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GLOBAL CHANGE AND FOREST SOILS

CULTIVATING STEWARDSHIP OF A FINITE NATURAL RESOURCE

EDITED BY Matt Busse, Christian P. Giardina, Dave M. Morris, and Deborah S. Page-Dumroese

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CHAPTER 4

History of forest soils knowledge and research

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ABSTRACT

Human history is intricately linked to the soil. As human populations increased agricultural land use intensified. Wood availability was also important and resulted in the management of forested land for fuel, fiber and food. Soil mapping was an essential tool in planning future expansion of agriculture and resulted in an increased understanding in the factors that regulate soil formation. This understanding eventually lead to the formation of forest soil science as a separate area of research. Early forest soil research focused on silviculture, harvesting, soil chemistry and acid rain. As the science progressed areas of research broadened to include specialized forest harvest methods and eventually to ecosystem-related research designed to understand how soils function as an integral part of the forest.

> *Essentially, all life depends upon the soil … There can be no life without soil and no soil without life; they have evolved together.*
>
> *Charles E. Kellog, 1938.* USDA *Yearbook of Agriculture (on page 864).*

Introduction: forest soils in history

Humans depend on soil for their survival. Its role in providing food and sustaining plant-based agriculture was critical in the development of ancient civilizations. With sustainable food (and fuel) production nearby, humans were able to live in one place indefinitely. The production of a surplus of food and fuel meant that large numbers of the population were released from foraging and hunting, with food and fuel production allowing them to become builders, artisans, and scientists. As food and fuel production efficiency increased, successful land managers developed enhanced production skills that allowed continued advancement and creation of many civilizations. Eventually, development of trade led to large-scale redistribution of food and fiber from producers to consumers, and government

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policies and taxation allowed the collection, stockpiling and redistribution of food and fuel supplies when harvests were sufficient (see Box 4.1 for what happened when they were not sufficient).

BOX 4.1 Soils and Societal Collapse

Historians point out that the inability to produce food at rates required to sustain a population has led to the decline and/or, ultimately, the collapse of a civilization (Montgomery, 2007). When food was scarce, wars were waged as a means to increase food supply and control resources of an adversary. The ability of an invading army to forage sufficient food and fuel to feed and warm soldiers was often the difference between military success or failure. Famous examples include the successful Russian strategies of denying resources during French and later, German invasions, and the "Scorched Earth Policy" exemplified by Sherman's "March to the Sea" during the US Civil War. Likewise, when one group conquered another, one of the ultimate acts cited to prevent the rebuilding of that previous civilization was "Salting of the Earth" to destroy soil productivity where the city once stood (Weinfeld, 1992; Papanck, 1995).

Wood and forest products have also been integral to the development of most civilizations. Wooden implements, stored in large caches and estimated to be 5000 years old, have been discovered in India (Baker et al., 2009). Because oak (*Quercus* spp.) forests are so widespread, they have been described as the "frame of civilization" and used throughout history to provide weapons, boats, homes, and inspiration (Logan, 2005). Until quite recently, wood was almost always the primary source of energy for cooking, heating, and industrial processes. Wood, like grain, was eventually imported from remote areas, and wood supply was critical to the continued success of civilizations (Perlin, 1989). As human populations and land use increased, so did the need for forest products. As populations became more stationary, forests closest to population centers came under greater pressure to produce. These changes, along with colonization, wars, and invasions, usually resulted in the over-exploitation of forests.

Though much of the early land management involved removing trees from forestland to convert it to agricultural land, the purposeful management of forestland and thus forest soils developed from the need to produce wood sustainably, as well as to produce the myriad of environmental benefits forests can provide. Greek and Roman historians noted that the destruction of soil, which resulted in the flooding of cities and silting of rivers and harbors, often started with clearing forests for the conversion of land to agriculture (Hughes, 2001). There was also an early awareness of the impacts of clearing steep land. Plato noted in the fifth century BC that "the loss of timber had denuded the hills and plains surrounding Athens and caused massive soil erosion" (Chew, 2001). Romans attempted to protect forests through regulation (Chew, 2001), but it is unclear how effective these efforts were. While the relationships between agricultural productivity and soil quality were clear, and were commonly pointed out in ancient writing from Egypt and China, this understanding of the relationship between soil and tree growth is less well-documented. As civilizations developed, and over exploitation of soil resources, including forest soils, occurred, the need for knowledge about forest soils became increasingly important.

