INTRODUCTION

The early Latin derivation of Homo (Latin for man) was hemo, meaning the earthly one; akin to the Latin word for earth or soil, namely, humas, and the Latin word for humans, namely, humanus.[1] The history of humankind, and our ancestral Homo species, is the history of our relationship to the Earth and its environment.[2] Archeological evidence in many parts of the world reveals our penchant to alter the environment,[3–5] be it to our boon or bane.[6] Soil is a major component of the natural resource trinity (soil–sun–climate) from which humankind’s sustenance is rooted. And soil is the common earthen parchment upon which humanity’s cultural signatures are imprinted. Speech, tools, and fire (allowing for clustered habitation in inclement climates) formed the tripod of culture for Paleolithic man and his later counterparts.[6] Today, the sophistication and capability of modern tools, the development of multiple energy sources, and the increase in population have resulted in the capacity for modern civilization to alter the environment in ways, and at scales, unprecedented in human history. As early as the mid-19th century, human activity was recognized as a significant force in altering the environment.[6–10] Even at the turn of the 20th century, geologists were calling humans the dominant geological force of the planet.[9] Still, progress was measured in terms of our increasing control over nature, marching through the stages of our cultural evolution as if the Earth was simply the stage upon which this human drama was acted out.[9] The impact of progressive stages of civilization on the environment, and the tapping of the Earth’s stocks of natural resources to sustain these civilizations, were largely ignored.[9] Yet, there were those thinkers and writers who recognized that civilization was dependent upon soil and other natural resources for its preservation, and that humankind had failed in its role as steward of the soil and natural resources heritage that sustains it and civilization itself.[7,8,11]

Both nature and humans have left (and are still leaving) imprints on the Earth’s soil resources. Soil is the Earth’s equivalent to anatomical derma—a planetary vellum with the “signature” of pedogenic processes, such as climate, acting upon a variety of soil parent materials (e.g., sedimentary, igneous, or metamorphic bedrock; alluvium; glacial deposits; wind-blown silts or loess; and volcanic ash and lava). The morphology and character of the soils originating from these interactions are further modified by the topographic configuration of landscapes, the flora and fauna adapted to the resulting ecological niches, and the duration of these active processes. The spectrum of soils and ecosystems born of these pedogenic and ecological processes constitutes the natural resource heritage from which humankind and its civilizations are sustained. Agriculturally productive soils, occupying only a limited portion of the planetary soil resource pool, were precursors for the genesis of civilization. They are primary requisites for generating the necessary biomass to sustain more than 6 billion humans now occupying this planet, with another 2 to 3+ billion projected to be here within the next 4–5 decades.

HISTORICAL PERSPECTIVE

The dawn of civilization was rooted in the soil. As Bradley[12] noted, “the fabric of human life has been woven on earthen looms. It everywhere smells of the clay.” And an old saying, attributed to the Chinese, states that, “Man—despite his artistic pretensions, his sophistication, and his many accomplishments—owes his existence to a six-inch layer of topsoil and the fact that it rains.” The domestication of plants and animals, i.e., the beginning of agriculture, occurred about 10,000 years ago[2,5,13–17] and released the human species from its bondage to a hunting and gathering existence since its origin. Evidence of plant and animal domestication in the early Holocene has been documented on several continents.[5,15–17] The effect of this profound and transforming revolution in human history was to increase the carrying capacity[18] of a region and its ecosystem. Archeological evidence within the Fertile Crescent and areas around the Mediterranean suggests that their inhabitants were domesticators of animals and cultivators of the earliest founder cereals, such as einkorn wheat, emmer wheat, and barley, and founder legumes such as lentil, chick pea, pea, and bitter vetch.[14] This domestication of nature’s provisions allowed the accumulation of surplus food supplies that underwrote major population expansion, the division
of labor, which released many from the task of gathering—producing food, and the rise of cities and urban states.\textsuperscript{[13,19]}

Diamond\textsuperscript{[20]} posits that the development of agriculture was “the worst mistake in the history of the human race.” Most historians, anthropologists, and others, however, see this agricultural transformation of 10,000 years ago as “the greatest single step forward in the history of mankind”—the most momentous turn in the progress of humankind.\textsuperscript{[13,21]} In the words of Thomas Hobbes, life before agriculture was “nasty, brutish, and short.”\textsuperscript{[21]}

