.

> Since its reading I found that I have many facts which fall perfectly into the system which you have laid out; the meaning of these facts I did not understand before.[30]

In a subsequent letter he indicated a little more clearly that

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[28]Ibid., pp. xix, 13. The last topic was later undertaken and published by the U. S. Geographical and Geological Survey of the Rocky Mountain Region, Houses and House Life of the American Aborigines, by Lewis H. Morgan, Contributions to North American Ethnology, vol. 4 (Washington, D.C.: 1881).

[29]Letter, J. W. Powell to Lewis H. Morgan, November 16, 1876, Louis Henry Morgan Papers, University of Rochester Library, Rochester, N.Y.

[30]Ibid., May 23, 1877.

it was the gens and its kinship-based social system that he found so enlightening.

> After reading your book and more thoroughly understanding the gentile organization, and after reviewing certain facts which I had noted among the Indians of the west, I am satisfied that the gens exists among tribes where I supposed it absent. I expect to look up this matter more thoroughly this summer.[31]

Powell was soon using Morgan's concepts in his own work. In a paper delivered in 1880 before the American Association for the Advancement of Science, Powell described Wyandot society using Morgan's concepts as a framework. Family and gens organization, the structure of government, rights and obligations respecting persons and property--each of these topics related directly to a fundamental Morgan insight.[32]

By 1882 Morgan's concepts were well integrated into Powell's work plan for the new Bureau of Ethnology at the Smithsonian Institution. Powell presented them in different terms, however--terms that lent themselves better to the objective definition and empirical study most approved in science. Moreover, the terms Powell chose reflected the same physical-mechanical perspective he used to advantage in his geological studies. Broadly speaking, the *ideas* that manifested themselves in human society for Morgan were transformed by Powell into *human activities*.

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[31] Ibid., July 18, 1877.

[32] J. W. Powell, "Wyandot Government. A Short Study of Tribal Society," in *First Annual Report, 1879-80*, Smithsonian Institution, Bureau of Ethnology (Washington, D.C.: Government Printing Office, 1881), pp. 59-69.

The Bureau of Ethnology would pursue investigations "in the four departments of objective human activities," Powell proclaimed. These were "arts, institutions, languages, and opinions." The subsistence practices that for Morgan produced the record of inventions and discoveries became arts for Powell. Morgan's three institutional ideas of family, government, and property were collected under the term institutions. Powell's opinions entailed Morgan's idea of religion as well as Powell's studies in mythology, and in a larger sense gave recognition to the whole spectrum of mankind's continuing intellectual accomplishment. The category of languages reflected activities judged important by both Morgan and Powell.[33]

Powell retained the Morgan notion of progress as an interdependent development of the various culture elements.

> The study of the arts is but the collection of curiosities unless the relations between arts, institutions, languages, and opinions are discovered. The study of institutions leads but to the discovery of curious habits and customs unless the deeper meaning thereof is discovered from arts, languages, and opinions. In like manner the study of language is but the study of words unless philogic research is based upon a knowledge of arts, institutions, and opinions. So also the study of opinions is but the collection of mythic stories if their true meaning is not ascertained in the history of arts, institutions, and languages.[34]

This interdependence emphasized the cooperative dimension of human

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[33] Smithsonian Institution, Bureau of Ethnology, Second Annual Report, 1880-81 (Washington, D.C.: Government Printing Office, 1882), p. iii.

[34] Ibid., pp. iii-iv.

life. As we shall see in chapter Seven, it played an important role for Powell in drawing distinctions between the operation of evolution in the human realm and that elsewhere in creation.

A few years later Powell attempted a reformulation of Morgan's sequence of culture stages using his own concept of human activities. Rather than relying solely on material artifacts as indicators of cultural development, Powell tried to identify each major stage with levels of achievement reached collectively among the several categories of human activities. This multidimensional system was more complicated than Morgan's, however, and it applied only to the major stages of culture. It represents less a real advance over Morgan's system than an acknowledgment of its specious simplicity. Nevertheless, the attempt testifies well to Powell's multidimensional, dynamic view of human culture.[35]

Powell's appreciation of Morgan's insights was not limited to their use in his framework for ethnological research. He also believed that Morgan's ideas on human cultural progress had at last laid a proper foundation for the scientific study of government.[36]

Powell especially appreciated that insights from studies on the governmental organization of Indian peoples were available for the

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[35]See Powell's "From Savagery to Barbarism," Transactions of the Anthropological Society of Washington, 1885, 3:173-96; "From Barbarism to Civilization," American Anthropologist, 1888, 1:97-123; and also "On Actival Similarities," in Third Annual Report, 1881-82, Smithsonian Institution, Bureau of Ethnology (Washington, D.C.: Government Printing Office, 1884), pp. LXV-LXXIV.

[36]J. W. Powell, "Sketch of Lewis H. Morgan," Popular Science Monthly, 1880, 18:120-21.

use of those who administered Indian policy in the West. Mishandling of Indian problems caused by ignorance of tribal relations and other aspects of their culture had concerned Powell since his commission for the Bureau of Indian Affairs in 1873. Later in the decade Powell saw the value of ethnological studies in setting and carrying out Indian policy as a key reason justifying the government's support of the work of the geographical and geological surveys in the West. The influence of Morgan's concepts was apparent in his plea that the different but very real social structures of Indian cultures be recognized and carefully considered before attempting to enforce modern civilized ways.

The "Indian problem" was a most pressing one, Powell contended in 1878.

> In the whole area of the United States, not including Alaska, there is not an important valley unoccupied by white men. The rapid spread of civilization since 1849 has placed the white man and the Indian in direct conflict throughout the whole area, and the "Indian problem" is thus forced upon us, and it must be solved, wisely or unwisely. Many of the difficulties are inherent and cannot be avoided, but an equal number are unnecessary and are caused by the lack of our knowledge relating to the Indians themselves.

Many of the difficulties were unavoidable, but just as many were caused by ignorance and might have been avoided with better knowledge of Indian culture.

> Savagery is not inchoate civilization; it is a distinct status of society, with its own institutions, customs, philosophy, and religion; and all these must necessarily be overthrown before new institutions, customs, philosophy, and religion can be introduced. The failure

> to recognize this fact has wrought inconceivable mischief in our management of the Indians.[37]

The radically different attitude of primitive peoples to property, he noted, flew in the face of the government's efforts to civilize the Indian.

> Among all the North American Indians, when in a primitive condition, personal property was almost unknown; ornaments and clothing only were recognized as the property of the individual, and these only to a limited extent. The right to the soil as landed property, the right to the products of the chase, etc., were inherent in the gens, or clan, a body of consanguinii, a group of relatives, in some cases on the male side, in others on the female. Inheritance was never to the children of the deceased but always to the gens. No other crime was so great, no other vice so abhorrent, as the attempt of an individual to use for himself that which belonged to his gens in common.

Consequently, Powell observed, the Indian found the property rights of civilization intensely obnoxious, "an enormous evil and an unpardonable sin," and this doomed the government to the difficulties it had met in attempting to distribute lands among Indians on an individual basis.[38]

Powell also pointed out the government's failure to understand and properly deal with the Indian's tribal form of government:

> . . . We have usually attempted to treat with tribes through their chiefs, as if they wielded absolute power; but an Indian tribe is a pure democracy; . . . the chief is but the representative, the speaker of the tribe, and can do no act by which the tribe is bound without [its consent]. . . . The blunders we have made and the wrongs we have inflicted upon the

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[37] "Surveys of the Territories," Misc. Doc. 5, 1878, p. 26.

[38] Ibid.

> Indians because of failure to recognize this fact have been cruel and inexcusable, except on the ground of our ignorance.[39]

Ethnology had taught Powell that the Indian had to be dealt with as he was, as a product of evolutionary development. His progress toward civilization could be accelerated by contact with the ideas and institutions already discovered in more advanced cultures, but the process would be slow.

> We must either deal with the Indian as he is, looking to the slow but irresistible influence of civilization with which he is in contact to effect a change, or we must reduce him to abject slavery.
>
> The attempt to transform a savage into a civilized man by a law, a policy, an administration, through a great conversion, "as in the twinkling of an eye," or in months, or in a few years, is an impossibility clearly appreciated by scientific ethnologists.[40]

Through ethnology Powell thus joined in a current of socio-anthropological inquiry that had always sought quite as much for insights on modern problems as it had for facts on primitive culture.[41] Social reform and social theory were never far from the nineteenth-century ethnologists' door. Powell would be comfortable here, however. Indeed, in chapter Seven we shall return to Powell's ethnological ideas to see how they cross-fertilized with social theory and grew.

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[39] Ibid., p. 27.

[40] Ibid., p. 26.

[41] See Fred W. Voget, A History of Ethnology (New York: Holt, Rinehart, and Winston, 1975), pp. 41-164.

Powell's discovery of ethnology's practical advantages for problems arising in the government's Indian policy was paralleled by a recognition of other opportunities for his survey to serve western needs. There were fundamental conflicts arising between the century-old national land system and the new modes of subsistence spawned in the West, and Powell found that these above all might benefit from his survey's work. Powell's recognition of this, and his consequent deep involvement in reform of the land system are the subjects we will next examine.

CHAPTER FOUR

IRRIGATION: AN ENGINEERING PERSPECTIVE

During the middle years of the 1870s John Wesley Powell quickly became convinced that his survey's study of western physical conditions was indispensable for the government's proper administration of western settlement. This perception eventually spawned a special geographical report dealing with the West's land policy needs and also an attempt by Powell to abolish and replace the surveys of the General Land Office with a bureau of scientific surveys organized on a permanent basis.

As background to these later events the present chapter will focus on irrigation, the public lands problem that took center stage in Powell's involvement with land system reform. We will briefly review irrigation's development as the nation expanded into the American West from its early, desultory practice at mid-century to the period Powell witnessed in the 1870s, when irrigation was being undertaken systematically on large tracts of land both by associations of settlers and by corporate entrepeneurs.

Culminating this review will be an examination of a special federal commission on irrigation in California authorized by Congress in 1873.[1] This commission's analysis of the physical

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[1]U. S. Congress, House, "Irrigation of the San Joaquin, Tulare, and Sacramento Valleys, California," Ex. Doc. 290, 43rd Cong., 1st sess., 1874.

conditions making irrigation a necessity in the West and its assessment of the problems that had to be overcome if irrigation's full potential were to be realized will be useful for clarifying the basis of certain Powell viewpoints: namely, his commitments to large-scale irrigation systems and to overcoming the institutional obstructions to their development, and his conviction that scientific surveys similar to his were essential if such projects were to be effective.

It is quite probable that the work of this commission actually played a part in the development of Powell's views, although direct evidence linking Powell to the commission is lacking. One can only point out that, with Powell's location at the hub of federal activity in Washington and with the great public interest in irrigation early in the 1870s, it is unreasonable to assume Powell was unaware of the commission's work; that Powell spoke out on irrigation as a public lands problem began only after the commission had completed its work; and finally, that during the period of the Irrigation Survey (more than fifteen years later) at least some on Powell's staff considered the commission's report a milestone contribution to the study of irrigation development's problems.[2]

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[2]William Culp Darrah, Powell of the Colorado (Princeton: Princeton University Press, 1951), pp. 218-20, recounts Powell's social life in Washington. The commission's report was completed in February, 1874 and submitted to Congress on March 24, whereas Powell's earliest expressions followed in a letter to the Secretary of Interior one month later, U. S. Congress, House, Committee on Public Lands, "Geographical and Geological Surveys West of the Mississippi," H. Rpt. 612, 43rd Cong., 1st sess., 1874, p. 10. Herbert M. Wilson, "American Irrigation Engineering," in Thirteenth

Even if Powell did not make direct use of the commission's work in California, it remains that the commission's study of irrigation, its engineering solutions, and the role it identified for scientific surveys all are clear expressions of views not so explicitly developed in Powell's work. Powell's approach to problems of public lands settlement thus can be better understood in the light of the commission's work.

Irrigation as an adjunct to agriculture has a long history in the American West dating to 800 A.D. when it was already playing a key role in the subsistence of Indians in the southwest. The Spanish adopted the practice, using it prominently by the seventeenth and eighteenth centuries in establishing the network of Spanish missions. Irrigation was well established in Los Angeles by the time the pueblo became a United States possession, and the situation was the same along the upper Rio Grande in New Mexico and southern Colorado.[3]

Annual Report, 1891-92, U. S. Geological Survey, Pt. 3: Irrigation, Washington, D.C., 1892, p. 138, commented on the importance of the commission's work.

[3]There is a large literature bearing on the history of irrigation and reclamation in the United States which can more easily be entered thanks to Lawrence B. Lee, Reclaiming the Arid West. An Historiography and Guide (Santa Barbara, Calif.: American Bibliographical Center, Clio Press, 1980). The more valuable general histories I have used are Ralph H. Hess, "The Beginnings of Irrigation in the United States," Journal of Political Economy, 1912, 20:807-833; Elwood Mead, "Rise and Future of Irrigation in the United States" in Yearbook, 1899, U. S. Department of Agriculture, Washington, D.C.: 1900, pp. 591-612. Clesson S. Kinney, A Treatise on the Law of Irrigation and Water Rights, and the Arid Region Doctrine of Appropriation of Waters, 2nd ed., vol. 1 (San Francisco: Bender-Moss, 1912), pp. 400-422; and John T. Ganoe, "The Beginnings

Mormon settlers took up irrigation when they established Salt Lake City in 1847.[4] Depending on cooperative efforts and administrative authority of the church, irrigation made their Great Basin kingdom a success by the 1850s. Throughout the third quarter of the century the Mormon settlements testified to the value of irrigation to gold seekers and other immigrants passing through the territory. As General Land Office Commissioner Joseph S. Wilson noted in 1868, the Mormon success story "established the fact of the productiveness of the mountain valleys of the west."[5]

Irrigation also developed erratically as an adjunct to the mining camps opening up California and Colorado before the Civil War. However, general growth of irrigation only began with the rapid influx of settlers that came when the war was over. This growth was attended by the adoption of certain institutional innovations to overcome the requirements of capital and labor demanded for

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of Irrigation in the United States," Mississippi Valley Historical Review, 1938, 25:59-78.

Wilson, "American Irrigation Engineering," pp. 133-37, and Alfred R. Golze, Reclamation in the United States (New York: McGraw-Hill, 1952), pp. 1-36 provide detail on early Indian and Spanish developments. Golze's Reclamation also adds perspective with his coverage of twentieth-century developments. Gilbert C. Fite, The Farmer's Frontier 1865-1900 (New York: Holt, Rinehart, and Winston, 1966), pp. 166-71, 178-92 relates irrigation to other agricultural developments.

[4]For the Mormons see Charles Hillman Brough, Irrigation in Utah, Johns Hopkins University Studies in Historical and Political Science, Extra Volume 19 (Baltimore: Johns Hopkins Press, 1898).

[5]U. S. Interior Department, Report of the Secretary, 1868, Washington, D.C.: 1868, pp. 65-66.

the construction of irrigation canals and other related works.

In Colorado the irrigation colony made its appearance through the successful establishment of the Union Colony at Greeley. The Union Colony was the brainchild of Nathan C. Meeker, agricultural editor of Horace Greeley's New York Tribune. Meeker toured Colorado in the fall of 1869 looking for agricultural possibilities. Impressed with the small efforts he saw already in place, he returned to New York and in December organized the Union Colony. This was a joint-stock company, selling shares to aggregate sufficient capital for the purchase of a large tract of land, for constructing the necessary irrigation works, and for establishing a community with the rudiments of civilized town life.[6]

The colony was able to enter 12,000 acres of land by preemption and by private purchases from railroads, and options were purchased on additional tracts. The first settlers arrived in 1870. City and farm lots remaining after disposition to original colonists were sold to other immigrants to expand the colony. Farm units varied in

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[6]Early irrigation developments in the state of Colorado are reviewed by Alvin T. Steinel, History of Agriculture in Colorado (Fort Collins, Colo.: State Agricultural College, 1926), pp. 167-266, 383-401. On the colony at Greeley see [David Boyd], A History of Greeley and the Union Colony of Colorado (n.p.: [1890?], a detailed account by an original colonist and community leader. The immediate interest expressed in the Union Colony is reflected in the articles "Colonization," in Report of the Commissioner, 1870. Agriculture, U. S. Patent Office, Washington, D.C.: 1871, pp. 569-72, and "Modes and Results of Irrigation," ibid., pp. 576-84; these are also informative on the early history of the Union Colony. The uniqueness of the colony enterprise as compared with corporate irrigation is noted in "Irrigation Systems of Different Countries," in Report of the Commissioner, 1871. Agriculture, U. S. Patent Office, Washington, D.C.: 1872, pp. 286-87.

size, but were typically small parcels, from five to eighty acres. Water rights were attached to the lands sold and were administered through the colony government. The colony's lands were fenced, and cattle were grazed on the surrounding lands with other range stock in the area.

This organizational plan was no doubt the source of John Wesley Powell's inspiration for a homestead land disposal law to encourage settlement and irrigation of desert lands in the West. Powell had traveled Colorado extensively since 1867 of course, and unquestionably was familiar with the colony and its cooperative, municipally styled approach to the capitalization, construction, and administration of irrigation systems. We will discuss Powell's proposal in chapter Five.

Despite a difficult start, Union Colony was successful and by about 1872 promised a prosperity that, thanks to the frequent coverage given by Horace Greeley's Tribune, could not escape national attention. The colony spawned several other enterprises in the area, each imitating its organization to greater or lesser degrees. These included the Chicago Colony at Longmont (1870), the colony at Fort Collins (1872), and others at Boulder and at Loveland. It also sparked some speculative land development schemes promoted by railroad companies and other private groups.

At about the same time in California speculative irrigation land development ventures made their appearance. Earlier in 1857 German immigrants had established the settlement of Anaheim on a colony plan similar to that used later in the Union Colony, but it spawned no imitators. The entrepreneurial ventures commenced about 1870, taking advantage of the availability of privately held Spanish grant lands of considerable size. Promoters purchased large tracts, then constructed irrigation canals, subdivided the lands, and sold them to settlers (typically with a firm water right attached).

The present-day city of Riverside was established in this manner in 1870 by a small group of investors enlisted by a carpet-bagger and former Nevada federal judge, John Wesley North. Operating as the Southern California Colony Association, North subdivided and sold parcels along the Santa Ana River at prices ranging up to $25 per acre. Ten years later the colony's success with the navel orange brought prices of unimproved land into the $300 to $500 per acre range. Pasadena had similar origins in the San Gabriel Orange Grove Association organized by a group of Indiana investors in 1874. Colton, Pomona, and Cucamonga were all established through like means by 1875. The collective success of these ventures led to a boom period in southern California land development during the following decade.[7]

One of the greatest speculative schemes of all was undertaken in northern California early in the 1870s by San Francisco-based investors led by Bank of California magnate William C. Ralston. Their desire to obtain a federal subsidy for the venture led to a

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[7]Oscar Osburn Winther, "The Colony System of Southern California," Agricultural History, 1953, 27:94-103. For a review of the great growth of the following decade see Glenn S. Dumke, The Boom of the Eighties in Southern California (San Marino, Calif.: Huntington Library, 1966 [c. 1944]).

federal commission's scientific study of irrigation and its physical circumstances in 1873.

The San Joaquin and Kings River Canal was the first main branch of a huge, four-canal system envisioned eventually to flank the east and west sides of both the Sacramento and San Joaquin valleys and drain into San Francisco Bay. The canal was planned to run from Tulare Lake in the south end of the San Joaquin Valley 160 miles northward along the west slope to the delta area, where the San Joaquin and Sacramento rivers converge east of the bay. The promoters advertised the project to provide transportation of freight, domestic and industrial water supplies, and a sufficient agricultural water supply to irrigate 30,000 acres of desert and incidentally-reclaimed swamp lands.[8]

Construction began about 1871, but the scheme was financially undermined after droughts in 1871 and 1872 bankrupted one of the project's principal investors. Eventually it slipped away to the control of stock growers and cattle-kings-to-be, Henry Miller and Charles Lux. Prior to this outcome, however, Ralston first tried to

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[8] The Great San Joaquin and Sacramento Valleys of California. A Great Irrigation Scheme (n.p.: [1873?]), a promotional pamphlet; J. Ross Browne, "Reclamation and Irrigation," Transactions of the California State Agricultural Society during the Year 1872 (Sacramento: T. A. Springer, State Printer, 1873), pp. 420-23. Other northern California canal projects underway early in the 1870s are described in another pamphlet, [Isaac Friedlander], Irrigation in California. The San Joaquin and Tulare Plains (Sacramento: Steam Book and Job Printing House, 1873). The history of the enterprise as a business venture is recounted in David Lavender, Nothing Seemed Impossible. William C. Ralston and Early San Francisco (Palo Alto, Calif.: American West Publishing Co., 1975), pp. 354-55, 365.

sell the project off in England, and failing there, he turned to the federal government for a subsidy. The promoters ultimately hoped to receive a grant of land similar to those received by railroads.[9] Their cause was championed in Congress by Senator William M. Stewart, of Nevada, expert on mining law and legal representative to the Bank of California in its Nevada silver mining interests. Steward managed to win authorization of a special commission for the purpose of "reporting on a system of irrigation" for the valley[10]--to undertake, that is, a comprehensive survey, to propose an integrated and effective system, and to provide the information to parties interested in prosecuting the work.[11] A similar initiative by Steward fifteen years later, ironically, would begin the Irrigation Survey in the U. S. Geological Survey.[12]

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[9] Irrigation Scheme, pp. 27-29.

[10] "Irrigation," Ex. Doc. 290, 43-1, 1874, p. 3. See also the Congressional Globe, 42nd Cong., 3rd sess., 28 February 1873, vol. 46, pt. 3: 1930.

[11] This amplification of purpose is based on a proposal in a general essay on the needs of irrigation development in California by Stewart associate J. Ross Browne in his "Reclamation and Irrigation," p. 398. Browne was a U. S. State Department official who had prepared reports on the mineral industry in the West, and who as minister to China in 1868 investigated their irrigation practices at the request of the General Land Office; see U. S. Congress, House, "Irrigation of Public Lands," Ex. Doc. 293, 40th Cong., 2nd sess., 1868, pp. 2, 4-5. Browne also participated in various speculative ventures in land and mining properties. On Browne and his association with Stewart see David Michael Goodman, A Western Panorama 1849-1875. The Travels, Writings, and Influence of J. Ross Browne (Glendale, Calif.: Arthur H. Clark, 1966), pp. 243-49, 264.

[12] See Everett W. Sterling, "The Powell Irrigation Survey, 1888-1893," Mississippi Valley Historical Review, 1940, 27:421-34.

The commission was composed of two officers of the Army Corps of Engineers, Lieutenant Barton S. Alexander and Major George H. Mendell, and an officer of the U. S. Coast Survey, Professor George Davidson, all based in San Francisco. Also to be included were the director of the California State Geological Survey Josiah D. Whitney and a civilian engineer R. M. Brereton, but neither chose to participate. The commission availed themselves of topographic maps from the State Geological Survey and others as could be obtained from railroads and canal companies, and they made a field reconnaissance of the valleys during the spring, summer and fall of 1873. Their report was tendered in February 1874.[13]

The first concern of the commissioners was to assess the physical conditions of climate and landscape in California in order to explain why irrigation was necessary and whether it could be expected to fulfill its popular expectations.[14] Using precipitation records and charts prepared by the Coast Survey's Charles A. Schott and the experience of the region's farmers, the report concluded that the need for irrigation stemmed more from an unfavorable seasonal distribution of rainfall than from an absolute deficiency in the annual average. The rainfall at sixteen inches annually averaged less than half of the thirty-five inches available in the

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[13]"Irrigation," Ex. Doc. 290, 43-1, 1874, pp. 3-5, 28. Brereton had been associated with the San Joaquin and Kings River Canal Company enterprise, according to Lavender, Nothing Seemed Impossible, pp. 353-54.

[14]"Irrigation," Ex. Doc. 290, 43-1, 1874, pp. 7-15.

East; but good crops had been raised in the valleys with as little as ten or twelve inches of rain--provided that it fell during the growing season.

In California, the commissioners found, the wet season was very marked and confined to the period between October 1st and April 1st. Progressively, the amount of rainfall decreased and the wet season was shorter in duration from the northern reaches to the south. This rainfall pattern provided water for crops only early in the growing season. Even then rains were undependable. One region might have rain and another not; or worse, the rains might cease altogether in February and wipe crops out entirely.

Furthermore, rainfall records extending over periods of about twenty years revealed great variability in the annual rainfall. There were many drought years, some having less than five inches of precipitation. On the other hand, some wet years might exceed thirty inches. Based on the experience of the valley farmers the commissioners concluded that although the valleys' annual rainfall averaged sixteen inches, only one crop in three years or perhaps two to five years could be depended upon without irrigation.

The commissioners next discussed to what extent irrigation could alleviate the problem. They noted that, because of orographic effects on the distribution of rainfall, precipitation in the vast mountainous regions of the Coast Range and the Sierra Nevada was considerably higher than in the valley regions--in the wetter portions three, four, even more times higher. The question to be resolved was simply whether the excess of rain in the mountains could compensate for the deficiency in the valleys. The commission calculated from precipitation records that the basin-wide average annual rainfall, including both mountains and valleys, was not less twenty inches. This supply, they concluded, was adequate. It was, on the average, "a super-abundance for all purposes of maturing crops."[15] It was sufficient to insure good crops annually throughout the valley, given that irrigation works could be constructed to satisfactorily redistribute the water.

The report noted further that irrigation was a proven solution, not just a hypothetical one. The commissioners during their reconnaissance had been able to observe various locations around the valley, where stream waters were being successfully diverted onto grain fields to save crops from drought. They also noted that the potential for expanded use of irrigation was high, for the topographic characteristics of the region were well suited to irrigation systems. The valleys drained by the Sacramento and the San Joaquin were broad, smooth, gently sloping plains with tributary streams conveniently located for the control and delivery of water.[16]

Using topographic maps, the commissioners broke the valleys and surrounding mountain areas into fifty-seven individual watersheds to serve valley lands below, and calculated more precisely the adequacy of water supply from the catchment area. They estimated the land

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[15]Ibid., p. 13.

[16]Ibid., pp. 15, 21-22.

that could be served by canals at 13,300 square miles, or about one square mile for each three to three and one-half square miles of mountain catchment. During a good season, they reasoned, this catchment ratio could conceivably provide the cultivated area with the equivalent of as much as ten inches of rainfall monthly. Furthermore, a calculation for less favorable conditions based on a relatively low-flow measurement of the Kern River's discharge indicated a supply over the irrigable area of about one-third of the previous figure--still a satisfactory amount.[17]

Having demonstrated the physical need for and practicability of irrigation, the commission then turned to the subject of irrigation works. The basic process in use in California, the commissioners found, was comparable in principle to that used in India and southern Europe. Water was diverted from a stream and allowed to flow by gravity in a carefully controlled manner to the fields. These were then flooded and allowed to absorb the waters. The typical system was comprised by main canals and primary ditches to distribute water throughout the irrigable lands, secondary ditches to convey water onto the fields, and by drainage ditches to collect and carry off excess water.

Main canals diverted water from a stream upstream from the fields typically at a point where banks could be cut through and where a gently sloping channel could carry water toward the field. Ideally, the higher upstream the point of diversion the better,

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[17]Ibid., pp. 22-24.

because more land could be served by the canals. Usually the stream level had to be raised by a dam to allow diversion through the banks, and a gate was typically constructed in the canal at that point to regulate flow. These diversion appliances were termed head works.

Canal dimensions were properly dependent upon the volume of water needed. This in turn was a function of the amount of land to be served, the nature of the soil and the expected crops. A canal's slope was ideally kept small, perhaps one foot per mile, to minimize scouring of the banks.[18]

Unfortunately, the commission found, the systems in use in California were poorly engineered: they were seldom well planned or constructed with an eye to fundamental scientific principles. "So-called" canals and ditches had been constructed without "the least amount of foresight," they remarked, without any regard to permanency or plan. The existing works produced "lavish waste of water," and their execution without system had led to dog-in-the-manger conflicts over water rights.[19]

Such enterprises had accomplished much for the individuals who developed them, the commission's report acknowledged, but a continuation of the same practices would obstruct future development and prevent the valleys from rising to their agricultural potential. The commissioners had discovered an ample water supply available for farming extensive areas of the valleys, but a system of the highest

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[18] Ibid., pp. 27, 34-37.

[19] Ibid., p. 37.

character would be required to attain this end. Diversion dams and headworks had to be located high on the streams, and canals needed to be carefully located and planned so that "the largest area practible" could be irrigated "at reasonable cost." A "minimum of water" had to be carefully "husbanded to accomplish a maximum of results." Efficiency and the Benthamite dictum of the greatest good for the greatest number were the watchwords for the commissioners here. But with few exceptions, the existing systems did not measure up. The present "disjointed canals" could not be made to approximate the desired results, they noted; "and when others are added in similar defiance of sound engineering, the result will be a partial and temporary good for only a part of the valley, and will lead to an intricacy of legal troubles."[20]

The commissioners were advocating large, carefully planned, and comprehensive systems as the only means for irrigating the large areas of land allowed by the abundant rainfall on the highland watersheds. This was a principle John Wesley Powell tacitly endorsed as well, as we shall see in the following chapter.

