

USDA-ARS National Sedimentation Laboratory: A Historic Perspective

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Abstract

Most authorities concede sediment from soil erosion to be the largest single stream pollutant. Physical damage from sediment includes reservoir storage loss, navigation channel filling, stream channel morphology alterations, ecological impacts, and clogging of drainage pathways. Ultimately, soil erosion is a very expensive problem. In the United States, accelerated soil erosion has been an ongoing issue since the establishment of the colonies. Through the initiative of great minds and the labor of countless individuals, the USDA was established and continues to fight for the people, providing assistance, guidance, and research. In this manuscript, the historical groundwork is laid for the establishment of the USDA-ARS National Sedimentation Laboratory (NSL) and a synopsis of NSL research is provided. This brief perspective of soil erosion research conducted on behalf of the people is but a small portion of the illustrious history of the USDA.

Keywords

Soil Erosion, Sedimentation, Ephemeral Gully, Water Quality, Modeling

1. Historic Introduction

1.1. “The People’s Department”, United State Department of Agriculture (USDA)

From humble beginnings, an idea of people helping people through sharing ideas and concerns, water and electricity, seeds and school lunches, the United States Department of Agriculture has and will always remain, a department for the people. First established as the Agricultural Division, Patent Office, Department of State in 1839, continued growth within the Department of the Interior (1849-1862), and expansion into a separate entity,

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the Department of Agriculture (1862-1889) eventually achieved cabinet status in 1889 (Table 1).

Impetus for the creation of an Agricultural Division began with President George Washington. In his final address to Congress, 1796, he proposed the establishment of an Agricultural Board that would collect experimental results and observations, and pass the information on to the appropriate officials in the States. By 1825, both the House of Representatives (1820) and the Senate had established agricultural committees. Potentially one of the first influential lobbying groups, the United States Agricultural Society was formed (1852) to direct official interest to the agricultural needs of the time. President Abraham Lincoln signed an Act establishing the United States Department of Agriculture in 1862. The purpose of the Department was:

“to acquire and diffuse among the people of the United States useful information on subjects connected with agriculture in the most general and comprehensive sense of that word, and to procure, propagate, and distribute among the people new and valuable seeds and plants.” (Lincoln, 1862)

The Department of Agriculture was organized under the leadership of Commissioner Isaac Newton. Annual reports were generated by the Commissioner to the President for the purpose of reporting agricultural statistics, seed collections and distributions, report on regional crops, and use of chemicals in agriculture. In his first commissioner’s report to President Lincoln, Newton wrote:

“Agriculture furnishes the food of the nation, the raw materials of manufactures, and the cargoes of domestic and foreign commerce. It is the cause and the evidence of true civilization; for, when tillage begins barbarism ends, and the various arts commence. When agriculture prospers, all other interests prosper.”

The birth of the Department of Agriculture preceded the Homestead and Morrill Acts by only a few months. The Homestead Act granted government lands to small farmers at a low price and the Morrill Act established land-grant colleges for the benefit of agriculture. Both pieces of legislation have been key to the long-term efficacy of sustainable agriculture. In 1875, the first agricultural experiment station was established at Wesleyan University, CT. In 1887, the Hatch Act provided for the federal funding of agriculture experiment stations in each state and in 1888, the Office of Experiment Stations was established within the Department of Agriculture. The seventh Commissioner of Agriculture, Norman Coleman, in his annual report to the President in 1888 wrote:

“The Department of Agriculture can aid the experiment stations in their relations to each other, in their use of the results of experimental research, and in their connection with the agricultural public. To be first among the stations the Department should be the servant of them all. It should exercise not dictatorship, but leadership. Its influence should be powerful in bringing the stations together in coordinating their work; in making the fruits of other research and experience, past and present, at home and abroad, available to them; in prosecuting lines of pioneer research which will in a measure relieve the stations of a difficult but necessary task, and enable them to apply their energies more fully and successfully to the study of the questions which bear directly upon the practice of agriculture; in collating, condensing, and distributing their results, and in helping to carry the practical outcome to the farmer in a form in which he will appreciate and use.”

Under pressure from advocacy groups, the United States Department of Agriculture (USDA) was given cabinet status in 1889 by President Grover Cleveland, and the first Secretary of Agriculture was Norman Coleman. In 1890, the second Morrill Act was passed, which stipulated states that maintained separate colleges for different races would equitably divide land-grant funds. Also during this time, the USDA began a series of Farmers’ Bulletins that were used as a vehicle of information dispensation of the various Bureaus and Offices of the Department. These bulletins reached out to the people and conveyed the agricultural discoveries and observations of the time.

During the period 1862 to 1929, the USDA experienced major expansion in program activities and areas of responsibility. USDA had grown from a small division in the Patents Office that primarily collected and dispersed seeds to a cabinet Department that carried out agricultural research in irrigation, land drainage, hydrology, and agronomy, as well as responsibility for the protection of National Forest lands and licensing the use of water for the production of power. Activities within the Department had established the fact that land and water cannot be separated, since all surface runoff is derived from the land and all fresh water recharge must pass through the soil. The Department, therefore, had achieved a stature and scope that permitted it to fulfill future responsibilities in the field of water resources development.

Table 1. Select timeline of soil erosion history in the United States and popular culture.

