Short History of Watershed Management in the Forest Service: 1897 to 2100

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Congressional direction for administration of the forest reserves, now called national forests, began in 1897 with passage of the Organic Administration Act. One of the defined purposes for which forest lands were set aside from settlement was "securing favorable conditions of water flow." Subsequent passage of over 25 other federal statutes further defined watershed management on these lands, and federal courts have interpreted these laws since 1908 in ways that sometimes expanded, sometimes contracted, delegated authorities. The Research Branch began watershed experiments in 1910 at Wagon Wheel Gap, Colorado, and has since expanded to 24 research watersheds. The contributions of certain individuals, the 1930s Civilian Conservation Corps, the barometer watershed program in the 1960s, and the State and Private Forestry suite of watershed technical assistance are discussed. Finally, possible future watershed management scenarios in the Forest Service in the years 2050 and 2100 are briefly discussed.

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Beginnings: 1897-1911

When the first forest reserve (Yellowstone) was proclaimed in 1891, President Harrison was trying to stop exploitation and destruction of the forests adjacent to Yellowstone National Park – nothing more. No direction was provided to the General Land Office personnel responsible for administering this piece of the public domain, nor was much money appropriated for it. Other forest reserves established from 1892 to 1897 suffered from the same lack of consistent direction. Foresters in the federal Bureau of Forestry were fearful of the consequences and supported efforts in the Congress, led by Senators A. S. Paddock and R. Pettigrew and Congressman T. R. McRae, to obtain passage of a bill that would put the federal forest lands on a course of purposeful and professional management (Steen 1976). The answer was what is known today as the Forest Service Organic Administration Act of 1897.

Gifford Pinchot, then an employee of the Bureau of Forestry, was the first professional forester in the United States. He had studied in France and had read George Perkins Marsh's 1864 landmark monograph *Man and Nature: Or, Physical Geography as Modified by Human Action*. He was also greatly influenced by Marsh's conclusions that many civilizations had vanished as a result of abusing their watersheds to the point where severe erosion and polluted water supplies deprived them of necessary resources for their survival. Pinchot hired other college educated professionals able to put American forest conservation on a solid footing, and who were capable of persuading local settlers to accept wise use of forest resources and the need to obtain special use permits prior to removing timber, grazing livestock, building dams, and conducting other activities on the national forest reserves.

In 1898 the Department of the Interior's General Land Office (GLO) made its first timber sale on a forest reserve. The Homestake Mining Company purchased 15 million board feet (35396 m^3) of timber on the Black Hills reserve (South Dakota) at one dollar per thousand board feet (Fedkiw 1998). By 1901, the GLO and the USDA Division of Forestry were sharing the management of the forest reserves, with the GLO patrolling them for trespassers and the foresters providing technical advice. In 1902, Interior issued its Forest Reserve Manual. When the reserves were transferred to the Department of Agriculture in 1905, the Forest Service quickly issued its own Use Book which had stated objectives of the forest reserves as … "preserving a perpetual supply of timber for home industries, preventing the destruction of forest cover which regulates the flow of streams, and protecting local residents from unfair competition in the use of forest and range." (USDA Forest Service 1905)

Raphael Zon was one of Pinchot's hired professionals. Born in Russia and an immigrant into the United States in the 1890s, Zon was a key figure in establishing and continuing the watershed experiments on the Rio Grande National Forest at Wagon Wheel Gap, Colorado, from 1910 to 1926 (Schmaltz 1983). The experiment in clearcutting one small watershed while leaving an adjacent, similar watershed uncut, to test whether stream flows

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were changed by the logging after seven years of baseline monitoring of both drainages was the first time in the world that such a scientific experiment was undertaken. The controversy derived from questions on the relationship between forests and rainfall, and the best way to control floods: reforestation of denuded watersheds, or building dams and levees? Pinchot and most foresters advocated reforestation, while Hiram Chittenden of the Army Corps of Engineers (CoE) strongly advocated a structural approach to flood control. To win this argument, in July of 1910 the Forest Service appointed C.R. Tillotson, while the Weather Bureau, then part of USDA, appointed B.F. Kadel to initiate the Wagon Wheel Gap experiments. After 16 years of careful measurements were completed, it took the personal involvement of Zon to work with Carlos Bates, in charge of the Wagon Wheel Gap work at the time, and his counterpart, A.J. Henry of the Weather Bureau, to produce the final report in 1928 on the results of the experiment, after disagreements arose between the two men as to the significance of the results (Bates and Henry 1928).