Milestones in forest soil knowledge

Soil classification and survey

Initial attempts to classify soils were made 4000 years ago in China (Vilenskii, 1957) with documented mapping of soils to access their 'generosity' in the first century (Krupenikov, 1981). In 15th century

Russia, farmers described forest soils on their property as being potentially arable or non-arable; also at this time perhaps the first pedological description of forest soils was made (Remezov and Pogrebnyak, 1965). This discernment of suitability for agriculture resulted in the description of the differences among forest types on soils mineral and organic (a.k.a., forest floor) soil surface horizons. This led also to the inclusion of plant species in the description of soils (Remezov and Pogrebnyak, 1965).

Organized efforts to map soils began in earnest across the globe in the 19th century. The systematic study of soils in European Russia began in 1838 and continued onto the Asian area of Russia in 1908. Soil mapping in Germany (Behrens and Scholten, 2006), India (Bhattacharyya et al., 2013), and the United States (Soil Science Division Staff, 2017) began in the 19th century, and in the early 20th century in Canada (Anderson and Scott Smith, 2011). Almost all early maps were focused on identifying the suitability of a site for agriculture.

Russian soil surveys used a method developed by V.V. Dokuchaev in which mapping was based on soil description and vegetation, but also included the chemical analysis of soils (Fig. 4.1). Early efforts in other parts of the world focused on site geology (parent material) to differentiate among soils and explain differences in soil properties. In the US soil survey, the concept of the soil series was developed