As an alternative to the haphazard developments observed in the valleys, the commissioners recommended a comprehensive system of irrigation works and irrigation districts they believed could fulfill the valley's potential. The system was formed by aggregating the fifty-seven watersheds they had identified from State

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[20]Ibid., pp. 16, 27, 78.

Geological Survey maps into a smaller number of drainage basin units containing the larger rivers and adjacent irrigable valley land. These were the "natural irrigation districts," which by their common water supply and system of canals were independent and would not normally coincide with any of the artificial boundaries of township or county.[21]

On the west side of both the San Joaquin and Sacramento valleys the commissioners availed themselves of the topographic information developed earlier in the surveys done by the San Joaquin and Kings River Canal Company and by others. They were able to determine "with tolerable accuracy" the dimensions and alignment of a few long canals running from the upper reaches of both valleys to the delta area near San Francisco Bay.[22]

On the east side of the valleys, however, the commission was frustrated by a shortage of topographic data. They suggested a system, but considered it only approximate. On each main river near the edge of the foothills an approximate location for headworks was identified and a main canal laid out from each bank. Each ran high along the edge of the foothills until it connected with another from an adjacent district, so that the eastern edge of the valleys would be bordered by a peripheral system of connected but independent canals. From the main canals more than forty branch canals were laid out carrying water into the valleys. Primary and secondary

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[21]Ibid., p. 37.

[22]Ibid., pp. 28-29, map 1.

ditches to carry water onto the lands of individual farmers would originate from these branch canals.[23]

The commissioners were confident that a proper system of irrigation would greatly benefit California. Defending against irrigation's critics in the state, they argued that a properly designed irrigation system could serve mining needs as well as agricultural, and that navigation interests would more likely be helped than harmed. Reservoirs for water storage would eventually be needed high in the foothills, and these would provide water to mine additional gravel deposits for gold. Abstraction of water and the lowering of river levels would be a problem for navigation only in a few areas, the commissioners argued, and usually only in off seasons. More often the navigation season would probably be extended through irrigation's storage and use of the wet season's peak discharges. Percolating slowly back to the rivers later, these waters would raise streams above their usual low, dry season levels. Moreover, extensive tracts of swamp land in the valleys might be reclaimed in the process.[24]

The commission knew that irrigation development brought special problems. The construction of irrigation works was an expensive proposition requiring the organization of capital and labor for its accomplishment. Furthermore, competition over limited water supplies brought continuing conflict among irrigators.

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[23] Ibid., pp. 37-38, map 1.

[24] Ibid., pp. 30-33, 39.

The rest of the world had developed various means to deal with these institutional problems. The commission tried to help provide answers by describing the practice of irrigation in India, Italy, Spain, and France. They drew particular attention to the example of the world's greatest and most systematically planned irrigation systems to date, those of India which were constructed and maintained by the British government. They also commented favorably on the irrigation associations of Italy and Spain, organized to administer water supplies and water disputes on the principle that control should be in the hands of the water users.[25]

The commissioners also discussed probable construction costs. Based on pertinent foreign experience they concluded that in California one cubic foot of water per second could reasonably be expected to irrigate crops on about 200 acres. From this and statistics on construction costs they estimated that irrigation works for California's valleys would cost about five to seven dollars per acre. This they considered a great expense, but one that would be repaid many times over in appreciated land values.[26]

The commission took the opportunity to outline its views on government's responsibilities in irrigation development. This had been a matter of some concern in Congress, for there had been more than fifty bills introduced over the previous six years seeking some form of government assistance. The expense of irrigation systems

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[25]Ibid., pp. 65, 68-70, 81-88.

[26]Ibid., pp. 73-77, 79.

was one focus of attention. The commissioners believed that, all other considerations aside, "the best policy is for farmers to build and own the canals." This was because the farmers were the land owners and the parties chiefly benefiting from irrigation. But the experience of other countries was that cooperative associations of farmers were limited in the size of systems they could build. Extensive systems, such as those contemplated for the valleys of California--and which had to be established if the fullest benefits of irrigation were to be obtained--"if built at all, must be built by the State or by private capital."[27]

The commission believed it would be appropriate for states or counties to construct such works, because they would directly benefit by increased tax revenues from appreciating land values. Caution was urged, however, for not all land was valuable enough to justify improvement by irrigation. Moreover, development of the land would necessarily be a slow process that might not provide rapid revenue returns.[28]

Private enterprises, the commission concluded, had proven themselves capable of undertaking large works. Unfortunately, the history of such enterprises showed them to be precarious ventures. The risks were not very attractive to investors, and for the present, the commissioners gently hinted, perhaps the state or federal governments ought to offer "special inducements" to aid

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[27]Ibid., pp. 78-79.

[28]Ibid.

corporate efforts.[29]

Farmers had to be protected under such enterprises however. The commissioners believed ownership and control of the system should eventually lapse to the farmers or the state. Furthermore, water rights should be permanently attached to the lands they served, so that the farmers would be guaranteed "in perpetuity the use of the water necessary for irrigation." Also recommended were irrigation associations on the European example, chartered to control water distribution and to represent the farmers collectively in all dealings with the company.[30]

In the commission's view, however, the primary responsibility of government lay in another area--an area Powell later took very much to heart. The government's first concern should be to assure a well planned, comprehensive irrigation system providing the maximum benefit to the public. For this, careful surveys were required in order to lay out an appropriate system of irrigation works and designate lands to be served. Entailed would be, initially,

> a complete instrumental reconnaissance of the country to be irrigated, embracing the sources from whence the irrigating canals ought to commence, gauging the flow of the rivers and streams, and defining the boundaries of the natural districts of irrigation into which the country is divided.

Then later when a particular district was to be developed a very

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[29]Ibid., pp. 79-80.

[30]Ibid.

accurate topographical survey of that district should be made. In this way an intelligent and economical system could be designed in harmony with the other districts in the system.[31]

The preliminary topographical surveys were very important. Indeed, the absence of such surveys on the eastern side of the valleys had forced the commission to make only approximately recommendations on systems for those areas.

> Although we have examined all rivers on the eastern side of the valley with great attention, we do not know that we have in any single case selected the proper point on any river from which a main exterior canal should leave it, and of course it follows that we do not know that we have laid down any canal in the position it ought to occupy.

No comprehensive irrigation system, the commission stressed, could be designed without a complete instrumental survey.[32]

This, as the next chapter will reveal, was another underlying assumption in John Wesley Powell's approach to problems of desert land development, an important link connecting his survey work with practical service to needs on the public lands.

The report of the commission on irrigation in California was a scientific study treating irrigation primarily as a physical problem. It reviewed the characteristics of California's climate, and showed how the marked seasonality and annual variability conspired to make irrigation a necessity for successful agriculture over most of the state. The commission demonstrated the validity of

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[31] Ibid., p. 78.

[32] Ibid., p. 38.

irrigation as a solution by comparing the water supplies available in the moist mountain regions with the requirements of the lower lying valley lands, and showing that vast valley areas could likely be reclaimed. It also discussed the physical principles of irrigation, and indicated how large, comprehensive systems were needed to fulfill irrigation's potential. Finally, the commission argued that to assure the development of the approved systems, the government should undertake the necessary surveys for their proper delineation.

The commission's work made little direct impact. Congress undertook no support of irrigation projects in California in the form of land grants or even any extended surveys of the kind recommended. Whatever assistance the study might have provided the Ralston canal scheme did not save the project from failure.[33]

Some of the principal views of the commission presented themselves again about five years later, however, in Powell's arid lands report and in his subsequent attempt to abolish the Land Office survey organization. The commission's commitment to large-scale, carefully engineered irrigation systems and to the need for surveys to help locate and plan them are represented in Powell's

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[33] One consequence of the commission's activity in the longer run, however, might be represented by California's establishment of the Office of State Engineer in 1878. Its duties included the study of irrigation problems in the state. See Charles P. Korr, "William Hammond Hall: The Failure of Attempts at State Water Planning in California, 1878-1888," <u>Historical Society of Southern California Quarterly</u>, 1963, 45:305-11; Gerald D. Nash, <u>State Government and Economic Development. A History of Administrative Policies in California, 1849-1933</u> (Berkeley: University of California, Institute for Governmental Studies, 1964), pp. 188-89, 192-93.

vision as well. They underly Powell's belief that great engineering problems stood in the way of western settlement, and his conviction that the topographical and other aspects of his survey's work had an important role to play in the West's future.

We will turn now to Powell's own assessment of the arid region and its needs.

CHAPTER FIVE

PHYSICS AND POLITICS. A NEW GEOGRAPHY OF THE WEST

Powell's Report on the *Lands of the Arid Region*[1] was a physical geography of the public domain in the West, a scientific picture of the newest region Americans sought to settle and raise to prosperity. The report's object was to show government how a scientific understanding of the region could be useful in carrying out its responsibilities as custodian of the public domain.

The *Lands of the Arid Region* and the mission it represented was an outgrowth of several years of concern by Powell over the government's handling of western settlement. He first drew special attention to some of the problems he saw in testimony before the House Committee on Public Lands in the spring of 1874. This committee was investigating possible duplications of effort among the geographical and geological surveys operating in the West, and its hearings gave Powell an opportunity to express his opinion on the proper objectives of survey work. The economic needs of the

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[1] U. S. Congress, House, *Report on the Lands of the Arid Region of the United States, with a More Detailed Account of the Lands of Utah*, by J. W. Powell, Ex. Doc. 73, 45th Cong., 2nd sess., 1878. I have used the second edition issued the following year with only printing and other minor errors corrected, U. S. Geographical and Geological Survey of the Rocky Mountain Region, *Report on the Lands of the Arid Region of the United States, with a More Detailed Account of the Lands of Utah, With Maps*, by J. W. Powell, 2nd ed., Washington, D.C.: 1879 (hereafter cited as *Lands of the Arid Region*).

region needed more systematic attention. He mentioned railroads and mining interests, but he drew special attention to the needs of agriculture. The western territories for the most part have "a climate so arid that agriculture cannot be pursued without irrigation," he warned. Small portions of the region might be reclaimed, "varying in different territories perhaps from 1 to 3 per cent." And this, he observed (striking notes sounded by the commission that had reported on irrigation in California the previous month), would require large-scale undertakings. The larger streams of the region would have to be developed, and this would only be accomplished by "cooperative organizations, great capitalists, or by the General or State governments."[2]

It was thus "of the most immediate and pressing importance," Powell argued, that surveys should be made "for the purpose of determining the several areas" where the land could be redeemed by such developments. The surveys of the General Land Office were already wasting their effort, extending their work over large areas that were without water and could never be settled. A geographical and geological survey, he intimated, should locate the areas that could be irrigated. His survey had done so, he pointed out; and it had also identified areas suited for grazing and for timber.[3]

Powell's views probably played a part in the outcome of the

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[2]U. S. Congress, House, Committee on Public Lands, "Geographical and Geological Surveys West of the Mississippi," H. Rpt. 612, 43rd Cong., 1st sess., 1874, p. 10.

[3]Ibid., pp. 10, 53.

House hearings. At the end of the session Congress removed Powell's survey from the Smithsonian Institution and placed it under the Interior Department. Powell joined the Hayden survey as the Second Division of the United States Geographical and Geological Survey of the Territories and received specific instructions to identify lands that were irrigable and otherwise economically valuable. In addition to preparing a general map of the region surveyed, Powell and Hayden were to provide special maps whenever necessary to represent "mining districts, mineral, agricultural, pasture, or timber lands," and also such "portions of the country as might be susceptible of cultivation by means of irrigation."[4]

Indeed, the Interior Department over the previous few years had become increasingly interested in knowing which lands were valuable for certain economic purposes. In 1872 General Land Office Commissioner Willis Drummond announced restrictions on agricultural entry in California because mineral lands (presumably placer gold deposits) were being inadvertently taken by homestead and preemption[5] settlers and lost to mining interests. This had resulted because

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[4]U. S., Interior Department, Report of the Secretary, 1874, Washington, D.C., 1874, pp. XXVIII-XXIX. Powell survey operations after transfer to the Interior Department were outlined in these reports annually through 1878. Fuller accounts are contained in Smithsonian Institution, Annual Report of the Board of Regents, 1874 (Washington, D.C.: Government Printing Office, 1875), and in subsequent volumes for the years 1875 to 1878.

[5]Preemption sale, under provisions of legislation permanently enacted in 1841, allowed a settler to enter and purchase lands at $1.25 per acre in advance of regular survey and public auction. Homestead entry was free (except for minimal processing fees), but it was available only for lands surveyed and parceled by the public land surveys.

surveyors failed to designate the lands' actual mineral character, Drummond complained. He lamented further that no authority was available for proper investigations by a geologist.[6]

Lands with valuable stands of timber were also a concern for the Land Office. No special entry for commercial logging had ever been enacted, and depredations by timber companies had already become a problem in the 1850s. During the following decade, fraudulent entry under homestead and preemption laws became a leading means of theft. In 1874 Land Office Commissioner Samuel Burdett urged that the land survey system be corrected to assure proper designation of the remaining "pine lands" in the East and more importantly in the comparatively intact "fir lands" of the Pacific coast. Burdett also recommended an immediate investigation by a forest specialist on lands yet to be surveyed to take stock of the problems faced.[7]

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[6] U. S., Interior Department, Report of the Secretary, 1872, Washington, D.C., 1872, pp. 32-34.

[7] Interior Department, Report of the Secretary, 1874, p. 6. The Interior Department's attempt to control timber depredations is also discussed by Harold H. Dunham, Government Handout. A Study in the Administration of the Public Lands 1875-1891 (Ph.D. dissertation, Columbia University, 1941; reprint ed., New York: De Capo Press, 1970), pp. 47-99.

The recommendation for a report by specialists was probably in response to a committee of the American Association for the Advancement of Science. The committee led by F. B. Hough, but including scientists as prominent as botanist Asa Gray and geologists J. D. Whitney and J. S. Newberry, lobbied hard in 1873 and 1874 for an investigation and report on preservation of the nation's timber resources. Success was finally met in 1877. See John Ise, The United States Forest Policy (New Haven: Yale University Press, 1924), pp. 34-35, 42.

These and other recommendations for reforms from the Interior Department brought little legislative response from Congress. Unfortunately, a fear of monopoly in large land holdings on the part of the public and the ability of many interests to serve their needs easily and remarkably well simply by circumventing the existing land laws obstructed substantive changes in the land system throughout the 1870s and most of the next decade.[8] The Powell survey's attention to identifying mineral, grazing, timber, and irrigable lands likewise was ignored, with no provision ever being made for the Land Office to avail itself of its work.

Nevertheless, a very considerable sentiment for public land system reform existed in the Interior Department. In the summer of 1875 President Grant toured the West, visiting particularly the territories of Utah, Colorado, and Wyoming. In his annual message to Congress in December he reported that his tour had convinced him that the "existing laws regulating the disposition of public lands . . . and probably the mining laws themselves are defective and

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[8] Dunham's Government Handout focuses on the inadequate post-Civil War administration of the land system, and its reform through the 1870s and 1880s. See also U. S. Public Land Law Review Commission, History of Public Land Law Development, by Paul W. Gates and Robert W. Swenson, Washington, D.C.: 1968, pp. 435-94. Henry Nash Smith, Virgin Land, The American West as Symbol and Myth (Cambridge: Harvard University Press, 1950; Harvard Paperback, 1973), pp. 123-200 provides insight into the agrarian ideological foundations of the land system and their clash with physical conditions in the West during this period; and Roy M. Robbins, Our Landed Heritage. The Public Domain 1776-1970, 2nd ed. (Lincoln: University of Nebraska Press, 1976), pp. 203-298 reviews this period in terms of a clash between the agrarian land system and the rise of corporate enterprise.

should be carefully amended and at an early date."[9] The President urged a law that would allow settlers access to timber without becoming trespassers, and he suggested that entry to land in larger quantities was necessary both for stock raising and for irrigation enterprises. He urged a joint committee of Congress visit the territories and recommend appropriate legislation.[10]

During the remaining two years of Grant's term the Interior Department under Secretary Zachariah Chandler tried to bring about land system reform over a broad front. The department had capable leadership from General Land Office Commissioners Samuel S. Burdett and James A. Williamson, but Congress enacted little of the legislation they sought.[11]

However, the department's disposition to reform during this period provided Powell a fertile environment for developing his ideas. Land Office Commissioner Burdett in 1875, for example, longed to have the geographical and geological surveys' information on mineral resources made available to his office. The loss of revenue resulting from coal and mineral land passing from the government for prices below those required by law, he contended, need not be continued where scientific surveys were operating on

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[9]Quoted in Dunham, Government Handout, p. 19.

[10]Ibid.; U. S. Congress, Congressional Record, 44th Cong., 1st sess., 1875, vol. 4, pt. 1:181.

[11]Dunham, Government Handout, pp. 20-24.

the public lands. Burdett hoped Congress might provide more fully for annual and other reports that would make their information available for Land Office use.[12]

Both Burdett and Williamson saw special problems and needs where lands were valuable for timber or where lands were too dry for normal farming but were still valuable for stock raising or if they could be irrigated. Burdett still despaired over the failure of the land surveys to discern whether or not lands contained valuable pine or fir, because that made the depredation problem practically insoluble. With lands properly identified he believed it was possible to minimize waste and depredation through carefully administered sales either of timber land or of the timber alone as stumpage. When Williamson entered office in 1876 he took up a more aggressive campaign against depredations, but also favored timber land identification and sale.[13]

In the drier regions where grasslands provided free pasturage for a burgeoning cattle industry, or where the availability of water for irrigation promised to make desert land productive, Burdett again favored special entry provisions. Both enterprises required

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[12] Interior Department, Report of the Secretary, 1875, pp. 15-16.

[13] Dunham, Government Handout, pp. 44-50; Interior Department, Report of the Secretary, 1875, p. 10; idem, Report of the Secretary, 1876, pp. 7-9. Under the Hays administration in 1878 Congress responded to these pressures with the Timber Cutting Act and the Timber and Stone Act, but neither proved very effective in controlling waste and destruction of timber; see Dunham, Government Handout, pp. 53-58.

larger quantities of land than the 160-acre parcels traditionally allotted the pioneer farmer. Where only stock raising was feasible Burdett favored sale in unlimited quantities at the usual government minimum price of $1.25 per acre. Where irrigation was practicable he thought two policies appropriate. In the smaller mountain valleys he thought homesteading was still feasible, but elsewhere he was persuaded that large-scale systems were necessary and other policies were in order. Corporate land development companies wishing to construct such projects depended on sale of improved lands for their success, and entry laws aimed at small farmers could not legally fill their needs. Burdett favored sale of such developable lands in whatever quantities were necessary to make the projects a reality. Williamson endorsed Burdett's views when he became commissioner, but Dunham reports his preference ran to a system of land grants to encourage large scale projects rather than outright cash sales.[14]

Congress's only immediate attempt to address this problem was the controversial Desert Land Act. Passed at the end of the second session of the 44th Congress in March, 1877 it allowed a citizen to enter 640 acres without residing on it and ahead of any public land survey. The entrant was to reclaim it "by conducting water" onto it within three years, at which time title would be issued at a purchase price of $1.25 per acre. The act may have been intended to

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[14] Dunham, Government Handout, p. 28; Interior Department, Report of the Secretary, 1875, pp. 6-9; idem, Report of the Secretary, 1876, pp. 4-7.

facilitate colony enterprises, but its loose provisions have been judged much better suited to cattle growers intent on accumulating lowlands for water and hay production. The measure was attacked soon after its passage by concerned westerners. Moreover, both Land Office Commissioner Williamson and new Secretary of Interior Carl Schurz criticized it in the department's annual report for the year.[15]

Powell also responded to the Land Office's needs when in 1877 he focused his survey's attention on irrigation and other land system problems in the Rocky Mountain region. Field work undertaken in that season provided the foundation of a large part of the Report on the Lands of the Arid Region.

Powell's reports on the Colorado River explorations and on the geology of the Uinta Mountains were behind him in 1877, and with his survey's work expanding westward into Utah's more heavily settled central and northern basins, Powell perhaps found it convenient to turn greater attention to irrigation. Probably, too, events surrounding the passage of the controversial Desert Land Act prompted Powell's more active interest: he was not likely to have missed the implications G. K. Gilbert recognized for the act, that it meant there would be "no need" for land classification work by

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[15] Dunham, Government Handout, pp. 29-35. This notorious piece of legislation is also reviewed in Public Land Commission, History of Public Land Law Development, pp. 638-43, and John T. Ganoe, "The Desert Land Act in Operation 1877-1891," Agricultural History, 1937, 11:142-57.

the Powell survey. We also note, judging from C. E. Dutton's laments about the short notice given, that Powell decided to take up the irrigation work late and may well have been reacting to the events of the winter legislative session.[16]

The season's field work entailed G. K. Gilbert's return to the Great Salt Lake basin, where in the early part of the 1876 season he had begun a study of the shoreline features evidently left by the Pleistocene Lake Bonneville. Gilbert's geological work in 1877 would be turned to evidence of vertical displacements appearing in the shorelines, but he was also to extend land classifications into the northern part of the Salt Lake basin mapped earlier by the King survey.[17]

In addition, Gilbert took on two special studies related to irrigation. The first was an assessment of agricultural development in the Mormon settlements on the eastern side of the basin and its future state with full use of available stream water supplies. For this Gilbert availed himself of an earlier economic census, interviewed area residents, and measured flows on some of the major streams in the region. His results were included in the Report on the Lands of the Arid Region.

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[16] Letters, C. E. Dutton to J. W. Powell, 25 May 1877; C. E. Dutton to J. W. Powell, 26 September 1877; G. K. Gilbert to J. W. Powell, 28 June 1877; "Letters Received. Survey of the Rocky Mountain Region," Record Group 57: Records of the Geological Survey (Microfilm Publication No. 156), National Archives, Washington, D.C.

[17] Smithsonian Institution, Annual Report of the Board of Regents, 1877, pp. 72-77.

Gilbert found 3.9 per cent of the district drained by the Bear, Weber, and Jordan river systems in current agricultural production. To assess the future production required estimates of water supplies which, because of great annual and seasonal fluctuations, needed to be based on several years of measurements taken in the season of highest demand. This was not possible, so Gilbert's results were extrapolated from such discharge measurements as could be taken and the experience of the residents.

Gilbert's estimates of the water requirement for crops grown in the area, which also depended on the experience of the region's farmers, were set in terms of the amount of land that normally could be served by a given stream flow during the season when demand was greatest. He concluded that about 100 acres of land could be cultivated for each cubic foot per second[18] of stream flow available. Because the larger streams in the region were little developed, Gilbert estimated that about twice as much land remained to be

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[18]The Powell Survey's choice of the cubic foot per second (or "second-foot," as Powell preferred, Lands of the Arid Region, p. 81) as a standard unit of discharge underscores Powell's conscientious dedication to the exact methods of the physical and engineering sciences. Throughout the West water supplies were customarily measured by the "miner's inch"--the discharge through an orifice one square inch in area under constant pressure. Unfortunately, standards were loose. The pressure head might be four, six, or some other number of inches depending on the region; and the devices for measuring the discharges varied greatly in the shape and dimensions of the outlet. This was another problem earlier noted by the commission on irrigation in California, U. S. Congress, House, "Irrigation of the San Joaquin, Tulare, and Sacramento Valleys, California," Ex. Doc. 290, 43rd Cong., 1st sess., 1874, p. 48.

brought into production as was then in use. Still, the sum total of all potentially cultivable land in this comparatively well-watered district was only 12.7 per cent.[19]

Similar estimates of irrigable land area were made for the Sevier River drainage by Clarence Dutton, who in 1877 was in that area studying the geology of central Utah's high plateaus. The region was drier than Gilbert's territory, and Dutton found that one cubic foot per second of discharge there would serve only about 50 acres. The region was also less developed, and he could see a tripling or quadrupling of the cultivated land when larger streams were fully utilized and better practices used. Dutton's report exemplified the advantages of land classification by one who was well schooled in geology and the sciences generally. His report carefully noted such factors limiting agricultural use of the lands as high altitude and the consequent common occurrence of late frosts, the durability of certain volcanic rocks and the development of workable alluvial soils, and evaporation of subsurface water and the production of alkaline soils.[20]

A third report on the extent of irrigable land in Utah was prepared by Almon H. Thompson, Powell's chief geographer. Thompson summarized the findings on the small amount of irrigable land found

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[19] G. K. Gilbert, "Irrigable Lands of the Salt Lake Drainage System," in Lands of the Arid Region, pp. 113-27; Letter, Gilbert to Powell, 28 June 1877, "Letters Received. Survey of the Rocky Mountain Region."

[20] C. E. Dutton, "Irrigable Lands of the Valley of the Sevier River," in Lands of the Arid Region, pp. 128-49.

in the Colorado River drainage, the scene of most of the Powell survey's work since it began in 1869.[21]

The second special study Gilbert undertook was an investigation into the rise in the level of the Great Salt Lake. This rise had taken place since the beginning of the Mormon settlements, and it had profound implications for the region's climate and water supply. Gilbert's analysis was typical of the best of his work, marked by thorough presentation of relevant facts, use of mechanical models and equilibrium concepts, and careful arguments comparing facts with deductions from hypotheses. Gilbert compiled evidence on the levels of Great Salt Lake in various years at several locations and carefully connected them with key synchronous observations to construct a record extending continuously from 1847. This record demonstrated a rise of approximately ten feet to a new level that had remained comparatively constant since about 1869. Gilbert carefully noted that vegetation intolerant of saline conditions formerly grew in the periphery now submerged, for this suggested that the earlier, lower level of the lake had been stable for decades or perhaps centuries.[22]

Gilbert concluded that the change in level represented a new equilibrium position of the lake. He then carefully examined three hypothetical causes. Upheaval and alteration of the basin bottom

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[21] A. H. Thompson, "Irrigable Lands of that Portion of Utah Drained by the Colorado River and its Tributaries," in Lands of the Arid Region, pp. 150-64.

[22] G. K. Gilbert, "Water Supply," in Lands of the Arid Region, pp. 57-67.

was rejected, not only because the rise by all accounts was uniform at all points in and around the lake, but also because such a cause, in the face of necessarily increased evaporation from the expanded lake surface, could not explain the apparent permanence of the higher level. Increased rainfall as a cause could not be addressed directly because records were inadequate; but its feasibility was demonstrated by historical evidence of increased stream discharges and by rainfall records from regions elsewhere in the nation showing large variations from decade to decade.[23]

Gilbert was struck by the evidence that the former, lower level of the lake had been stable for a very long period of time, and by the coincidence of the subsequent rise with the onset of the settlement of the country. He leaned toward a third explanation--Powell's theory of human agencies. Neither Powell nor Gilbert subscribed to the popular idea of settlement somehow causing an increase of precipitation.[24] They considered the evidence of increased rainfall ambiguous, and they thought the means proposed--electrical effects of rail lines or telegraphs, greater retention of rainfall by cultivated soil--were speculative or at best inconsequential in the face of the great global-scale factors known to affect atmospheric circulation.

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[23]Ibid., pp. 67-71.

[24]Ibid., pp. 70, 90-91. The Hayden survey, particularly through the reports of Cyrus Thomas lent a measure of scientific support to this idea, which was much abused in promoting immigration and land sales in the plains states. Henry Nash Smith, "Rain Follows the Plow: The Notion of Increased Rainfall for the Great Plains," Huntington Library Quarterly, 1947, 10:169-93; David M. Emmons and Charles R. Kutzleb, "American Myth: Desert to Eden," Forest History, October 1971, vol. 14, no. 3:6-21.

Powell's theory of human causation emphasized different effects of civilization on environment. As related by Gilbert, the Powell theory maintained that man, through swamp drainage and other stream improvements and by destruction of vegetation through stock raising and timber cutting, had significantly reduced opportunities for precipitation to evaporate. A greater percentage of the rainfall was finding its way into streams and eventually lakes. Irrigation produced an opposite effect, but Gilbert argued that the practice was employed only a few months of the year and involved a small amount of water compared to the total needed to explain the new level of the lake.[25]

Though his sentiments were clearly with the human agencies hypothesis, Gilbert allowed that neither it nor the theory of increased rainfall could be considered proven.

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[25]Lands of the Arid Region, pp. 73-77. Powell's theory on the effects of civilization on stream flows was probably derived from a study he cited on another occasion (see U. S. Congress, House, "Survey of the Territories," Misc. Doc. 5, 45th Cong., 3rd sess., 1878, p. 20) the same year, Charles Ellet, Jr., On the Physical Geography of the Mississippi Valley, with Suggestions for the Improvement of the Navigation of the Ohio and Other Rivers, Smithsonian Institution, Contributions to Knowledge, vol. 2 (Washington, D.C.: Smithsonian Institution, 1850). Ellet's ideas are more concisely expressed in a reorganized version of the same study, The Mississippi and Ohio Rivers (Philadelphia: Lippincott, Grambo, 1853), pp. 83-87.

Ellet had proposed reservoirs on the headwaters of the Mississippi River to control its flooding, and in the middle 1870s his ideas surfaced again only to be attacked by the Engineer Department of the Army. Powell's knowledge of these contemporary engineering issues, it may be added, is further evidence of his probable familiarity with the commission investigating irrigation in California in 1873.