In 1908, President Theodore Roosevelt's Inland Waterways Commission reported on its survey of U.S. waterways for commercial navigation and other water resource uses and problems. Pinchot was a member of this commission. Modeled after the successful 1905 Forest Conference, Pinchot hoped this commission would lead to the establishment of a national, federal policy for managing water resources in the United States. Indeed, the commission recommended that both local and national benefits of a water policy be considered as well as costs; that plans for improving waterways should consider all of the uses of water including flood control, water power, irrigation and pollution control; and that a national waterways commission be created to coordinate the work of the Corps of Engineers, the Reclamation Service, USDA's Forest Service and Bureau of Soils, the Bureau of Corporations, and other concerned federal agencies in making multiple-purpose plans for waterways in cooperation with state and local governments. (USDA Economic Research Service 1972). However, the commission's report failed to spur creation of a national water policy largely because it would have usurped 50 years of western states' water laws, customs, and policies, and these states would have none of that! One other result of this commission and the National Conservation Commission of 1909 was increased discussions within the Congress that resulted in passage of the Weeks Act in 1911. This Act provided authority to the Forest Service to purchase lands in the eastern United States, in watersheds whose water supplies were needed to preserve river navigability. The Act also created the National Forest Reserve Commission and provided that the Secretary of Agriculture, in cooperation with Interior's U.S. Geological Survey, could recommend for purchase such lands in the watersheds of navigable streams needed to regulate water flow. This Act is responsible for the eventual acquisition of 25.3 million acres (10.2 million ha) in the East as national forests (USDA Forest Service 2003).

Custodial Era: 1911-1945

Between 1911 and 1945, the Forest Service was largely focused on the acquisition and reforestation of abandoned and abused watershed lands in the East and Midwest; establishment and expansion of the Research Branch in 1915; passage of a few new laws such as the Clarke-McNary Act of 1924; and the work of the Civilian Conservation Corps (CCC). Many Forest Service employees, including Chief Henry Graves, enlisted in the Army Expeditionary Force during World War I, where they served in Europe setting up sawmills and acquiring timber needed for trench walls, railroad ties and other purposes.

The National Waterways Commission was authorized in 1917 to coordinate the work of all federal agencies with water resource responsibilities on preparation of nationwide multiple purpose plans, either by the federal government alone, or in cooperation with states and localities. The commission members were never appointed due to World War I, and in 1920 the Federal Power Act expressly repealed the 1917 law that created the commission. A Forest Service engineer, O.C. Merrill, helped Congressional staffers write the Federal Water Act in a manner that served the public interest, rather than the many land speculators then buying many of the best hydropower sites on private lands.

The Research Branch did almost all of the watershed work for the Forest Service until the CCC was established in 1933. Even while Wagon Wheel Gap was still operating, other watershed and soil erosion research was begun in Utah, Arizona and California. Harold Croft, Charles Hursh, and others whose names are now lost, were some of the first soil or water scientists hired by the agency in the 1910s and 1920s. In 1917, Research produced one of the first soils reports, and in 1928, a well written report on the role of forests in watershed management was issued (Shepard 1928).