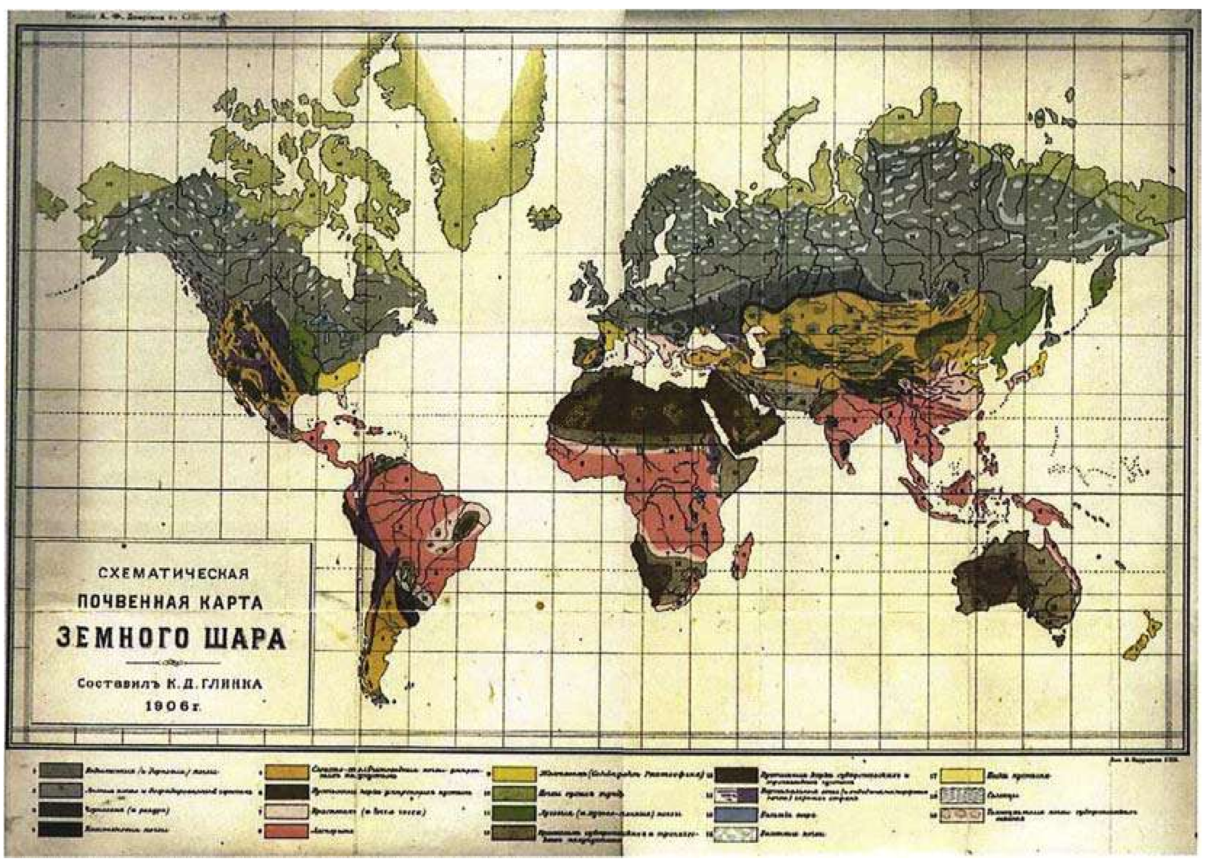

FIG. 4.1

This world map shows soil types as understood in 1908. It was developed by Konstantin Dmitrievich Glinka (1867–1927), a prominent Russian soil scientist (Hartemink et al., 2013).

early, with soils being mapped into groups with similar colors, subsoil character, relief, drainage, and origin (Marbut et al., 1913). As the concept of soil formation and genesis broadened to include not only geology but also climate, vegetation, topography, and age as important influences on soil properties, these concepts were incorporated into the mapping of soils (Marbut, 1921).

In the US, the goal of soil survey was to describe the characteristics of the soils in a given area, plot the boundaries of the soils on a map, and make predictions about the suitability and limitations of each soil for multiple uses, with the primary foci being crop production and erosion control (Soil Science Division Staff, 2017). As more areas were mapped, the number of soil series expanded, and a classification system, based on the Russian system, was developed to organize the knowledge of the soils encountered (Marbut, 1928). In 1938, the system was revised to incorporate new concepts of soil genesis. In this system, the lowest category was the soil series which had the most information describing a soil's properties and served as the basis for soil mapping and interpretation. The 1938 system, however, lacked rigid limits among classes above the series and was not well suited for interpreting soil behavior (Baldwin et al., 1938).

Because of these shortcomings, efforts to develop a new system of US soil classification were begun in 1951 and completed in 1975 with the publication of Soil Taxonomy (Smith, 1983). Although developed in the US, Soil Taxonomy was designed for use worldwide, and involved the efforts of scores of foreign and domestic soil scientists and scientists from other disciplines including geology, geography, agronomy, forestry, botany, and ecology, to assemble the current knowledge on properties, genesis, distribution, and interpretation of the soil resource. It is a morphogenetic system, i.e. many of the diagnostic components of the system reflect specific processes and pathways of soil genesis, but class limits are rigidly defined by observable or measurable properties of the soil (Soil Survey Staff, 1999). Thus, the taxonomic nomenclature of a soil reflects many important properties, including presence of thick organic horizons, A horizon color and base saturation, subsoil texture and mineralogy, presence of water and root restrictive horizons, and depth to bedrock.

The importance of the soil survey to forest management was evident early in the history of both soil science and forestry. For example, after the establishment of the US Forest Service in 1905, soil scientists from the Bureau of Soils conducted small scale reconnaissance surveys of many of the National Forests to locate potentially arable soils (Roth, 2002). Additionally, surveys of farms often included areas of woodlands for completeness and to locate additional arable soils. However, forestry-related interpretations were not included in these surveys, which limited their usefulness for forest management. Soil scientists did observe that differences in soil properties, especially surface horizon properties, were related to forest type, which led to descriptions of tree and understory species being commonly included in descriptions of soils in forested areas (Remezov and Pogrebnyak, 1965). Nonetheless, the American Soil Survey Association was very much interested in forest soils, as shown by their sponsorship of a "Forest Soil Symposium" at their 1936 Annual Meeting. The papers were published in the January 1937 issue of the *Journal of Forestry* with abstracts in the official report of the Soil Science Society of America for 1936.