An axiom of agricultural geography, still valid today, holds that cultivation-based agriculture is predominantly located on soils derived from relatively young geologic parent materials such as alluvium, glacial deposits, loess, and volcanic ash. Soil provides the medium through which nutrient flows and energy conversions take place. Thus, it is not coincidental that early agriculture, and the civilizations that sprang from it, originated in broad alluvial flood plains and adjacent foothills such as the Tigris and Euphrates rivers (the Fertile Crescent), the Jordan Valley, the Nile River, the Indus River, the major rivers of Asia, and intermontane (alluvial) valleys of the Middle East. Similarly, the other early cultures were nurtured by agriculture rooted in soils derived from loess and other relatively young soil parent materials.\textsuperscript{[15,0,16,22]} Contemporary agricultural equivalents include the North American Corn Belt (glacial deposits and loess), the Central Valley of California (alluvium), the wheat region of the northwestern United States (volcanic deposits), the rice cultures of Asia (alluvium), and the Chernozem-Black Soils of the Russian grain belt (glacial and loess materials).

The advent of the agricultural revolution was accompanied by increasing ecological manipulation. The development of the ox-drawn plow, followed by the plow, occurred approximately 5000–6000 yr ago throughout Mesopotamia, Egypt, and China.\textsuperscript{[13,23,24]} Then came plows of increasing sophistication and improved design, including seeder plows that simultaneously allowed the opened furrow to be planted, the design of which is still used today in parts of the Middle East.\textsuperscript{[13]} These developments ratcheted up the capacity to manipulate the environment and commonly resulted in deleterious environmental impacts, with soil erosion being the Achilles heel of cultivation-based agriculture. Hillel\textsuperscript{[13]} has opined that, contrary to the prophet Isaiah, the plowshare became more destructive than the sword. Similarly, animal herding and overgrazing of hillsides exacerbated the environmental impacts of agriculture.

Another early technological innovation accompanied the advance of cultivation-based agriculture: irrigation. Early societies, cultures, and civilizations that developed in the arid and semiarid regions of the Middle East needed to manipulate the hydrologic cycle for crop production. The earliest evidence of irrigated farming was found in the Jordan River Valley, within which, lay the ruins of the ancient city Jericho, dating back perhaps eight millennia.\textsuperscript{[23]} It is not surprising that irrigation was an early achievement, given the juxtaposition of the alluvial soils and the watercourses from which the alluvium was derived.

Canal systems were built throughout much of the Middle East to intercept portions of the adjacent river flows and distribute the water to crop fields. These elaborate irrigation networks relied on gravity flow, although there were gates and other features to accommodate the rise and fall of the rivers’ seasonal discharges. Water-lifting devices, such as Archimedes’ screw (tambour) and the animal-powered water wheel (sagia) were designed to lift water from irrigation canals and rivers to crop fields.\textsuperscript{[25]}

Irrigation came to be relied on to support civilizations throughout the history of Mesopotamia and much of the semiarid Middle East. Today these cultures are characterized as hydraulic civilizations,\textsuperscript{[26]} riverine,\textsuperscript{[27,28]} or irrigation-based civilizations.\textsuperscript{[25]} But civilizations that try to sustain themselves in these rainfall-deficient environments are vulnerable to two soil-related problems: silt and salt. As these civilizations’ populations expanded, and agriculture and grazing moved further up-slope into the watersheds supplying the rivers and irrigation systems, accelerated soil erosion began its insidious gnawing away at the soil resources of the uplands. The silts and sediments carried downstream eventually flowed into the irrigation canals and networks, clogging them and reducing their effectiveness. Likewise, the river channels themselves became silt-laden, raising the riverbed, rendering the river unstable and prone to flooding the adjacent fields. Thus, in addition to tending to the agriculture and irrigation systems, intensive diking and levee building were required—the classic example being China’s Yellow River.\textsuperscript{[24]} Removing this silt and diking river courses became labor-intensive. Some cultures resorted to enslaving others for labor, capturing them as the spoils of conflict between nation-states.