Edward Munns served in the Chief's Office from 1923 to 1951, as the modern equivalent of the director of watershed research, where he played a key role in maintaining the agency's focus on scientific research of many soil and water issues. He helped establish the experimental forests, watersheds and laboratories at Coweeta (NC), Fernow

(WV), H.J. Andrews (OR), Fraser (CO), South Umpqua (OR), San Dimas (CA), Teakettle (CA), Manitou (CO), Sierra Ancha (AZ), Calhoun (SC), Delta (MS), Koen (AR), Santee (SC) and Tallahatchie (MS), which have cumulatively contributed much knowledge about how mountain watersheds behave. He also recruited many of the research hydrologists and soil scientists who worked at these experimental areas, and insured their growth and survival when times got tough during the Great Depression and World War II. Munns was also successful in getting the CCC enrollees to help build the research laboratory infrastructure at many of these locations between 1933 and 1942, including access roads, measuring weirs, lab buildings, and telephone lines (Otis et al. 1986).

Chief Forester Pinchot created a separate State and Private Forestry Branch in 1908 to render assistance to private forest landowners, in cooperation with USDA's Bureau of Entomology for pest control work and with the Bureau of Plant Industry on forest tree diseases, among other tasks (Williams 2000). The 1911 Weeks Act expanded the scope of this work to include firefighting on all land ownerships. The Clarke-McNary Act of 1924 expanded the Weeks Act to improve conditions on private forest land, and modified taxation policy to favor retention of forests.

In 1939 the Chief established a Division of Watershed Management within the National Forest System (NFS) Branch with Gordon Salmond as Director. Mr. Salmond served in that position until he retired in 1961. None of the 13 subsequent directors of this staff have served as long as he.

In 1949, Congress passed the Federal Classification and Pay Act which authorized the Civil Service Commission to create the job classification system in use today in most federal agencies. Prior to this Act, it was very difficult to assess how qualified applicants were for many technical job series, such as hydrologists, geologists or soil scientists, and to keep track of how many people in each job series were employed by federal agencies.

Development Era: 1945-1969

Demand for timber to build homes and other needs for returning GIs skyrocketed after World War II. Clear-cutting became normal practice on many national forests, and access roads were built to move the logs to the mills. Forest Service watershed research was maintained, but not expanded, until the 1960s. The most significant watershed developments during these 25 years included establishment of the barometer watershed program starting in 1962, and greatly accelerated hiring of soil, water and geology specialists in many Forest Service Regions and Research Stations, as a result of the McIntire-Stennis Act in 1962 which greatly expanded university-based forestry research at land-grant institutions (Glazebrook 1969; Steen 1998).

Barometer watersheds were intended to apply results from small experimental watersheds to larger basins, where typically a fuller set of multiple uses of land and resources were in place, so that effects on water quantity and quality could be determined. Some 24 barometers, ranging in area from 24,000 to 189,000 acres (9,700 to 76,500 ha) and representing 24 hydrographic provinces in 18 states were selected, instrumented, and staffed by 1970. A few fulfilled their original intent, but most never did for a variety of reasons that are more fully covered in a paper by Larry Schmidt and Byron Beattie in this publication.

The barometers were successful in helping justify the need for more agency hydrologists and hydrologic technicians. Probably close to 50 of these professionals worked at some point in their career on a barometer watershed. I was one of them, and my experience on the Lake Creek barometer in Colorado in 1969 was a very valuable training opportunity.

The Forest Service also hired more soil scientists in the 1960s to do soil surveys in cooperation with the then-Soil Conservation Service, now Natural Resources Conservation Service (NRCS). The national Soil Survey program was initiated in 1961 under John Retzer's leadership in the Washington Office. Many Soil Conservation Service soil scientists transferred to the Forest Service in the 1960's, bringing their expertise with them.

The 1954 Small Watershed Program (P.L. 83-566) expanded Forest Service authority to include flood prevention on farmland watersheds less than 250,000 acres (101,000 ha) in size by means of structures, upstream protection measures, and livestock controls. The Forest Service has worked with USDA's NRCS and Agricultural Research Service, the Army Corps of Engineers, the states, and local entities to implement these projects on NFS lands. Funding for maintaining these structures has diminished over time and there is a growing need to repair, replace or de-commission some of these structures as they approach the end of their design life.