The correlation between soils, vegetation species composition, site productivity, and other biological, physical and chemical ecosystem characteristics, has been an important product of soil surveys for decades, with significant implications for forest soils research. Specifically, without these, the extrapolation of results from soil-dependent research to sites with similar soils would not be possible, and the research would be a one-of-a-kind project and relatively useless for design of forest management systems to enhance productivity and/or restore degraded natural forest and grassland areas (Roth, 2002). Thus, understanding the properties of and properly classifying soil at research sites is a critical component of both forestry research and the design of forest management systems. Understanding these relationships is also a useful tool for soil mapping and developing interpretations of expected soil behavior to various types of land management.

In addition to extrapolation of research results, soil surveys have been used for soil property inventories, establishing relationships among soil properties, and design of sampling schemes for regional and national inventories of soil and ecosystem properties. Specifically, in recent decades, numerous studies have based inventories of soil organic carbon (C) across states, regions, nations, and globally on soil survey databases (Bliss et al., 1995; Johnson and Kern, 2003; Sundquist et al., 2009; Bliss and Mausetter, 2010). Similarly, site variables, including soil Order, drainage class, texture, slope, and elevation, have been used to successfully predict soil organic C pools (Tan et al., 2004). Finally, because a soil's classification reflects many important properties (surface horizon color, subsoil texture and mineralogy, presence of root restrictive horizons, base saturation, soil moisture and temperature regimes), it has proven to be useful for design of sampling schemes that represent the range of soil properties across an area (Wills et al., 2013).

Soil surveys were initiated to aid development and application of tools and management systems to help conserve and enhance soil resources, and to provide a basis for understanding and communicating knowledge of and relationships among soils. Over the past decades, soil survey and applications of soil survey data have evolved substantially and will continue to evolve as new knowledge of soil properties, soil behavior, and relationships among ecosystem properties becomes available (Fig. 4.2). Only through interaction among soil scientists, foresters, agronomists, and ecologists will this evolution continue to result in improvement of soil inventory and its use to effectively manage global ecosystem resources.

An overview of the development of forest soils knowledge

A 1928 English translation of the 1917 German text, 'The evolution and classification of soils,' by E. Ramann, described the factors impacting soils: climate (temperature, precipitation, evaporation), soil climate (effects of plant cover), and soil formation including physical and chemical weathering, water movement, and dead organisms (Ramann, 1928). This text references the interactions of plants, microorganisms and soils, "…the plant covering and the soil—each influences the other. This holds good, not only for the higher plants, but for soil organisms in general. Not only are the members of a plant community inter-related, but the animal life of the soil and the world of micro-organisms assume different aspects under the influence and protection of the vegetative covering. All these organisms are members of a great community, all, through long periods of time, have become adapted to one another and the properties of the soil, so as to give the impression of a single organization whose members live in intimate association with one another and are dependent on one another for their existence. *These effects are seen to the best advantage in woodlands*." (italics added for emphasis).

The examination of these interactions has formed the basis of forest soils research ever since. Scientists have studied not only how these factors affect forest soils and determine the characteristics of soils in specific locations but also have extensively evaluated how forest soils change over time and respond to change. To provide a brief overview of forest soils research, we examined trends in research publications dealing with forest soils and various topics through time. (See Chapter 19: Long-term forest soils research: lessons learned from the US experience for methods, and caveats). Our methodology