> So far as we know, neither theory is inconsistent with the facts, and it is possible that the truth includes both. The former [climate theory] appeals to a cause that may perhaps be adequate, but is not independently known to exist. The latter [human agencies theory] appeals to causes known to exist but quantitatively undetermined.

Whatever the cause, Gilbert concluded, the region's residents could take heart in knowing that the change was either "practically permanent," if caused by the beginning of a new, long-period climatic cycle, or literally permanent if caused by mankind's industries.[26]

The work by Gilbert, Dutton, and Thompson comprised five chapters in Powell's Report on the Lands of the Arid Region--in a sense a final report on the survey's land classification work in the region. Powell's contribution to the report was more interpretive. He presented a description of the physical circumstances governing conditions in the western regions, pointed out their consequences for human industrial pursuits, and outlined the implications for the nation's land system. It was physical geography, describing the landscape scientifically in terms of altitude, climate, natural productions, and other objectively observable features; but it was not merely descriptive. It was *pre*scriptive to a degree as well, applying the insights gained from scientific understanding to the resolution of land policy problems. Science for Powell became a foundation for analysis and decision making--a basis for judicious action.

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[26]Lands of the Arid Region, p. 76.

Powell's arid region was that area of the country beginning at about the one hundredth meridian midway into the plains and extending westward to the Pacific Ocean, excepting only the mountainous regions along the coast of Washington, Oregon, and northern California. It was roughly coincident with the great area he had called the Rocky Mountain Region, after its often mountainous and sparsely vegetated landscapes, in his geological report on the Uinta Mountains.[27]

Utah, where his survey's work had been centered, Powell thought was "a fair type" for the larger district. A zone of mountains (the Wasatch Range) and high plateaus generally nine to eleven thousand feet in altitude rose abruptly and extended from the northern boundary nearly to the southern through the central portion of the territory. Other elevated plateau districts, the Uinta Mountains on the north and the Tavaputs Plateau farther south, extended from the elevated central zone toward the east. These elevated districts were typically cut by rivers to form many valleys and canyons substantially lower than the general elevation, and in the lower plateau area to the south of the Tavaputs Plateau the Colorado River system had produced a greatly incised canyon region.[28]

The Unita and Tavaputs highland districts were separated by a

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[27]Ibid., pp. 1, 5.

[28]Ibid., pp. 6, 93. To highlight the logical connections of Powell's thought I have combined materials appearing in different places in Powell's report. No misconceptions have been introduced, so far as I am aware.

large, broad and comparatively low basin drained by the Uinta and White rivers, each a tributary of the Green River cutting across the basin toward the canyon country to the south. Other broad basins lay to the west of the elevated central mountain and plateau zone, including the Great Salt Lake basin and the Sevier River district. Low, dry, and barren, separated by short linear ranges of mountains, these were part of the Basin Ranges geological district extending across Nevada and into Oregon and Idaho.

From the standpoint of drainage, the central zone of highlands divided the territory into two distinct regions: the area on the east draining to the ocean by way of the Colorado system, and the internally drained, isolated desert basins on the west. Powell mentioned that the geological characteristics of these two districts were also significantly different, particularly as to structure, and he summarized some of his earlier geological results.[29]

Describing the territory's various districts, Powell pointed out its diverse conditions. In the Wasatch Mountains there were high valleys with pleasant summer climates, abundant water, and vigorous vegetation. The adjacent, higher mountain slopes bore a good growth of spruce, fir, and pine. High table lands near by and to the south were less hospitable. Summers were brief, and the surface of the land was frequently covered with lava sheets or volcanic cinders. The higher of the plateaus held occasional small

[29] Ibid., pp. 93-96.

lakes and were forested with a gnarled tangle of evergreens. In the Uinta highlands the cover was sometimes grass.

The elevated districts, Powell noted, contained all the usable timber to be found in the territory. Being well watered, the highlands were also the source of the region's streams. Their high elevation brought abundant precipitation as snow and rain, but also cool, brief summers unsuited to the agriculturalist. The highland areas stood in stark contrast to the lower, warmer, drier, and barren basin districts, suited differently but no better to agricultural needs.[30]

All things considered the region presented only rare opportunities for the farmer. Except where the high and rugged mountains drew greater amounts of precipitation it was an "Arid Region" where, throughout, "the mean annual rainfall is insufficient for agriculture." Only in the lowlands near the mountains, where the more abundant precipitation produced streams that could be used for irrigating crops, could agriculture be carried on successfully.[31]

The dry climate was the prime factor producing the distinctive characteristics of the arid region, Powell recognized, and like the commission that studied irrigation in California before him Powell outlined the relevant climatic facts and conditions. Powell devoted a separate chapter to presentation of the most up to date weather records compiled for the Smithsonian Institution by Charles A. Schott

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[30] Ibid., pp. 5-7, 96-98.

[31] Ibid., pp. 5-6.

of the Coast Survey. This data accompanied by a national map of mean annual precipitation underscored the arid character of the region, and it showed certain subregions characterized by seasonal biases in their rainfall patterns.[32]

The report opened with a review of the pertinent facets of general atmospheric circulation responsible for the climates in the West. Westerly moisture laden winds off the Pacific Ocean bathed the mountainous regions of the coast in moisture, Powell showed, but precipitation fell off rapidly away from the mountains toward the east. Excepting the localized effects of mountains, there was no general increase in precipitation until reaching the plains region, where more humid winds drawing moisture from the Gulf of Mexico and the Atlantic Ocean were encountered.[33]

Accurate rainfall records for the western region were too meager for a definitive assignment of arid region boundaries, but Powell was confident that, except in the case of mountain zones where generally unsatisfactory agricultural conditions made the question academic, records and experience were adequate for good approximations. These taught generally that agriculture turned risky as one moved from the moist, eastern farm lands westward into lands receiving less than twenty inches of rainfall throughout the year.

The twenty-inch isohyetal through most of the plains coincided

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[32]Ibid., pp. 46-56.

[33]Ibid., p. 1.

approximately with the one hundredth meridian on Schott's national precipitation chart.[34] Although in the north the line deviated eastward, Powell pointed out mitigating physical circumstances that brought the approximate arid boundary back toward the west: because of the more northerly latitude, temperatures were cooler and less rainfall was required by the crops. In addition the preponderance of the areas precipitation fell in the spring and summer months when it was most needed. Thus, agriculture in that area had proven itself successful west of the twenty-inch rainfall line, out to and perhaps even somewhat beyond the one hundredth meridian.[35]

Variability in the annual rainfall further complicated definition of the eastern limit of the arid region. Eastward to about the twenty-eight-inch isohyetal, the annual variability meant disastrous droughts would occasionally strike. Powell expected irrigation to be taken up there to some extent, but he called it a sub-humid belt where irrigation was necessary only periodically.[36]

Seasonality and annual variability complicated the general picture to a more limited extent in California. As the federal

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[34]The demarcation of the dry or desert regions at the one hundredth meridian was not a new idea. General W. B. Hazen used it conspicuously in his article "The Great Middle Region of the United States, and Its Limited Space of Arable Land," North American Review, 1875, 120:1-34. Hazen drew attention as well to meteorological reports on the region by Lorin Blodget during the Pacific railroad surveys that push the idea back another twenty years. On the development and destruction of the idea of a "Great American Desert" see Smith, Virgin Land, pp. 174-83.

[35]Lands of the Arid Region, pp. 2-3, 46.

[36]Ibid., pp. 3-4, 50-53.

commission visiting the state in 1873 had pointed out, Powell observed that a seasonal rainy period from December through April in the northern and central parts of the state mitigated the low annual precipitation, allowing some crops to be grown without irrigation. But still, the rainfall was undependable from year to year, and the threat of drought gave irrigation a wide appeal.[37]

The arid region, then, was the area where dependable agriculture required irrigation, extending from the one hundredth meridian to the west coast, and including all but the small humid region along the northwest coast of California, Oregon, and Washington.

Within this region there was only a small proportion of the land that could be brought into production. The diverse topography and its local effects on climate combined to differentiate the various districts of the region with respect to their potential economic use. The high mountains and plateaus were the natural timber districts of the region--"an upper region set apart by nature for the growth of timber necessary to the mining, manufacturing, and agricultural industries of the country." They were unsuited to agriculture, being subject to killing summer frosts and their surfaces steep and broken or scored by canyons.[38]

Temperature considerations limited agriculture to the lower lands, and the necessity of irrigation further limited suitable tracts to those lying along streams. Some higher valleys in Utah

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[37]Ibid., pp. 5, 54-55.

[38]Ibid., pp. 6, 18.

produced hay, and there was a narrow belt of country on the flank of the Wasatch Range with rainfall sufficient for farming without irrigation, but these were exceptional. The volume of water running in the streams limited the amount of land that could be brought into use except where land itself was limited in some of the narrower valleys. In Utah only about 2.8 per cent of all the land surface was estimated to be available for use in irrigation farming. These irrigable tracts were "scattered along the water courses," and were "in general the lowest lands of the several districts to which they belong." They were well below the timber lands and would be even farther removed from them as larger streams were developed.[39]

Between these lowlands, on the one hand, and the high timbered mountains and plateaus on the other, Powell saw "a great body of valley, mesa, hill, and low mountain lands" bearing grasses--a scanty growth, but "nutritious and valuable both for summer and winter pasturage." Climatic conditions dependent upon latitude and altitude affected the utility of these lands, the districts farthest to the south and lowest in altitude generally being true deserts. There were also large areas where geological conditions did not allow development of satisfactory soils for any kind of growth--bad lands, canyon districts, and lava beds for example. Still, where water was also available in isolated springs and small brooks, there was much useful grassland that could support grazing stock.[40]

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[39]Ibid., pp. 6-9.

[40]Ibid., pp. 9, 19.

The highly differentiated character of the grasslands, timber lands, and irrigable tracts had important implications for the resolution of problems besetting the nation's public land system. Indeed it was Powell's self-proclaimed intent not merely to describe the character of the lands in the arid region, but to help create the "wise prevision" or foresight needed for a new, more effective public lands policy.[41] This was true of the three major classes of lands he treated, which owe their identification more to considerations of human use than to any natural characteristics distinguishing them.

The timber lands presented the simplest problems in Powell's view. He followed Land Office Commissioner Williamson in his desire to sell the standing timber apart from the land. He also saw no particular need for special measures to protect the timber supplies from waste, in part because in this region the timber lands were poorly suited to agricultural purposes and were not under pressure from agricultural settlers.[42]

More importantly, Powell noted that the area where good timber could grow in the West (in Utah about 23 per cent of the land surface) was nearly double the actual area of standing timber. Indians driven to the higher regions by advancing civilization often set fires to drive game on their hunting excursions, he noted, and these had devastating results on the standing timber. Powell

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[41]Ibid., p. viii.

[42]Ibid., pp. 27-28.

claimed to have witnessed five separate fires in the region, each of which he was convinced consumed "more timber than that taken by the people of the territory since its occupation." If the forests were protected from fire, Powell thought--and either removing the tribes to reservations or prohibiting them from setting fires might accomplish this--no limitations to forest use would be necessary; "The renewal by annual growth will more than replace that taken by man."[43]

The irrigable lands on the other hand presented the most imposing problems for the region's public lands. These in fact symbolized for Powell the kind of problems faced throughout the nation in its public domain. Everywhere, compared to their whole extent, he noted in the preface to his report, only "a very small fraction" of the public lands were immediately available for agricultural use. Irrigation was required to redeem the arid lands, he insisted, and echoing opinions of the commission that earlier reported on irrigation in California he warned that irrigation presented "engineering problems" demanding the "greatest skill" for their solution. Similarly, the public lands of the Atlantic and Gulf coasts were often swamps or floodplains requiring either "drainage or protection from overflow"--another class of engineering difficulties. Powell's original objective was to discuss the lands of each of these regions, he stated, together with all of the

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[43]Ibid., pp. 16-18.

engineering problems involved in rescuing them "from their present worthless state."[44]

With the limited information at hand Powell had not been able to execute this larger project. He knew the arid region well, however, and for that region he could address problems of development. Irrigation made agriculture feasible in the arid region primarily by freeing the farmer from the viscissitudes of rainfall. But this immunity was not to be had without cost. Again raising a point earlier made by the commission on California irrigation, Powell noted that "small streams can be taken out and distributed by individual enterprise, but cooperative labor or aggregated capital must be employed in taking out the larger streams." In the arid region most of the smaller streams were already so employed, Powell judged--certainly, Gilbert had found this to be the case in Utah--and hence "the chief future development must come from the use of larger streams."[45]

The development of irrigation on larger streams posed two problems. In the first place these projects were great undertakings requiring a large outlay of labor and materials. It was a commonplace that men settling under homestead or preemption laws were not able to accomplish it, and also it was very difficult under the prevailing system for corporate enterprises to enter the field. Cooperative labor or private investment were required, and

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[44]Ibid., pp. vii-viii.

[45]Ibid., p. 11.

a land system better accommodating such efforts was a necessity.

This institutional obstacle was the most immediate problem Powell tried to address in his report. The second problem was primarily technical in nature, but there were institutional dimensions to its solution as well. It will be convenient to review this second problem fully, and then return to the institutional problems uppermost in Powell's mind.

The diversion of large streams both promised and required the irrigation of large tracts of land. Powell did not elaborate on the engineering fundamentals of irrigation, but clearly the projects he held in view were technically indistinguishable from those envisioned earlier by the commission reporting on irrigation in California. The use of large streams required large and comprehensive works which Powell observed generally could not be justified without using all the waters available. Reservoir storage was an important consideration because the very significant amounts of water discharged outside the agricultural seasons could be stored and reserved for growing season use. Powell thought reservoir storage would be undertaken more fully in the future, but that the better sites needed to be identified and reserved against entry so they would be available when needed.[46]

Using large amounts of water also required serving a large amount of land. Often, Powell noted, this was obstructed by

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[46] Ibid., pp. 12-14.

previous development of the more easily diverted streams. The lower portions of the larger streams often had small tributaries whose waters were easily carried to the better low lands lying near the trunk stream. Where this had already occurred, irrigators had vested rights in lands needed for development of the larger project, "and a practical prohibition" was placed on the use of the larger river. In Utah the authority of the Mormon church adjusted such conflicts to a degree, Powell noted. But he believed this was a problem that soon would loom very large everywhere in the arid region as people were forced to resort to the larger streams. "Some provision" against this difficulty, he warned, "is an immediate necessity."[47]

The proper selection of irrigable lands was discussed in a separate chapter on "Certain Important Questions Relating to Irrigable Lands." The extent of irrigable lands, as exemplified in Gilbert's work, was usually determined by demands of the crops for water, and the amount of water flowing in the streams. Suitable land being more plentiful than the streams' supply of water, the issue of exercising the best selection of land arose for

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[47] Ibid., p. 12. Powell was probably also aware of controversy in Colorado between Union Colony and the colony upstream at Fort Collins. Disputes over water rights between these two colonies after 1874 led to the incorporation into the Colorado constitution in 1876 of the doctrine of water rights according to priority in time, and eventually it led to the state's acclaimed administrative system of water rights management and adjudication. See Robert G. Dunbar, "Water Rights and Controls in Colorado," Agricultural History, 1948, 22:180-86.

consideration.[48]

Although factors such as proximity to a mining district or railroad transportation might at times affect the choice, Powell held that the problems involved were usually resolved by consideration of physical factors. Evaporation losses were lower at higher elevations, but on the other hand the growing season was longer further down, and more hospitable to a variety of crops. Distance from the source of supply affected water losses, but the plains near the stream were subject to flood damage. Gentleness of slope was an important factor. Alkaline soils needed to be avoided. But typically, Powell found, the factor exercising greatest control in selecting irrigable lands was an engineering matter: "The question of the best sites for the construction of works for controlling and distributing the water has usually determined the selection of lands within restricted limits."[49]

The other factors, it would seem, presented options in any given area. Engineering problems apparently were more critical problems. On this point the commission reporting on California's irrigation needs would have heartily agreed.

The irrigable tracts Powell designated on his map of Utah took such factors into consideration, but the selections are only approximations. The people settling the lands could better take all

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[48] Lands of the Arid Region, pp. 81-86.

[49] Ibid., pp. 88-89.

relevant circumstances into account, Powell contended.[50] He had a means in mind by which those decisions could be made through the joint consideration of the community at large. At the same time, his plan addressed the most immediate institutional obstacle to further development of the irrigable lands--the large outlay of labor and material necessary to harness the larger streams.

In Utah, Powell noted, these problems were resolved through cooperative institutions under the eclesiastical authority of the Mormon church. Settlements were organized to a certain extent on a collective basis: town-sites were established by a number of people organized for the purpose, and they constructed and operated their irrigation systems using cooperative labor. This had been very successful. But Powell knew the great body of people settling the arid region would not be Mormons and, without church authority, would not so easily attain their success.[51]

Powell pointed out that cooperative efforts had been tried outside of Utah. The instances were rare, but he observed that at Greeley the "system has been eminently successful"--successful enough, in fact, that he used the Union Colony as the template for a proposed new settlement law.[52]

Following the recent sentiments of the commissioners of the General Land Office, Powell agreed that irrigable lands might be

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[50]Ibid., p. 89.

[51]Ibid., pp. 11-12, 89.

[52]Ibid., p. 11.

sold in the large tracts needed for corporate development, so long as provision was made that the land development companies actually provided irrigation before sale of the lands to settlers. But if the homestead system were to be preserved, "if these lands are to be reserved for actual settlers, in small quantities, to provide homes for poor men"--and this he no doubt preferred--then the "colony system" should be tried. A general law should be enacted, he maintained, "under which a number of persons would be able to organize and settle on irrigable districts, and establish their own rules and regulations for the use of the water and subdivision of the lands."[53]

Specifically, Powell proposed that nine or more persons be permitted to settle and acquire large tracts of public land by homesteading in an irrigation district in accordance with general regulations to be established by the General Land Office. Within those regulations those persons could determine their own by-laws for parceling lands and administering water use. Each homesteader would be entitled to acquire no more than 80 acres of land, and proof of irrigation would be required before issuance of patent. Within three years the irrigation district was required to provide an accurate survey of the tract and its parcels to the Land Office. Water rights were established from the date of district organization, and were attached to the land irrigated, except that such rights lapsed for any undeveloped lands after five years.

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[53]Ibid., pp. 27, 29.

Provision was also made for the increase in size of the district (to the extent water supplies were adequate) by the addition of new settlers under similar regulations. The suggested law presupposed the designation of lands suitable for irrigation districts, and defined such lands as unclaimed public lands for which a water supply available sufficient to irrigate a minimum of 320 acres.[54]

By these means settlers with comparatively small means at their disposal could repeat throughout the public lands the experience of the colonists at Greeley, Colorado. They could aggregate the quantities of land necessary to justify the costs of irrigation works easily and legally, and without the burden of land purchase incurred by the Union Colony.

Powell had suggested policies on timber lands and on lands suitable for irrigation development, two of the three major problems troubling Interior Department officials in preceding years. The remaining problem was the opening of grass lands suitable for pasturage of stock. Given that timber lands were readily identifiable highlands, and that irrigable lands would be lowlands designated and limited by the water supplies available in suitable streams, the remainder of the lands could be easily classed as pasturage. These would be dry, middle elevation lands for the most part, with a scanty cover of grass suitable to varying degrees as

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[54] Ibid., pp. 30-33.

forage for stock.[55] Here the fundamental problem was to provide enough land for the often meager forage to sustain the number of stock required in a paying operation. In Powell's view based on his experience in the West, four full sections (2560 acres) were required. Such a parcel size had several consequences that troubled Powell, however. For one thing, the distribution of springs and other small surface water sources was not uniform enough for a division of the vast stretches of dry lands into a regular array of pasturage farms. Secondly, such an array even where feasible would leave the farms too isolated for a civilized existence.[56]

Whereas Interior Department officials had leaned toward sale of pasturage lands, Powell again proposed a homestead plan based on the colony system.

> A general law should be enacted to provide for the organization of pasturage districts, in which the residents should have the right to make their own regulation for the division of lands, the use of the water for irrigation and for watering of the stock, and for pasturage of the lands in common or in severalty. But each division or pasturage farm of the district should be owned by an individual.[57]

Powell envisioned a small community (nine or more families) clustered around a stream or area of springs, each family irrigating a domestic garden area of about 20 acres, and each family having

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[55] Ibid., pp. 19-20.

[56] Ibid., pp. 21-23.

[57] Ibid., p. 28.

access to water for its stock. Surrounding pasture area would be unfenced and grazed in common. This was, of course, in keeping with the open range practices that had been spawned by the plains cattle industry.[58] Powell proposed legislation very similar to that offered for the irrigable lands. Pasturage lands were defined as those not designated as irrigable, and pasturage districts would be settled, subdivided, and surveyed by the colonists themselves.[59]

Powell recognized that allowing the settlers to parcel the land for themselves was somewhat revolutionary. But it was not actually so, he argued. Mining districts had been doing this and otherwise regulating their own conduct for years.[60]

Furthermore, he pointed out that a proper parceling of the public lands according to the principles earlier outlined was no longer really practicable. Such a survey would be feasible only in advance of settlement; but now there were already too many people on the land trying to make homes and lives for themselves, "clamoring for some means by which they can obtain titles" to the lands they needed. "The tens of thousands of individual interests would make the problem a most difficult one for the officers of the Government

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[58] On the range cattle industry and its history in the West see Louis Pelzer, The Cattlemen's Frontier. A record of the Trans-Mississippi Cattle Industry from Oxen Trains to Pooling Companies, 1850-1890 (Glendale, Calif.: Arthur H. Clark, 1936), and Ernest Staples Osgood, The Day of the Cattleman (Minneapolis: University of Minnesota Press, 1929).

[59] Lands of the Arid Region, pp. 22, 33-37.

[60] Ibid., p. 28.

to solve." A proper parceling survey, ignoring individual interests "and considering only the interests of the greatest number," would meet great local opposition, Powell believed.[61]

The remaining course was to let the settlers themselves settle their conflicting interests.

> Under these circumstances it is believed that it is best to permit the people to divide their lands for themselves--not in way by which each man may take what he pleases for himself, but by providing methods by which the settlers may organize and mutually protect each other from the rapacity of individuals.[62]

Powell also commented that abandoning the system of regular, rectangular parcels was not to be feared. Townsites were not surveyed on that system, but rather were simply and advantageously described by a plat of numbered blocks and lots.

> While the system of parceling and conveying by section, township, range, etc., was a very great improvement on the system which previously existed, the much more simple method used in our cities and towns would be a still further improvement.[63]

Powell's proposals for homestead-based land entry on a colony plan were novel ideas. Although Powell addressed problems known and attacked by others in the Interior Department, Powell alone proposed a means by which the homestead principle could be preserved. Wallace Stegner's characterization of Powell's report as a "blue-print for a dryland democracy" is indeed appropriate, for his proposals specifically aimed at preserving yeomanry and community

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[61] Ibid., p. 37.

[62] Ibid., p. 38.

[63] Ibid., p. 39.

self-determination in the face of rapidly increasing corporate presence in the West.[64] Nonetheless, they represented radical departures from the existing system of land laws, Henry Nash Smith has noted, and in part for that reason Powell's ideas found little support in Congress.[65]

We are less interested in the legislative fate of Powell's proposals than in their relations to science, however. We find that for Powell scientific knowledge helped create the "wise prevision" needed for prudent legislation[66]--it represented a base of positive information from which one could draw insights on a proper course of action.

Although simple factual information played a significant part in this, the role of higher order theoretical conceptions was more important. Through the same mechanical conceptions that served him in his more narrowly scientific work, Powell gained insights into the present and long-term availability of nature's material resources, and consequently he was helped to form judgments on more

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[64] Wallace Stegner, Beyond the Hundredth Meridian. John Wesley Powell and the Second Opening of the West (Cambridge, Mass.: Riverside Press, 1954), title to Chapter III. The influence of colony enterprises such as the Union Colony escape Stegner's notice, however; he points (misleadingly I believe) only to Powell's experience with Mormon institutions as the basis for his reform proposals, pp. 227-28.

[65] Smith, Virgin Land, pp. 174-88, 199-200. More on the reception of Powell's proposals can be found in Gates and Swenson, History of Public Land Law Development, pp. 424-29.

[66] See above, p. 132.

appropriate land system policies. By outlining the dynamic and geographical aspects of climate and topography over the western region, Powell was able both to establish the general conditions of aridity demanding the use of irrigation in the region, and at the same time to explain as special cases the few favored areas where conventional agriculture had met with success. He was able to show why streams were largely restricted to highland areas in the region where rainfall was abundant, and why because of evaporative losses agriculture would tend to be restricted to the lower lands closest by. Finally, Powell used a physical analysis to advantage in assessing the probable effects of civilized settlement on naturally occurring stream water supplies, examining the roles of precipitation, evaporation, vegetation changes, and altered channel conditions in runoff and in the discharge of streams.

The use of such information as a guide to a prudent administration of the public domain made the Report on the Lands of the Arid Region a very different exercise in physical geography. Powell's report was not simply physical description.[67] It was more accurately the application of physical science. And for Powell this

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[67]William Goetzmann has emphasized the empirical and descriptive character of the western explorations and surveys in his Exploration and Empire. The Explorer and the Scientist in the Winning of the American West (New York: Alfred A. Knopf, 1966), pp. 191-98, 303-304, 485-87. See also William Goetzmann, "Paradigm Lost" in The Sciences in the American Context: New Perspectives, ed. Nathan Reingold (Washington, D.C.: Smithsonian Institution Press, 1979), pp. 21-34. Powell, I would suggest, better represents the breakdown of that older descriptive tradition in the wake of the growth and specialization of science than he does its main stream currents.

application of science served social needs, not merely industrial; science was a tool to be used for better government.

Powell's report implied a continuing and even greater role for scientific surveys in serving the administration of the public domain. If the irrigation district concept were accepted, something akin to the preliminary engineering surveys advocated in 1874 by the commission on irrigation in California would be necessary. Sites for diversion works would have to be located, typically, in order to designate the lands most practicably and effectively irrigable. Reservoir sites needed to be identified. Without a survey of some form, one could hardly be sure (as Powell wanted to be) that the irrigable lands were being designated in a manner to give agriculture "the greatest possible development."[68]

Moreover, if the different provisions for land entry were to have any meaning, an "authoritative" classification of the public lands had to be carried out. This Powell called for explicitly. In addition to designating the irrigable lands, the boundaries of timber lands had to be fixed. Otherwise they might be entered fraudulently as pasture lands in large tracts and virtually at no cost. Furthermore, valuable mineral lands had to be located by geological survey. All remaining lands could then be left as pasturage lands. No more definitive classification was necessary, Powell believed, because these were worthless for any other

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[68] Lands of the Arid Region, p. 44.

purpose.[69]

Powell's call for a proper classification of the public lands hinted at a need for great changes in the survey system of the General Land Office. The *Report on the Lands of the Arid Region* was in fact the prolegomenon of an aggressive move by Powell to abolish that system and to lodge its duties with a permanent scientific survey. We turn now to those events, and to the light they shed on Powell's conception of a scientific survey's function and responsibilities.

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[69] Ibid., pp. 43-45.

CHAPTER SIX

A PROPER SCIENTIFIC SURVEY

John Wesley Powell was convinced that the nation's progress demanded much greater benefits than it was receiving from its miscellany of survey efforts. Problems of settlement and land development in the West were acute, and Powell hoped to expand his geographical and geological surveying responsibilities to include service to those needs. Powell wanted the scientific surveys to take over the surveying responsibilities carried out by contract surveyors under the Land Office's system of regional surveyors-general.

In 1878 circumstances provided Powell his best opportunity to install what he believed was a "proper scientific survey," a system suited to a modern nation's needs. The plans he proposed at that time, together with some of the views interwoven in his Report on the Lands of the Arid Region, provide us a complete picture of Powell's ideas on the objectives and responsibilities to be undertaken by a government survey. We will find that a utilitarian scheme of justification prevails, but with a broad construction sensitive to institutional and public engineering needs as well as to the narrowly industrial. We also find a premium placed on basic scientific work in geography and geology as the foundation for this utilitarian service. Powell's plan contributed to the establishment of the unified United States Geological Survey in 1879, although his primary objectives were rejected. Powell was able to implement his plan to some degree, however, during his tenure as the second director of the Geological Survey.

Powell first indicated his belief in the need for some revision of the government's survey efforts in 1874. The House Committee on Public Lands in that year held an inquiry into the question of duplication of effort among the surveys--the result of some unseemly confrontations between Lieutenant Wheeler and F. V. Hayden.[1] Powell was critical of the military's conduct of survey operations, but he made a good attempt to keep discussions above the plane of personal or institutional rivalries. He spoke more in abstract terms about general survey objectives.

Powell pointed out that there were no unexplored regions left in the United States, so exploration for general purposes was no longer of any great importance. Moreover, these ventures were ill-suited to other purposes.

> . . . Their methods do not produce results sufficiently accurate to warrant their continuance for economic purposes, as the industrial interests of the country are not greatly subserved by them; nor are their results for scientific purposes commensurate with their expense.[2]

"A more thorough method, or a survey proper" was now necessary,

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[1]For the most complete discussion of the rivalry among the surveys see Thomas G. Manning, Government in Science. The U. S. Geological Survey 1867-1894 (n.p.: University of Kentucky Press, 1967), pp. 31-36.

