ONE

Good Old Dirt

What we do to the land, we do to ourselves.

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ON A SUNNY AUGUST DAY IN THE LATE 1990S, I led an expedition up the flank of Mount Pinatubo in the Philippines to survey a river still filled with steaming sand from the massive 1991 eruption. The riverbed jiggled coyly as we trudged upriver under the blazing tropical sun. Suddenly I sank in to my ankles, then my knees, before settling waist deep in hot sand. While my waders began steaming, my graduate students went for their cameras. After properly documenting my predicament, and then negotiating a bit, they pulled me from the mire.

Few things can make you feel as helpless as when the earth gives way beneath your feet. The more you struggle, the deeper you sink. You're going down and there's nothing you can do about it. Even the loose riverbed felt rock solid after that quick dip in boiling quicksand.

Normally we don't think too much about the ground that supports our feet, houses, cities, and farms. Yet even if we usually take it for granted, we know that good soil is not just dirt. When you dig into rich, fresh earth, you can feel the life in it. Fertile soil crumbles and slides right off a shovel. Look closely and you find a whole world of life eating life, a biological orgy recycling the dead back into new life. Healthy soil has an enticing and wholesome aroma—the smell of life itself.

Yet what is dirt? We try to keep it out of sight, out of mind, and outside. We spit on it, denigrate it, and kick it off of our shoes. But in the end, what's more important? Everything comes from it, and everything returns to it. If that doesn't earn dirt a little respect, consider how profoundly soil fertility and soil erosion shaped the course of history.

At the dawn of agricultural civilizations, the 98 percent of people who worked the land supported a small ruling class that oversaw the distribution of food and resources. Today, the less than 1 percent of the U.S. population still working the land feeds the rest of us. Although most people realize how dependent we are on this small cadre of modern farmers, few recognize the fundamental importance of how we treat our dirt for securing the future of our civilization.

Many ancient civilizations indirectly mined soil to fuel their growth as agricultural practices accelerated soil erosion well beyond the pace of soil production. Some figured out how to reinvest in their land and maintain their soil. All depended on an adequate supply of fertile dirt. Despite recognition of the importance of enhancing soil fertility, soil loss contributed to the demise of societies from the first agricultural civilizations to the ancient Greeks and Romans, and later helped spur the rise of European colonialism and the American push westward across North America.

Such problems are not just ancient history. That soil abuse remains a threat to modern society is clear from the plight of environmental refugees driven from the southern plains' Dust Bowl in the 1930s, the African Sahel in the 1970s, and across the Amazon basin today. While the world's population keeps growing, the amount of productive farmland began declining in the 1970s and the supply of cheap fossil fuels used to make synthetic fertilizers will run out later this century. Unless more immediate disasters do us in, how we address the twin problems of soil degradation and accelerated erosion will eventually determine the fate of modern civilization.

In exploring the fundamental role of soil in human history, the key lesson is as simple as it is clear: modern society risks repeating mistakes that hastened the demise of past civilizations. Mortgaging our grandchildren's future by consuming soil faster than it forms, we face the dilemma that sometimes the slowest changes prove most difficult to stop.

For most of recorded history, soil occupied a central place in human cultures. Some of the earliest books were agricultural manuals that passed on knowledge of soils and farming methods. The first of Aristotle's fundamental elements of earth, air, fire, and water, soil is the root of our existence, essential to life on earth. But we treat it as a cheap industrial com-

modity. Oil is what most of us think of as a strategic material. Yet soil is every bit as important in a longer time frame. Still, who ever thinks about dirt as a strategic resource? In our accelerated modern lives it is easy to forget that fertile soil still provides the foundation for supporting large concentrations of people on our planet.

Geography controls many of the causes of and the problems created by soil erosion. In some regions farming without regard for soil conservation rapidly leads to crippling soil loss. Other regions have quite a supply of fresh dirt to plow through. Few places produce soil fast enough to sustain industrial agriculture over human time scales, let alone over geologic time. Considered globally, we are slowly running out of dirt.

Should we be shocked that we are skinning our planet? Perhaps, but the evidence is everywhere. We see it in brown streams bleeding off construction sites and in sediment-choked rivers downstream from clear-cut forests. We see it where farmers' tractors detour around gullies, where mountain bikes jump deep ruts carved into dirt roads, and where new suburbs and strip malls pave fertile valleys. This problem is no secret. Soil is our most underappreciated, least valued, and yet essential natural resource.