Year	Precedent
1789	Congress creates Departments of State, Treasury, and War.
1793	Invention of cotton gin.
1825	Agriculture Committee, U.S. House of Representative established. Agriculture Committee, U.S. Senate established.
1835	Henry Leavitt Ellsworth, appointed U.S. Commissioner of Patents; began collecting and distributing new varieties of seeds; known as founder of what became the USDA.
1839	Agricultural Division, Patent Office, Department of State: Compile agricultural statistics, collect and distribute seeds, report on regional crops, and use of chemicals in agriculture.
1849	Agricultural Division, Patent Office, Department of the Interior: creation of new department to handle domestic matters; transfer of Ag. Div. with similar functions.
1852	United States Agricultural Society formed.
1860	<i>Farmers made up 58% of the labor force.</i>
1862	Agricultural Act: United States Department of Agriculture established; President Lincoln, in an address to Congress, called the USDA the “People’s Department”. Homestead Act: grant public land to small farmers at low cost. Morrill Act: establish land-grant colleges for the benefit of agriculture.
1870	<i>Farmers made up 47% of the labor force.</i>
1875	First state agricultural experiment station established at Wesleyan University, CT.
1879	Creation of U.S. Geological Survey within Department of the Interior.
1880	<i>Farmers made up 49% of the labor force; 1 in 4 were tenant farmers.</i>
1887	Hatch Act: set up federal-state cooperation in agricultural research.
1888	Office of Experiment Stations established.
1889	USDA moved to Executive branch and given cabinet status. Soil Survey established within Weather Bureau of USDA.
1890	Morrill Act: established equitable divisions of land grant funding for blacks; 16 new colleges were created in the South. <i>Farmers made up 43% of the labor force.</i>
1894	Division of Agricultural Soil established in Weather Bureau of USDA. Farmers’ Bulletin No. 20: “Washed soils: How to prevent and reclaim them” by Charles Dabney; milestone publication in soil conservation.
1899	Field mapping of soils began by USDA.
1900	<i>Farmers made up 38% of the labor force.</i>
1903	Wilbur and Orville Wright airplane flight (longest trial is 59 seconds and 852 feet).
1908	T. C. Chamberlain gives talks on “soil wastage”.
1910	<i>Farmers made up 31% of the labor force.</i>
1911	First Farm Bureau formed in Broome County, NY.
1914	Smith-Lever Act: sets up national extension service.
1920	<i>Farmers made up 27% of the labor force.</i> Soil classification system developed.
1925	Purnell Act: authorized funds to experiment stations for research on the economic and social problems in agriculture. Soil erosion is identified as a serious threat to agricultural productivity. Mc Sweeney-Mc Nary Forest Research Act: authorized USDA to conduct research on favorable conditions of water flow and the prevention of erosion.
1928	Buchanan Amendment: provided first Congressional appropriation to set up experiment stations to conduct soil erosion research operated by USDA. Circular 33: Soil Erosion, A National Menace published by Hugh Hammond Bennett and W.R. Chapline. Model A automobile launched.

Continued

1930	<i>Farmers made up 22% of the labor force.</i>
1932	Dust Bowl: persistent drought conditions on the Great Plains caused widespread crop failures and exposed the region's soil to blowing wind.
1933	National Industrial Recovery Act: Soil Erosion Service (SES) established in Department of the Interior; Hugh Hammond Bennett, "father of soil conservation", was named Chief.
1934	Dust storm on May 11, 1934 swept fine soil particles over Washington, D.C. and three hundred miles out into the Atlantic Ocean.
1935	On March 6 and again on March 21, 1935 dust clouds passed over Washington, D.C. and darkened the sky just as Congress commenced hearings on a proposed soil conservation law. Hugh Hammond Bennett holds court with Congress. Soil Conservation and Domestic Allotment Act: SES moved to USDA and renamed Soil Conservation Service (SCS); Hugh Hammond Bennett named Director. Bankhead-Jones Act: provided expansion of agricultural research. Concept of vegetative waterways developed to channel runoff and prevent gully erosion.
1936	Flood Control Act: determine the most effective methods to control erosion and prevent floods.
1937	First soil conservation district organized in Brown Creek watershed, Anson County, NC.
1940	<i>Farmers made up 18% of the labor force; 2 in 5 were tenant farmers.</i>
1942	Agricultural Research Administration (ARA) established within USDA.
1944	Flood Control Act: SCS begins work on 11 watershed projects. SCS initiates upstream land treatment through the Yazoo-Little Tallahatchie (Y-LT) Project.
1948	A small-scale research project was initiated by the SCS at State College, MS (now Mississippi State University). Saint Anthony Falls stilling basin designed (Minneapolis, MN).
1950	<i>Farmers made up 11% of the labor force.</i>
1953	Agricultural Appropriations Act: SCS given 63 additional watershed projects. Agricultural Research Service (ARS) division of USDA is created; SCS transfers research activities.
1954	Watershed Protection and Flood Prevention Act: Congress gave SCS permanent watershed planning authority. ARS consolidates research projects of Y-LT within Soil and Water Research Conservation Division.
1956	Congress appropriates funds for sedimentation research; Y-LT/ARS research moved to Oxford, MS; temporarily housed on campus of University of Mississippi.
1957	Funds appropriated for Sedimentation Laboratory in Oxford, MS. Civil Rights Act. Sputnik launched.
1958	Universal Soil Loss Equation (USLE) developed.
1970	<i>Less than 5% of the labor force is made up of farmers.</i>
1971	Microcomputers invented.
1980	CREAMS: A Field Scale Model for Chemicals, Runoff and Erosion from Agricultural Management Systems published.
1989	Water Erosion Prediction Project (WEPP) developed.
1995	Revised Universal Soil Loss Equation (RUSLE) completed.