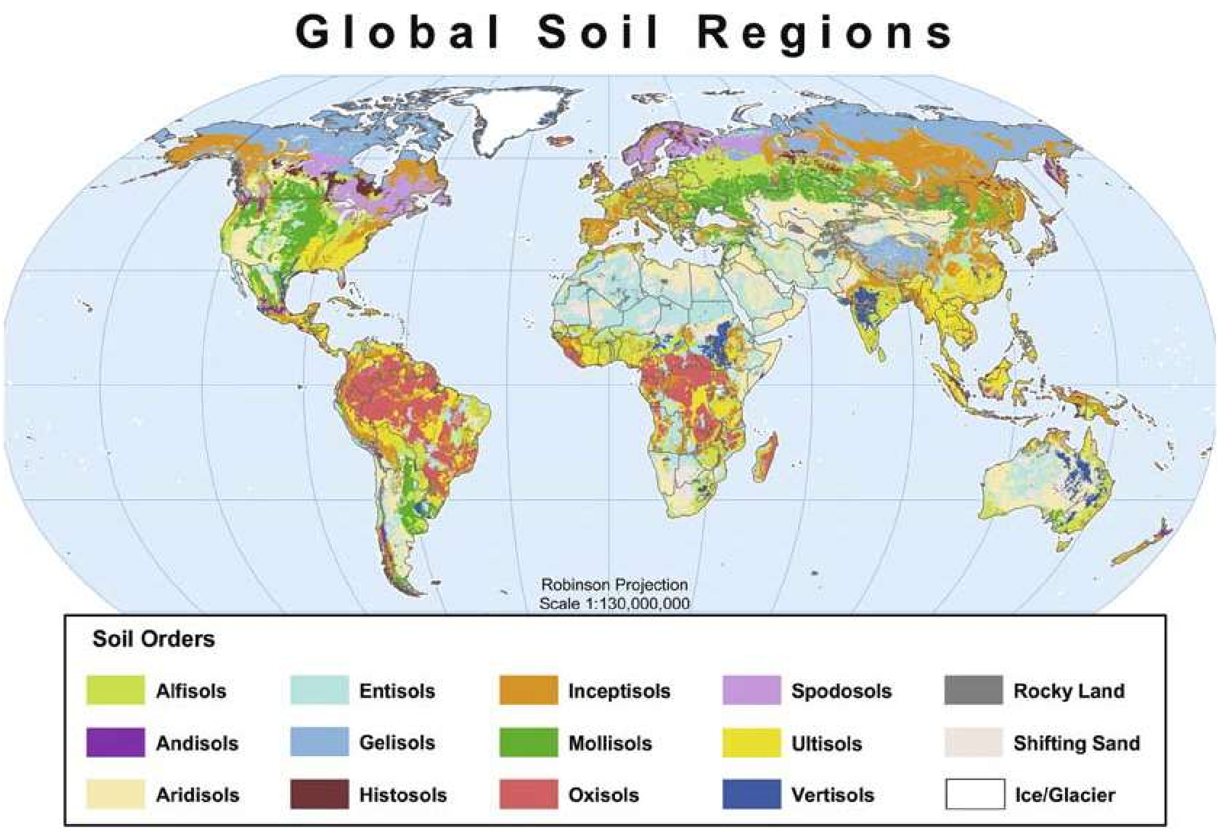

FIG. 4.2

FAO/UNESCO soil map of the world, 2018, 1:130,000,000 scale (www.fao.org).

FAO/UNESCO Soil Map of the World, http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/faounesco-soil-map-of-the-world/en/. Reproduced with permission.

is applicable to the 20th and 21st centuries, so does not address older texts and research, but provides an interesting overview nonetheless.

Forest soils research in the first half of the 20th century was focused on soil survey, silviculture, harvesting, chemistry, organic matter, and acid rain (Table 4.1). Much work was done on describing and classifying forest soils. Research came predominantly from the USA, Sweden and New Zealand. During the second half of the century, the USA, USSR, Canada and the Federal Republic of Germany had the most publications dealing with forest soils. In the 2000s, the USA remained the most prolific publisher, followed by the People's Republic of China, Germany, Brazil and Canada.

It is interesting to note that "acid rain" has been a research topic since 1910 and that nearly as many papers were published about acid rain during 1910–49 time frame as for papers about "Forest Soils". Acid rain was perhaps the first global environmental problem that resulted in worldwide research about causes, impacts and methods of recovery. Although knowledge of forest soils is strongly tied to acid rain research, publications that include both "Forest Soils" and "acid rain" didn't begin until 1980 and due to low numbers could not be analyzed for country of origin (see Chapter 19: Long-term Research chapter for a more detailed information).

Table 4.1 Research publications, by topic, through time (1900–2018).