The 1960s also brought the seeds of the environmental movement, with passage of the Multiple-Use Sustained-Yield Act of 1960, the Wilderness Act of 1964, the Jobs Corps Act of 1964, the Wild and Scenic Rivers Act of 1968, and the grand-daddy of them all – the National Environmental Policy Act (NEPA). These statutes, plus U.S. Supreme Court decisions involving reserved water rights from 1908 through 1963, portended that watershed management of the national forests and grasslands was about to change in the 1970s.

Environmental Era: 1970-1990

The year 1970 saw the passage of NEPA, the Youth Conservation Corps Act, and creation of the U.S. Environmental Protection Agency (USEPA), all of which helped change watershed management in the Forest Service. NEPA certainly created many more specialist jobs in the Forest Service at all levels within the NFS Branch, and improved the quality of land use decisions in ways that have lessened adverse impacts on the environment. The Youth Conservation Corps program provided new opportunities to educate young people about the environment and for them to learn job and life skills that have served them well (Figure 1). Some valuable soil and water improvement work has been accomplished by this program.

The USEPA has certainly changed water and air quality management in the Forest Service through their many rules, regulations, requirements, and interactions. We in the Forest Service often underestimate the amount of change that USEPA has brought about in this nation, including how NFS lands and natural resources are actually managed. Both the Clean Water Act of 1972, as amended, and the Clean Air Act of 1977, as amended, have resulted in the hiring of more Forest Service hydrologists and air quality specialists to work on evaluating likely effects of proposed resource extraction activities upon water and air quality and identifying mitigating measures for those activities. For example, the number of hydrologists went from 76 in 1970 to 203 in 1980, and 225 in 1989, while the number of air quality specialists increased from none in 1970, to 10 in 1980, to 22 in 1989 (USDA Forest Service 1970, 1980, 1989). Improvements in both water and air quality have resulted from these specialists' efforts in local areas.

The Bitterroot National Forest clear-cutting and terracing controversy, together with the District and Appeals Courts' decisions in the Monongahela National Forest case, led to Congressional hearings, passage of the National Forest Management Act (NFMA), and greatly restricted the size of clear-cuts on NFS watersheds in the mid 1970s. They also caused a large expansion in water quality monitoring of logging and road construction activities by hydrologists. In the Northern Region, several forest hydrologists developed "Hydrologic Cutting Guides" as a tool to assess water yield changes; they were fairly effective and other regions adopted modified guides as well. A major report, An approach to water resources evaluation of non-point silvicultural sources (A procedural handbook), also known as WRENSS (USEPA 1980), was issued as a tool for controlling non-point sources of water pollution from silvicultural activities. It had limited utility, because the data input needs were too large and complex, the handbook itself was 861 pages long, and the computer had not yet matured as a usable tool at the forest level.

The first inter-disciplinary teams were formed in early 1971 as a mechanism for implementing NEPA at the project level scale; almost all of them included soil, water, and geology expertise, as well as forestry/silviculture, fire, engineering and landscape architecture skills. I was part of the first team formed in Region 2, the Rocky Mountain Region. The previous multiple use surveys gave way to unit planning by these teams. There was a large degree of freedom to develop data collection and analysis methods,

Figure 1. The Youth Conservation Corps doing stream stabilization work on a national forest in the 1980s. Photo from the Forest Service achives.

write reports, and participate as an equal or almost equal member of the team as long as the team leader and other members were willing to operate in that manner. By 1973, a few national forest teams were starting to develop forest-wide land use plans, some of which went beyond the forest boundaries and eventually led to at least one forest supervisor losing his job. These early teams broke the ground for later planning teams that were helping implement long-range planning requirements of the Resources Planning Act and NFMA. They also certainly showed many line officers the value of hiring soils, water, geological and air specialists.