1.2. Natural Resources Conservation Service (NRCS)

The USDA Bureau of Soils began to make county-based soil surveys in 1899. Amid cumulative evidence highlighting erosion within the states, Chief Milton Whitney, Bureau of Chemistry and Soils, published Bulletin 55, in which he related that:

"The soil is the one indestructible, immutable asset that the Nation possesses. It is the one resource that cannot be exhausted; that cannot be used up."

Perhaps presumptive or naïve, more likely politically calming in nature, statements and thoughts of this type

were and, in some cases, continue to flourish. Still, in 1910, a field party consisting of three members of the Mississippi Geological Survey and two USDA Bureau of Soils surveyors, Hugh H. Bennett and Howard C. Smith, completed a survey of Lauderdale County, Mississippi [1]. This survey identifies an “erosion phase” of Orangeburg sandy loam, designating a soil not as a distinct soil type, but as a soil that is modified by erosion. They assert through classification that the soil difference was the result of erosion. Reports of excessive erosion in South Carolina [2] and Georgia [3] were made by Hugh H. Bennett, further expressing the need for federal involvement in this pivotal problem area. USDA Bulletins 71 [4], 180 [5], and 512 [6] document the principles underlying soil erosion, the devastation caused by soil erosion in the southern United States, and soil erosion prevention measures, respectively. Chief of the Bureau of Chemistry and Soils, Henry G. Knight, placed Hugh H. Bennett in charge of a special study of the extent of soil erosion and methods of control, effective January 1928. Later that same year, Bennett’s best-known publication of the period was published, “Soil Erosion, A National Menace” [7]. Written with the help of W. R. Chapline of the U.S. Forest Service, the circular was regarded as more effective than previous erosion bulletins because it was not technical and did not discuss erosion control measures. Instead, coming shortly after the great Mississippi flood of 1927, Bennett and Chapline’s bulletin emphasized only the damages caused by erosion and the need for action to stop erosion. Owing to this growing concern over soil erosion, in 1928, two instrumental pieces of legislation were passed: McSweeney-McNary Forest Research Act (authorized research on erosion prevention) and Buchanan Amendment (funds were appropriated for soil erosion investigations and regional soil erosion experiment stations). The locations selected for the Regional Soil Erosion Experiment Stations were as follows:

Batesville, Arkansas; Tifton and Watkinsville, Georgia; Dixon Springs, Joliet, and Urbana, Illinois; Lafayette, Indiana; Clarinda, Cortana, Beaconsfield, Independence, and Seymour, Iowa; Hays, Kansas; Baton Rouge, Louisiana; Presque Isle, Maine; Benton Harbor and East Lansing, Michigan; Holly Springs and State College, Mississippi; Bethany and McCredie, Missouri; Hastings, Nebraska; Bumerville, Marlboro, and New Brunswick, New Jersey; Ithaca, Geneva, and Marcellus, New York; Statesville and Raleigh, North Carolina; Coshocton and Zanesville, Ohio; Cherokee and Guthrie, Oklahoma; Clemson and Spartanburg, South Carolina; Knoxville and Greenville, Tennessee; Temple and Tyler, Texas; Blacksburg, Virginia; Pullman, Washington; Lacrosse, Madison, and Owen, Wisconsin; and Mayaguez, Puerto Rico.

A short time later, 1933, the National Industrial Recovery Act established the Soil Erosion Service (SES) within the Department of the Interior. Hugh H. Hammond, now regarded as the nation’s soil erosion expert, was named the first SES Chief. The SES was an emergency/temporary agency set up to administer unemployment relief funds used for erosion control and conduct a national reconnaissance erosion survey. In a move of brilliant political strategy, Hugh H. Hammond successfully convinced Congress and the President that soil conservation was of the utmost importance. In 1935, under the Soil Conservation Act, the SES was moved to the USDA, made a permanent agency within the government, and renamed the Soil Conservation Service (SCS) with Hugh H. Bennett as director. For a brief period, 1942-1945, Executive Order 9280 consolidated the SCS with a few other agricultural Bureaus and Offices to form the War Food Administration, with the mission to meet wartime food requirements.

In 1994, Congress initiated a major reorganization of the USDA and renamed SCS the Natural Resources Conservation Service (NRCS) to better reflect the broad scope of the agency’s mission. These changes marked the beginning of two major trends that have defined the Service’s role in conservation since: responsibility for administering financial assistance for conservation programs and substantial increases in the amount of financial assistance available for conservation. The result over the last two decades has been rapid growth in innovative programs that give conservationists and landowners the necessary means to protect our nation’s natural resources.