Search topic	First publication	–1979	1980–89	1990–99	2000–09	2010–18
Forest soils	1900	788	1,084	10,934	25,110	49,305
Forest soils &						
Soil survey	1945	10	4	463	1,109	2,078
Silviculture	1928	1		55	151	279
Harvest or management	1930	5	22	1,715	5,256	10,421
Whole tree harvest	1986		3	102	155	494
Clear cut harvest	1977	3	16	248	540	616
Biomass or bioenergy	1973	9	20	2,173	5,278	9,606
Acid rain (only)	1910	389	1,499	8,027	11,469	19,297
Forest soils &						
Acid rain	1980		27	843	879	929
Clean Air Act	1958	86	614	2,723	3,057	3,649
Chemistry	1925	24	51	2,171	4,184	6,274
Carbon (organic matter)	1928	31	78	3,527	10,610	20,025
Biodiversity	1967	1	3	964	3,863	9,418
Ecosystem	1969	13	45	3,112	8,463	16,544
Long-term	1975	3	22	1,252	3,172	5,521
Water quality/ chemistry	1977	1	3	926	1,956	2,885
Climate change	1987		2	742	2,693	8,765

See Chapter 19 for methods.

In the latter decades of the 20th century, the number of research topics increased, with more specialized types of forest management (e.g. whole tree harvest, biomass or bioenergy), and more ecosystem-related subject areas (climate change, water quality, carbon). This change in topical areas also came as experimental designs evolved. Early forest soils research often used traditional single-site studies, or slightly more sophisticated catena experiments (space-for-time substitution) to address questions related to site quality evaluation and impacts. As the century progressed, experimentation evolved to incorporate the concept of ecosystems, which evaluated the processing of water, energy, and nutrients through forests. Later in the 20th century, large experiments and networks of research sites became more prevalent. As these developed, experimental designs evolved to incorporate more complexity, including longer time frames, encompassing decades, and larger geographical scales of inference.

Finally, the increasing number of publications in the late 20th and early 21st centuries also represents a proliferation of research journals, as well as more scientists engaged in forest soils research. One of the prime outlets for forest soils research during the late 20th century was the North American Forest Soils Conference (NAFSC), which has been held every 5 years since its inception in 1958. Although focused on North America, the research encompasses soils in managed forests around the globe, with a long history of participation from Australia, New Zealand, Europe, and more recently Asia and South America. At the 11th NAFSC, Burger (2009) provided a timeline of the development of forest soils knowledge and concepts for managed forests, which identified some of the same themes as brought out in Table 4.1. In particular, research at the early conferences was mostly focused on site quality evaluation and classification for multiple uses. In the middle years, conceptual models of forest soils (Stone, 1975) were superimposed on management systems, which lead to focused research on soil/site productivity and sustainability, largely focusing on nutrient cycling and organic matter and carbon. Forests as tools for rehabilitation and restoration of soils was also important in the mid-to late 20th century, and has again become a focus with concerns about climate change. Burger (2009) also points out that forest soils research has evolved from nearly all applied research to an approximately equal distribution of applied and basic research. Most recently, as technologies for exploring soil biological communities have developed, there has been a greater focus on understanding belowground ecosystems, and their role in sustaining forest soil productivity and providing ecosystem services.

Currently, soil survey and classification are also evolving, with the concept of continuous change in soils over time being explored in a world with changing climate, numerous insect and disease infestations, and altered vegetation communities due to agricultural use, land abandonment, and forest management. Under these perturbations, a static soil is unlikely. Polygenesis, or continued evolution of soils, incorporates this paradigm into the existing or historical concepts of soil formation and soil classification (Richter and Yaalon 2012 ; Yaalon, 2012). Soils change when exposed to novel environmental conditions, and these responses occur at varying rates, i.e., soil organic matter (<100 years) and weathering or clay formation (>1000 years) (Yaalon, 1990). Forest soil scientists understand that these changes do not necessarily over-ride the impact of soil forming factors, but rather require novel experimentation, and long-term research to understand the changes in forest soils as well as their past, current, and future role in sustaining forest ecosystem services.