The year 1978 saw passage of the Cooperative Forestry Assistance Act and issuance of the Mimbres water rights decision by the U.S. Supreme Court. This Act expanded the suite of technical and cost-sharing assistance programs that the Forest Service could deliver for private forest landowners and state foresters, including new soil and water stewardship programs. In addition, Title IV of the Agricultural Credit Act of 1978 authorized the Secretary of Agriculture to undertake emergency measures for runoff retardation and soil erosion prevention to safeguard lives and property from floods, drought, erosion after fire, or other natural occurrences that caused watershed impairment. The Mimbres decision restricted the scope of federal reserved water rights under the 1897 Organic Act to the minimum needed to secure favorable conditions of water flow, or for sustained timber supplies. In dicta, the Supreme Court dismissed reserved rights claims for recreation, grazing, and fisheries under the Multiple-Use Sustained-Yield Act of 1960.

To encourage technology transfer, agency hydrologists published an important summary of forest watershed management knowledge (Anderson et al. 1976) and convened national meetings at Grand Targhee in 1974, and Atlanta in 1978. These were the first meetings of mostly field based hydrologists, and contrasted markedly with the 1955 soil and water meeting in Denver which consisted entirely of 85 Washington Office and Regional Office based personnel. Some 83 hydrologists and hydrological technicians attended the Targhee meeting (82 men and 1 woman), while 130 attended the Atlanta meeting (119 men and 11 women). Both meetings were very successful in accomplishing their networking and technology transfer objectives. They helped set the stage for the following era and the 1992 FS National Hydrology Workshop in Phoenix.

Planning and Ecosystem Management: 1980-Present

Development of the initial round of Forest and Resource Plans based on the 1979 planning regulations that followed passage of NFMA engaged almost every physical scientist or practitioner during this period. As a result, very few new watershed initiatives were undertaken and some of those started in the 1960s, like the barometer watershed program and many water quality monitoring efforts, were terminated. There has also been a slow but steady decline in inflation-adjusted Forest Service watershed administration and research funds in this period.

Several important watershed events did occur. The Forest Service and USEPA cooperated in a massive water quality sampling effort in 1985 as part of the National Acid Precipitation Assessment Program. Over 2,000 remote lakes, often in wilderness areas, were sampled during their fall overturn period, under often difficult weather and logistical conditions, for their vulnerability to acidification from deposition of atmospheric pollutants. Limited, concurrent sampling by USEPA personnel in helicopters that landed on the lakes within minutes of the Forest Service ground-based crews that rafted out to the deepest part of the lakes proved that the Forest Service crews did a superb job of their sample collection, preservation, and transfer of samples to mobile labs set up at nearby airports within four hours of sample collection. This effort greatly increased the trust that USEPA had in Forest Service personnel.

Also in 1985, Data General mainframe computers were installed at almost all agency offices. This network allowed better communication among employees and sharing of ideas, methods, draft papers and data. They also allowed batch processing of large data sets using FORTRAN. Both were significant improvements over earlier dumb Typagraph terminals and tiny CPU processors.

The number of watershed councils and other ad hoc committees devoted to improving some aspect of watershed management has blossomed during this period. They are trying to accomplish what earlier federal river basin planning commissions and groups never could: application of real solutions to local problems of water quantity, quality, or both.

The year 1992 saw the New Perspectives and PACFISH initiatives, and the Appeals Reform Act. President Clinton's Northwest Forest Conference in 1993 and the Ecosystem Management Conference in 1994 also changed how watershed management is practiced by the agency by greatly expanding the number of stakeholders and the planning processes used to make a decision. In 1997, Chief Mike Dombeck introduced the "Collaborative Stewardship" term to describe his vision of working together with many partners to accomplish the "Taking care of the land and serving people" mission statement of the agency. Watershed management is embedded within the collaborative stewardship terminology. The late 1990s also

saw an interagency, inter-disciplinary team effort led by this author to develop agency policy, and technical and legal guidance for managing the ground water resources of the national forests and grasslands. This effort is expected to be completed in 2005.

The large wildfires of 2000 and 2002 led to creation of the National Fire Plan and passage in 2003 of the Healthy Forests Restoration Act (HFRA) by Congress. This Act could result in a shift of soil, water, geology and air resources expertise toward work on planning and execution of projects designed to reduce woody fuel accumulations in the wildland-urban interface zone. The Act also provides for small increases in watershed expertise in state forestry organizations.