1.3. Agricultural Research Service (ARS)

Executive Order 9069, 1942, consolidated certain agencies within the USDA and established the Agricultural Research Administration (ARA). The ARA functioned chiefly to coordinate research activities of the Bureaus of Agricultural Chemistry and Engineering, Animal Industry, Dairy Industry, Entomology and Plant Quarantine, Home Economics, and Plant Industry; and the Office of Experiment Stations. Two important changes occurred in 1953: 1) Secretary’s Memorandum 1320, abolished the ARA and the various independent Bureaus it served,

transferred forest disease and entomology functions to the Forest Service, and transferred non-forest research functions to the Agricultural Research Service (ARS); and 2) Secretary's Memorandum 1318, abolished the SCS's Office of Research and transferred responsibility for soil erosion research functions to the ARS. ARS also exercised supervision over the Office of Experiment Stations until separation as the Cooperative State Experiment Station Service (CSRS) in 1961. ARS consolidated with CSRS, Extension Service, and National Agricultural Library by Secretary's order in 1978 to form the Science and Education Administration (SEA). ARS functions were assigned to the Federal Research Staff, re-designated Agricultural Research Staff in 1979. Secretary's Memorandum 1000-1 abolished the SEA, and the ARS and other components were re-established in 1981.

The Agricultural Research Service is the principal in-house research agency of the United States Department of Agriculture. ARS is one of four agencies in USDA's Research, Education and Economics mission area and is charged with extending the nation's scientific knowledge and solving agricultural problems through its four national program areas: nutrition, food safety and quality; animal production and protection; natural resources and sustainable agricultural systems; and crop production and protection. ARS research focuses on solving problems affecting Americans every day.

The National Program of ARS to which the theme of the present work serves is NP 211: Water Availability and Watershed Management. This national program seeks information regarding processes that control water availability and quality that may be used to improve water resources management. The overlying theme of the program is that water is fundamental for sustained health of society and the environment.

1.4. USDA-ARS National Sedimentation Laboratory (NSL)

Go west and prosper was the sentiment of early American settlement. Following the Treaty of Pontotoc in 1832, north Mississippi was opened to homesteading. Early homesteaders found dense forests and clear streams. At first the settlers cultivated only the fertile bench lands along the streams. Pressure for cropland led to clearing and plowing of steep, highly erodible soils. The agriculture system itself was exploitative and the chosen crops invited land deterioration. The clean, tilled crops of cotton and corn left the erodible soil exposed year round. Rain and gravity did the rest. As early as 1850, the state geologist made comments concerning severe erosion problems in northern Mississippi. Following the Civil War, cropland pressures increased and so did soil loss. Hillside after hillside was abandoned to the ravages of erosion. Large gullies and sediment-choked streams were commonplace. The serious lack of concern for and knowledge of our soil resource had left the land and the people destitute.

The Flood Control Act of 1944 named 11 watersheds throughout the United States for monitoring and authorized public works to improve them. By far, this is recognized as the most important piece of federal flood control legislation in the nation's and in Mississippi's history. This legislation explicitly committed the federal government to massive flood control work and provided strong impetus for establishing research facilities throughout the United States. In Mississippi, the Yazoo-Little Tallahatchie (Y-LT) Flood Prevention Project (1948-1985) was launched in 1947. Congress appropriated money to the SCS where the main objectives, as defined by law, were the reduction of floodwater and sedimentation damage, proper land use, channel stabilization, and improvement of affected local economies. The SCS allocated funds to the Forest Service (FS) who carried on the largest tree-planting program in US history to rehabilitate eroding lands in north Mississippi. Over a time span of 20 years, some 450,000 acres were transplanted with 550,000,000 Loblolly pine seedlings [8].

To assist in the design and to obtain evaluation data for the Y-LT project, a small-scale research project was initiated in 1948 by the SCS at State College (now Mississippi State University), MS. This project consisted primarily of sediment gauging of streams. However, as early as 1928, soil erosion studies were being conducted at Holly Springs and State College, MS; and, in 1953, soil erosion research was transferred from the SCS to the ARS (Secretary's Memorandum 1318). The USDA Sedimentation Laboratory originated as an extension of studies of soil erosion, gully formation, channel instability, and other sedimentation-related phenomenon that began in Holly Springs and State College, MS. Under the direction of Russell Woodburn ([Table 2](#)), these projects together with other research programs were consolidated in 1954, and assigned to the Soil and Water Research Conservation Division of the newly established Agricultural Research Service. Funds for the new Laboratory were appropriated in 1957 and the construction was completed in the fall of 1959. Senate Document No. 59, 86th Congress states the purpose of the Laboratory.

Table 2. USDA-ARS-NSL directors.

Year	Director
1956-1961	Russell Woodburn
1961-1963	Carl Miller
1963-1969	Donald Parsons
1969-1974	August Robinson
1974	Roger McHenry (acting)
1974-1978	Donn De Coursey
1978-1979	Roger McHenry (acting)
1979-1981	Donn De Coursey
1981-1988	Neil Coleman
1988-1992	Calvin Mutchler
1992-1996	George Foster
1996-1998	Mathias Römken (acting)
1998-2014	Mathias Römken (recently retired)

Sedimentation Laboratory, Oxford, MS

“Knowledge of the amount of sediment transported in waterways and deposited in structures for impounding runoff and of the mechanics of sediment transportation and deposition is essential for the proper development of programs for watershed protection. Sediment transport is a complex process, and studies of this problem require unique facilities and competence. Since a major effort within the USDA is directed toward assisting local groups with watershed protection projects, the Department should maintain the necessary supporting program on sedimentation research.