[2]U. S. Congress, House, Committee on Public Lands, "Geographical and Geological Surveys West of the Mississippi," H. Rpt. 612, 43rd Cong., 1st sess., 1874, p. 10.

Powell believed. He cited a few examples. Railroads, he intimated, could be better served in the construction of lines with more accurate mapping and information; and state and federal governments would find survey results valuable "for purposes of intelligent legislation" concerning the lines. Mineral resources needed to be discovered. Moreover, because the future agricultural development of the West depended upon irrigation, it was "of the most immediate and pressing importance" that surveys be made to identify the limited irrigable areas.[3]

In this brief list Powell identified all the basic economic needs he would strive to serve in his survey work for the rest of his career: industrial needs, both in identifying resources and in providing information for engineering purposes; and the needs of government in providing information for administrative and policy-making purposes.

He also pointed casually to the survey system he would eventually try to supplant in serving those needs, the land surveys under the General Land Office. Because so little of the West could be settled agriculturally, Powell pointed out, the land surveys were already "being extended over broad districts of the country which can never be settled, on which no drop of water can be had." His surveys had noted the location of useful irrigation, timber, and grass lands, however, and had placed survey monuments in their vicinities so that limited land surveys could be run when needed.

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[3]Ibid.

"I think," he maintained, "that, over the region of the country [he had surveyed] . . . , the saving to the Government in the land-surveys of that area will more than pay the expense of my survey." He hastened to add that the Interior Department had budgeted $15,000 to establish the boundary line between Arizona and Utah territories. "I have already established it," he crowed, "with far greater accuracy than those boundary lines have been usually established between the territories."[4]

After these hearings the Powell survey was placed under the charge of the Interior Department. There Powell's ideas on the utility of rigorous scientific surveys found a receptive ear in General Land Office Commissioner Samuel S. Burdett. We have already mentioned that Powell's advocacy of more systematic efforts in classifying the public lands seems to have been well received, for both he and Hayden were directed to prosecute such work. Then in 1875, the year following the inquiry, we find Commissioner Burdett in his annual report echoing Powell's criticism of useless extension of land surveys over dry lands in the West.

The wholesale survey of the public lands lying east of approximately the ninety-fifth meridian had been appropriate and successful, Burdett observed, because those lands were generally fertile and

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[4]Ibid., p. 53. For some perspective on costs, note that Powell's appropriations for the four fiscal years ending in June, 1874 were $12,000; $12,000; $20,000; and $10,000, respectively. He also drew rations from the War Department of a little more than $8000. Thus his average annual budget was about $15,550--barely more than the budgeted cost for the boundary survey alone.

easily adapted to some economic use. Nearly any tract of land gave reasonable promise of eventual sale, so indiscriminate survey was justifiable. Westward of that line, however, Burdett saw different conditions--and potentially a great waste of public money if the same practices were continued. "I am not satisfied," he stated,

> that such waste has not already been incurred by running the surveys in localities west of the one hundredth meridian, where, from lack of water and through the general prevalence of barren conditions, the probability of settlement is so remote that all traces of the work done must disappear before its purpose can by any possibility become available.[5]

Burdett had taken steps to minimize waste by requiring the surveyors-general to justify their selections of the areas to be surveyed. He also gave priority to the extension of the necessary baselines and standard meridians, and let the subdivision work be taken up as needed. Nevertheless, Burdett insisted that broader reforms were needed.

The surveys could no longer be considered accurate. "The chain and solar compass, which are the principle instruments of execution, are now regarded as among the ruder appliances of engineering science," he pointed out. Although still useful in comparatively level regions, they were unfit for mountainous terrain. Moreover, the land surveys lacked much in their permanency. The requirements for marks and monuments were wholely inadequate; they suffered from decay in the case of wooden corner posts, and in all cases from the various obliterating effects of settlement, cultivation, and the

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[5] U. S. Interior Department, Report of the Secretary, 1875, vol. 1, Washington, D.C.: 1875, p. 13.

elements. The Land Office suffered a large correspondence load from litigants seeking to restore disputed lines, the commissioner pointed out, which to him indicated the general inadequacy of marking. Further evidence was indicated by the great difficulty encountered in actually restoring the lost lines, for surveyors often found other original corners in the vicinity obliterated as well.[6]

Burdett wanted all principle corners marked by indestructible monuments of iron or stone. But he also went further, heeding Powell's earlier suggestion of assistance from the scientific surveys. The land surveys and the geographical and geological surveys might "supplement" one another, Burdett suggested, "to the better assurance of all the desirable results which ought to be insisted upon in a project involving so much expense." The geodetic survey system could be connected with the land survey grids, providing economies through selective extension of the grid and by giving much greater permanence to the work.

> Astronomical positions could then be determined by means of connections made with the triangulations of the coast and geographical surveys, thus compensating for the cost by avoiding, as to all future work, the necessity of a resurvey, either by State or national authority, which will some time surely arise as to much of the work done in the past. The further advantage will also be assured through such a connection of the systems that a principal monument of the public surveys, destroyed from any cause, can be re-established with absolute accuracy of position by reference to the connection-lines of triangulation.

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[6]Ibid., p. 14.

Accordingly, Burdett explicitly asked that the geographical and geological surveys be authorized to establish geodetic datum points from which the land surveys could be extended.[7]

James A. Williamson replaced the ailing Burdett in 1876. Although he was quick to support his predecessor's views on the need for more rigorous land classification and entry policy changes, Williamson does not appear to have endorsed Burdett's proposals for survey system reforms. There were attempts made in Congress to base the land surveys on geodetic datum points, however. These occurred during House deliberations on appropriations for the public lands and scientific surveys. They were probably prompted by Powell, as they were proposed by men from Powell's home state of Illinois and neighboring Ohio. The ensuing reaction demonstrated the deep resistance among western public lands states to tampering with the public land survey system. It also revealed a special hostility toward the geographical and geological surveys, which competed with the land surveys for appropriations in the hard economic times and budget-pinching of the middle 1870s.

Martin Maginnis, delegate from Montana Territory, was dismayed at the House's approval of only $200,000 for public land surveys, less than one-third of the previous year's appropriation. This, he complained, had been followed by the approval of $145,000 for the scientific surveys, "chiefly for the purpose of taking photographs

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[7]Ibid., pp. 15-16.

and sticking pins through bugs." And now the representative from Ohio wanted a further increase.

> This House has just voted $145,000--which the gentleman from Ohio wished to increase--. . . for the geological survey, for gentlemen who roam all over the Territories and make wonderful and startling new discoveries of interesting places discovered long before they went there; and whose chief business seems to be to take up the names of the historic old romantic landmarks of the country and to bestow on those mountains and ranges the names of the parties belonging to their expedition. This House has just now, on the recommendation of the gentleman from Ohio, voted $145,000 for this fanciful sort of work; and yet you only propose to give only $200,000 for [land surveys for] the benefit of the actual settlers of sixteen States and Territories.

Maginnis acknowledged that the public land surveys had in places been extended into regions where they were not needed. But still, the need for the surveys and their tried and true system was very great.

> Why should we be asked to break down our ancient system of surveys, so long and so well established, and to introduce an untried system, except it be to still further perpetuate the doings of those [scientific] gentlemen who successfully tickle the ear of the House, and who by judicious distribution of pictures and patronage manage to make many and enthusiastic friends.
>
> I have no reason to find fault with these geological surveys. . . . But, I say, when the interests of the actual settlers of sixteen States and Territories are on the one hand, and this fanciful work of making photographs and handsomely-colored maps on the other, this House makes a mistake when it discriminates in favor of the fanciful and throws the practical work to one side. I do not urge the too rapid extension of surveys. When carried too far in advance of settlements the monuments perish and the surveys are lost. But there are in Montana, portions of the Yellowstone Valley, the Deer Lodge Valley, and the Beaverhead Valley, quite thickly settled, where the surveys need to be extended, and I certainly think that the needs of these settlers should appeal more loudly to Congress than other considerations.[8]

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[8] U. S. Congress, House, Congressional Record, 44th Cong., 1st sess., 23 June 1876, vol. 4, pt. 5:4102.

In 1877, however, Williamson came out for wholesale reform of the land survey system. He did not simply recommend supplementing the land surveys with geodetic monuments: Williamson sought closure of the offices of the surveyors-general, abandonment of the entire contract-based system because it led to poor quality work, and transfer of the work to a federal, Washington-based office of U. S. Surveyor-general. Moreover, in this he had the support of Interior Secretary Carl Schurz.[9]

At least in part, Williamson seems to have been helped to this position through the influence of Powell. The New York Times reported in spring, 1877, that Powell, Williamson, and even Smithsonian Institution Secretary Joseph Henry were publicly lobbying for Powell's idea that the land surveys rely on geodetic datum points for their expansion rather than extending standard bases and meridians.[10] On the other hand, in subsequent consideration of the Williamson initiatives by a House committee, Williamson seemed far more enthusiastic about administrative reorganization than about changes in surveying methods. One may suppose, then, that abandonment of the contract system was perhaps Williamson's idea and not Powell's.[11]

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[9] U. S., Interior Department, Report of the Secretary, 1877, vol. 1, Washington, D.C.: 1877, pp. XXIV, 9-10.

[10] "Notes from the Capital," New York Times, 30 April 1877, p. 5.

[11] See Williamson's testimony in U. S., Congress, House, Committee on Public Lands, "Public Surveys," Misc. Doc. 55, 45th Cong., 2nd sess., 1878, pp. 39-46.

Whether Williamson's idea or his own, Powell allied himself with it. In late March 1878 the House Committee on Public Lands took testimony on a bill seeking to provide "a more economic and accurate survey of the public lands." This legislation, which the testimony strongly suggests was authored at least in part by Powell, abolished the sixteen state and territorial offices of surveyor-general and the contract system of surveying they administered. It was replaced with a central office of U. S. Surveyor-general staffed by skilled, salaried engineers as deputy surveyors. It also authorized the Surveyor-general to use such methods as he deemed best "to secure accuracy of measurement and certainty of identification."[12]

In presenting the merits of the measure to the committee Powell gave a preview of the findings in his Report on the Lands of the Arid Region.[13] The vast majority of the unsurveyed public lands, he argued, were either wholely worthless or would pass from the government only in very large parcels as timber or pasturage lands. Consequently, the existing system of connected, closely subdivided surveys was inappropriate and uneconomic. Moreover, it was inaccurate; it was poorly suited to mountainous terrain; and the system actually increased the threat of monopoly in grassland regions

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[12] Ibid., p. 6.

[13] U. S. Congress, House, Report on the Lands of the Arid Region of the United States, with a More Detailed Account of the Lands of Utah, by J. W. Powell, Ex. Doc. 73, 45th Cong., 2nd sess., 1878.

where water sources were scarce and localized. Powell could not help but express his opinion that a more suitable parceling--perhaps one providing greater access to localized water sources--might well be carried out by the settlers themselves, much like what was already the practice in mineral districts. This was an element of the colony homestead plans he subsequently offered in the report on the arid lands. The present legislation, however, was only to provide machinery for a geodetic connection of parceling surveys in the various and remote districts where they were needed, irrespective of what systems of parceling Congress might authorize.[14]

The measure seems to have been doomed from the beginning. The key provision abolishing the existing administrative system was not even discussed. Instead the committee occupied themselves with the potential consequences of altering the rectangular system of designating and surveying parcels. That threat was presented by the provision giving the U. S. Surveyor-general discretion on survey methods, which Powell was at pains to explain referred only to the methods of execution and not to the system of designating and subdividing parcels.[15] That no critic offered an amendment to forestall a change in the rectangular system suggests, however, that this issue was actually a smoke screen covering opposition to the fundamental administrative reorganization proposed.

Powell emphasized, for his part, the more advantageous and

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[14] "Public Surveys," Misc. Doc. 55, 1878, pp. 1-6.

[15] Ibid., pp. 15, 33-38.

economical execution of the survey work if linked to a geodetic system. He was not greatly helped in his cause by others testifying, unfortunately, even by the measure's apparent supporters. Commissioner Williamson seemed more interested in the administrative changes than the advantages of a geodetic frame of reference. J. E. Hilgard of the Coast Survey spoke for the geodetic reference system, noting that it was adopted in Canada; but he also spoke strongly against abandoning rectangular parceling on the township system. Lieutenant Wheeler and F. V. Hayden, who competed with Powell for survey appropriations, did not help Powell's cause either, despite acknowledging the benefits to be derived from geodetic reference points. Wheeler suggested that the systematic land classification known to be favored by Powell and Interior Department officials would be exceedingly expensive; Hayden intimated Powell was a reformist, and perhaps possessed of too much personal ambition.[16]

The land survey reform measure was never reported out of the Committee on Public Lands. The measure did gain the interest of Appropriations committee chairman John D. C. Atkins during the hearings, however, if one is to judge from his own introduction of similarly aimed legislation.[17] Atkins support represented a new opportunity to win reforms by using his Appropriations committee

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[16]Ibid., pp. 9-10, 15-16, 30-33, 39-41.

[17]Cong. Record, 45-2, 22 March 1878, 7(2):1985; ibid, 25 March 1878, 7(2):2012. The following month Powell's ideas on irrigation and pasturage district entry laws were also introduced by a representative from California, ibid., 22 April 1878, 7(3):2709.

to circumvent the intransigent Committee on Public Lands. As it happened, Atkins had raised the issue of duplication of effort among the competing geographical and geological surveys a year earlier and threatened an investigation.[18] Now Atkins made good on his promise, and the inquiry that would eventually lead to the establishment of the United States Geological Survey was begun. Another committee member (at Clarence King's suggestion) proposed submitting the matter to the National Academy of Sciences for review, and in June, 1877, this course was approved. But Powell, acting through Atkins most probably (the maneuvering behind the scenes in these events has never been fully revealed), managed to broaden the scope of the investigation to include the public lands surveys as well.[19]

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[18] Cong. Record, 44-2, 23 February 1877, 5(2):1878.

[19] We shall not be following here in any detail the events leading to the establishment of the U. S. Geological Survey. The rivalry among the predecessor surveys and its contribution to the founding of the U.S.G.S. are reviewed in detail by Manning, Government in Science, pp. 30-59; see also William H. Goetzmann, Exploration and Empire. The Explorer and the Scientist in the Winning of the American West (New York: Alfred A. Knopf, 1966), pp. 577-91. The broadening of issues to include revision of the land system by Powell was identified by Henry Nash Smith, "Clarence King, John Wesley Powell, and the Establishment of the United States Geological Survey," Mississippi Valley Historical Review, 1947, 34:37-58.

The land system problem is center stage in the Pulitzer prize winning (if somewhat overly moralistic) account by Wallace Stegner, Beyond the Hundredth Meridian. John Wesley Powell and the Second Opening of the West (Cambridge, Mass.: Riverside Press, 1954), pp. 202-42; see also William Culp Darrah, Powell of the Colorado (Princeton: Princeton University Press, 1951), pp. 221-54. Other accounts are found in A. Hunter Dupree, Science in the Federal Government. A History of Policies and Activities to 1940 (Cambridge: Belknap Press of Harvard University Press, 1957), pp. 195-214; and

Just as was the case in the earlier inquiry on the geographical and geological surveys in 1874, Powell was not content to let larger questions on the organization and objectives of government scientific surveys be submerged in an unseemly debate over institutional rivalry and personal competence. When the National Academy of Sciences requested the opinions of the parties involved, Powell was ready to present his full views on the value and proper responsibilities of geographical and geological surveys--on the conduct, as he put it, of "a proper scientific survey."[20]

The quintessential element of Powell's scheme for organization of government supported survey work was his conviction that their work serve the pressing needs of the nation's public lands. "A geographical and geological survey, to be permanent, rigorous, and efficient, should include the survey of the public lands and be subsidiary thereto." With that emphatic comment Powell declared his wish to replace the existing public land surveys with a reorganized system of scientific surveys that would serve more effectively and much more comprehensively the needs of national progress.[21]

Powell talked in the abstract about government support of science. He accepted the general proposition that science should

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U. S. Geological Survey, Minerals, Lands, and Geology for the Common Defence and General Welfare, by Mary C. Rabbitt, vol. 1: Before 1879, Washington, D.C.: 1979, pp. 363-88.

[20] U. S. Congress, House, "Surveys of the Territories," Misc. Doc. 5, 45th Cong., 3rd sess., 1878, p. 21.

[21] Ibid., p. 23. Emphasis in the original.

be left to advance through the initiative of individuals--except in circumstances where individuals could not or would not pursue them. He was certain few would disagree, however, that topographical and general geological surveys fell into that exceptional class. These surveys "may and ought to be sustained by the government," he maintained, "because of the great magnitude and expense of such undertakings, which place them far beyond the reach of individual enterprise."[22] Indeed, as he pointed out in a slightly different context, the work was so great that none of the four geographical surveys were individually strong enough to execute it properly. Despite the obvious need, Powell argued, no survey had been able to devote itself adequately to geodetic triangulation, to hypsometry, or to cartographic methods.[23]

But an enlightened government that values, patronizes, and sustains such investigations, Powell claimed, has the unquestioned right to demand a substantive return from its support. It has the right

> . . . to demand in return results which shall be not merely for the benefit of the scientific, the learned, and the cultured, but for the immediate use and wants of all classes. It has the right to demand not only results of general value, but those of utilitarian value.

In a democratic government, Powell maintained, these principles were critical.

> A survey in this country, sustained by the government, which does not ally itself to those utilitarian demands cannot be

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[22]Ibid., p. 24.

[23]Ibid., pp. 15-16.

> strong or permanent; . . . [it cannot] face the public with demands for subsidies, as if they were things of right. These surveys should be both ostensibly and really so closely related to the practical wants of the people and of the government itself that no question could ever be reasonably raised against their utility or even necessity.[24]

To achieve such close relations to practical wants, both these "of the people" and those "of the government," Powell sought to take over the surveys of the public lands.

Of course Powell recognized the traditional practical service of a geological survey to mineral industries. The immediate incentives to settlement in the West were still its "vast and inexhaustible wealth" of precious metals, its gold and silver, cinnabar, copper, lead, iron, and coal. Over all the public domain a geological survey would prove its value "by properly exhibiting the character and extent of our mineral resources."[25]

Narrower, scientific interests in geology need not be ignored, however. On the contrary, Powell was convinced that all basic scientific research, if "properly coordinated" with utilitarian benefits, would be resistant to objections even from "the most captious" critics.[26] It was manifest that all geological research led eventually to practical results, Powell would explain on another occasion, because all geological insights helped reveal the

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[24]Ibid., p. 25.

[25]Ibid., p. 21.

[26]Ibid., p. 25.

wealth buried beneath the surface of the earth.[27]

But the most pressing wants of the nation lay in other areas. Powell's major occupation in his letter to the National Academy of Sciences was to outline the new public needs that he recognized. Agriculture was perhaps the most important industry in the nation because it touched so many people in every region. Powell reiterated a point made briefly in the preface to his Report on the Lands of the Arid Region: the continued expansion and development of the nation required an engineering assault on the widespread conditions in the physical environment of the west so obstructive of agricultural settlement.

> The greater part of the lands yet remaining in the possession of the general government either needs protection on the one hand from overflow, because of excessive humidity, or irrigation on the other, because of excessive aridity. The utilization of all such lands depends upon the correct solution of great engineering problems.[28]

Powell noted there were great tracts of Gulf coastal swamp lands that could be improved by protection from tidewater with dikes; and near the Great Lakes millions of acres of swamps and small lakes could be converted to use through drainage. But uppermost in his mind was the Mississippi valley and Rocky Mountain region where the diverse engineering problems had "important mutual

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[27] U. S. Congress, Senate, "Testimony before the Joint Commission to Consider the Present Organizations of the Signal Service, Geological Survey, Coast and Geodetic Survey, and the Hydrographic Office of the Navy Department," Misc. Doc. 82, 49th Cong., 1st sess., 1886, p. 700.

[28] "Surveys of the Territories," 1878, p. 20.

relations." On the great flood plains of the south were vast tracts of the rich land that could be redeemed, he pointed out, "by protecting them from periodic river floods." This, he noted, was now known by the better scientific men in the country to be best achieved by storage of flood waters in reservoirs.[29]

In the neighboring Rocky Mountain region agriculture was dependent upon irrigation. This, as he had pointed out in his Report on the Lands of the Arid Region, was a great engineering problem in itself. In that region, Powell claimed, not a single farm could be cultivated nor a site for an agricultural field selected "without first determining by leveling the practicability of reaching it with water." Moreover, Powell believed, the time was near when the waters of the Missouri, Arkansas, and Red rivers would all be diverted to irrigate land along their courses. This would mitigate flooding in the Mississippi valley, and eventually there would be

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[29] Ibid. The use of reservoirs to supplant dikes as protection from floods was first advocated in a pioneering engineering study cited by Powell on this occasion, Charles Ellet, Jr., On the Physical Geography of the Mississippi Valley, with Suggestions for the Improvement of the Navigation of the Ohio and Other Rivers, Smithsonian Contributions to Knowledge, vol. 2 (Washington, D.C.: Smithsonian Institution, 1850). Ellet's proposals were treated as fanciful by the Corps of Engineers, and became controversial in the 1880s in the wake of disastrous flooding on the Mississippi River in 1874 and subsequent pressures for better protection from floods; see U. S. Congress, House, "Report of the Commission of Engineers Appointed to Investigate and Report a Permanent Plan for the Reclamation of the Alluvial Basin of the Mississippi River Subject to Inundation," Ex. Doc. 127, 43rd Cong., 2nd sess., 1875, pp. 540-41, and also Appendix A. See also the biography by Gene D. Lewis, Charles Ellet, Jr. The Engineer as Individualist 1810-1862 (Urbana: University of Illinois Press, 1968).

even more protection resulting from the construction of reservoirs to store water for irrigation. In light of this eventual impact from irrigation Powell thought the whole question of flood control now needed "a thorough investigation."[30]

Powell firmly believed that these engineering problems could be much more effectively addressed through a geographical survey and through accurate topographical maps. This, he intimated was one of the reasons he placed such importance on the hypsometric work of the surveys--an accurate determinations of altitude.[31] Properly constructed maps, Powell maintained, "would be a sufficient guide to the engineer, for all general purposes, in the location" of hydraulic and other engineering works.[32] On a later occasion Powell emphatically detailed the full range of engineering uses he had in mind: municipal water works; roads, railroads, canals; works for drainage, irrigation, and flood protection.[33]

The broad engineering problems standing in the way of national progress comprised but one of the two major new problems Powell had come to recognize. The other was in the nation's administration of the public lands. A major thrust of Powell's Report on the Lands of Arid Region had been that an authoritative classification of the

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[30]"Surveys of the Territories," Misc. Doc. 5, 1878, pp. 15, 20.

[31]Ibid., pp. 15-16.

[32]Ibid., p. 19.

[33]"Testimony," Misc. Doc. 82, 1886, pp. 198-99.

public lands was needed to administer properly the land system. This was a point he reiterated here, but he now emphasized more fully how the land survey system failed in serving those needs. The deputy surveyors, who do the work under contract, "fail entirely to provide the facts necessary to the proper administration of the laws," In practice, Powell insisted, the facts upon which transactions in the department were based were obtained "not from experts employed as government officers and competent to perform the task, but on affidavits made by the parties interested, or by persons selected by them," and the history of the Land Office abundantly demonstrated that this had resulted in widespread fraud.[34] The contract surveyors were required to report on resources, but that was not the basis on which they were paid. The result was that the geography and geology of the country were studied to a limited extent, "but not with sufficient accuracy and thoroughness" for economic or scientific purposes.[35]

The records of the Land Office, Powell insisted, furnish "a gigantic illustration of the evils" of poorly directed survey work.

> A large corps of surveyors has been employed for nearly a century. Forests, prairies, plains, and mountains have been traversed in many directions; millions of miles have been run with compass and chain; chart after chart has been constructed with great labor; folio on folio has been placed among the national archives, containing facts incoherent and worthless; and the record has been made that here are trees, there swamps, and yonder glades; that the lands surveyed are level,

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[34]"Survey of the Territories," Misc. Doc. 5, 1878, pp. 19-20.

[35]Ibid., p. 16.

> hilly, or rolling; that sandstones are found here, limestones there, or granite elsewhere; and so the records of useless facts have been piled up from year to year until they are buried in their own mass.

The Land Office files contained manuscript township maps of more than a million square miles of the nation's lands accompanied by manuscript reports relating to the physical characteristics and geology of the areas surveyed, all "of little or no value in the consideration of economic questions relating to the public lands."[36]

Moreover, they were "absolutely valueless" for any scientific purpose. No maps of any real value could be constructed from them. The survey grids had proceeded from a number of separate initial points by extending straight lines north and south, east and west. Few precautions were taken to assure straight lines, however. Latitudes and longitudes where determined at all were not established with any accuracy, and "no scientific checks were made in extending the lines." Finally, in topography and cartography no general system was demanded, and the large number of persons contracting to do the work each adopted "a system of his own."[37]

The only consistent value Powell saw in the land survey work was the parceling of lands as the basis for passing title. Even here the results had to be viewed as imperfect from the standpoint of methods currently available. As he had pointed out earlier in the year to the House Committee on Public Lands, the methods of marking

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[36] Ibid., p. 17.

[37] Ibid.

corners were horrendously impermanent. Wood corner posts subject to rot were problem enough, but on the plains and in the Rocky Mountain region where wood was not easily obtained, even less satisfactory marking was used--heaps of earth raked together, for example, soon to be washed away by storms. Without coordinates of latitude and longitude, which alone gave true permanence to the work, the land surveys had left "a heritage of litigation relating to boundary-lines," ever increasing along with the value of the land.[38]

The basic problem with the land survey system in Powell's view was the lack of proper--and properly scientific--supervision. The deputy surveyors who executed the work as a consequence of the production-oriented contract system had personal interests that were "opposed to accurate and scientific work." And then the basic system although wise in many respects "was never faithfully executed, from the fact that after its first inception it never had proper scientific supervision." In the multiplicity of surveyors-general working independently of one another there was never proper oversight. Intermediate between the Land Office and the contracted deputy surveyors who actually performed the work, the surveyors-general were selected for their "legal acquirements and administrative talents," not for their scientific qualifications. "For this reason it has happened that the system of surveys has not kept pace with modern science, and has scarcely been improved."[39]

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[38] Ibid., pp. 16, 18.

[39] Ibid., p. 17.

If this work were put on a professional and scientific basis, Powell was suggesting--and he noted there still remained more than 67 million square miles of public domain to be surveyed--the defects he cited need not be continued. The geology and geography would be done with greater system and consequently become more useful to general economic purposes. Establishment of a geodetic reference system would yield a parceling system with true permanence. And finally, information would be available to serve the administrative needs of the General Land Office.[40]

Moreover, Powell believed the geographical improvements could be available at no increase over the existing cost of the land survey system. Establishing geodetic datum points by triangulation methods was certainly costly in level, forested areas; but it was inexpensive in the mountainous, open landscapes of the West where long, clear lines of sight were the rule. Moreover, with geodetic methods it was possible to pass over barren mountainous and desert areas to the isolated fertile areas where surveys were actually in demand. Finally, by abandoning the contract system, in which the deputy surveyors frequently selected lands to survey based on convenience and profitability rather than settlement's needs, a great deal of wasted effort would be spared.[41]

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[40] Ibid., pp. 17-19.

[41] Ibid., pp. 18, 23. Powell subsequently provided more detailed views on estimated survey costs in U. S. Congress, House, "Cost of Geographical Surveys," Ex. Doc. 72, 45th Cong., 3rd sess., 1879.

In brief, Powell believed the geographical and geological surveys might be combined with the surveys of the public lands with the advantages that parceling surveys would be more accurate and permanent; that the great mining and agricultural industries would be better served by resource and other physical information; that administrative needs of the Land Office would be properly served; and of course that science would profit by the support.

Powell's scheme for a reorganized geographical and geological survey that included surveys of the public lands was actually a rather elegant scheme. Its scientific and practical work were well integrated, with the geographical work of topographical mapping providing much of the unity among diverse elements. The geographical work produced much of the basic data needed for both practical and scientific results. Its geodetic framework would form the foundation for parceling surveys (by whatever system, the conventional rectangular, or the community-determined surveys envisioned in Powell's irrigation and pasturage districts); its physical data would serve through maps and otherwise the land classification needs of the General Land Office, and serve as well for the solution of the great engineering enterprises facing agriculture. Scientifically, the geographical work provided the basis of organizing evidence collected in the field, and presenting final results in the form of geological maps. The structural and topographic features so important to Powell in his personal geological studies made the geographic work even more valuable than it might appear to others at first glance.

Just as geology was aided in part by topographic mapping, geological insights added materially to practical results. Information was available for mineral industries and for the land classification needs of the Land Office. Moreover, it was also available for engineering purposes, as in the siting of dams or in locating materials for construction.

Looking at the scheme more abstractly, one is impressed at how Powell had managed to place the scientific work--the descriptive geographical work as well as the geological--at the very heart of the system. This scientific work was prosecuted with an eye to scientific concerns, but by its land-oriented nature the scientific results were eminently applicable to broad and fundamental human needs. Geography and geology, Powell had demonstrated, each offered practical results for mining and agricultural industries, for the administrative needs of the government on the public lands, and--as the Report on the Lands of the Arid Region illustrated--for making more effective public policy.