Future Prognosis: Present to 2100

This section is based upon an evaluation of current demographic, societal and natural resource trends projected into the future. Since the future is really unknowable, these projections represent a mix of subjective and some objective views of the author and others. Only time will tell if any of these projections or views were correct; they are intended to stimulate discussion now.

The population of the United States in the 2000 Census was 283 million. The Population Reference Bureau projects that number to be 422 million in the year 2050 (Haub 2003). I estimate it could be 650-700 million in the year 2100. Not only will the absolute numbers be higher, but the average population is projected to grow steadily older, richer, healthier, and more ethnically diverse and urbanized (Cetron and Davies 2003). All of these factors, plus future legislation and court rulings, will affect the commodities and amenities Americans expect from their national forests and grasslands.

By the year 2040, the 1990 RPA Water Situation report (Guldin 1989) predicts water supply shortages in many parts of the southwestern U.S., depletion of groundwater in California, Nevada, Utah, and growing shortages in eastern and midwestern states. Projected changes in freshwater withdrawals for public and domestic uses from 2000 to 2050 could rise 85 percent, industrial and commercial uses could increase 71 percent, and irrigation could decline by nine percent in the west coast states of California, Oregon, Washington, and Idaho (Houston et al. 2003) The amount of cropland being irrigated in the East and South is growing rapidly (Hutson et al. 2004) and is likely to cause more rivers to become partially or totally dewatered in the future unless state water rights laws are changed to prevent it. Based on the rate of change in western states water rights laws, the chances of the eastern states upgrading their laws appear "iffy" at best in my opinion.

By 2050, water quality effects from non-point sources of pollution typically found on NFS lands are expected to approximate today's conditions. It is very difficult to make large improvements in what are often small amounts of pollutants resulting from current land uses in forested watersheds, compared to the large amounts of eroded sediment from colonial farming practices that still clogs many eastern waterways. Drinking water will become more costly to consumers and the amounts of reclaimed wastewater will also have to increase to partially solve local shortages of water for non-potable uses. Today's challenges arise from hardrock mining, oil and gas and coal-bed methane extraction, suburbanization of forested areas, and atmospheric deposition of acidic precipitation and other pollutants. Effective solutions have been difficult to implement for these types of land uses or sources; nevertheless, these parts of what has been dubbed the "Restoration Economy" (Cunningham 2003) will continue to grow rapidly. Forest Service soil scientists, geologists, hydrologists, and air resource specialists employed in 2050 will need to devote increasing shares of their time and attention to tackling these problems over future decades, and there will be fewer of these experts than at present.

By 2100, it is quite possible that the national forests and grasslands will be used primarily for recreation, other amenity values, and for water production. The amounts of timber harvesting, livestock grazing, and oil, gas, and mineral production could decrease greatly. The number of special use authorizations is expected to increase from today's 75,000. Unfortunately, as these numbers grow, the general public's access to their public lands continues to diminish since each of these authorizations essentially becomes a separate in-holding and more expensive and troublesome for the agency to administer. Water shortages will continue in the same basins as in 2050. A better water rights marketplace will develop by 2100 that will allow more transfers of agricultural water rights to ever-growing communities at lower unit transaction costs than in 2000.

Satellites will monitor air, soil, geological and water resources continuously by 2100. They will feed this data into large data warehouses where the few remaining agency specialists will use it to develop contracts for private sector firms of resource specialists to bid on to do the actual watershed analysis work for NFS lands. Since federal pay in 2100 could be much lower than the private sector for similar work, I think there will be fewer physical science practitioners in the Forest Service in 2100 than there were in 2000. It is also possible that there will be fewer NFS acres in 2100 than there were in 2000,

as land ownership consolidation continues unabated and Water and Conservation Fund monies dry up. There has been, and will continue to be, pressure from individuals, corporations, and perhaps states and the Congress to dispose of federal forest lands for various other needs or wants just as in the 1800s and in the 1930s, when federal forest land acreage actually declined. I certainly hope that I am wrong about this.

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