The Sedimentation Laboratory currently being constructed will provide the necessary national center for sedimentation research. It should be emphasized that in order for this laboratory to operate effectively it will need to be fully staffed and adequately supported. Provisions should be made for research workers located outside the USDA to come to the Laboratory on temporary assignments to use the new facilities. The Oxford Laboratory can also serve as a center for field research on sedimentation in the critical southern loess hills area. The research program at the Laboratory will include an attack on the fundamental physics and fluid mechanics problems involved in sediment transport and deposition. Work also will be directed toward development of sediment instrumentation for measuring the amounts of sediment carried by streams and deposited in reservoirs.”

The original Sedimentation Laboratory building was 2137 m² that included office space, a large hydraulics laboratory, shop facilities, and laboratories for sediment, chemical and radiochemical analysis. In 1969, the Sedimentation Laboratory was expanded by the addition of 1858 m² that included more office space, a second large hydraulics laboratory, several new chemical laboratories and a 952 m² outdoor test channel. The last expansion was in 1986 where new chemical laboratories and office space were added. Great tribute must be given to the late Mississippi Congressman, Mr. Jamie Whitten, of the 1st Congressional District, who had the foresight, the will, and the power to address this cause. The USDA-ARS Sedimentation Laboratory was designated USDA-ARS National Sedimentation Laboratory (NSL) in 1987 [9].

The mission of the NSL is to seek solutions to soil erosion and sedimentation related problems with emphasis on problems associated with the agricultural use of lands. The laboratory is specifically charged with seeking, through fundamental and applied research, for better methods of a) improving soil and water quality; b) controlling erosion and sedimentation; and c) conserving and managing agricultural land and water resources. The

laboratory is further charged with communicating its findings through various scientific and technical publications, from which the research information generated is put to use by operational agencies concerned with soil erosion and sedimentation, such as the USDA NRCS.

Prior to the appointment of Director August R. Robinson (**Table 2**) in 1969, there was essentially no formal organization of the staff. Some obvious organizational and functional difficulties prompted Robinson to organize the Sedimentation Laboratory into research groups, although the number of research Units and names have changed from time to time. Presently, the NSL is directed by Mathias J.M. Römken (**Table 2**) and has two Research Units: Watershed Physical Processes (Seth M. Dabney, Research Leader) and Water Quality and Ecology (Martin A. Locke, Research Leader). Current listing of professional staff is provided in **Table 3**.

2. Research at the NSL

2.1. Nationwide Reservoir Sedimentation Survey and Nuclear Applications Technology

Sedimentation surveys in more than 1200 reservoirs across the nation were made in cooperation with the committee on sedimentation of the USGS Water Resources Council. Also, in northern Mississippi Dr. Stanford Happ reactivated long-term valley aggradation studies initiated by the SCS in the mid-1930s to determine aggradation rates since land cultivation had shifted from the hills to the valleys during the intervening period. In 1968, research began on the application of fallout radionuclides to determine sediment deposition and soil redistribution rates and patterns in agricultural and natural ecosystems. This research was based on the use of fallout Cesium-137 (Cs-137) from nuclear weapon tests in the 1950s and 1960s that injected Cs-137 into the stratosphere that subsequently re-deposited on the landscape in uniform patterns related to precipitation patterns [10]. Once Cs-137 reaches the soil surface, it is strongly and quickly adsorbed by soil particles and is essentially nonexchangeable [11]. The distribution of fallout derived Cs-137 and its usefulness for dating sediment deposits was the focus of [12]-[15]. The unique advantages of using the Cs-137 technique to study soil erosion are that it a) requires a single sampling trip to the field; b) provides results quickly; c) allows retrospective assessment of soil erosion rates (average losses for 35 - 40 years period thus is less influenced by extreme events); d) provides estimates of soil erosion rates, deposition rates, and export rates; and e) allows a sampling strategy to provide any spatial resolution required [16]. More recently, a combination of radiometric techniques was used in [17], to identify the time history of Sky Lake, a Mississippi River oxbow cutoff near Belzoni, MS. A main conclusion of the study was that sedimentation rates in the lake have increased dramatically since land clearing in the late 19th century. In slightly more than a century since land clearing began, a thickness of sediment equivalent to that laid down over the previous several millennia was added, doubling the total sediment thickness. Radioisotope data and recent observations of sediment accumulation over the past 5 years indicate that the 50-fold increase in sediment accumulation rate continues unabated.

Table 3. Current professional staff listing for the NSL.

<i>Mathias Römken</i>		Director	
Watershed Physical Processes	Position	Water Quality and Ecology	Position
<i>Seth M. Dabney</i>	Research Leader	<i>Martin A. Locke</i>	Research Leader
Ronald L. Bingner*	Agricultural Engineer	Michael B. Jenkins	Res Microbiologist
James V. Bonta	Res. Hydraulic Engineer	Scott S. Knight	Res. Ecologist
Roger A. Kuhnle	Res. Hydraulic Engineer	Richard E. Lizotte, Jr.	Res. Ecologist
Eddy J. Langendoen	Res. Hydraulic Engineer	Mathew T. Moore	Res. Ecologist
James R. Rigby	Res. Hydrologist	Jason M. Taylor	Res. Ecologist
Robert R. Wells	Res. Hydraulic Engineer		
Glenn V. Wilson	Res. Hydrologist		
Daniel G. Wren	Res. Hydraulic Engineer		

*Split Appointment with WQERU.