Case studies: the value of research networks and long-term studies

As described above, long-term research in an ecosystem context brought considerable rigor to forest soils research. Some of these studies are described in more detail in Chapter 19: Long-term forest soils research: lessons learned from the US experience. We highlight a few case studies to illustrate important concepts in forest soils research. In collaboration with the National Science Foundation and International Biological Program (IBP), US Forest Service scientists began long-term soil nutrient studies and sample archiving at the Calhoun Experimental Forest (South Carolina), and biogeochemical cycling studies at the Hubbard Brook Experimental Forest (New Hampshire) and the Coweeta Hydrologic Laboratory (North Carolina) in order to understand fundamental aspects of nutrient cycling patterns and processes, responses to disturbances, forest management and forest growth (Vose et al., 2014). These long-term studies, and their sample archives have proven repeatedly useful in understanding how forest soils respond to various stressors. In particular, at the Calhoun Experimental Forest, soil scientists, ecologists, and others have examined soil change at multiple time scales, from the decadal to millennial. Their work documented soil recovery processes following abandonment after protracted agriculture for cotton and associated accelerated soil erosion, followed by planting to loblolly pine (*Pinus taeda*) (see Chapter 2).

The Experimental Forests and Ranges (EFRs) of the USDA Forest Service represent a network of field sites covering over 235,000 ha and are in almost every forested ecoregion in the country (Box 4.2), and have a wide variety of historical data sets, some dating back 100 years. Hundreds of

BOX 4.2 US Forest Service Experimental Forests and Ranges (EFRs)

Plans for the first Experimental Forests and Ranges (EFRs) by the USDA Forest Service (USFS) were developed within just the past century. Gifford Pinchot established the Section of Silvics in 1903 to coordinate data collection across the Agency, and Raphael Zon, who began with the USFS in 1901, became head of the renamed Office of Silvics in 1907. In 1908, the first experimental forest, the Fort Valley Experiment Station near Flagstaff, AZ, was established with a focus on ponderosa pine (*Pinus ponderosa*) ecology and management. This was the first of 82 Experimental Forests and Ranges that were established across the US to conduct "experiments and studies leading to a full and exact knowledge of American silviculture, to the most economic utilization of the products of the forest, and to a fuller appreciation of the indirect benefits of the forest" (Shapiro, 2014). Within 5 years of the establishment of Fort Valley, the Forest Service had field research stations or experimental forests in Idaho (Priest River), Washington (Wind River), Colorado (Wagon Wheel Gap and Fremont), Utah (Great Basin), New Mexico (Jornada Experimental Range) and the Forest Products Lab in Wisconsin, among other locations.

past and current Forest Service scientists, academic partners, other collaborators, and countless students pursuing undergraduate and graduate degrees have used the forests, and data from them. Basic and applied research activities on EFRs have provided a more thorough understanding of forested ecosystems and answer pressing questions about air quality, soils and water on public and private lands. They also provide approaches to improve the effectiveness of land management actions and better understand the potential unintended impacts of these activities, as well as strategies to mitigate or avoid these impacts. Most EFRs also have served as focal points for education and demonstration and as a venue for the interaction between land managers and scientists. These facilities offer some of the few places in the United States where forest soils research can be conducted over large areas and long time frames (Stine, 2016).

Case studies: forest management and soils

In forest and range ecosystems, soil-based variables offer effective and practicable indices of sustainable productivity (Powers et al., 2014). The North American Long-Term Soil Productivity cooperative research program (LTSP) is the world's most extensive coordinated effort to address questions of sustainable productivity in managed forests. The study was established in 1988 to determine long-term effects of soil disturbance on fundamental productivity. Four USFS Experimental Forests were pivotal in piloting the study, Palustris, Challenge, Priest River, and Marcell, however, the study grew to include many more EFR and industry sites, and has expanded into Canada and New Zealand. The results illustrate the physical importance of organic soil cover in reducing soil erosion and maintaining favorable soil temperature and moisture relations during summer drought. Findings also show that the biological significance of soil compaction depends on soil texture. Also, the continuity of this network of long-term study plots has allowed researchers to investigate soils in a whole ecosystem context and answer many questions about functionality of soils and soil processes that exceed the questions asked at the initiation of the study.