Without drainage systems and intensive water management in these water-deficient environments, irrigation caused water tables to slowly rise, exacerbated by silt clogging river channels causing the riverbed to rise. These rising water tables brought with them salts that eventually wicked to the soil surface, rendering the soils inhospitable to crop production with many soil areas becoming sterile. Coupled with invasions from other peoples, competition for water, reduced agricultural production, and internal conflicts and weaknesses, the collapse of civilizations throughout Mesopotamia and the Middle East reads like an historical casualty list.

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in the “Graveyard of Empires,” including once-mighty Babylon itself.\textsuperscript{24}

The scarred and soil-denuded landscapes of this region and many areas around the Mediterranean, attest to the ravages of soil erosion caused by cropping or overgrazing the hillsides. Many structures and entire cities of these early civilizations are entombed in the sediments and salts unleashed by mismanagement of the land. It is ironic that the soil resources that were the heritage of these civilizations eventually became the materials contributing largely to the collapse and burial of these empires. Indeed, humankind had deeply etched its early history into the soil that became the heritage of subsequent civilizations.

The rocky and barren skeletal remnants of the upland landscapes in these regions stand in stark contrast to the original soil resources and vegetative cover. The lush cedars of Lebanon, once covering more than one half million hectares, were clear-cut for the ships of Phoenicia, for King Solomon’s temple, to make way for agriculture, and other uses. Today, only four small (few hectares) remnant groves remain. Standing on Mount Nebo overlooking the Jordan Valley, the site where Moses once saw the lush land of “milk and honey,” one sees today a denuded and decimated land, capable of producing only a small fraction of its original potential.\textsuperscript{24,29} But within these degraded ecosystems is a lesson that is still valid today. Those soils that were protected from erosion by terraces and other measures are still being cultivated as they had been for two or more millennia.

The Nile Valley has nurtured and sustained more than five uninterrupted millennia of civilizations.\textsuperscript{13,30,31} The duration of the Nile River civilizations and multiple collapses of Mesopotamian civilizations, are because of the different soil and water regimes of the two riverine ecosystems. The scourges of siltation and salinization were not as severe along the Nile during its annual pulses as they were in the Tigris–Euphrates plain. Thus, the land of Egypt could remain perennially cultivated and productive while the land of Mesopotamia were not as severe along the Nile during its annual pulses as they were in the Tigris–Euphrates plain. The lush cedars of Lebanon, once covering more than one half million hectares, were clear-cut for the ships of Phoenicia, for King Solomon’s temple, to make way for agriculture, and other uses. Today, only four small (few hectares) remnant groves remain. Standing on Mount Nebo overlooking the Jordan Valley, the site where Moses once saw the lush land of “milk and honey,” one sees today a denuded and decimated land, capable of producing only a small fraction of its original potential.\textsuperscript{24,29} But within these degraded ecosystems is a lesson that is still valid today. Those soils that were protected from erosion by terraces and other measures are still being cultivated as they had been for two or more millennia.

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The influence of soil on civilizations was not lost on the Greek or Roman empires. Plato offered the reason that Attica, a region in southeast Greece, in former times could support a soldiery exempt from the toil of farming: its soils, as is proved by the remnants now left, surpassed all others in fertility.\textsuperscript{9} The Greek poet Hesiod and Roman writers such as Virgil, Pliny, Varro, and Columella recognized the human impacts on nature and the importance of soil quality, particularly soil fertility and its conservation, to sustain civilization and its cultures.\textsuperscript{9}

The Book of Genesis in the Old Testament had a profound impact on the formation of conceptions about the relationship of humans to the Earth. The commandment was to be fruitful and multiply, and take possession of the Earth. In much of western culture, humankind, by divine authority, assumed a powerful control over nature that led to seeing its place in manipulating nature, which had been so wonderfully designed by the Creator.\textsuperscript{9} By the 17th century, the classical notion of a design in nature, the Old Testament ideas, and the new passion for science coalesced and provided the stimulus for the study of nature. The concept of civilization cooperating with nature began to unfold. By the 19th century, especially in the works of Marsh,\textsuperscript{7} it is recognized that human-kind’s unsteward-like manipulations of nature were upsetting its balance and harmony.\textsuperscript{9}

Population growth, the progressing of civilization, and increased pressure on the environment do not necessarily have to lead to accelerated environmental damage, although most of human history has proven otherwise. As Butzer\textsuperscript{32} noted, we can learn much about the environmental successes and failures through the study of human history and the lessons of our human heritage encoded in the settlement and land-use histories.