2.2. Pesticide Research and Water Quality

In the early 1970s, nationwide environmental concerns also impacted the research program at the Sedimentation Laboratory. A number of pesticide studies were conducted in the late 1960s and 1970s concerning the presence of chlorinated hydrocarbon insecticides in streambed sediment of the Mississippi River and its tributaries in Arkansas, Louisiana, Tennessee and Mississippi. The scope of research concerning pesticides effect on the ecosystem and pesticide persistence in and wash-off from canopies as affected by weather variables, application methods, formulation, and time after application broadened over the years. Research activities at the NSL began to include ecological impacts of conservation practices [18] [19] and residual pesticide persistence [20] [21]. Through these activities, water quality research began to evolve from conventional ecological surveys and assessments to more impact-oriented agricultural contaminant fate and effects studies. Researchers at the NSL began to look at the entire watershed system and evaluate ecosystem function within the watershed as affected by agricultural activities. Over the years, research focused on habitats within constructed erosion-control structures [22], wetland systems as filters for agricultural waste [22] [23], ecological integrity and streambank rehabilitation [24] [25], ecological impacts of conservation practices [26], drainage ditches as a new best management practice [27]-[29], and non-point source mitigation through hydrologic modification [30].

2.3. Soil Erosion Research

Throughout the years, the laboratory has maintained a continuous effort to quantify the processes and impacts of soil erosion. Research in this area was and continues to be conducted in both field and laboratory settings. Scientists and collaborators have studied soil loss related to crop and/or residue management [31]-[34], soil erodibility [35]-[42], effect of landscape features [43], erosion control [44] [46], rill erosion mechanics [47]-[49], sediment size distribution [50] [51], and sediment distribution prediction [52]-[54]. Various ancillary studies were also conducted to quantify impacts of related physical processes, e.g. infiltration [55]-[57], surface seals [58] [59] and surface roughness effects [60]-[63].

2.4. Gully Erosion Research

Gullying occurs in every state within the United States and has been a central issue for the US government since its inception. Besides ruining fertile land, gullies interfere with farm operations, undermine buildings, encroach on public highways, endanger the life of stock, and often ruin the beauty and lower the market value of a farm. Gullies are also largely responsible for filling reservoirs and streams with sediment, and for covering once fertile bottomlands with deposits of sand. Early research activities [64]-[66], primarily focused on descriptive characteristics of gullies in the South, rates of sediment production, downstream impacts and conservation measures to control them. Headcut erosion, a primary process in gullies, is caused by the falling of water over the edge of a gully. The edge is washed away and caves in, owing to the undermining action of the falling water, and the waterfall moves back upstream. The undermining goes on rapidly when sand or easily eroded subsoil saturated with seepage water underlies the surface soil. Ephemeral gully erosion was first described as a distinct erosion phenomenon a few decades ago. This type of gully had previously been categorized as rills, as both were obliterated by routine tillage operations (unlike classic gullies which were not repairable by tillage). Research objectives during the 1980's and 1990's not only was concerned with quantifying rates of erosion but also turned toward prediction of concentrated flow erosion [67]-[72] and remote sensing technologies [73]. Foster [74] noted that while rills on hillslopes did not tend to reform in the same location, those located in the thalweg between hillslopes were persistent, perennial features that were only obscured by tillage and reformed in the same location year after year. While they fit the definition of a rill, they behave hydraulically as a larger channel and should be treated as individual channels in erosion analyses and modeling efforts [75]. More recently, studies have been conducted that include effects of slope [76], discharge [77], initial step height [78], conservation measures [79], soil stratification [80], soil type [81], tail-water and pore-water [82], imposed upstream sediment loads [83], channel width adjustment [84], and soil pipes [85]-[87]; as well as model technology [88]. Also, in cooperation with NRCS, NSL researchers assisted in the preparation of a document that described ephemeral gully erosion, current research activities and modeling technologies [89].

2.5. Sediment Transport Research

Laboratory research on sediment transport over the years have included topics such as the initiation of motion of

sediment [90], suspended sediment transport [91]-[94], bed load transport [90], bed forms [95]-[97], local scour [98] [99], prediction of sediment loads in streams [100] [101], and physical processes of sediment transport [102]-[104]. Field studies of flow and sediment movement have been conducted on experimental watersheds and have provided baseline data on the movement of sediment in field channels. While these studies have yielded valuable data on the effect of land management practices on runoff and sediment yield as well as important data sets for watershed model development and validation, the fundamental attributes of the transport of sediment by flowing water are difficult to study in the field. In recent years, cooperative research projects with the National Center for Physical Acoustics (NCPA) have yielded instruments that use acoustic backscatter to collect information on suspended sediment concentrations in laboratory flumes [105]-[107]. Established in 1989 by Congressional Act, NCPA is located on the University of Mississippi campus and maintains basic and applied research programs in many areas of physical acoustics. NCPA investigates a variety of acoustic phenomenon, from ultrasonic to infrasonic. The porous media group is focused acoustic/laser imaging and detection as well as agriculture related projects with the USDA and additional research addresses areas specifically important to Mississippi, such as catfish health, termite and fire ant infestations and viability of flood control dams. For more information about NCPA, please visit <http://ncpa.olemiss.edu/>.