It may have been noticed that Powell left no place for ethnology, zoology, or botany within his scheme. In fact Powell did argue the great need for ethnological studies and the justification for government support. There were few individual workers in the field he noted; the materials on the American Indian were in danger of rapid destruction by civilization; and as was noted earlier in chapter Three, a knowledge of Indian cultural institutions was valuable for establishing prudent and effective policies on Indian affairs. Nevertheless, Powell argued that such studies were probably best situated in the Smithsonian Institution.[42]

Powell had never pursued zoology and botany to any great extent,[43] and he contended it would be unadvisable for government to support research in those areas. Many workers were in the field, Powell observed, and through them a great deal of progress had been made. Adding "half a dozen workers to the great army of independent investigators," or contributing further to, in his opinion, already sufficient vehicles for publication, Powell believed, would be unproductive. Only "for very narrow and special purposes" having immediate effects on the national welfare, as perhaps in the case of insect pests or the growth of forests, did Powell believe government patronage was called for. Such exceptions could always be taken up on an ad hoc basis as they arise.[44]

Powell offered this basic approach to the survey issue before the National Academy of Sciences: the four geographical and geological surveys needed to be unified under one head and assigned responsibility for surveys of the public lands; and the primary geodetic survey system of the Coast Survey needed to be extended across the continent and made the foundation of all other topographic and parceling survey systems. These ideas were incorporated in their

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[42]"Surveys of the Territories," Misc. Doc. 5, 1878, pp. 26-27.

[43]Powell reviewed the scope of his survey work in detail in response to the Congressional inquiry in U. S. Congress, House, "U.S. Geographical and Geological Surveys," Ex. Doc. 80, 45th Cong., 2nd sess., 1878.

[44]"Surveys of the Territories," Misc. Doc. 5, 1878, p. 25. These views served also to indict Hayden's methods.

essential features in the Academy's own recommendations, although the Academy drew sharper distinctions between geography and geology. The Academy recommended all "surveys of mensuration," including geodesy, topography, and land parceling be placed under an enlarged Coast Survey organization, and all "surveys of geology and economic resources of the soil" be consolidated under a United States Geological Survey.[45]

The legislation proposed in Congress closely reflected the Academy's report. It sought to abolish the public land survey system and to restructure the system of scientific surveys on the lines proposed by the Academy. Strong opposition to changes in the land system were recognized, however, and provisions were included to place the question of parceling system and other public lands administrative issues before a special public lands commission. To summarize the legislative history briefly, opposition was still so strong that the only provisions enacted--and even these with great difficulty--were that establishing the lands commission and that consolidating the geographical and geological surveys in the United States Geological Survey. The public lands surveys remained intact.[46]

The ideas Powell expressed to the National Academy of Sciences were not merely political rhetoric. Congressional critics accused

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[45]Ibid., p. 2.

[46]Cong. Record, 45-3, 15 February 1879, 8(2):1423-26; ibid., 18 February 1879, 8(2):1558-67; Manning, Government in Science, pp. 46-54.

Powell and those who shared his views of trying "to ingraft themselves on to the public land surveys" in order to perpetuate their work,[47] but it is clear that Powell's ideas were perfectly consistent with the developing scope of his survey's work. Moreover, Powell subsequently shaped the operations of the United States Geological Survey along lines similar to those he advocated in 1878.

Powell became the second director of the Geological Survey in 1881 when King's ambitions in mining and other speculative business ventures finally won out over his interest in science. King had put together a fine organization reflecting his primary interest in mining and economic geology. When Powell took the helm he immediately worked to gain a truly national scope for the survey and a more balanced approach to general geological research. Powell managed authorization for national topographic mapping which became and has continued to be a principle Geological Survey occupation. In geology he aimed at a national geological map, and to his own emphasis on structures he added vigorous efforts in paleontology and stratigraphy.[48]

Moreover, Powell continued to make the most of every opportunity to interject scientific findings into administrative problems and policy issues related to settlement on the public lands. Shortly after taking office in 1881 Powell managed to carry the survey's geological expertise to a program for boring experimental artesian

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[47] Remarks by Rep. Dudley Haskell, Cong. Record, 45-3, 11 February 1879, 8(2):1211.

[48] Manning, Government in Science, pp. 60-121.

wells begun in the Department of Agriculture the year before. The program was intended to demonstrate the feasibility of irrigated agriculture on the high plains of Colorado and Kansas. The Geological Survey's Charles A. White was delegated as part of a geological commission to advise the program on further selections of test sites and to help evaluate the program's progress. The commission led by White assessed the project in 1881 and 1882. It found artesian prospects generally poor on the plains, but it was able to suggest sites that would at least provide fair tests. In the end no successful wells were established, and the Department of Agriculture abandoned the program in 1884.[49]

Powell saw to it that White's work was followed by a geological treatise on artesian wells, however. T. C. Chamberlin's Requisite and Qualifying Conditions of Artesian Wells published in 1884 reviewed the geological principles of artesian conditions, the physical considerations bearing on well performance and capacity,

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[49] U. S. Department of Agriculture, Report of the Commissioner, 1880, Washington, D.C.: 1881, p. 16; idem, Report of the Commissioner, 1881, Washington, D.C.: 1882, pp. 16, 26-27; idem, Report of the Commissioner, 1883, Washington, D.C.: 1884, pp. 14-15; idem, Artesian Wells upon the Great Plains, [Report No. 19], Washington, D.C.: 1882; C. A. White, "Artesian Wells upon the Great Plains," North American Review, 1882, 135:187-95; letters, C. A. White to J. W. Powell, 9 August, 26 August, 2 September, 1881; "Letters Received by the United States Geological Survey 1879-1901," Record Group 57: Records of the Geological Survey (Microfilm Publication No. 590), National Archives, Washington, D.C.

and the technology of well drilling and testing.[50]

The experience of this work was brought to the fore in 1890 when Powell attempted to respond to pressures from plains states' representatives seeking Irrigation Survey benefits for their region. Plains interests looked to underground water sources for their future. Powell was skeptical of the potential they imagined, both for artesian water sources and for the percolating "underflow" of the region's rivers. The comprehensive geological study Powell advocated was indignantly rejected, however, and instead Congress lodged a program of model experimental projects in the Department of Agriculture. Known as the Artesian and Underflow Investigation, the program did not produce the hoped-for results.[51]

The Irrigation Survey carried out under Geological Survey auspices from 1880 to 1890 in the mountain west was Powell's best known later attempt to forge a link between scientific surveys and problems of public lands development.[52] Sponsors in Congress

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[50]T. C. Chamberlin, "Requisite and Qualifying Conditions of Artesian Wells," in Fifth Annual Report, 1883-84, U. S. Geological Survey, Washington, D.C.: 1884, pp. 125-73.

[51]Powell's response to plains states demands appears in U. S. Congress, House, "Irrigation in the United States," H. Rpt. 3767, Appendix B, 51st Cong., 2nd sess., 1891, pp. 136-56. Reports on the project initiated in the Department of Agriculture were U. S. Congress, Senate, "A Report on the Preliminary Investigation to Determine the Proper Location of Artesian Wells," Ex. Doc. 222, 51st Cong., 1st sess., 1890, and idem, "Final Report of the Artesian and Underflow Investigation, and of the Irrigation Inquiry," Ex. Doc. 41, pts. 2-4, 52nd Cong., 1st sess., 1892.

[52]The basic historical interpretation of the rise and fall of the Irrigation Survey is Everett W. Sterling, "The Powell Irrigation Survey, 1888-1893," Mississippi Valley Historical Review, 1940-41,

intended this survey as a means of encouraging private development of water storage reservoir by locating appropriate sites on the public lands.[53] Powell saw this initiative as an invitation to conduct the comprehensive kind of surveys he had envisioned in 1878: topographic surveys to aid the public in the development of large irrigation systems and to help the government administer the lands such systems would open for settlement.

Powell undertook a systematic topographic survey to identify sites for reservoirs and for other irrigation works in the arid region and supplemented it with a study of stream water supplies. The latter involved gauging the flows on a number of selected streams and combining the results with other physical characteristics of the watersheds to construct empirical water supply models. The surveys were essentially an extension and elaboration of the topographic surveys the Geological Survey had been carrying on to support its scientific work. At Congress's insistence Powell also carried out

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27:421-34. Greater detail is added by Stegner, Hundredth Meridian, pp. 294-324, and by Manning, Government in Science, pp. 168-203, who also includes a useful review of Irrigation Survey operations. See also the accounts in Darrah, Powell, pp. 299-314, and in U. S. Geological Survey, Minerals, Lands and Geology for the Common Defence and General Welfare, by Mary C. Rabbitt, vol. 2: 1879-1904, Washington, D.C.: 1980, pp. 164-88. Except as otherwise noted the account presented here generally follows that outlined by Sterling, by Stegner, and by Manning.

[53] Interestingly, one of the prime movers for the Irrigation Survey was Nevada Senator William M. Steward, who had earlier sponsored the similar survey by the federal commission on irrigation in California in 1873 (see Chapter Four above).

close engineering surveys, where desirable, to more precisely locate and estimate costs for dams, diversion works, and canals. And, finally, in keeping with the plan advocated fifteen years earlier in the commission on irrigation in California, Powell made an effort to divide the West into more or less independent watershed units to serve as the basis of irrigation districts. These he promoted as essential for establishing western agriculture on a stable basis with minimum conflict over the allocation and use of water supplies.[54]

Unfortunately, Powell's methodical survey ran afoul of a protracted fight in Congress over land law reform that had escalated in 1886 and 1887 and would not be substantially resolved until 1891. The Irrigation Survey had been approved through a precarious alliance between two groups, both anxious to change the Desert Land Act but poles apart in their motives. Western interests wanted a more liberal entry policy that would facilitate corporate development

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[54]U. S. Geological Survey, Tenth Annual Report, 1888-89, Pt. II: Irrigation, Washington, D.C.: 1890; idem, Eleventh Annual Report, 1889-90, Pt. II: Irrigation, Washington, D.C.: 1890; see also the subsequent annual volumes on irrigation published in the twelfth and thirteenth annual reports. Powell's proposals for irrigation districts appear most fully in testimony before the Senate, Committee on Irrigation and Reclamation of Arid Lands, "Report of the Special Committee of the United States Senate on the Irrigation and Reclamation of Arid Lands," S. Rpt. 928, 51st Cong., 1st sess., 1890, pt. 5, pp. 6-95, and before the House, "Irrigation in the United States," H. Rpt. 3767, Appendix B, 1891, pp. 12-104. See also the public appeals made by Powell, "The Non-Irrigable Lands of the Arid Regions," Century, 1890, 39:915-22; idem, "Irrigable Lands of the Arid Region," Century, 1890, 39:766-76; and idem, "Institutions for the Arid Lands," Century, 1890, 40:111-16.

of water supplies. On the other hand, a land law reform faction distrustful of large land holdings and appalled at the continuing abuse of land laws sought repeal of the Desert Land Act and a return to a pure homestead policy.[55]

The latter group had inserted a provision in the Irrigation Survey enactment that reserved from entry any lands made irrigable through irrigation works located by the survey. The original survey supporters strongly disliked this provision, but consented to it on the presumption that more favorable desert land law revisions could be won.[56] They pushed for such legislation in 1889 and 1890 through the action of the Senate Special Committee on the Irrigation and Reclamation of Arid Lands.[57]

Unfortunately, neither this committee's nor Powell's nor any other plan for a new desert land policy commanded agreement among

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[55]The rising pitch of the debate over public land law reform late in the 1880s, which resulted eventually in the landmark General Revision Act of March 3, 1891, has not received the attention it deserves in the literature of Irrigation Survey history. For discussions of land law reform efforts between 1885 and 1891 see Harold H. Dunham, Government Handout. A Study in Administration of the Public Lands 1875-1891 (Ph.D. dissertation, Columbia University, 1941; reprint ed., New York: De Capo Press, 1970), pp. 165-211, 387-344; U. S. Public Land Law Review Commission, History of Public Land Law Development by Paul W. Gates and Robert W. Swenson, Washington, D.C.: 1968, pp. 471-85, 640-42.

[56]Sterling, "Powell Irrigation Survey," pp. 422-23.

[57]Manning, Government in Science, pp. 182-83, misconstrues this committee's primary objective when he contends its purpose was to discredit Powell. Although this became important for the committee's majority as time wore on, legislation was its first aim. Consult the "Report of the Special Committee," S. Rpt. 928, 1890, pt. 1. See also the brief review by John T. Ganoe, "Origin of a National Reclamation Policy," Mississippi Valley Historical Review, 1931-32, 18:36-37.

the opposing factions by 1890. As a result the reservation provision attached by the reform faction and then ready to take effect threatened to stop all normal land business in the West. The Irrigation Survey's original supporters were compelled to repudiate the program. The Irrigation Survey's appropriation was cancelled, and for all practical purposes conditions returned to the status quo of 1888. Identification of reservoir sites and publication of reports on results of work of 1889-1890 continued for a few years, but only out of regular Geological Survey appropriations.

Recently, Powell has been criticized for his failure to serve the practical needs of the nation's mineral industry through a vigorous program of economic geology.[58] Such a criticism may be justifiable, but it would be a great mistake to conclude that Powell eschewed utilitarian service altogether. The events reviewed in this and preceding chapters show that Powell was very much dedicated to serving the practical needs of the nation.

Powell's view of the practical benefits of science included much more than just mineral industry needs. Powell's experience as head of the Geographical and Geological Survey of the Rocky Mountain Region had taught him that the basic scientific work of his survey brought results and insights of great value for the nation in sustaining its march into the West. The West, he found, in its

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[58] U. S. Geological Survey, Minerals, Lands, and Geology, vol. 2, pp. 238-39.

varied topography and harsh climatic conditions presented great physical obstacles to continued settlement and development. Great engineering efforts in irrigation had to be undertaken, and in drainage, flood control, and transportation as well. These great efforts needed scientific information to be effective--information easily provided through the geological and geographical work of his survey. Powell even found his ethnological studies valuable, for they helped illuminate the culture and social organization of the Indian peoples the government had to deal with as the tide of settlement pushed West.

Moreover, Powell found the general scientific understanding of the physical environment of the West a valuable asset for developing the new public lands policies needed in the West. The insights into the conditions governing availability of water, timber, and other natural resources gained through studies in physical science, Powell had shown in his Report on the Lands of the Arid Region, pointed the way to effective resource use and to prudent public policy. It was also clear to Powell that, whatever policies held sway, the administration of the various provisions of entry necessitated an authoritative classification of the lands. This required for its proper execution the special attention of scientific professionals, students of nature whose interests and methods of investigation were specially suited to the task. For this reason Powell believed that the contract system of land surveys under the General Land Office should be abandoned and its duties assigned to a permanent scientific agency responsible for all geographical and geological surveys of the public domain.

Institutional as well as industrial needs were raised to the fore by the nation's post-Civil War expansion into the West. Because of its public land focus, Powell found his geographical and geological survey produced a broad spectrum of useful information as a by-product of its scientific work--information as useful and important for the government's administration of public lands policy as for the more conventional uses in industry. Powell organized and carried out his survey work in response to this experience. This is an essential element in understanding Powell's linkage of science and land system reform.

There are also certain theoretical views held by Powell on the nature and course of human evolution that provide an important intellectual context for his actions. We turn now to this second element in the explanation of Powell's mix of science and reform.

CHAPTER SEVEN

EVOLUTION AND HUMAN PROGRESS

An intellectual context for Powell's actions and attitudes in conducting his survey work can be found in his ideas on the evolution of man and society. These were presented early in the 1880s primarily in "The Three Methods of Evolution" and "Human Evolution," both of which were annual presidential addresses given before the city of Washington's Anthropological Society.[1] Products of Powell's interests in ethnology, these addresses also provide insight into the background of thought out of which they grew. They present a theory of evolution and picture of human progress constructed from the ideas of Lewis H. Morgan and English social philosopher Herbert Spencer, a theory that fuses--with subtle but important changes--Morgan's broad based cultural evolutionary scheme with Spencer's theory of universal evolution as increasing organization of matter. The resultant is a dynamic theory in which human progress is achieved along multiple fronts and is dependent upon an evolving growth of cooperative arrangements.

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[1] J. W. Powell, "The Three Methods of Evolution," (annual address of the president, December 8, 1883), Bulletin of the Philosophical Society of Washington, 1884, 6:XXVII-LII; idem, "Human Evolution," (annual address of the president, November 6, 1883), Transactions of the Anthropological Society of Washington, 1883, 2:176-208. These were reprinted by the Smithsonian Institution, Smithsonian, Miscellaneous Collections, in vols. 33 and 25, respectively.

In this chapter we will examine these evolutionary ideas closely and show their origin in the debates over accommodating evolution with social philosophy during the decades following the publication of the Origin of Species. In the final chapter we will discuss the meaning of these ideas and the positivistic intellectual currents important in spawning them for motivating and sustaining Powell's systematic involement of science with social reform.

Powell's addresses on "The Three Methods of Evolution" and on "Human Evolution" seem to have been precipitated by his review earlier in the year of Lester F. Ward's Dynamic Sociology.[2] The ideas developed in these papers represent a dissent from the evolutionary propositions presented by Ward. Although broadly sympathetic to the aims and intellectual accomplishments of Ward's work, Powell disputed Ward's representation of human accomplishment as a fundamentally intellectual process and considered such a view too narrow a foundation for a proper sociology.

Reviewing Ward's ideas will prove helpful later in this chapter for discerning both the distinctiveness of Powell's thought and its general filiations with positivistic intellectual currents in America. However, Powell cannot be understood in terms of Ward's ideas alone. Both Powell and Ward were being driven in the evolutionary framework of their thinking by the specter of another:

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[2]Idem, "Ward's Dynamic Sociology," Science, 1883, 2:45-49, 105-8, 171-74, 222-26; Lester F. Ward, Dynamic Sociology, or Applied Social Science, 2 vols. (New York: D. Appleton & Co., 1883).

Herbert Spencer, laissez faire social philosopher and apostle of universal evolution. Indeed to a large degree it was a dread of Spencer's individualism that inspired both men. Moreover, it was Spencer's evolutionary positivism, pruned of its survival-of-the-fittest individualism and subtly modified to accept a vigorous graft of L. H. Morgan-inspired cooperative social dynamics, that provided the framework for Powell's thought. We shall turn first to a discussion of Spencer's work.

Herbert Spencer (1820-1903) was a self-styled English social philosopher who as a product of his family background in the British dissent and liberal traditions came early in life to advocate individualism as the basis of social ethics. His early career began in railroad engineering, but he turned from that in the 1840s to take up a writing career as a defender of laissez faire economic theory against the rising tide of interventionist sentiment. This course occupied Spencer for the rest of his life and led him to the writing of his imposing, evolutionist System of Synthetic Philosophy, published in a series of volumes between 1862 and 1897.[3]

Spencer's first book was Social Statics, published in 1850.

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[3]Two good biographical treatments of Spencer are J. D. Y. Peel, Herbert Spencer. The Evolution of a Sociologist (New York: Basic Books, 1971); and David Wiltshire, The Social and Political Thought of Herbert Spencer (Oxford: Oxford University Press, 1978). For a concise treatment, see Robert C. Bannister, Social Darwinism. Science and Myth in Anglo-American Thought (Philadelphia: Temple University Press, 1979), pp. 34-56. The System of Synthetic Philosophy included First Principles (1862), Principles of Biology (1864-67), Principles of Psychology (1870-72), Principles of Sociology (1876-97), and Principles of Ethics (1879-93) according Peel, Spencer, p. 319.

This was an attempt to correct the drift of utilitarian social philosophy toward interventionism. In it he tried to ground his individualist ethics empirically, through an evolutionary appeal to the course of human development.[4] Spencer had been attracted to evolution in the 1840s. He like many others in England was introduced to the Lamarkian theory of transformation in Charles Lyell's critical but fair account of the theory in Principles of Geology.[5] Lamark portrayed the progression of life as the adaptation og organisms through their active and habitual responses to the changing conditions of their environment. Although Lyell was skeptical of transformation, Spencer apparently was impressed with parallels he had seen in economic theory, in the concept of increasing productivity through specilization and a division of labor. Spencer took evolution as a self-evident truth.

In the Social Statics Spencer equated progress with adaptation, and saw the phenomenon operating in both the biological and social realms. Applying the development idea to society, Spencer saw mankind progressing out of the intense competition and coercive social structure of savagery through mankind's inventiveness, and especially through man's development of a moral nature and a

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[4]Spencer's early intellecutal development through the writing of the Social Statics is reviewed in Pell, Spencer, pp. 82-111, 113-36, and by John C. Green, "Biology and Social Theory in the Nineteenth Century: Auguste Comte and Herbert Spencer" in Critical Problems in the History of Science, ed. Marshall Clagett (Madison: University of Wisconsin Press, 1959), pp. 428-34.

[5]Loren Eiseley, Darwin's Century. Evolution and the Men Who Discovered It (Garden City, N.Y.: Doubleday & Co., 1958, pp. 98-99.

cooperative spirit. The development of this moral spirit diminished the need for coercive institutions; as mankind progressed these were progressively abandoned in favor of voluntary cooperative associations. Spencer saw for the future a purely moral state with mankind unencumbered by any need for governmental institutions.

Following Social Statics Spencer recognized the operation and applicability of the development idea in ever widening vistas. He saw a key parallel in Karl von Baer's embryological principle of transformation from homogeneity to heterogeneity, and from this a coherent theory of evolution began to develop. Another important step was Spencer's first edition of the Principles of Psychology (1855) in which he gave idealism (and his ethics) an empirical veneer by taking fundamental ideas to be products of evolution--the cumulative experience of preceding generations incorporated into the structure of the mind.[6]

The final years of the 1850s saw Spencer becoming convinced that evolution as the progressive organization of matter was a universal principle of nature. He conceived of a project to link the whole of human understanding into a unified system framed on a universal law of development. This unification of all human understanding on a universal law of development was the task of Spencer's System of Synthetic Philosophy, announced in 1860. The First Principles and four additional multiple-volumed tracts in biology,

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[6]Ibid., p. 434; Peel, Spencer, pp. 115-25; Wiltshire, Spencer, pp. 63-64.

psychology, sociology, and ethics were eventually produced over the next thirty-seven years of Spencer's life.

The evolutionary framework of Spencer's System was laid out in 1862 with the publication of the First Principles.[7] In its synthetic character, as his biographer has noted, it represents the culmination of Spencer's earlier work, and the end point of Spencer's intellectual achievement. Most of what was to follow in the subsequent volumes of the System of Synthetic Philosophy was exposition and elaboration.[8]

In the short introductory part of the First Principles Spencer attempted to reconcile religion with the pursuit of scientific knowledge by drawing an epistemological division of labor. He saw all knowledge, religious and scientific, to be relative and imperfect, but held that its pursuit was an activity of life that could not be abandoned. The only knowledge within science's grasp was empirical knowledge, he maintained, and science had to be content to seek only after relations of coexistence and sequence, i.e., relations in space and in time among objectively observable phenomena. Spencer admitted to the existence of an ultimate, imperfectly knowable reality which he termed the Unknowable Cause,

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[7] Herbert Spencer, First Principles, 4th ed. (New York: D. Appleton, 1880; reprinted 1898). This widely available edition differs in no substantial way from the reorganized second edition of 1867.

[8] Wiltshire, Spencer, p. 72.

or simply the Unknowable. But this Spencer contended was not in the domain of science; it was a matter to be left to theologians.[9]

These discussions, though merely prefatory to the evolutionary principles presented in the major portion of the work, were important to Spencer's reception, especially in America. As will be noted later, Spencer's empiricist epistemology and agnosticism appealed to those who sympathized with Comte's Positive Philosophy but were antagonized by its hostility toward religion. Spencer's empiricism was actually only a veneer, for his method in the First Principles and in subsequent works was thoroughly deductive. Spencer drew his principles from a poor empirical base, when not from simple intuition, and he apparently equated truth with simple plausibility.[10] But veneer or not, Spencer's advocacy of empiricist methods was a factor in his appeal.

In the main body of the First Principles Spencer essayed on the Knowable, on the world of experience. For Spencer, the whole of that world was comprised by matter in motion. In the conservation

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[9] Spencer, First Principles, pp. 3-128.

[10] Peel, Spencer, p. 31. See also the critique by James R. Moore, The Post-Darwinian Controversies. A Study of the Protestant Struggle to Come to Terms with Darwin in Great Britain and America (Cambridge: Cambridge University Press, 1979), pp. 164-66. Spencer's uncritical approach was tolerated "under a philosophical point of view" by more rigorously scientific men like Charles Darwin. But his principles were of such a nature that, as Darwin put it, "they do not seem to me to be of any strictly scientific use. They partake more of the nature of definitions than of the laws of nature" (quoted ibid., p. 162). Indeed while Darwin was concerned to argue vigorously that transformation had in fact occurred, Spencer was content merely to demonstrate that facts were in harmony with the idea.

of energy principle, which had been broadly established by mid-century, Spencer sensed the universality of energy ("force") as a cosmic agency. Denominating this principle the persistence of force to highlight its enduring character, Spencer saw all matter under its influence. Everywhere matter was in a state of flux undergoing continuous redistribution. The processes underlying this fundamental redistribution were rhythmic constructive and destructive processes Spencer termed evolution and dissolution.[11]

In the evolutionary process three fundamental principles operated: integration, segregation or differentiation, and equilibration. We shall look at them carefully, for in modified form they appear in Powell's scheme of evolution. Matter in the undifferentiated, incoherent, homogenous state was unstable under the persistence of force, Spencer maintained. However, aggregations of matter were produced spontaneously, Spencer insisted, and in these aggregations motion was dissipated and a state of greater stability reached. This led to a continuing aggregational process Spencer called <u>integration</u>. Where forces producing aggregation were strong, the evolutionary process resulted in centrally ordered simple aggregates. But usually the process was slow enough for second-order aggregations to form within the larger aggregative structure. Where this secondary redistribution process operated, most notably in the realm of organic nature, the evolutionary

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[11] Spencer, <u>First Principles</u>, pp. 161-296.

process and its products were called compound. Differences in the material units undergoing aggregation caused segregation or differentiation of those units, for Spencer held that different units could not respond equally to what he believed was a uniform environment of chaotic force and motion. This differentiation resulted in an internal interdependence of subordinate units within the larger integrative structures.[12]

The motion dissipating process which led to stability in the aggregated structures Spencer called equilibration. He portrayed it as a process wherein the internal forces of an aggregate came into eventual balance with the forces external to it. In the organic world equilibration was most notably manifested by adaptation of the organism to its environment.

> When, through a change of habit or circumstance, an organism is permanently subject to some new influence, . . . there arises, after more or less disturbance of the organic rhythms, a balancing of them around the new average condition. . . . If the quality of motion to be habitually generated becomes greater than before, its nutrition becomes greater than before . . . [and] the excess of nutrition becomes such that the muscle grows. And the cessation of its growth is the establishment of a balance between the daily waste and the daily repair. . . . The new forces brought to bear on the system have been compensated by the opposing forces they have evoked. And this is the interpretation of the process called adaptation.[13]

Later during the late 1860s as Spencer made room for natural selection in his evolutionary scheme, this Lamarkian adaptive

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[12] Ibid., pp. 287-495.

[13] Ibid., pp. 513-14.

process as the basic cause of organic evolutionary change was renamed _direct_ equilibration. Natural selection, or Spencer's famous "survival of the fittest," became a complementary winnowing process called _indirect_ equilibration.[14]

Fully elaborated, Spencer's definition of the cosmic evolutionary stood thus:

> Evolution is an integration of matter and concomitant dissipation of motion; during which the matter passes from an indefinite, incoherent homogeneity to a definite, coherent heterogeneity; and during which the retained motion undergoes a parallel transformation.[15]

Spencer brought all manner of phenomena under the purview of this universal process. In the inorganic realm there was the structure of the solar system as recounted in the nebular hypothesis, and the structure of the earth through the process of cooling from a molten condition. In the organic realm of matter he pointed to the growth of organisms by the incorporation of nutrients, and to the evolution of life forms by a similar process acting over a longer time frame. And in the "super-organic" realm Spencer saw human society develop through aggregation of individuals, tribes, nations, and federations; through social specialization into guilds, professions, and other classes; and by the specialization of human activities such as languages, science, and the industrial and aesthetic arts.

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[14] Bannister, _Social Darwinism_, p. 45.

[15] Spencer, _First Principles_, p. 407.

> That which the German physiologists have found to be the law of organic development, is the law of all development. The advance from the simple to the complex, through a process of successive differentiations, is seen alike in the earliest changes of the Universe to which we can reason our way back; and in the earliest changes which we can inductively establish; it is seen in the geologic and climatic evolution of the Earth, and of every single organism on its surface; it is seen in the evolution of Humanity, whether contemplated in the civilized individual, or in the aggregation of races; it is seen in the evolution of Society in respect alike of its political, its religious, and its economical organization; and it is seen in the evolution of all those endless concrete and abstract products of human activity which constitute the environment of our daily life. From the remotest past which Science can fathom, up to the novelties of yesterday, that in which Progress essentially consists, it is the transformation of the homogeneous into the heterogeneous.[16]

Spencer spent little time on the destructive process of dissolution, evolution's opposite, in the First Principles (it was ignored completely until the second edition, 1867). He saw evolution and dissolution as processes in cyclical perpetuity, with dissolution being the net result after a system of matter had become fully equilibrated under the persistence of force, i.e., its motions dissipated to a minimum.[17]

Spencer further elaborated on the fundamentals of the First Principles in the Principles of Biology (1864-67), a new edition of the Principles of Psychology (1870-72), the Principles of Sociology (1876-97), and the Principles of Ethics (1879-93).[18] Little of this

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[16] Ibid., pp. 317-71. The quotation, included in Peel, Spencer, p. 137, is from an 1857 paper announcing his universal law, "Progress. Its Law and Cause."