**CONTEMPORARY PERSPECTIVE**

More than two centuries ago, Malthus\textsuperscript{33} recognized the decreased “power of the land” resulting from human-induced land degradation. During the 18th century, European powers were still vying for dominance, control, and settlement of the North American continent. Settlement of the continent was accompanied by the same exploitive behavior that occurred throughout history. It was during this time that Marsh\textsuperscript{7} and others\textsuperscript{6,8–10} recognized the significance of human impacts on the environment and the historical arrogance toward nature.\textsuperscript{14–37} White\textsuperscript{34} argued that this attitude is dominant in western traditions stemming from westerners’ religious beliefs. But Tuan\textsuperscript{37} argued that the tendency toward environmental degradation, and the desire to maximize one’s well-being characterize all human existence. White\textsuperscript{34} stated that “the emergence in widespread practice of the Baconian creed that scientific knowledge means technological power over nature can scarcely be dated before about 1850. Its acceptance as a normal pattern of action may mark the greatest event in human history since the invention of agriculture, and perhaps in nonhuman terrestrial history as well.”

The early American settlements became the catalyst for mass migrations of Europeans to this new land,
migrations that lasted for three centuries. The vast and resource-rich continent that lay before these settlers, and the speed with which it was populated, are unprecedented in history. As a testimonial to the resources that these settlers inherited, the dense forests were considered an obstacle to agriculture even though they were utilized for fuel and timber. The volume of this timber resource was so large that the center of the commercial lumbering industry did not move beyond western New York until after 1850. Between 1850 and 1910, American farmers cleared more forest than in the previous 250 yr—about 77 million hectares (190 million acres), equivalent to clearing 35 square kilometers (13.6 square miles) every day for 60 yr.

During these westward migrations, the vastness of the resource base, and the open and cheap land areas still available to the West, became the settler’s talisman, and worked against a psychology of permanence. The knowledge that these western lands were still available tended to salve the anxiety of failure, and was not conducive to fostering a conservation ethic or to promoting a sense of stability. So plentiful was the North American natural resource heritage that its vastness betrayed its vulnerability.

To illustrate this impermanence syndrome and the environmental impact of its perpetrators, Trimble cited one wit of the late 1830s, who summarized the situation in the southern Piedmont by noting that “the scratching farmer’s cares and anxieties are only relieved by his land soon washing away. As that goes down the rivers, he goes over the mountains.” Gray also pointed out the tendency to deplete land and then migrate west by stating that: “Over the upland soils from Virginia to Texas the wave of migration passed like a devastating scourge. Especially in the rolling piedmont lands, the planting of corn and cotton in hill and drill hastened erosion, leaving the hillsides gullied and bare.” An 1853 appraisal of Laurens County, South Carolina, was written in apocalyptic prose: “The destroying angel has visited these once fair landscapes, and left only the washer and the woe. Our fences are buried, the house is hidden in the 1930s: “We’re through. It’s worse than the papers say. Our fences are buried, the house is hidden in the eaves, and our pasture which was kept from blowing by the grass, has been buried and is worthless now. We see what a mistake it was to plow up all that land, but it’s too late to do anything about it.” Others were not so articulate about the problem. They simply packed their few belongings and headed West, much as they and their predecessors had done when the water-induced erosion to the East had rendered the land scarred and unyielding. These hardy but tragic people became the human pulp for Steinbeck’s The Grapes of Wrath. They left behind the scars of a squandered heritage: a damaged ecosystem totaling many tens of millions of hectares.

In response to this ecological disaster, a new federal agency was formed in 1933, the Soil Conservation Service, which became the Soil Conservation Service in 1935. Soil conservation became a national policy, although its implementation was based on voluntary participation of land owner-operators baited with the incentives of technical and financial assistance. As the necessity to manage ecosystems more holistically became understood, and the concept of ecological sustainability entered the global lexicon, agencies and institutions took a more comprehensive view of ecosystem management. During the 1990s, the Soil Conservation Service was renamed the Natural Resources Conservation Service, and many federal and state agencies adopted sustainable ecosystem management as their mantra.
CONCLUSIONS

Is modern society, with all of its technological sophistication, still bound by the limits of its environmental heritage as were previous societies and cultures? Or do science and technology allow humankind to pursue its prerogatives, unhindered from any obligation for stewardship and sustainable management of its natural resources and soil heritage? The answer to these questions is a resounding "no." The laws of nature and thermodynamics preclude any shortcuts to sustaining civilizations without the sustainable management of the ecosystems and ecological processes that undergird our sustenance and well-being. Even though humankind has opted out of the tyranny of natural selection, the inextricable interconnectedness of the environment and human well-being requires our understanding of the global environment. The sustainability of the biosphere is now seen to be inseparably bound to issues of economic development, social equity, and international peace and security.