2.6. Field and Watershed Modeling

The NSL is the custodian of three computer-based models—The Revised Universal Soil Loss Equation (RUSLE; [108]), which is a computer program that initiates rates of soil erosion caused by rainfall and overland flow on upland areas (agricultural land, construction site, etc.); the Agricultural Non-Point Source Pollution (AGNPS; <http://go.usa.gov/KFO>; [109]) model, a computer model that predicts non-point source pollutant loadings within agricultural watersheds and includes erosion and sediment transport of the stream system; and the Conservation Channel Evolution and Pollutant Transport System (CONCEPTS; <http://www.ars.usda.gov/Research/docs.htm?docid=5453>; [110]-[112]), a process-based computer model of in-stream and riparian processes that includes the effect of sediment generation due to channel bed changes and modifications. Recently, RUSLE2 (for details see <http://www.ars.usda.gov/Research/docs.htm?docid=6010>) was completed.

The National Center for Computational Hydroscience and Engineering (NCCHE) is a research unit of the School of Engineering at the University of Mississippi in Oxford, MS. NCCHE is funded through Congressional mandate with primary support from USDA-ARS and more recently through support by the Department of Homeland Security. The mission of the center is to advance the understanding of fundamental characteristics and develop modeling technologies of water flow, soil erosion, sediment transport phenomena and their effect on water resources, soil conservation, flood control, waterways safety as well as their impact on the environment/ecology; educate future professionals through graduate degrees in Engineering Science; assist government agencies in carrying out research; and promote knowledge exchange through publications and other related activities. The computational models developed by the research members of NCCHE apply to the following areas:

- Free Surface Turbulent Flows (1D, 2D, 3D, and Unsteady)
- Sediment/Contaminant Transport (1D, 2D, 3D and Unsteady)
- Water Quality (with chemical kinetics and fate processes)
- Watershed Management Decision Support Systems
- Ecological and Environmental Impact Assessments
- Ground Water and Surface Water Interactions
- Dam-Break/Levee-Breach Flooding and Simulations
- Multi-Objective and Multi-Constraint Optimizations
- Coastal Processes with Current, Wave and Storm Surge Effects

All models developed at NCCHE have been rigorously tested by the comprehensive verification and validation procedure developed by the ASCE-EWRI Task Committee. For more information about NCCHE, please visit <http://www.ncche.olemiss.edu/>.

2.7. Pigeon Roost Watershed

The early research activities at the NSL represented a continuation of previous work conducted prior to its establishment. Among those were sediment sampling at twelve discharge stations in the 117 mi² Pigeon Roost

Creek Watershed (PRCU). This work was designed to determine runoff and sediment production for several differing watershed conditions relative to land use and conservation practices. These measurements were made from 1950-1979 on drainage areas ranging from 100 acres to 117 mi². This study has provided a large data base on sediment movement that has been widely used in the development of sediment transport equations in channels.

2.8. Demonstration Erosion Control (DEC)

The Goodwin Creek Experimental Watershed (GCEW) near Batesville in North Central Mississippi was established as part of the Demonstration Erosion Control (DEC) project [113]-[117]. The project was designed to evaluate the performance of stream channel erosion control structures constructed by the U.S. Army Corps of Engineers in the highly unstable streams draining the Bluff Line Watersheds of the Lower Mississippi Valley. Construction began in 1977 and completed in 1981. A large number of smaller studies have been conducted including rainfall and runoff relationships, bank stability, bed forms and sediment transport, effect of land use on runoff and sediment loading, enhancement and verification of numerical watershed models and the determination of fine sediment sources using naturally occurring radio nuclides. This watershed has been continuously in operation since 1981 and serves as a unique outdoor laboratory. This watershed is one of the best-instrumented ARS benchmark watersheds where long-term, continuous hydrologic databases are being collected.

2.9. Mississippi Delta Management Systems Evaluation Area (MDMSEA)

From 1995 to 2005, the NSL was assigned responsibility to assess the environmental impact and effect of agricultural applications practices, especially in cotton production, on water quality and ecology of oxbow lakes in the Mississippi Delta and develop alternative practices that would reduce and minimize these effects. Three oxbow lake watersheds (Thighman (1497 ha, 9 ha lake); Beasley (850 ha, 25 ha lake); and Deep Hollow (202 ha, 8 ha lake)) were included in the study, each with its own management practices: conventional farming practices; conventional farming practices in combination with edge-of-field practices (vegetative strips, slotted board risers); and agronomic conservation practices (conservation tillage and cover crops) as well as edge-of-field practices [118]. The results indicated that conservation management practices reduced sediment and non-point source pollutants to the oxbow lakes [119] [120].

2.10. Conservation Effects Assessment Project (CEAP)

CEAP is a multi-agency effort that began in 2003 to quantify the environmental effects of conservation practices and programs and develop the science base for managing the agricultural landscape for environmental quality (see also [121]). The program has two components critical to the NSL: 1) Watershed assessment studies to provide detailed quantification of conservation program effects on soil and water quality; and 2) National and regional assessments using watershed scale models and NRCS data bases to estimate the environmental effects and benefits of conservation practices on the landscape. Three of the 14 national watershed assessment studies were assigned to the NSL: Goodwin Creek Experimental Watershed in northern Mississippi, Beasley Lake watershed in the Mississippi Delta [122]-[124], and Topashaw Creek Watershed in the Yalobusha River Basin in Mississippi.