[17] Spencer, First Principles, pp. 531-50.

[18] Dates as given in Peel, Spencer, p. 319.

interests us here, other than Spencer's enlarged ideas on the progress of civilization. These were presented between 1876 and 1882 in the serial publication of the Principles of Sociology.

In the First Principles Spencer had recognized two groups of institutions through which mankind had long worked cooperatively: the regulative, which were broadly linked to governmental, administrative and military functions; and the operative institutions by which men cooperated industrially to provide for their material needs. In the Principles of Sociology Spencer explicitly associated the former modes of social integration with a primitive, brutish existence where cooperation was necessarily coercive. The latter modes, on the other hand, were linked with voluntary cooperation and a developing moral spirit incipient in primitive society. This morality and spirit of cooperation according to Spencer led to new, vastly superior forms of social integration in mankind's industrial activities. Over time, this industrial development would continue to evolve, Spencer believed, and ultimately would render government unnecessary. Social evolution, for Spencer, became a progressive evolution of society from militarism to industrialism.[19]

Herbert Spencer became the archetype social Darwinist. He was opposed to such government interventions as public sanitation measures, poor relief laws, and popular education, which brought him

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[19]Ibid., p. 327; Herbert Spencer, The Principles of Sociology, vol. 2, pt. 5: "Political Institutions" (New York: D. Appleton, 1897; preface dated 1882), pp. 244-64, 568-667.

much attention in the 1880s.[20] Spencer did not always use evolution and the concept of the survival of the fittest to justify his positions, however. Early, in the Social Statics, Spencer relied on a limited organic analogy to support his laissez faire doctrines. In comparing living beings and society he focused mainly on the similarities of aggregated structure and of differentiated functions among subordinate units. He avoided, on the other hand, the authoritarian implications of the subordination of the constituent units for the benefit of the whole, which was so plainly exhibited in living organisms. Spencer continued to use the analogy in the First Principles, where it was manifest in his choice of the terms "super-organic" and "social organism" to denominate the integrated structures made up of aggregations of organisms.[21]

Spencer in his use of the organic analogy wished both to have and to eat his cake: he took the analogy where it served to illustrate his universals of integration and differentiation, but denied it in its strict sense where it threatened his social theory. Powell used similar terminology, as we will see below, but not with the same meaning or polemical intent--and consequently not with the inconsistency that opened Spencer to criticism. Although he did not abandon the organic analogy altogether, Spencer late in the 1860s began to draw instead on parallels between natural selection and

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[20] These are detailed by Wiltshire, Spencer, pp. 134-45.

[21] Ibid., pp. 225-42; Peel, Spencer, pp. 166-91.

the free market economy. By the late 1870s, having overcome his earlier moral qualms over linking social progress to a brutish struggle for existence, Spencer made natural selection prominent as indirect equilibration in his evolutionary scheme. With the offering of the first part of the Principles of Ethics in 1879, Spencer held the laws of nature's biological species to be mankind's laws as well. No gulf separated man and animal under Spencer's law of the "survival of the fittest."[22]

Spencer's System of Synthetic Philosophy was more warmly received in the United States than in his own homeland. In England, Peel has noted, the emergence of working class self-consciousness, unionism, and the growth of civil service professions combined to generate increasing demands for a more active role for the state than Spencer's individualism would allow.[23]

In the United States, on the other hand, these movements had yet to have a strong impact. The country was still sympathetic to individualism and welcomed Spencer's ideas. Spencer's optimism and the scientific underpinnings of his views added to his appeal as well. It was that spirit that won for Spencer the formidable support of Edward L. Youmans who, through Popular Science Monthly and the D. Appleton publishing house, tirelessly and effectively promoted Spencer's System. The same spirit also appealed to intellectuals like John Fiske (Outlines of Cosmic Philosophy, 1874),

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[22]Bannister, Social Darwinism, pp. 47-56.

[23]Peel, Spencer, pp. 224-48.

a theist who had abandoned orthodoxy for the attraction of empirical knowledge in the Positive Philosophy of Auguste Comte. Comte, in continuing the Enlightenment's effort to re-establish social order on a more stable rational footing, had identified in his Cours de Philosophie Positive (1830-42) and Système de Politique Positive (1851-54) the empirical methods of science as the only means for achieving certain, or positive, results. Comte argued that mankind had advanced by means of his intellect through stages of theological, metaphysical, and now scientific (positive) systems of knowledge. His arguments were compelling to many, but his system demanded a break with idealist systems that many others were not prepared to accept. Fiske was one of these; in Spencer's evolutionary principles he found a new affirmation of moral progress, and, together with the doctrine of the Unknowable, a means of reconciling positivism and religion.[24]

The substitution of Spencerian thought for Comtean was also reflected among those who were a part of the movement for social science in America. This heterogeneous movement drew much of its early inspiration from the methods and sociological imperative of

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[24]Spencer's reception in the United States is reviewed by Richard Hofstadter, Social Darwinism in American Thought, revised ed. (Boston: Beacon Press, 1955), pp. 31-50; and by Bannister, Social Darwinism, pp. 57-78. A recent treatment of Fiske and his relation to Spencerian thought is available in Jacob Franklin Lester, "John Fiske's Philosophy of Science: The Union of Science and Religion through the Principle of Evolution" (Ph.D. dissertation, Oregon State University, 1979). On Auguste Comte and his Positive Philosophy see Gertrud Lanzer, ed., Auguste Comte and Positivism. The Essential Writings (New York: Harper Torchbooks, 1975).

the Positive Philosophy. After mid-century, however, in the wake of increasing dissatisfaction with the atheism and intellectual despotism of Comte's later works, the movement welcomed more palatable variants. British thinkers, steeped in empiricism and affecting a humanist spirit, were readily available to fill the void. With their ascent as guiding spirits, positivism departed from Comte's original system but gained new vigor and influence. Among the so-called British positivists were historian H. T. Buckle, anatomist T. H. Huxley, economist John Stuart Mill, and Herbert Spencer. Spencer's ideas were especially prominent, however, and by the 1870s he was perhaps the chief representative of positivism in the United States.[25]

Being classed as a positivist disconcerted Spencer, for he deeply resented suggestions of intellectual obligation to Comte. Spencer rejected in totality Comte's view that human progress was fundamentally intellectual; he regarded Comte's three stages of progress, the metaphysical, theological, and positive or scientific, as superficial; and considered Comte's positive methodology to be no advance over other perceptions of the method of science. Letters to

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[25] On the social science movement in America, and the influence on it of Comte, and of Spencer and other British thinkers, see L. L. Bernard and Jessie Bernard, Origins of American Sociology. The Social Science Movement in the United States (New York: Thomas Y. Crowell, 1943), pp. 115-60.

this effect were published in the New Englander magazine and in the first American edition of First Principles. The positivist label pursued Spencer nevertheless.[26]

Spencer's popularity in the United States grew strongly through the 1870s, peaking perhaps about 1882 with the publication of the second volume of his Principles of Sociology, and with a well-publicized American visit.[27] He was not without his critics in America, however. The philosopher Chauncey Wright (1830-1875) was an early and perceptive opponent of Spencer's system, which he recognized as only superficially empirical. He condemned Spencer as a poor metaphysician dealing in abstractions that were mere summaries of knowledge, useless as working ideas that helped extend human understanding.[28]

Other critics were more concerned with the sociological implications of Spencer's laissez faire social doctrines. One was Lester Frank Ward (1841-1913), whose Dynamic Sociology Powell reviewed in 1883. Ward from an early time was deeply committed to popular education as a means for those low in origin to raise themselves from their humble lot. For Ward, Spencer's social doctrines and his

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[26] Ibid., pp. 152-53; Wilshire, Spencer, pp. 70-72.

[27] One important consequence of his popularity was an infusion of Lamarkian evolutionary ideas in the social sciences. See George W. Stocking, Jr., "Lamarkianism in American Social Science: 1890-1915," Journal of the History of Ideas, 1962, 23:241-42.

[28] Hofstadter, Social Darwinsim, p. 126. See Wright's "Philosophy of Herbert Spencer" in Chauncey Wright, Philosophical Discussions, ed. Charles E. Norton (New York: Henry Holt, 1877), pp. 43-96.

antagonism to public education were anathema.[29]

Ward's sociological treatise was a product of his evolving intellectual development in Washington, D.C., beginning after the Civil War. Ward quickly embraced much of Comtean philosophy, editing a radical publication called the Iconoclast. He also began a proposed book celebrating popular education, "The Great Panacea," but late in the 1870s Ward rewrote it as the Dynamic Sociology in light of wider reading in science and social philosophy.[30]

Ward was very impressed with Herbert Spencer's universal system. Taking his cue from Spencer, Ward elaborated a similar view of the cosmic order and devoted nearly half of the Dynamic Sociology to its presentation. Intended to provide the context for Ward's social physics, this introductory discourse was strongly reminiscent of Spencer not only in its scope but also in its evolutionary principles. Ward modified some terminology, opting for "aggregation" in preference to Spencer's integration as a basic evolutionary process, and subdividing the material universe into primary, secondary, and tertiary classes to correspond roughly with Spencer's inorganic, organic, and superorganic realms. But the

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[29] Clifford H. Scott's Lester Frank Ward (Boston: Twayne Publishers, 1976), is a useful biographical treatment and analysis of Ward's ideas. See also Samuel Chugerman, Lester F. Ward. The American Aristotle (Durham, North Carolina: Duke University Press, 1939). Hofstadter, Social Darwinism, pp. 67-84, outlines some main elements of Ward's thought, and Bannister, Social Darwinism, pp. 126-31, adds insight into the growth of Ward's ideas over his career. Gabriel, American Democratic Thought, pp. 215-20, underscores Ward's positivist leanings, as well as his contributions to to general-welfare political philosophy.

[30] Scott, Ward, pp. 13-43.

Spencerian framework is plainly recognizable, and Ward's respect for the intellectual achievement of Spencer's synthesis is openly acknowledged.[31]

Ward's point of departure from the Spencerian evolutionary process was at Spencer's insistence on a continuity between the processes underlying the phenomena of nature and the processes that gave rise to the special character of man. The demarcation in evolutionary laws between animal and man was quite blurred for Spencer, as we have seen, but biological evolutionists saw it a little more plainly. Charles Darwin and particularly Alfred Russel Wallace had agreed by the early 1870s that the development of man's mind had shielded his physical structure from the unrestrained operation of natural selection. Wallace even denied a continuing influence for natural selection on man's intellectual and moral development.[32]

Ward, in keeping with his Comtean intellectualist presuppositions, observed the same fork in the evolutionary road. He

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[31] Ward, Dynamic Sociology, vol. 1, pp. 139-206.

[32] Wallace's position was well developed by 1870 in his essay "The Limits of Natural Selection as Applied to Man." See Malcolm J. Kottler, "Alfred Russel Wallace, the Origin of Man, and Spiritualism," Isis, 1974, 65:145-92. Wallace in this essay turned to supernatural causes to account for man's intellectual and moral development. Wallace's views were well received in America according to Bannister, Social Darwinism, pp. 32-33, 65. Charles Darwin, The Descent of Man, and Selection in Relation to Sex, 2nd ed. (New York: D. Appleton, 1874), pp. 129-31, maintained that natural selection continued to operate on man's intellectual and moral faculties. For a review of Darwin's views on evolution and man see John C. Greene, "Darwin as a Social Evolutionist," Journal of the History of Biology, 1977, 10:1-27.

identified the rise of intellectually directed endeavor ("indirect conation") as the dividing line between the world of nature and the world of man. All organized beings were motivated by feelings, but in the natural world the result was struggle, brutishness, and waste. In the human realm intellect guided human action; through foresight and calculation, brutishness and waste were avoided. The human realm for Ward was an "artificial" world, a world of progress through invention and artifice that contrasted sharply with the raw realm of nature.[33]

With inventiveness and artificiality the rule in the human world, Ward had both the key to human progress and the license needed for interventionism. In the remainder of the Dynamic Sociology Ward erected a platform to support the cause of popular scientific education. He argues for this as the true avenue to continued human progress. Popular scientific education was the best means to diffuse knowledge and thus to add to man's calculated endeavors. All, thereby, could achieve individual happiness, and social progress would result.

When Powell reviewed Dynamic Sociology he was broadly sympathetic to Ward's purposes. He recognized its argument was a counterpoint to laissez faire doctrine and to Spencer's foundation for it in biological law, that it attempted to offer "a new philosophy of society" in support of "the earnest people of the world in their efforts to benefit the race." Drawing on the example

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[33]Ward, Dynamic Sociology, vol. 2, pp. 76-106.

of the increasing public administration of stream waters for irrigation in the West, Powell noted that the public's demand for governmental regulation of social conduct sharply contrasted with the supposed natural order of limited government. Everywhere people clamored for greater governmental involvement, he complained, only to be obstructed by evolutionary laws drawn from the domain of biology.

> . . . In every community there is a body of good and earnest people demanding reform, or devising methods for the improvement of mankind in diverse ways,--for the relief of the unfortunate, for the education of the masses, to diminish suffering, crime, and ignorance; and the energies of these people, exerted everywhere, in season and out of season, create a sentiment that law-making bodies cannot ignore.

Yet in opposition to all this, Powell observed, "the publicists ask for less government, and say, 'let society alone.'" This opposition was theoretical, arising from the "phase of the philosophy of evolution" at which the thinkers of the day had arrived. Laws of biological evolution were being misapplied to sociology, Powell complained. The philosophies of science, which were yet inchoate, were being "adjudged to be complete, and principles that require restriction are held to be universal."[34]

Powell displayed little interest in the dynamic principles of reform Ward was aiming for in the second volume of his work. As W. C. Darrah has noted, Powell's orientation was different than Ward's.[35] Powell was interested more in society's basic structure

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[34] Powell, "Ward's Dynamic Sociology," p. 106.

[35] Darrah, Powell, p. 281.

and function than in programs for broad social reform.

Powell seemed to accept Ward's view of society as artificial or inventive. Indeed it would have been surprising if he had not, for the Morgan theory of cultural evolution that had so impressed Powell also entailed mankind advancing by progressively imposing control over the material forces of nature. Ward characterized human endeavor narrowly as fundamentally intellectual, however, and here Powell sounded a note of dissent.

> Mankind has made progress, i.e., secured happiness, quite as much by the effort for peace and the establishment of justice as by the effort to know and the acquisition of truth. It can be shown in other and diverse ways that his view of successful human endeavor is philosophically narrow.[36]

Alternatively, Powell contended that the "indirect" evolution characteristic of Ward's anthropological realm was not merely intellectual or "philosophic," but also "philologic," "technologic," "sociologic" (institutional), and "psychologic." These facets were interrelated and none could be ignored. Powell saw them "so bound together that the absence of one would void all." They were "interdependent and coordinate" in such a manner that "the evolution of one is dependent on the evolution of all." Thus Powell had to conclude that Ward's theory was incomplete, that it was only "a half-truth," and that it could not help but to lead to flawed conclusions.[37]

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[36]Powell, "Ward's Dynamic Sociology," pp. 173-74.

[37]Ibid., pp. 171, 223.

In Ward's Dynamic Sociology Powell missed the richness of human culture he had come to know in his experience as a student of Indian cultures. If Ward's effort would provide the foundation for a new and better society of tomorrow, it first had to prove itself by accounting for society as it was presently known to be. Powell put it to that test, and found it inadequate.

Powell presented his own views on evolution and its consequences for man in "Human Evolution," an address before the Anthropological Society of Washington in November, 1883 and in "The Three Methods of Evolution" given the following month at the city's Philosophical Society. Like Ward, Powell rejected Spencerian social philosophy while subscribing to the larger framework of his views.

Powell generally endorsed Spencer's concept of universal evolution through the differentiation and integration of matter. The indefinite character of this process, its empirical insufficiency, does not seem to have troubled him.[38] He seems in fact to have been quite taken with its explanatory power, observing that three of the landmark theories of modern science were based on "phenomena of sequence." These were the nebular hypothesis "of astronomic evolution," the theory of the evolution of life, and the

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[38]This was despite Powell's own admonition concerning the purely "verbal" explanation as one of the rocks on which much research was wrecked: "Phenomena appear, but whence is not discovered, and resort is had to verbal statement, and the verbal statement oft repeated comes to be held as a fact itself. This is the vice of all metaphysics, by which words are held to be things--spectral imaginings that haunt the minds of introverted thinkers as devils possess the imaginations of the depraved." "Three Methods of Evolution," p. XXXIV.

atomic theory, which he contended had "gradually assumed the shape of an hypothesis of chemical evolution." The time has come, Powell maintained, "when in all fruitful research evolution in some form is postulated by each investigation."[39] But Powell's evolutionary scheme was more thoroughly dynamic than Spencer's; and more importantly Powell observed more rigorously than Spencer the idea of human society as a superorganic level of organization.

Like Spencer and Ward, Powell felt compelled to lay some philosophical groundwork for his views. The opening portion of his address was a discourse on the kinematic hypothesis, the view that all insubstantial phenomena such as gravitation, magnetism, chemical affinity and various energy forms would be explained eventually in terms of underlying particulate motions. Powell was setting the stage for a subsequent focus on motion and its organization, rather than on matter and its structure which was more to Spencer's taste.

Matter, to Powell, had little intrinsic meaning. On the molecular scale its parts were found to be "so minute as almost to disappear in the perspective toward the infinitesimal," whereas in its combined forms

> bodies of such magnitude are produced that they are but dimly discerned in the perspective toward the infinite--stellar systems that appear not to the eye, but only to the mind's eye.[40]

Indeed, it was only because that matter combined, or aggregated, that Powell found it to be of interest. By its mode of

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[39]Ibid., p. XXVII.

[40]Ibid., p. XXXV.

combination and recombination, Powell noted, three orders of material were produced. By chemical affinity, mineral substances were produced. By vital processes these were in turn combined into organic material, which was known chiefly in the temporary forms of living things. Then these organic forms might in turn undergo superorganic combination through by active cooperation "through the agency of mind."[41]

But for Powell combination was not the establishment of a static structure or dissipation of motion that it was for Spencer. Combination for Powell focused on motion--composed or organized motion. In the inorganic or mineral kingdom Powell pointed to the linear and vibrational motions exhibited in forms of energy such as heat and electricity. These motions were organized hierarchically, according to Powell, and he listed several of the larger systems of importance.

> Again, among the aggregations of the physical kingdom, stellar systems are aggregates by virtue of motion. The combination observed is due to composed motion. Of the mechanical combinations, that exhibited in the atmosphere is such by virtue of motion--that is, the gaseous state is preserved by the interference of molecular motions, and the bodies into which it is imperfectly differentiated, i.e. currents of air, are such by virtue of motion. Again, the imperfectly aggregated bodies of water are such by virtue of motion. This is seen to be true of the clouds floating in the air, and of rivers rolling to the seas. Lakes with outlets are bodies of water in motion, forever fed from the clouds, forever discharging into the sea; and mediterranean seas without outlet are perpetually receiving and discharging their waters; and so far as

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[41]Ibid., p. XXXVI.

> the sea is differentiated into currents, these are bodies imperfectly aggregated by motion.[42]

The different realms were also hierarchically related to each other, but here the processes by which motions were composed served to differentiate the realms. The organic was differentiated from the inorganic by the life processes that changed the forms of mineral substances and transmuted motions from one form of energy to another. The superorganic was differentiated from the organic by "actival" processes--the cooperative activities of mankind Powell had earlier identified as the objects of ethnological study. These altered both mineral substances and organic substances into new arrangements.

> By the combination of matter motion is composed. Mineral substances and aggregates exhibit this composition of diverse modes of motion. Biotic bodies exhibit compositions of modes of motion, and also composition of transmutations of motion, and it is this latter characteristic which distinguishes biotic from physical motion. Activital combinations exhibit a composition of modes of motion, and a composition of the transmutation of motion, and a composition by co-operative action. It is the last characteristic which distinguishes activital motion from biotic.[43]

Having characterized natural phenomena as organized motion, Powell now delineated the process of evolution in his own terms. He defined evolution as the development of systems.

> Evolution is progress in systemization. It must be noted that not all changes are progressive; some are retrogressive. It is only progressive change that is here called evolution; retrogressive change is

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[42]Ibid., p. XXXLX.

[43]Ibid., p. XLII.

> dissolution. As the term is here used, a System is an assemblage of interdependent parts, each arranged in subordination to the whole so as to constitute an integer.

He also showed his respect for Herbert Spencer's evolutionary principles by providing an alternative definition in Spencerian terms.

> It is progress in differentiation by the establishment of unlike parts, and in the integration of these parts by the establishment of interdependence. Dissolution [on the other hand] is retrogression by lapsing of integration through the destruction of interdependence, and the lapsing of differentiation through the loss of heterogeneity in parts.

In its terminology and concern for the direction of change Powell's definition of evolution is vintage Spencer. Only the emphasis on interdependence marks the subtle conceptual differences.[44]

Another Spencerian idea appearing in Powell's evolutionary scheme is the concept of adaptation. In contrast to Spencer's usage, however, the nature of adaptation changes significantly for Powell from realm to realm as the order of organization or aggregation--and hence the objects affected in the process--increases.

In the mineral or inorganic realm, Powell described evolution practically in Spencerian terms as a passive accommodation to the forces of the environment.

> In mineral bodies combinations proceed by molecular, molar, and stellar methods. It has been shown that the changes in these bodies are due to external conditions or forces. If a given body be in harmony with external

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[44] Ibid., p. XLII.

> conditions no change occurs in its constitution, but if it be out of harmony the impinging agencies effect such modifications as will produce harmony. This may be done by a change in the body as a substance or aggregate, or by its separation and re-combination in some more harmonious form. The evolution of mineral bodies is thus accomplished by direct adaptation to external conditions.[45]

Inorganic bodies came into equilibrium, then, with their environment. The direction of the change was according to the principle of least resistance.

In the organic realm change was not only direct accommodation to the external forces of the environment, but it was also indirect as a consequence of the internal composition of motion by organs. Explaining as Spencer had before him, Powell noted that organic bodies incorporate mineral substances into their organs at rates varying with the activity of the organ. Habitual changes in activity thus caused change in another sense.

> Exercise increases the rate of change in the constituent matter of a biotic organ, and thus the slow change in its structure, which proceeds from life to death, is accelerated. This accelerated change results in increased differentiation of the organ, and it thereby becomes more and more efficient in the performance of its function. This change, therefore results from exercise. Organs that are exercised increase in efficiency, by non-exercise they decrease in efficiency. This change in the organization of any one individual is but slight, but as the slight changes pass from one generation to another, continuous exercise of one set of organs greatly modifies them; continuous neglect of exercise in another set modifies them also, until at last they are atrophied. Thus by exercise and non-exercise important structural changes are produced when conjoined with the changes due to heredity.

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[45]Ibid., p. XLIV.

This Lamark-inspired, Spencer-perpetuated type of change was then joined with the selective process given to the world by Darwin.

> All these changes result in progress, from the fact that those individuals whose change is in a direction out of harmony with the environment ultimately perish, while those whose change is in a direction in harmony with the environment survive. This method of adaptation or evolution in biology is called "survival of the fittest.[46]

This "survival of the fittest" was accelerated by competition among organisms, and also by a psychic factor Powell called "choice." This was equivalent to Darwin's sexual selection, but Powell chose terminology more clearly reflecting the teleological considerations that were entailed in a theory of evolution committed to the notion of progress.[47]

Higher order levels of composed or organized motions had resulted in a new locus of adaptation and an altered evolutionary process in the realm of living substance. In the superorganic or "anthropic" kingdom Powell saw similar developments. Whereas in the biological realm organs represented the new level of organization and were seen as the new locus of adaptation and change, associative or cooperative activities represented the new prime level for the superorganic.

> In anthropic combinations the units are men, and men at this stage are no longer passive objects, but active subjects; and instead of man being passively adapted to the environment, he adapts the environment to himself through his activities. . . . In this change certain parts of the human organism [primarily the mind] are

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[46] Ibid., pp. XLV-XLVI.

[47] Ibid., p. XLVII.

> increasingly exercised from generation and generation. This steadily increasing exercise results in steadily increasing development, and the progress of the unit--man. . . . Man is more than an animal. Though an animal in biotic function, he is man in his anthropic activities; for by them men are combined--i.e., inter-related--so that they are not discrete beings, but each acts on, for, and with, his fellow man in pursuit of happiness. Human activities, thus combined and organized, transcend the activities of the lower animals to such a degree as to produce a new Kingdom of matter.[48]

This conception of the "superorganic" is much different than Herbert Spencer's. For Spencer--at least when extolling the virtues of individualism and the improvement of man by survival of the fittest--human society was little more than mankind in the aggregate; as a species improves in the struggle for existence, so human society improves. But for Powell, society is not just men, but men working. Society is organized activity.

We will examine Powell's ideas on human evolution more closely. In the tradition of Wallace and Darwin, and like Lester Ward, Powell saw man as freed, comparatively, from the operation of the evolutionary laws that affected lower life forms. This was the result of man's great mental superiority, and a consequent reduction of the effects of competition.

> It has been shown that the great efficiency of the biotic method of evolution by survival depends upon competition for existence in enormously overcrowded population. Man, having acquired superiority to other animals, passed beyond the stage when he had to compete with them for existence upon the earth and into the stage where he could utilize plants and animals alike

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[48] Ibid., p. XLVIII.

> for his own purposes. They could no longer crowd him out, and to that extent the law of the survival of the fittest in the struggle for existence was annulled in its application to man.[49]

Yet in so far as biological evolution was independent of competition, it still resulted in some specialization according to Powell. At an early time when "man was spreading from some center throughout the earth," varieties developed exhibiting differences in skin color, hair texture, the position of the eyes, and shape of the cranium. This scenario differed in no important way from Darwin's in the Descent of Man,[50] but at this point for Powell the biological evolutionary process began to be overshadowed by the development of the new pattern or organization.

> Had the laws of biotic evolution continued paramount, it cannot be doubted that these varieties would steadily have become more and more pronounced, and the genus homo would ere this have included man species. But . . . the laws of biotic evolution, though perhaps not absolutely repealed, were superseded by other methods and laws which changed the course of man's progress. By the spreading and admixture of activities, and by the concomitant admixture of streams of blood, varieties were prevented from becoming species. The tendency of heterogeneity of species was checked, and a tendency to homogeneity was established.[51]

Broadly speaking, Powell identified cooperation as the new factor in the evolutionary process. Both Darwin and Spencer had earlier emphasized the importance of cooperation in evolution, but

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[49]Ibid., p. XLVII.

[50]Cf. Darwin, Descent of Man, pp. 180-85.

[51]Powell, "Human Evolution," pp. 182-83.

each had viewed it simply as a quality to be explained. Cooperation was a consequence of moral development, which was in turn the result of mental development.[52] Powell on the other hand used the existence of cooperative behavior as a point of departure for a different evolutionary process--the evolution of human activities.

Powell discussed the four ethnology-inspired classes of activities that he viewed as the fundamental vehicles of human cooperative action. The arts arose out of man's desires in relation to the external world. "The arts have evolved by human invention, and man has been impelled thereto by his endeavor to supply his wants." It was through progress in the arts, as Lewis H. Morgan had earlier observed, that mankind gained control over the forces of nature. Powell represented these developments as the outgrowth of a selective process operating on the inventions of art.

> A vast multiplicity of arts have been devised, of which comparatively few survive in the highest civilization. As the inventions have been made, the best on the average has been chosen. Man has therefore exercised choice. The evolution of arts has been by the method of invention and choice, in the endeavor to gratify desire, and by them man has adapted the environment to himself.[53]

The unit man, through his inventiveness and selective powers, was the source and agent of change. But it was the activity itself that was transformed in the process.

The activity Powell denominated institutions shows the influence of Spencer as well as Morgan, for Powell included industrial

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[52] See for example Darwin, Descent of Man, chapter 4; and Spencer, Principles of Sociology, vol. 2, pt. 5, chapter 2.

[53] Powell, "Three Methods of Evolution," p. XLVIII.

cooperation as part of this category, and observed Spencer's distinction between operative and regulative institutions. Institutions were, in essence, cooperative arrangements.

> Every institution is an organization of a number of individuals, who work together for a common purpose, as, for example to prosecute some industrial enterprise, to cooperate in the pursuit of pleasure, to promote some system of opinions, or to worship together under the forms of some religion.[54]

Operative institutions developed early in association with the subsistence arts. Among the earliest perhaps were special associations for hunting, and making pitfalls and other appliances for taking game. Then as agriculture and other subsistence arts developed and tools and machines came into use, special associations were established to make the required implements. As mankind progressed many other institutions developed, some related to the arts and some serving religious and other purposes.