One of the major challenges for the future is to continue to ratchet up the carrying capacity of our soil heritage while sustaining its inherent productive qualities and minimizing leakages of production inputs. Humans have already expanded the carrying capacity of their agricultural ecosystems a 1000-fold through such innovations as genetic manipulation of plants and animals and the development of synthetic nitrogen. There are only certain areas of our soil heritage that can accommodate the intensity of these ecological manipulations productively and sustainably. Our soil heritage is as vital to modern civilization as it was to our ancestral hunter–gatherer kin. As Smil has noted, "our 'postmodern' civilization would do quite well without WWW but it would disintegrate in a matter of years without synthetic nitrogen fertilizers, and it would collapse in a matter of months without thriving (soil) bacteria. Our first duty is to take care of these true essentials." Modern civilization is not less dependent upon the soil and ecological heritage than its foraging and pastoral fore-bearers. The causes of the Earth’s major environmental problems are rooted in human behavior. Thus, our greatest challenge is to understand the limits and vulnerability of our soil and natural resources heritage and behave accordingly.

REFERENCES


A ready reference addressing a multitude of soil and soil management concerns, the highly anticipated and widely expanded third edition of Encyclopedia of Soil Science now spans three volumes and covers ground on a global scale. A definitive guide designed for both coursework and self-study, this latest version describes every branch of soil science and delves into trans-disciplinary issues that focus on inter-connectivity or the nexus approach. For Soil Scientists, Crop Scientists, Plant Scientists and More.

Human Society and the Planet: Soil as a Heritage / Fred P. Miller. Hydraulic Conductivity / Jacob H. Dane, Marc Jalbert, and Jan W. Hopmans. Hydrologic Cycle / Keith R. J. Smettem. Degradation, Food Security, and Poverty / Pierre Crosson. Degradation: Biological / Ibrahim Ortas. Degradation: Critical Limits of Soil Properties and Irreversible Degradation / Anthony R. Dexter. Degradation: Economic Implications Off-Farm / Dennis Wichels. Degradation: Food Aid Needs in Low-Income Countries / Shahla Shapouri. Degradation: Food Aid Needs in Low-Income Countries / Stacey Rosen. Degradation: Global Assessment / Selim Kapur. Degradation: Physical / Michael A. Zoebisch. Desertification / Paul T. Â Jeffrey W. Hopkins. Enchytraeidae / Maria Jesus Iglesias Briones. Erosion / Dennis C. Flanagan. Erosion and Carbon Dioxide / Pierre A. Jacinthe. Erosion and Crop Yield / Michael Stocking. Erosion and Global Change... Soil is the earthâ€™s fragile skin that anchors all life on Earth. It is comprised of countless species that create a dynamic and complex ecosystem and is among the most precious resources to humans. Increased demand for agriculture commodities generates incentives to convert forests and grasslands to farm fields and pastures. The effects of soil erosion go beyond the loss of fertile land. It has led to increased pollution and sedimentation in streams and rivers, clogging these waterways and causing declines in fish and other species. And degraded lands are also often less able to hold onto water, which can worsen flooding. Sustainable land use can help to reduce the impacts of agriculture and livestock, preventing soil degradation and erosion and the loss of valuable land to desertification. The dynamic soil system delivers functions and services vital for human societies and the environment. Soil is the basis for food and biomass production, and plays a central role as a habitat for biota and as a gene pool. Moreover, it stores, filters, buffers and trans-forms a large variety of substances, including water, inorganic and organic compounds, and is a major sink and source for greenhouse gases. Soil provides raw materials for human use. It also serves as the basis for human activities (landscape and heritage) and for our technical and socio-economic infrastructure, delivering mater...