3. Summary of NSL Scientific Impact

Considerable effort has been applied to explore soil erosion and, in part, the scientists of the laboratory have played a major role in defining the variables and processes of soil erosion. As a summary to this historic perspective of the NSL, an attempt was made to isolate and characterize the impact of research conducted by scientists from the NSL, specifically focusing on areas of research in which the science presented changed or modified how other researchers or the public in general view soil erosion and sedimentation. To this end, a list of five impact areas has been assembled, including: sediment tracer, soil erodibility, erosion processes by water, erosion technology (equipment and predictive), and soil conservation.

3.1. Sediment Tracing

Over the past 45 years, research has shown that Cs-137 can be used effectively and efficiently to study the

sources and redistribution patterns of soil particles on the landscape. Research primarily focused on sedimentation in lakes and reservoirs [45] [125] [126], provided the basis for the development of these radioisotope techniques that are now widely used around the world. Measurements of radioactive fallout Cs-137 in soils across the landscape can provide timely and quantitative estimates of soil redistribution patterns at many scales and provide independent estimates of soil erosion rates, patterns, redeposition, and sources on the landscape. When compared to a reference site, sites with a loss of Cs-137 are eroding while sites with a gain in Cs-137 are aggrading. The unique ability of Cs-137 to provide a point in time reference of soil erosion gave researchers studying sediment deposition and/or sediment sources a powerful tool for conservation planning.

3.2. Soil Erodibility

A fair amount of the early soil erodibility research at the NSL was concerned with USLE K-factor improvement [37] [38] [41] [42]. In particular, the seasonal variations in K values and the impact of freeze-thaw cycles. Later, the focus adjusted from a factor that reflected the combined effects of all soil properties to specific soil properties. Rhoton [127] related soil organic matter to declines in productivity within the southern Mississippi Valley Silty Uplands. In the fragipan soils studied, the yield-limiting factor was water storage capacity. The loss of soil organic matter resulted in unstable soil aggregates and low energy requirements for disruption. Similarly, [128] conducted an 8-yr study on conventional till versus no-till management. The findings suggested that the adoption of no-till practices resulted in improvements to fertility and erodibility parameters within 4-yr.

3.3. Erosion Processes by Water

Studies related to erosion mechanics from researchers at the NSL are significant in number; however, a few notable works stand out. Meyer [49] and Foster [47] studied rill erosion as affected by flow rate and canopy, as well as, velocity profiles in stabilized beds. Rainfall effects in interrill erosion [129] and soil roughness changes [63] were also studied, where interrill erosion rates were related to the rain intensity that caused them and changes in soil surface roughness, as related to cumulative rainfall, was described by an exponential decay function. Sediment size distributions in runoff affect sediment transport and deposition and, therefore, studies that quantify the eroded sediment distribution are fundamental. Rhoton [54] developed a laboratory technique to replicate sediment size distributions measured from runoff samples and Meyer [52] determined that aggregation and soil texture effect the size distribution of eroded sediment. Dominant in rill and ephemeral gully erosion, headcuts play a critical role in landscape evolution. Following a series of studies, Bennett [77] presented a detailed look at steady-state soil erosion. Erosion and migration of the headcut were related to removal of the surface seal and erosion of the scour hole was related to the turbulent flow structure impinging jet.

3.4. Erosion Technology

Inherent to the work, there will always be some aspect of the soil erosion process that cannot be measured and/or assessment and planning decisions need to be made. With research as the guide, physically- or empirically-based technology must forecast and assist management decisions. In the United States, USLE (1958; [130]) was the first major leap, developed from soil erosion data that was collected beginning in the 1930 by the SCS. USLE is an empirically based conservation-planning tool to predict the long-term average annual soil loss. Several scientists at the NSL were active with USLE research [131]-[133] that included runoff erosivity and variable slope length, slope steepness, and slope length. An important component within USLE research, rainfall simulators were also rigorously tested and improved [134], yielding a portable, variable intensity rainfall simulation apparatus with drop sizes and impact velocities near those of natural rainfall. However, as more research was conducted, physically based soil erosion technology [135], ignited by process research lead to CREAMS [75] and RUSLE [108]. The ever-expanding modeling prediction developments created model structure developmental needs to interface with GIS systems [136] to evaluate watershed conservation planning.

3.5. Soil Conservation

Continuing from early observations and traditional soil conservation methods handed down through generations of concerned farmers, the ARS continued to test emerging practices and develop new techniques of soil conservation. Dominant themes included no-till [137], grass hedges [44] [138], and cover crops [139] [140]. Recently,

vegetated drainage ditches [27]-[29] have been approved in both Mississippi and California as management practices, where farmers are offered incentives for implementation.

Each an integral part of the holistic pattern of soil erosion research and discovery, these accomplishments encourage every one of us to explore every avenue to protect our soil resources.

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Many have traveled the halls and laboratories of the NSL. As a laboratory of researchers, all have contributed to the success of the NSL. The success of the laboratory is attributable to perseverance and collaboration with the global community of concerned scientists, to whom much gratitude is owed. The scientists of the NSL thank you and appreciate your continued support.

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