> Farmers organize agricultural societies, mechanics organize trade-unions, manufacturers organize their associations. Then those bodies usually denominated corporations spring up, and groups of men are organized to prosecute a specific industry, as a gas company, composed of stockholders, officers, superintendents of various grades, and employes. Schools are organized, composed of principals, teachers, and pupils. Churches are organized with a hierarchy of officers and laymen. In a vast multiplicity of ways these institutions spring up, and the same individual may become a component unit in many institutions.[55]

Among the most important institutions for Powell were those regulating conduct to secure peace among members of society. Indeed,

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[54] Ibid., p. XLIX.

[55] Powell, "Human Evolution," pp. 191, 193.

often when Powell spoke of institutions it was only these that he treated. Following Morgan's chronology, Powell maintained that among the earliest of the regulatory institutions were communal family groups organized on the basis of gender. As the little tribal groups grew larger, they began to organize according to bloodlines into the clan or gentile organization. But this social structure based on kinship was superceded when it failed to serve property needs.

> At last the kinship society broke down; it no longer served the wants of the people as a method of organization; and slowly with its collapse a new system of organization was developed--that based upon property; and as land was then most important property, states came to have a territorial organization. So tribe coalesced with tribe, and nations were organized.[56]

As national units evolved, so too did laws and the apparatus of government. Powell represented the growth and development of government in distinctly Spencerian evolutionary terms, with an emphasis on specialization.

> In the evolution of government there is to be observed a progressive differentiation of function, as legislative, executive, and judicial; and in each of these great departments of government secondary and tertiary differentiations occur, while the whole system of government progressing from low tribes to highly civilized nations is marked by progressive integration in the establishment of relations of interdependence.[57]

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[56]Ibid., p. 195.

[57]Ibid., p. 195. Powell's interest in the evolution of government and his inclination to cast it in Spencerian terms is also evident in an earlier paper, "Outlines of Sociology," Transactions of the Anthropological Society of Washington, 1882, 1:106-129 (reprinted in Smithsonian Institution, Smithsonian Miscellaneous Collections, vol. 25).

This Spencerian cast was only superficial, however. As in the case of the arts, the evolution of institutions for Powell proceeded by human invention and choice, with those inventions most successful in securing justice and peace surviving.

> Institutions have been developed . . . that men might live together in peace and render one another assistance; and gradually, by consideration of particulars of conduct, . . . men have sought to establish justice, that they might thereby secure peace. Of the vast multiplicity of institutions--forms of state, forms of government, and provisions of law--which have been invented, but few remain in the highest civilization, and these few have been selected by men. . . . Institutions, therefore, have been developed by invention and the choice of the just in the endeavor to secure peace.[58]

Languages, Powell's third class of activities, developed for purposes of communication. Their use, Powell contended, was important to all classes of cooperative human endeavor. Many languages had been invented in history, he believed, but only a few survived. "Men have chosen the economic in the expression of thought," and languages "have developed by invention and choice in the struggle for expression."[59]

The fourth class of activities was "opinions," comprising mankind's efforts to form judgments. These exceptionally important activities

> have always reacted upon languages, institutions, and arts, and largely led them in their courses of progress.

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[58] Powell, "Three Methods of Evolution," p. XLIX.

[59] Ibid., p. XLIX. Powell detailed an evolution of languages in terms of syllabic aggregation and differentiation of the parts of speech in his "Human Evolution," pp. 197-202.

> Because of their opinions, men are willing to work together, and thus have common designs.

As with the other activities, Powell saw a comparatively few good opinions surviving out of the many opinions "and many systems of philosophy" that had been invented through the ages. The survival of those few in man's struggle to know was through the agency of choice "in the selection of the truth."[60]

Powell saw the evolution of opinions or philosophy largely in Comtean terms--as three stages of intellectual progress from mythological, through metaphysical, to scientific knowledge. Mythological opinion Powell equated with the projection by man of the "design and will" he discovered in himself "into all the external universe of his knowledge." All motions and changes were endowed with purpose. Later, metaphysical explanation came to predominate. The difficulty in this system, Powell seemed to suggest, was the confusion through language of ideas with objective phenomena. Man

> began to suppose that the basis of thought is language; . . . So he began to explain the phenomena of the universe simply as the phenomena of language, and the _names_ were the _things_.[61]

In modern times, scientific philosophy displaced both the metaphysical and the relics of the mythological. He described science in terms like Spencer used in the _First Principles_:[62]

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[60]Powell, "Three Methods of Evolution," p. L.

[61]Powell, "Human Evolution," pp. 202-203.

[62]Cf. Spencer, _First Principles_, pp. 161-75 passim.

> Knowledge, or science, is the discernment and classification of phenomena as they appear in coexistence and sequence; and when phenomena are discerned and classified they are said to be known.

But Powell's understanding of the methods of science was more sophisticated than Spencer's. This was reflected in Powell's ideas on the function of hypotheses.

> Every step in the advancement of knowledge is primarily made by the use of a hypothetic explanation. The mind having imagined an explanation of phenomena, tests the value of the hypothesis by more careful discernment and comparison. If the hypothetic explanation be not true, the discernment and comparison have yet led to an increase of knowledge. But there is no increase of knowledge without a precedent hypothesis. All human research, in every particular, is dependent upon antecedent hypothesis; for without some hypothesis there can be neither discernment nor comparison, as objective impressions are not woven into mental structure. Verified hypotheses are scientific opinions, and as they are systematized scientific philosophy is constructed.[63]

Like both Morgan and Spencer, Powell believed that the mind of man was intimately involved in his cultural development.[64] For Powell the mind was the seat of human powers of reason, and through its exercise in the prosecution of activities those powers were

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[63]Ibid., pp. 203-204. Powell's views on the philosophy of science can be found in his memorial to Darwin, "Darwin's Contributions to Philosophy," Proceedings of the Biological Society of Washington, 1882, 1:60-70.

[64]George W. Stocking, Jr., Race, Culture and Evolution. Essays in the History of Anthropology (New York: The Free Press, 1968), pp. 110-32, discusses many nineteenth century views on mental development in anthropology including those of Morgan, Spencer, and Powell protege W. J. McGee. Most saw mental differences among the races not as biologically determined, but rather as consequences of the more primitive states of the physical or cultural environment.

developed. The growth of the mind was thus interdependent and concomitant with the four classes of activities already mentioned. Powell classed exercise of the mind as a fifth group of activities characteristic of human society, but considered it a more subjectively defined class than the other four, and a class whose growth was consequent on the growth of the others. "The subjective evolution of the mind," he contended, is "the product of the objective evolution of activities." The study of the mind Powell left to the domain of psychology.[65]

For Powell human progress was the result of the joint operation of evolution in these five classes of activities. No one class could be treated without reference to the others. They are "interdependent," Powell contended; "they arise together, and their history proceeds by a constant interchange of effects."[66] Mankind's evolution could not be viewed as Lester Ward had seen it in terms of rational development alone, even if this was a particularly important factor. Nor could it be attributed to a crude Spencerian law of competition among men. For Powell this evolution was the product of man's collective endeavors in the fundamental activities of life.

There is no doubt that Powell's ideas on human evolution were profoundly influenced by the ideas of Lewis Henry Morgan. Morgan had emphasized mankind's cultural rather than physical existence; he

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[65] Powell, "Three Methods of Evolution," p. L. See also "Human Evolution," pp. 206-207.

[66] Powell, "Three Methods of Evolution," p. L.

focused on man's increasing control over the physical world through the subsistence arts; and he had underscored man's social relations, his collective endeavors. For Powell, Morgan's ideas on mankind's cultural progress stood in direct opposition to Spencer's atavistic view of the regulation of social conduct through government. They provided Powell a humanitarian antidote for Spencer's doctrine of the survival of the fittest.

The impact on Powell of Spencer's evolutionism cannot be overemphasized, however. Spencer's System of Synthetic Philosophy compelled Powell as it had Lester Ward to structure his views on social development within a framework of universal evolution. Powell's concern for progress and for the direction of change reflects Spencerian concerns, and his definition of evolution as the development of systems is a clear outgrowth of Spencer's conception as progressive organization. Powell's reliance on the concepts of integration and differentiation as principles of order, and his identification of adaptation with progressive change are testimony to his Spencerian intellectual debt.

Nevertheless, Powell modified Spencer's ideas substantively. Powell defined organization more in its relation to motion than to matter. In Spencer, the emphasis was on the increasing structure of matter as motion was dissipated; in Powell the structural relations of matter were less in focus as motion was organized into systems.

The significance of this alteration appears in the sharper conceptual demarcations Powell drew between the realms of matter. For Spencer the structural relations in moving from the organic to the superorganic could be sharpened or blunted to suit his needs. In society's economic organization, Spencer could portray human beings as part of a complex, closely paralleling physiological organization; for regulatory organization, men's needs could be construed as if they were merely the units of simple aggregation, the species man. For Powell on the other hand, the different realms of existence consistently represented distinctly different orders of dynamic organization. Higher order realms were seen to embrace and organize the motions of the units of the subordinate levels. Mankind as a cooperatively industrious organism produced in society a higher order system of matter in motion. Society was a dynamic system that, whether viewed as a productive industrial entity or an entity requiring self-regulation, was something considerably more than a mere aggregation of its parts. It was this transformation from a static organizational model to a dynamic one that allowed Powell to accommodate his Morgan-based cultural perspective on society within the general progress-as-organization framework of Spencer's universal evolution.

Powell's evolutionary scheme was speculative. As a grand cosmic evolutionary scheme it reflected its synthetic Spencerian roots, relying heavily on plausibility and the appeal of universal evolutionary principles to carry its case. Verification of the processes hypothesized was problematic, yet ignored completely. At its best in the more limited sense of a theory of human cultural evolution, it shared with the ideas of Morgan that inspired it the defects of a shallow empirical foundation and the dubious presumption of a common evolutionary path for all ethnic groups. Powell like many ethnologists and other proto-anthropologists in the nineteenth century walked an impossibly thin line between ideals of scientific study and an irresistible thirst for insights into contemporary man's place in nature.[67]

But speculative or not, Powell's views on human evolutionary processes provide insights into the foundations of his connection of science and reform. We turn to this next.

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[67] John S. Haller, Jr., Outcasts from Evolution. Scientific Attitudes of Racial Inferiority, 1859-1900 (Urbana: University of Illinois Press, 1971), pp. 96-97. The tensions between anthropological and sociological interests in nineteenth-century ethnology can be better appreciated through Fred W. Voget's view of the general social science movement growing out of general historical studies during the Enlightenment, A History of Ethnology (New York: Holt, Rinehart, and Winston), pp. 41-165.

CHAPTER EIGHT

THE POSITIVE CONTEXT OF SCIENCE AND REFORM

We have already discussed in chapters Two through Six how Powell found important practical bearings for public lands administrative problems in the results of his scientific survey work. That is to say, Powell found his survey work no less valuable for serving institutional ills than for serving the traditional needs of industry. His appreciation of a practical import through experience was one important reason Powell committed himself to serving land system administration.

Intellectual considerations also played a part in Powell's commitment to science and reform, however. Powell's theories of social evolution provided him a philosophical rationale for actively applying science in the service of institutional growth and reform. The processes of evolution reviewed in the preceding chapter argued for the dependence of social progress on (among other elements) the interdependent, collateral growth of knowledge and institutions. Consequently, a commitment to social progress dictated that interaction between science and institutional growth be encouraged.

Powell had no occasion to use this rationale directly, so far as I have been able to discover, but his use of evolutionary concepts and principles to justify related activities argues that evolution theory did play some part in his commitment to institutional reform. For example, Powell used his evolutionary ideas to support certain of his proposals for land law reforms. In 1890, during the period of the Irrigation Survey and renewed debate on desert land policy reforms, Powell again found himself advocating legislation to allow settlers to homestead and irrigate large tracts of public land on a colony or irrigation district plan. In advocating the new policy Powell used his evolutionary views as a framework to provide a stage-setting historical perspective on the course of western settlement and development.

> These [first] armies [of miners and prospectors] were composed of stalwart men, adventurous, brave, and skillful. Away in the wilderness, without capital, but endowed with brawn and brains, they established industries, [and] organized institutions . . . adapted to their industrial wants. It is thus that a new phase of Aryan civilization is being developed in the western half of America.[1]

In contemplating the role of one of the newer western corporate institutions, the water company, Powell again applied his evolutionary model.

> Many of the great industrial undertakings of mankind require organized labor, and this demand grows with the development of inventions and the use of machinery. The transfer of toil from the muscles of men to the sinews of nature [as mankind has progressed] has [had] a double result--social solidarity is increased, and mind is developed. . . . [More recently the] integration of society in industrial operations is accomplished through the agency of capital. This organization . . . is accomplished by instituting corporations [which] . . . furnish money and machinery, and employ men

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[1]J. W. Powell, "Non-Irrigable Lands of the Arid Region," The Century, 1890, 39:921-22.

> organized under superintendents, to accomplish the works necessary to our modern civilization.[2]

Powell then raised his idea of irrigation districts as the preferable format for arid lands settlement. He viewed these irrigation districts, it seems clear, as the latest in the line of institutional and industrial innovations contributing to the growth of civilization in the arid regions of the West. Powell thus used evolution theory to buttress his convictions on the value of certain reform proposals.

Powell justified the U. S. Geological Survey itself as a vital, progressive institutional innovation by reference to his evolution theory. This was illustrated in Powell's testimony in 1884 before a special congressional commission appointed to explore reorganization as a means of cutting the expense of the government's varied scientific efforts. Powell discussed the growth and function of the government scientific agencies at this time and again turned to his evolutionary scheme for perspective. Defending against the contention that private efforts in science were most productive, Powell emphasized the power of combined action as a universal principle of human progress. "In all the primary operations of civilization," Powell offered, "there is a steadily increasing division of labor and a steadily increasing integration by the organization of labor." This organization of labor took place through the establishment of corporations by private individuals

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[2] Idem, "Institutions for the Arid Lands," The Century, 1890, 40:115-16.

and also "through the assumption of operative functions by governments." In modern civilization, Powell maintained, the work of individuals was always inconsequent when compared to that organized as "an integral part of the operations of some body politic." Such organization of labor by governments was "the essential condition" for the advancement of modern society, and this was exhibited by operations of scientific research throughout the civilized world. It was "clearly illustrated," Powell insisted, "in the organization of the Geological Survey of the United States."[3]

Thus Powell saw exhibited in the Geological Survey, and more generally in all the bureaus of government involved in scientific work, the continuing specialization of purpose and combination of efforts that were characteristic of mankind's social progress.

Powell contended too that the work of these agencies displayed a high degree of integration with other activities in society. The government's scientific bureaus had evolved, he said, by a "long, slow growth, arising out of experienced wants." They had now reached a point where their work directly and indirectly cut across nearly the entire spectrum of American economic life, reaching "all the manufacturing establishments of the United States; . . . all the commerce of the United States on sea and on land;" and increasingly "all the agriculture of the United States as that agriculture

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[3] U. S. Congress, Senate, Testimony before the Joint Commission to Consider the Present Organizations of the Signal Service, Geological Survey, Coast and Geodetic Survey, and the Hydrographic Office of the Navy Department, Misc. Doc. 82, 49th Cong., 1st sess., 1886, p. 1080.

is dependent upon climate and weather." With the Geological Survey more particularly in mind Powell also cited "all the mining industries" and, through construction of highways and water systems and sanitary works, "all the engineering industries of the United States." Even the great administrative problems of the public domain, "the irrigable and pasturage lands of the arid country, . . . the reclamation of all swamp lands, [and] . . . the reclamation of all flood plains on the great rivers," Powell claimed were now connected to the evolving efforts of government science.[4]

There can be little doubt, then, that Powell's evolutionary scheme helped to sustain his commitment to land system reform by providing it a legitimating context: evolution theory delineated a natural order in which progress across the entire spectrum of human economic and social life depended on contributions from science.

There is a deeper and more important philosophical foundation for Powell's connection of science and reform, however. This is to be expected, for Powell's pattern of activism antedates the articulation of his evolution theory by nearly a decade. This foundation resides in the intellectual milieu that spawned Powell's evolutionary ideas. As an ethnologist and social thinker, the events and influences recounted in preceding chapters indicate that Powell was a product of the nineteenth century's broad social science intellectual currents. More particularly, Powell's thought and his commitments to science and its service for social reform reflect a

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[4]Ibid., p. 179.

heritage in nineteenth-century positivism.

We have seen that Powell encountered ideas originating in the realm of anthropological and social thought at least as early as the time of his Colorado River expeditions under Smithsonian auspices early in the 1870s. After 1873 and his special commission to study the condition of certain Great Basin tribes for the Bureau of Indian Affairs, Powell made ethnology a primary object of his scientific attention.

Over the middle years of the 1870s, at a time when experience was teaching Powell important practical connections between the geographical and geological work of his survey and a variety of public policy issues related to public lands settlement, this increasing involvement in ethnology simultaneously immersed him in a mass of social thought that underscored the lessons of his experience. The philosophy of Auguste Comte and the similar refrains of British social thinkers like Herbert Spencer--positivism broadly construed--preached a gospel of social reform rooted in a commitment to the broad social utility of science.

Positivism for some today means little more than a commitment to the empirical methods of science that were being identified and vigorously promoted in the first half of the nineteenth century by Comte, John Stuart Mill, and others. To others still, positivism means the Positive Philosophy of Comte and his doctrinaire disciples.[5] But to much of the nineteenth century after Comte and his call for sociology--for a science focused on man and society--positivism meant more than an epistemology: positivism meant a commitment to science as the means to a more just, rationally constructed social order. This broad understanding of positivism, we recall, lay at the base of the favorable reception accorded Herbert Spencer by many in the American social science movement. Thus, historian J. W. Burrow has characterized nineteenth-century positivism as "the attempt to apply scientific methods to as wide a variety of social phenomena as possible," and another, H. Stuart Hughes, as "the whole tendency to discuss human behavior in terms of analogies drawn from natural science."[6]

Historian Ralph Henry Gabriel has described Powell as a "high priest of the new positivism."[7] Indeed, although Powell's ambitions

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[5]An example of positivism in the purely epistemological sense and applied in nineteenth-century history is George H. Daniels, American Science in the Age of Jackson (New York: Columbia University Press, 1968), pp. 144, 262. Comte's assessment of scientific methodology, and the mutual influences of Comte and Mill on each other are discussed by Larry Laudan, "Towards a Reassessment of Comte's 'Method Positive'," Philosophy of Science, 1971, 33:35-53. W. M. Simon, European Positivism in the Nineteenth Century (Ithaca, N.Y.: Cornell University Press, 1965), pp. 3-4, advocates limiting the meaning of positivism to Comtism.

[6]J. W. Burrow, Evolution and Society. A Study in Victorian Social Theory (Cambridge: At the University Press, 1970; c. 1966), p. 1; H. Stuart Hughes, Consciousness and Society. The Reorientation of European Social Thought, 1890-1930 (New York: Alfred A. Knopf, 1958), p. 37.

[7]Ralph Henry Gabriel, The Course of American Democratic Thought, 2nd ed. (New York: Ronald Press, 1956), p. 179.

for social reform were not so sweeping as Comte's or many others active in later movements for social science and social reform, his objectives for reform of the nation's public land system were nevertheless predicated on positivist presumptions. The positivists' commitments to science and to its use in ameliorating the human condition are the keys to understanding John Wesley Powell's linkage of science and reform.

The tenets of nineteenth-century positivism helped Powell validate his increasing involvement of survey energies on behalf of land system problems. At a general level the positivist doctrines maintaining the possibility and desirability of science-based social reform presumably nurtured the similar ambitions kindled in Powell's mind through is experience in the West. More important, positivism provided Powell a rational basis to support his growing belief in the broad social utility of his survey work on the public lands. It provided a logic, in fact, linking basic science to the entire spectrum of human activities.

Comte cogently stated a fundamental presupposition of this logic, that man's power to act is in proportion to his understanding of the natural order.

> There can be no doubt that man's study of nature must furnish the only basis of his action upon nature; for it is only by knowing the laws of phenomena, and thus being able to foresee them, that we can, in active life, set them to modify one another for our advantage.

Whenever man accomplishes any great effects, Comte maintained, "it is through a knowledge of natural laws."[8]

The "prevision"[9] or foresight provided through knowing nature's patterns and being able to predict or forecast the consequences of events and actions--this was the basis of man's dominion over nature.

The spectrum of nature's organization from simple to complex phenomena demanded a hierarchical relationship among the sciences. Comte classified nature's phenomena from simple to more complex in the inorganic division as astronomical, terrestrial, and chemical. In the organic division of living forms phenomena were physiological and--for life in its gregarious aspects--sociological. The sciences were related to each other in a corresponding sequence, with those treating simpler phenomena being logical preconditions for comprehension of the more complex. Generally, Comte emphasized, "no science can be effectively pursued without the preparation of a competent knowledge of the anterior sciences on which it depends."[10]

A proper sociology, or science of man, thus depended upon mastery of all natural sciences. Moreover, scientific studies of any practical consequence for man were just as demanding if

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[8]Auguste Comte, The Positive Philosophy of Auguste Comte, trans. and condensed by Harriet Martineau, vol. 1 (London: John Chapman, 1853), p. 19.

[9]Ibid.

[10]Ibid., pp. 25-27, 30.

rigorously pursued. "A true theory of Agriculture," Comte contended, "requires a combination of physiological, chemical, mechanical, and even astronomical and mathematical science."[11]

Consequently, Comte held that the practical endeavors of mankind, in order to be progressive, had to be based on the proper comprehension of the simpler phenomena which they sought to control. Hence his dictum that man's study of nature furnish the only basis of his action on nature.

This same perspective characterized Powell's survey work. Powell knew, for example, that a knowledge of the earth's geological structure was a key to unlocking its resources. Without it man's search for mineral wealth in the hidden reaches below the surface would be an inefficient process indeed.[12]

Powell attacked land system problems from the same standpoint, using the knowledge of physical science as a foundation for judgment and action. Problems related to material resources, for example, were treated in terms of the geophysical processes producing them. In designating the lands in the arid region suited to timber production, we found Powell assessed not only the facts of existing locations and supplies of timber but also the probable impact on forest growth of fire and climatic extremes. Similarly, he determined the boundaries of the arid region not simply on the facts of

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[11] Ibid., p. 21.

[12] Senate, "Joint Commission," Misc. Doc. 82, 1886, pp. 699-700.

average annual precipitation, but with atmospheric circulation patterns and latitudinal insolation differences also held in mind. His assessment, too, of the rise in the level of Great Salt Lake and its significance for future water supplies in the arid region depended on a complex, if qualitative, physical stream flow model.

The view that a study of nature was the only proper foundation for effective human effort was also the basis of Powell's campaign to replace the contract land survey system of the General Land Office with a permanent, professional geographical and geological survey of the public domain. The Land Office surveys were inadequate not so much because they were rectangular surveys on the township system, but because they were broadly unscientific enterprises. There was no system to the collection of information about the land and its resources, nor means to assure its validity. The information acquired was inadequate and undependable, while daily the need for more and better information increased as administrative needs of the land system became more complex. Geological and geographical science, on the other hand, focusing naturally on the earthly stage of mankind's experience, systematically gathered information that was immediately useful for basic industrial needs and was valuable as well for the government's needs in its administration of development of the public lands.

Indeed, the entire thrust of Powell's report on the public domain and of his subsequent attempt to supplant the public land surveys is bound up in his hope that he could provide the "wise prevision"[13] needed to sustain the development of the arid West. Powell would create that prevision with science. That which Comte preached, Powell too believed: "From science comes prevision; from prevision comes action."[14]

This is not to suggest that Powell was a disciple of Comte's Positive Philosophy. On the contrary, Herbert Spencer's evolutionary positivism--excepting his sociological principles--predominated in Powell's philosophical make-up. But the Comtean viewpoint on the power promised by science in the full spectrum human endeavor best captures the essence of the positivist faith in science as a mainspring of human progress. That essential positivist perspective underlies the linkage in Powell's evolution theory of opinion or intellect as an interdependent part of the growth of all other human activities; it underlies Powell's confident pursuit of studies on the organization of American Indian society, and ethnological studies generally; it is the foundation of Powell's use of science in analyzing the problems of public lands development in his treatise on the Lands of the Arid Region. Positivism in essence is the foundation underlying his active involvement in land system issues throughout his public career.

In searching out the underpinnings of John Wesley Powell's joint commitment to science and to reform of the public land system

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[13]See above, p. 132.

[14]Comte, Positive Philosophy, p. 19.

we have ranged over a broad ground. We have traced the sources of Powell's activism to his practical and intellectual experience. Powell at an early point discovered the usefulness of the science carried out under his survey for problems faced in the growth and settlement of the West. His surveys took him to the scene of the frontier, and there he found geological and ethnological knowledge relevant to frontier problems. Ethnology taught about an economic and social structure of Indian culture that was largely incongruent with the assumptions of federal Indian policy, and it presented at the same time the potential of new avenues for approaching Indian problems. Similar lessons were learned in the survey's mainline geographical and geological work, where a broad appreciation of the physical phenomena present on the surface of the earth offered many implications for man's activities. Irrigation, which to achieve its full potential required the development of large rivers and great, carefully engineered water supply systems, created a need for topographical and geological information--the same kind of information generated under Powell's survey for scientific needs.

Moreover, a broad knowledge of the resource environment of the West promised great service in the government's oversight of economic development on the public domain. A policy that presumed erroneous physical conditions was doomed to ineffectiveness. This was Powell's view of homestead policy, which wrongly predicated a sufficient rainfall for farming everywhere on the public domain. Powell's knowledge of the western landscape suggested a more accurate picture of the distribution of key resources and thus a more realistic basis for policy-making.

Powell's innate capacity for insight was no doubt a factor in these discoveries, but the physical-mechanical perspective he displayed in his scientific work no doubt served him exceptionally well in drawing out practical implications. In his geology we saw a clear tendency to think and organize in terms of dynamic processes, and it is likely that such concepts proved especially fertile ground for contemplating the effects of various human actions. Powell's perspective on primitive cultures also was mechanical, emphasizing the active processes underlying the production of arts, institutions, languages, and opinion. Here, too, such a dynamic perspective was useful, as in assessing the consequences of forced institution of private property on Indians to encourage civilized ways.

Consequently, it was quite reasonable for Powell to try to extend the benefits of science into the social problems areas he felt could be addressed. This was the basis of his attempt in 1878 to dismantle the contract system of public land surveys and to take over their responsibilities.

But Powell also found philosophical support for his broad view of the value of science. In the ideas of ethnologist Lewis Henry Morgan he found a dynamic view of human progress that placed great stock in the growth of social and political institutions. It emphasized as well the interaction between these and all other aspects of culture. Powell combined these ideas with Herbert Spencer's framework of universal evolution to produce a theory that highlighted the roles of social institutions and, in the modern era, of science in driving the wheels of human progress. This theory provided Powell a legitimating context for his ambitions of an expanded governmental survey of the public domain and for other changes in land system institutions.

As this chapter has endeavored to point out, however, the presumptions underlying Powell's theory stem from the nineteenth century's optimism about how science could aid the cause of social progress. Nineteenth-century positivism combined a faith in the empirical methods of science with a humanist imperative for a better society. Positivism was committed to social progress through the use of science to improve the institutions of society.

John Wesley Powell as a socially concerned scientist was swept up in this intellectual current. Powell's work to promote both science and a more effective administration of the public domain stands as a monument to the influence of positivism in the last quarter of the nineteenth century.

SELECTED BIBLIOGRAPHY

Archival Materials

Rochester, New York. University of Rochester Library. Lewis Henry Morgan Papers.

Washington, D.C. National Archives. "Letters Received by John Wesley Powell, Director of the Geographical and Geological Survey of the Rocky Mountain Region, 1869-79." Record Group 57: Records of the Geological Survey. Microcopy No. 156.

________. "Letters Received by the United States Geological Survey, 1879-1901." Record Group 57: Records of the Geological Survey.

________. "Letters Sent by the United States Geological Survey, 1879-1895." Record Group 57: Records of the Geological Survey.

Public Documents (Periodical)

Smithsonian Institution. Annual Report of the Board of Regents. Washington, D.C. Annuals, 1869-1879.

________. Bureau of Ethnology. Annual Report. Washington, D.C.: Government Printing Office. First through Seventh reports, issued 1881-1891.

U. S. Congress. Congressional Globe. 39th through 42nd Congress, 1866-1873.

________. Congressional Record. 43rd through 53rd Congress, 1873-1895.

U. S. Department of Agriculture. Report of the Commissioner. Washington, D.C. Annuals, 1879-1888.

________. Report of the Secretary. Washington, D.C. Annuals, 1888-1892.

U. S. Geological Survey. Annual Report. Washington, D.C. First through Fifteenth reports, 1880-1894.

U. S. Interior Department. Report of the Secretary. Washington, D.C. Annuals, 1866-1890.

U. S. Patent Office. Report of the Commissioner. Agriculture. Washington, D.C. Annuals, 1847-1878.

Works by John Wesley Powell

Powell, J. W. "A Biographical Notice of Robert Archibald Marvine." Bulletin of the Philosophical Society of Washington, 1874-78, vol. 2, Appendix X.