Research on soils of oak-dominated, unmanaged forest stands in seven experimental forests ranging along a historical and current acidic deposition gradient from southern Illinois (Kaskaskia Experimental Forest) to central West Virginia (Fernow Experimental Forest) documented that differences in oak growth and mortality may be related to the differences in soil chemical status and soil N dynamics. This program provides an example of the way a functional network can address management-related questions across an environmental gradient.

Inclusion of soil science in forestry education in the US

From the inception of soil survey, the purpose for developing an inventory of soils was predicting and enhancing agricultural production and controlling erosion. Thus, relationships between soil properties and forest growth and forest management were secondary, if considered at all. However, Wilde (1953) pointed out that both Virgil and the early Roman Boethius commented on the relationships of forest growth to soil properties, showing that some early naturalists did observe and make use of obvious relationships between the growth and size of native trees and properties of forest soils. These observations and use of information were mostly limited to Europe and Asia. In North American academic communities in the early part of the 20th century, relationships between soils and forestry were dominated by the empirical (and rarely correct) conclusions of Ezra Meekers, circa 1920, that soils could be ignored when it came to tree growth.

It is therefore not surprising that soil science as a subject for study in the training of professional foresters, or as a research focus, did not command much attention in North America in the early years of colonial settlement, displacement of native peoples, expansion, widespread exploitation of natural resources, and development. At some forestry schools, students might have taken a soils course but these were given in the agricultural curriculum, with major emphasis on field crops. In some institutions, a silvicultural course might have introduced the subject of soils but did not treat it as an important factor of forest management (Box 4.3). This state of affairs existed generally through the 1930's with no significant improvement until the late 1940s, although several courses were taught prior to World War II

BOX 4.3 Forestry education in the US

Forestry as a western academic science in the US largely began at the Biltmore Forest School in what is now Pisgah National Forest in North Carolina (Jolley, 1998). Carl Alwin Schenck opened the Biltmore Forest School in the autumn of 1898, using the forests of the wealthy industrialist George W. Vanderbilt as his campus. This field based 'practical' forestry school began about the same time as Bernhard E. Fernow's 4-year university forest science curriculum at Cornell University. Pinchot, first chief of the Forest Service, believed a dual approach to forestry education was best and offered Biltmore Forest School graduates an assistant position with the then Division of Forestry at USDA. Pinchot (then head of Division of Forestry at USDA) and Henry Graves (second in command at the Division of Forestry), approached Yale University, and Yale accepted a $150K endowment from Pinchot to begin the post-graduate program at the Yale Forest School in 1900. Graves became the first professor of forestry and the department chair of the newly founded school; he became the second head of the Division of Forestry in 1910 (https://foresthistory.org/research-explore/us-forest-service-history/people/chiefs/henry-s-graves-1871-1951/).

that dealt with the importance of forest soils in tree growth by Robert. F. Chandler at Yale, Theodore. S. Coile at Duke, Harold Lutz at Cornell, and Sergei. A. Wilde at Wisconsin. These individuals and institutions played an important role in the early formative years of forest soil training and information development. Lutz and Chandler worked together extensively, leading the efforts in North America to develop information on forest soils and bring this information into teaching programs at their universities. An outcome of these efforts was the production of the invaluable book "Forest Soils", which was first published in 1946 but is, remarkably, still in use today. Both Lutz and Chandler also had effective graduate training programs at their respective institutions, as did Coile and Wilde. These college professors produced some of the early leaders in forest soil education and research.

Conclusions

Forest soils have been important in the history of human civilization, although sometimes as an afterthought relative to agricultural soils. Much of the early history of forest soils research is related to the quest to classify soils for agriculture potential. However, as forests became more important as sources of fuel, wood products, research began to evolve to consider forest soils separately, and in light of their capacity to provide important products, and more recently important ecosystem goods and services. Generally, forest soils research has been focused on temperate and boreal forests, but most recently, forest soils have become a truly global research area.

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