________. "A Classification of the Sciences," [abstract]. Science, 1883, 2:370.

________. "Competition as a Factor in Human Evolution." American Anthropologist, 1888, 1:297-323.

________. "Darwin's Contributions to Philosophy," Proceedings of the Biological Society of Washington, 1882, 1:60-70.

________. Exploration of the Colorado River of the West, and its Tributaries, Explored in 1869, 1870, 1971, and 1872, under the Direction of the Secretary of the Smithsonian Institution. Washington, D.C.: Government Printing Office, 1875.

________. "From Barbarism to Civilization." American Anthropologist, 1888, 1:97-123.

________. "From Savagery to Barbarism." Transactions of the Anthropological Society of Washington, 1885, 3:173-96.

________. "Human Evolution." Transactions of the Anthropological Society of Washington, 1883, 2:176-208.

________. "Indian Linguistic Families of America north of Mexico." In Seventh Annual Report, 1885-86, pp. 1-142. Smithsonian Institution. Bureau of Ethnology. Washington, D.C.: Government Printing Office, 1891.

________. "Institutions for the Arid Lands." The Century, 1890, 40:111-16.

________. Introduction to the Study of Indian Languages, with Words, Phrases and Sentences To Be Collected. Washington, D.C.: Government Printing Office, 1877.

________. "Irrigable Lands of the Arid Region." The Century, 1890, 39:766-76.

Powell, J. W. "Linguistics." In Tribes of California pp. 469-613. By Stephen Powers. U. S. Geographical and Geological Survey of the Rocky Mountain Region. Contributions to North American Ethnology, vol. 3. Washington, D.C.: 1977.

________. "Non-Irrigable Lands of the Arid Region." The Century, 1890, 39:915-22.

________. "On Actival Similarities." In Third Annual Report, 1881-82, pp. LXV-LXXIV. Smithsonian Institution. Bureau of Ethnology. Washington, D.C.: Government Printing Office, 1884.

________. "On the Evolution of Language." In First Annual Report, 1879-80, pp. 1-16. Smithsonian Institution. Bureau of Ethnology. Washington, D.C.: Government Printing Office, 1881.

________. "On the Limitations to the Use of Some Anthropological Data." In First Annual Report, 1878-80, pp. 73-86. Smithsonian Institution. Bureau of Ethnology. Washington, D.C.: Government Printing Office, 1881.

________. "Outlines of Sociology." Transactions of the Anthropological Society of Washington, 1882, 1:106-29.

________. "Outlines of the Philosophy of the North American Indians." Journal of the American Geographical Society of New York, 1878, 8:251-68.

________. [Remarks on "Political-Social Functions," by Lester F. Ward]. Transactions of the Anthropological Society of Washington, 1882, 1:42-43.

________. "Remarks on the Structural Geology of the Valley of the Colorado of the West." Bulletin of the Philosophical Society of Washington, 1871-74, 1:48-51.

________. Report on the Geology of the Eastern Portion of the Uinta Mountains, and a Region of the Country Adjacent thereto, with Atlas. U. S. Geological and Geographical Survey of the Territories. Second Division. Washington, D.C.: 1876.

________. "Sketch of Lewis H. Morgan." Popular Science Monthly, 1880, 18:114-21.

________. "Sketch of the Mythology of the North American Indians." In First Annual Report, 1879-80, pp. 19-56. Smithsonian Institution. Bureau of Ethnology. Washington, D.C. Government Printing Office, 1881.

Powell, J. W. "Some Remarks on the Geological Structure of a District of Country Lying to the North of the Grand Canyon of the Colorado." American Journal of Science, 3rd series, 1873, 5:456-65.

________. "The Three Methods of Evolution." Bulletin of the Philosophical Society of Washington, 1884, 6:XXVII-LII.

________. Truth and Error. Or the Science of Intellection. Chicago: Open Court Publishing, 1898.

[Powell, J. W.] "Ward's Dynamic Sociology," Science, 1883, 2:45-49; 105-108; 171-74; 222-26.

Powell, J. W. "Wyandott Government. A Short History of Tribal Society." In First Annual Report, 1879-80, pp. 59-69. Smithsonian Institution. Bureau of Ethnology. Washington, D.C.: Government Printing Office, 1881.

Powell, J. W., and Ingalls, G. W. "Report of J. W. Powell and G. W. Ingalls." In Annual Report of the Secretary, 1873, pp. 409-38. U. S. Interior Department. Washington, D.C.: 1873.

U. S. Congress. House. "Professor Powell's Report on the Survey of the Colorado of the West." Misc. Doc. 265, 43rd Cong., 1st sess., 1874.

________. "Report of the Survey of the Colorado of the West." Misc. Doc. 76, 42nd Cong., 3rd sess., 1873.

________. Report on the Lands of the Arid Region of the United States, with a More Detailed Account of the Lands of Utah, by J. W. Powell, Ex. Doc. 73, 45th Cong., 2nd sess., 1878.

________. "Survey of the Colorado River of the West." Misc. Doc. 173, 42nd Cong., 2nd sess., 1872.

U. S. Geographical and Geological Survey of the Rocky Mountain Region. Report on the Lands of the Arid Region of the United States, with a More Detailed Account of the Lands of Utah, with Maps. By J. W. Powell. 2nd ed. Washington, D.C.: 1879.

Other Sources

Alexander, Thomas G. A Clash of Interests: Interior Department and Mountain West, 1863-96. Provo, Utah: Brigham Young University Press, 1977.

________. "The Powell Irrigation Survey and the People of the Mountain West." Journal of the West, 1968, 7:48-53.

Baillie, John. The Belief in Progress. New York: Charles Scribner's Sons, 1951.

Bannister, Robert C. Social Darwinism. Science and Myth in Anglo-American Social Thought. Philadelphia: Temple University Press, 1979.

Barrell, Joseph. "The Growth of Knowledge of Earth Structure." In A Century of Science in America, with Special Reference to the American Journal of Science 1818-1918, pp. 170-88. Ed. by Edward Salisbury Dana. New Haven: Yale University Press, 1918.

Bartlett, Richard A. Great Surveys of the American West. Norman: University of Oklahoma Press, 1962.

Bernard, L. L. and Jessie Bernard. Origins of American Sociology. The Social Science Movement in the United States. New York: Thomas Y. Crowell, 1943.

Boller, Paul F. American Thought in Transition: The Impact of Evolutionary Naturalism, 1865-1900. Chicago: Rand-McNally, 1969.

[Boyd, David]. A History of Greeley and the Union Colony of Colorado. N.p.: [1890?].

Brough, Charles Hillman. Irrigation in Utah. Johns Hopkins University Studies in Historical and Political Science, Extra Volume 19. Baltimore: Johns Hopkins Press, 1898.

Browne, J. Ross. "Reclamation and Irrigation." In Transactions of the California State Agricultural Society during the Year 1872, pp. 420-23. Sacramento: T. A. Springer, State Printer, 1873.

Burrow, J. W. Evolution and Society. A Study in Victorian Social Theory. Cambridge: At the University Press, 1970; c. 1966.

Bury, J. B. The Idea of Progress. An Inquiry into its Origin and Growth. New York: MacMillan, 1932.

Carstensen, Vernon, ed. The Public Lands. Studies in the History of the Public Domain. Madison: University of Wisconsin Press, 1963.

Chamberlin, Thomas C. "Requisite and Qualifying Conditions of Artesian Wells." In Fifth Annual Report, 1883-84, pp. 125-73. U. S. Geological Survey. Washington, D.C.: 1884.

Chorley, Richard J.; Dunn, Antony J.; and Beckinsale, Robert P. The History of the Study of Landforms, or the Development of Geomorphology. Vol. 1: Geomorphology before Davis. London: Methuen and Co., John Wiley and Sons, 1964.

Chugerman, Samuel. Lester F. Ward. The American Aristotle. Durham, North Carolina: Duke University Press, 1939.

"Colonization." In Report of the Commissioner, 1870. Agriculture, pp. 569-73. U. S. Patent Office. Washington, D.C.: 1871.

Commager, Henry Steele, ed. Lester Ward and the Welfare State. Indianapolis, Ind.: Bobbs-Merrill, 1967.

Comte, Auguste. The Positive Philosophy of Auguste Comte. Translated and condensed by Harriet Martineau. 2 vols. London: John Chapman, 1853.

Dana, Edward Salisbury, ed. A Century of Science in America, with Special Reference to the American Journal of Science 1818-1918. New Haven: Yale University Press, 1918.

Daniels, George H. American Science in the Age of Jackson. New York: Columbia University Press, 1968.

________, ed. Nineteenth-Century American Science. A Reappraisal. Evanston, Ill.: Northwestern University Press, 1972.

Darnell, Regna Diebold. "The Development of American Anthropology 1879-1910: From the Bureau of Ethnology to Franz Boas." Ph.D. dissertation, University of Pennsylvania, 1969.

________, ed. Readings in the History of Anthropology. New York: Harper and Row, 1974.

Darrah, William Culp. Powell of the Colorado. Princeton: Princeton University Press, 1951.

________, ed. "Major J. D. Powell's Report on his Exploration of the Rio Colorado in 1869." Utah Historical Quarterly, 1947, 15:21-27.

Darwin, Charles. The Descent of Man and Selection in Relation to Sex, 2nd ed. New York: D. Appleton, 1874.

Davis, W[illiam] M[orris]. "Biographical Memoir of Grove Karl Gilbert." National Academy of Sciences. Biographical Memoirs. Vol. 21, no. 2. Washington, D.C.: National Academy of Sciences, 1926.

________. "Biographical Memoir of John Wesley Powell, 1834-1902." National Academy of Sciences. Biographical Memoirs. Vol. 8. Washington, D.C.: National Academy of Sciences, 1915.

Davison, Stanley Roland. "The Leadership of the Reclamation Movement, 1875-1902." Ph.D. dissertation, University of California at Berkeley, 1952.

De Laguna, Frederica, ed. Selected Papers from the American Anthropologist 1888-1920. Evanston, Ill.: Row, Peterson, 1960.

Dumke, Glenn S. The Boom of the Eighties in Southern California. San Marino, Calif.: Huntington Library, 1966; c. 1944.

Dunbar, Robert G. "The Significance of the Colorado Agricultural Frontier." Agricultural History, 1960, 34:119-25.

________. "Water Rights and Controls in Colorado." Agricultural History, 1948, 22:180-86.

Dunham, Harold H. Government Handout. A Study in the Administration of the Public Lands 1875-1891. Ph.D. dissertation, Columbia University, 1941. Reprint ed., New York: De Capo Press, 1970.

Dupree, A. Hunter. Science in the Federal Government. A History of Policies and Activities to 1940. Cambridge: Belknap Press of Harvard University Press, 1957.

Eisley, Loren. Darwin's Century. Evolution and the Men Who Discovered It. Garden City, N.Y.: Doubleday and Co., 1958.

Ekirch, Arthur Alphonse, Jr. The Idea of Progress in America, 1815-1860. Studies in History, Economics, and Public Law. No. 511. New York: Columbia University, 1944.

Ellegård, Alvar. "The Darwinian Theory and Nineteenth-Century Philosophies of Science." Journal of the History of Ideas, 1957, 18:362-93.

Ellet, Charles, Jr. The Mississippi and Ohio Rivers. Philadelphia: Lippincott, Grambo, 1853.

________. On the Physical Geography of the Mississippi Valley, with Suggestions for the Improvement of the Navigation of the Ohio and Other Rivers. Smithsonian Institution. Contributions to Knowledge, vol. 2. Washington, D.C.: Smithsonian Institution, 1850.

Emmons, David M. and Kutzleb, Charles R. "American Myth: Desert to Eden." Forest History, October 1971, vol. 14, no. 3:6-21.

Fine, Sidney. Laissez Faire and the General-Welfare State. A Study of Conflict in American Thought 1865-1901. Ann Arbor: University of Michigan Press, 1956.

Fite, Gilbert C. The Farmer's Frontier 1865-1900. New York: Holt, Rinehart, and Winston, 1966.

Follansbee, Robert. A History of the Water Resources Branch of the United States Geological Survey to June 30, 1919. [Washington, D.C.: 1939].

Fowler, Don D., and Fowler, Catherine S. "John Wesley Powell, Anthropologist." Utah Historical Quarterly, 1969, 37:152-72.

Fowler, Don D., and Matley, John. Material Culture of the Numa: The Powell Collection, 1868-1876. Smithsonian Contributions to Anthropology. Washington, D.C.: Smithsonian Institution Press, 1975.

[Friedlander, Issac]. Irrigation in California. The San Joaquin and Tulare Plains. Sacramento: Record Steam Book and Job Printing House, 1873.

Gabriel, Ralph Henry. The Course of American Democratic Thought. 2nd ed. New York: Ronald Press, 1956.

Ganoe, John T. "The Beginnings of Irrigation in the United States." Mississippi Valley Historical Review, 1938, 25:59-78.

________. "The Desert Land Act in Operation 1877-1891." Agricultural History, 1937, 11:142-57.

________. "Origin of a National Reclamation Policy." Mississippi Valley Historical Review, 1931-32, 18:34-52.

Giddens, Anthony, ed. Positivism and Sociology. London: Heinemann, 1974.

Gilbert, G[rove] K[arl], ed. John Wesley Powell: A Memorial to an American Explorer and Scholar. Chicago: Open Court, 1903.

Goetzmann, William H. Army Exploration in the American West 1803-1863. New Haven: Yale University Press, 1959.

________. Exploration and Empire. The Explorer and Scientist in the Winning of the American West. New York: Alfred A. Knopf, 1966.

________. "Paradigm Lost." In The Sciences in the American Context: New Perspectives, pp. 21-34. Edited by Nathan Reingold. Washington, D.C.: Smithsonian Institution Press, 1979.

Golzé, Alfred R. Reclamation in the United States. New York: McGraw-Hill, 1952.

Goodman, David Michael. A Western Panorama 1840-1875. The Travels, Writings, and Influence of J. Ross Browne. Glendale, Calif.: Arthur H. Clark, 1966.

The Great San Joaquin and Sacramento Valleys of California. A Great Irrigation Scheme. N.p.: [1873?].

Greene, John C. "Biology and Social Theory in the Nineteenth Century: Auguste Comte and Herbert Spencer." In Critical Problems in the History of Science, pp. 419-46. Edited by Marshall Clagett. Madison: University of Wisconsin Press, 1959.

________. "Darwin as a Social Evolutionist." Journal of the History of Biology, 1977, 10:1-27.

Haller, John S., Jr. Outcasts of Evolution. Scientific Attitudes of Racial Inferiority, 1859-1900. Urbana: University of Illinois Press, 1971.

Harris, Marvin. The Rise of Anthropological Theory. A History of Theories of Culture. New York: Thomas Y. Crowell, 1968.

Hawkins, Richmond Laurin. Auguste Comte and the United States. 1816-1853. Cambridge: Harvard University Press, 1936.

________. Positivism in the United States, 1853-1861. Cambridge: Harvard University Press, 1938.

Hays, Samuel P. Conservation and the Gospel of Efficiency. The Progressive Conservation Movement 1890-1920. Cambridge: Harvard University Press, 1959; reprint ed., New York: Atheneum, 1975.

Hazen W[illiam] B[abcock]. "The Great Middle Region of the United States, and Its Limited Space of Arable Land." North American Review, 1875, 120:1-34.

Hess, Ralph H. "The Beginnings of Irrigation in the United States." Journal of Political Economy, 1912, 20:807-833.

Hibbard, Benjamin H. A History of the Public Land Policies. New York: Peter Smith, 1939; c. 1924.

Hinsley, Curtis M., Jr. Savages and Scientists. The Smithsonian Institution and the Development of American Anthropology 1846-1910. Washington, D.C.: Smithsonian Institution Press, 1981.

Hofstadter, Richard. Social Darwinism in American Thought. Revised ed. Boston: Beacon Press, 1955. c. 1944, 1955.

Hughes, H. Stuart. Consciousness and Society. The Reorientation of European Social Thought 1890-1930. New York: Alfred A. Knopf, 1958.

"Irrigation Systems of Different Countries." In Report of the Commissioner, 1871. Agriculture, pp. 275-87. U. S. Patent Office. Washington, D.C.: 1872.

Ise, John. The United States Forest Policy. New Haven: Yale University Press, 1924.

James, Preston E. All Possible Worlds. A History of Geographical Ideas. Indianapolis: Odyssey Press, 1972.

Kinney, Clesson S. A Treatise on the Law of Irrigation and Water Rights, and the Arid Region. Doctrine of Appropriation of Waters. 2nd ed. 4 vols. San Francisco: Bender-Moss, 1912.

Korr, Charles P. "William Hammond Hall: The Failure of Attempts of State Water Planning in California, 1878-1888." Historical Society of Southern California Quarterly, 1963, 45:305-311.

Kottler, Malcolm Jay. "Alfred Russel Wallace, the Origin of Man, and Spiritualism." Isis, 1974, 65:145-92.

Laudan, Larry. "Towards a Reassessment of Comte's 'Method Positive'," Philosophy of Science, 1971, 38:35-53.

Lavender, David. Nothing Seemed Impossible. William C. Ralston and Early San Francisco. Palo Alto, Calif.: American West Publishing Co., 1975.

Lee, Lawrence B. Reclaiming the Arid West. An Historiography and Guide. Santa Barbara, Calif.: American Biographical Center, Clio Press, 1980.

Leeds. Anthony. "Darwinian and 'Darwinian' Evolutionism in the Study of Society and Culture." In The Comparative Reception of Darwinism, pp. 437-77. Edited by Thomas F. Glick. Austin: University of Texas Press, 1974.

Lenzer, Gertrud, ed. Auguste Comte and Positivism. The Essential Writings. New York: Harper Torchbooks, 1975.

Lester, Jacob Franklin. "John Fiske's Philosophy of Science: The Union of Science and Religion through the Principle of Evolution." Ph.D. dissertation, Oregon State University, 1979.

Lewis, Gene D. Charles Ellet, Jr. The Engineer as Individualist 1810-1862. Urbana: University of Illinois Press, 1968.

Lowie, Robert H. The History of Ethnological Theory. New York: Holt, Rinehart, and Winston, 1960; c. 1937.

Manning, Thomas G. Government in Science. The U. S. Geological Survey 1867-1894. N.p.: University of Kentucky Press, 1967.

Mead, Elwood. "Rise and Future of Irrigation in the United States." In Yearbook, 1899, pp. 591-612. U. S. Department of Agriculture. Washington, D.C.: 1900.

Merrill, George P. The First One Hundred Years of American Geology. New Haven: Yale University Press, 1924; facsimile ed., New York: Hafner Publishing Co., 1969.

Merz, John Theodore. A History of European Thought in the Nineteenth Century. 4 vols. London: William Blackwood & Sons, 1904-12; reprint ed., New York: Dover Publications, 1965.

"Modes and Results of Irrigation." In Report of the Commissioner, 1870. Agriculture, pp. 576-84. U. S. Patent Office. Washington, D.C.: 1871.

Moore, James R. The Post-Darwinian Controversies. A Study of the Protestant Struggle to Come to Terms with Darwin in Great Britain and America, 1870-1900. Cambridge: Cambridge University Press, 1979.

Morgan, Lewis H[enry]. Ancient Society, or Researches in the Lines of Human Progress from Savagery through Barbarism to Civilization. New York: Henry Holt, 1877.

Morgan, Lewis Henry. Ancient Society. Edited by Eleanor Burke Leacock. Gloucester, Mass.: Peter Smith, 1974; c. 1963.

________. Ancient Society. Edited by Leslie A. White. Cambridge: Belknap Press of Harvard University Press, 1963; reprinted from 2nd printing of original ed., New York: Henry Holt, 1878.

________. Houses and House-Life of the American Aborigines. U. S. Geographical and Geological Survey of the Rocky Mountain Region. Contributions to North American Ethnology, vol. 4. Washington, D.C.: 1881.

________. Systems of Consanguinity and Affinity of the Human Family. Smithsonian Institution. Contributions to Knowledge, vol. 17. Washington, D.C.: Smithsonian Institution, 1871.

Murphree, Idus L. "The Evolutionary Anthropologists: The Progress of Mankind. The Concepts of Progress and Culture in the Thought of John Lubbock, Edward B. Tylor, and Lewis Henry Morgan." Proceedings of the American Philosophical Society, 1961, 105:265-300.

Nash, Gerald D. "The Conflict Between Pure and Applied Science in Nineteenth-Century Public Policy: The California State Geological Survey, 1860-1874." Isis, 1963, 54:217-28.

________. State Government and Economic Development. A History of Administrative Policies in California, 1849-1933. Berkeley: University of California, Institute for Government Studies, 1964.

Nisbet, Robert. History of the Idea of Progress. New York: Basic Books, 1980.

"Notes from the Capital." New York Times, 30 April 1877, p. 5.

Osgood, Ernest Staples. The Day of the Cattleman. Minneapolis: University of Minnesota Press, 1929.

Pelzer, Louis. The Cattleman's Frontier. A Record of the Trans-Mississippi Cattle Industry from Oxen Trains to Pooling Companies 1850-1890. Glendale, Calif.: Arthur H. Clark, 1936.

Peel, J. D. Y. Herbert Spencer. The Evolution of a Sociologist. New York: Basic Books, 1971.

Pfeifer, Edward J. "United States." In The Comparative Reception of Darwinsim, pp. 168-206. Edited by Thomas F. Glick; Austin: University of Texas Press, 1974.

Pyne, Stephen J. Grove Karl Gilbert. A Great Engine of Research. Austin: University of Texas Press, 1980.

Reingold, Nathan, ed. Science in Nineteenth-Century America. A Documentary History. New York: Hill and Wang, 1964.

Resek, Carl. Lewis Henry Morgan. American Scholar. Chicago: University of Chicago Press, 1960.

Robbins, Roy M. Our Landed Heritage. The Public Domain 1776-1970. 2nd ed. Lincoln: University of Nebraska Press, 1976.

Scott, Clifford H. Lester Frank Ward. Boston: Twayne Publishers, 1976.

Sharlin, Harold I., Joseph F. Wall, and David A. Hollinger. "Spencer, Scientism, and American Constitutional Law." Annals of Science, 1976, 33:457-80.

Simon, W. M. European Positivism in the Nineteenth Century. Ithaca, N.Y.: Cornell University Press, 1963.

Smith, Henry Nash. "Clarence King, John Wesley Powell, and the Establishment of the United States Geological Survey." Mississippi Valley Historical Review, 1947, 34:37-58.

________. "Rain Follows the Plow: The Notion of Increased Rainfall on the Great Plains." Huntington Library Quarterly, 1947, 10:169-93.

________. Virgin Land. The American West as Symbol and Myth. Cambridge: Harvard University Press, 1950; Harvard Paperback, 1973.

Spencer, Herbert. First Principles. 4th ed. New York: D. Appleton, 1880; printed 1898.

________. The Principles of Sociology. 2 vols. New York: D. Appleton, 1897; preface dated 1882.

Stegner, Wallace. Beyond the Hundredth Meridian. John Wesley Powell and the Second Opening of the West. Cambridge, Mass.: Riverside Press, 1954.

Steinel, Alvin T. History of Agriculture in Colorado. Ft. Collins, Colo.: State Agricultural College, 1926.

Sterling. Everett W. "The Powell Irrigation Survey, 1888-1893." Mississippi Valley Historical Review, 1940, 27:421-34.

Stern, Bernhard J. Lewis Henry Morgan: Social Evolutionist. Chicago: University of Chicago Press, 1931.

________. "Lewis Henry Morgan Today. An Appraisal of his Scientific Contributions." Science and Society, 1946, 10:172-76.

Stocking, George W., Jr. "Lamarkism in American Social Science: 1890-1915." Journal of the History of Ideas, 1962, 23:239-56.

________. Race, Culture and Evolution. Essays in the History of Anthropology. New York: The Free Press, 1968.

________. "Some Problems in the Understanding of Nineteenth-Century Cultural Evolutionism." In Readings in the History of Anthropology, pp. 407-25. Edited by Regna Darnell. New York: Harper and Row, 1974.

Treadwell, Edward F. The Cattle King. A Dramatized Biography. Revised ed. Fresno, Calif.: Valley Publishers, 1966; c. 1950.

U. S. Congress. House. Committee on Public Lands. "Geographical and Geological Surveys West of the Mississippi." H. Rpt. 612, 43rd Cong., 1st sess., 1874.

________. Committee on Public Lands. "Public Surveys." Misc. Doc. 55, 45th Cong., 2nd sess., 1878.

________. "Cost of Geographical Surveys." Ex. Doc. 72, 45th Cong., 3rd sess., 1879.

________. "Geographical and Geological Surveys." Ex. Doc. 80, 45th Cong., 2nd sess., 1878.

________. "Irrigation in the United States." H. Rpt. 3767, Appendix B, 51st Cong., 2nd sess., 1891.

________. "Irrigation of the San Joaquin, Tulare, and Sacramento Valleys, California." Ex. Doc. 290, 43rd Cong., 1st sess., 1874.

________. "Report of the Commission of Engineers Appointed to Investigate and Report a Permanent Plan for the Reclamation of the Alluvial Basin of the Mississippi River Subject to Inundation." Ex. Doc. 127, 43rd Cong., 2nd sess., 1875.

________. Surveys of the Territories. Misc. Doc. 5, 45th Cong., 3rd sess., 1878.

U. S. Congress. Senate. Committee on Irrigation and Reclamation of Arid Lands. "Report of the Special Committee of the United States Senate on the Irrigation and Reclamation of Arid Lands." S. Rpt. 928, 51st Cong., 1st sess., 1890.

________. "Final Report of the Artesian and Underflow Investigation, and of the Irrigation Inquiry." Ex. Doc. 41, pts. 2-4, 52nd Cong., 1st sess., 1892.

________. "A Report on the Preliminary Investigation to Determine the Proper Location of Artesian Wells." Ex. Doc. 222, 51st Cong., 1st sess., 1890.

________. Testimony before the Joint Commission to Consider the Present Organizations of the Signal Service, Geological Survey, Coast and Geodetic Survey, and the Hydrographic Office of the Navy Department. Misc. Doc. 82, 49th Cong., 1st sess., 1886.

U. S. Department of Agriculture. Artesian Wells upon the Great Plains. [Report No. 19]. Washington, D.C.: 1882.

U. S. Geographical and Geological Survey of the Rocky Mountain Region. Report on the Geology of the Henry Mountains. By G. K. Gilbert. Washington, D.C.: 1876.

U. S. Geological Survey. Catalogue and Index of the Hayden, King, Powell, and Wheeler Surveys. By L. F. Schmeckebier. Geological Survey Bulletin No. 222. Washington, D.C.: 1904.

________. The Colorado Region and John Wesley Powell. By Mary C. Rabbitt, et al. Professional Paper 669. Washington, D.C.: 1969.

________. Minerals, Lands, and Geology for the Common Defence and General Welfare. By Mary C. Rabbitt. Vol. 1: Before 1879. Washington, D.C.: 1879. Vol. 2: 1879-1904. Washington, D.C.: 1880.

U. S. Public Land Law Review Commission. History of Public Land Law Development. By Paul W. Gates and Robert W. Swenson. Washington, D.C.: 1968.

Voget, Fred W. A History of Ethnology. New York: Holt, Rinehart, and Winston, 1974.

Ward, Lester F. Dynamic Sociology, or Applied Social Science, as Based upon Statistical Sociology and the Less Complex Sciences. 2 vols. New York: D. Appleton, 1883.

Walcott, Charles D.; Henderson, D. B.; Van Hise, C. R.; Gilbert, G. K.; McGee, W. J.; Langley, S. P.; and Warman, P. C. "John Wesley Powell. Proceedings of a Meeting Commemorative of His Distinguished Services." Proceedings of the Washington Academy of Sciences, 1903, 5:99-187.

Warman, P. C. "Catalogue of the Published Writings of John Wesley Powell." Proceedings of the Washington Academy of Sciences, 1903, 5:131-87.

Watson, Elmo Scott, ed. The Professor Goes West. Bloomington, Ill.: Illinois Wesleyan University Press, 1954.

Webb, Walter Prescott. The Great Plains. Boston: Ginn & Co., 1931.

White, Charles A. "Artesian Wells upon the Great Plains." North American Review, 1882, 135:187-95.

Wibberly, Leonard. Wes Powell: Conqueror of the Grand Canyon. New York: Farrar, Straus, and Cudahy, 1958.

Wilkins, Thurman. Clarence King. A Biography. New York: MacMillan, 1958.

Wilson, Herbert M. "American Irrigation Engineering." In Thirteenth Annual Report, 1891-92. Pt. 3: Irrigation, pp. 101-349. U. S. Geological Survey. Washington, D.C.: 1892.

Wiltshire, David. The Social and Political Thought of Herbert Spencer. Oxford: Oxford University Press, 1978.

Winther, Oscar Osburn. "The Colony System of Southern California." Agricultural History, 1953, 27:94-103.

Wright, Chauncey. Philosophical Discussions. Edited by Charles F. Norton. New York: Henry Holt, 1877.

Zittel, Karl Alfred von. History of Geology and Paleontology to the End of the Nineteenth Century. Translated by Maria M. Olgilvie-Gordon. London: Walter Scott, 1901. New York: Charles Scribner's Sons, 1901.