Personally, I'm more interested in asking what it would take to sustain a civilization than in cataloging how various misfortunes can bring down societies. But as a geologist, I know we can read the record previous societies left inscribed in their soils to help determine whether a sustainable society is even possible.

Historians blame many culprits for the demise of once flourishing cultures: disease, deforestation, and climate change to name a few. While each of these factors played varying—and sometimes dominant—roles in different cases, historians and archaeologists rightly tend to dismiss single-bullet theories for the collapse of civilizations. Today's explanations invoke the interplay among economic, environmental, and cultural forces specific to particular regions and points in history. But any society's relationship to its land—how people treat the dirt beneath their feet—is fundamental, literally. Time and again, social and political conflicts undermined societies once there were more people to feed than the land could support. The history of dirt suggests that how people treat their soil can impose a life span on civilizations.

Given that the state of the soil determines what can be grown for how long, preserving the basis for the wealth of future generations requires intergenerational land stewardship. So far, however, few human societies have produced cultures founded on sustaining the soil, even though most

discovered ways to enhance soil fertility. Many exhausted their land at a rate commensurate with their level of technological sophistication. We now have the capacity to outpace them. But we also know how not to repeat their example.

Despite substantial progress in soil conservation, the United States Department of Agriculture estimates that millions of tons of topsoil are eroded annually from farmers' fields in the Mississippi River basin. Every second, North America's largest river carries another dump truck's load of topsoil to the Caribbean. Each year, America's farms shed enough soil to fill a pickup truck for every family in the country. This is a phenomenal amount of dirt. But the United States is not the biggest waster of this critical resource. An estimated twenty-four billion tons of soil are lost annually around the world—several tons for each person on the planet. Despite such global losses, soil erodes slowly enough to go largely unnoticed in anyone's lifetime.

Even so, the human cost of soil exhaustion is readily apparent in the history of regions that long ago committed ecological suicide. Legacies of ancient soil degradation continue to consign whole regions to the crushing poverty that comes from wasted land. Consider how the televised images of the sandblasted terrain of modern Iraq just don't square with our notion of the region as the cradle of civilization. Environmental refugees, driven from their homes by the need to find food or productive land on which to grow it, have made headlines for decades. Even when faced with the mute testimony of ruined land, people typically remain unconvinced of the urgent need to conserve dirt. Yet the thin veneer of behavior that defines culture, and even civilization itself, is at risk when people run low on food.

For those of us in developed countries, a quick trip to the grocery store will allay fears of any immediate crisis. Two technological innovations—manipulation of crop genetics and maintenance of soil fertility by chemical fertilizers—made wheat, rice, maize, and barley the dominant plants on earth. These four once-rare plants now grow in giant single-species stands that cover more than half a billion hectares—twice the entire forested area of the United States, including Alaska. But how secure is the foundation of modern industrial agriculture?

Farmers, politicians, and environmental historians have used the term soil exhaustion to describe a wide range of circumstances. Technically, the concept refers to the end state following progressive reduction of crop yields when cultivated land no longer supports an adequate harvest. What defines an adequate harvest could span a wide range of conditions, from

the extreme where land can no longer support subsistence farming to where it is simply more profitable to clear new fields instead of working old ones. Consequently, soil exhaustion must be interpreted in the context of social factors, economics, and the availability of new land.

Various social, cultural, and economic forces affect how members of a society treat the land, and how people live on the land, in turn, affects societies. Cultivating a field year after year without effective soil conservation is like running a factory at full tilt without investing in either maintenance or repairs. Good management can improve agricultural soils just as surely as bad management can destroy them. Soil is an intergenerational resource, natural capital that can be used conservatively or squandered. With just a couple feet of soil standing between prosperity and desolation, civilizations that plow through their soil vanish.

As a geomorphologist, I study how topography evolves and how landscapes change through geologic time. My training and experience have taught me to see how the interplay among climate, vegetation, geology, and topography influences soil composition and thickness, thereby establishing the productivity of the land. Understanding how human actions affect the soil is fundamental to sustaining agricultural systems, as well as understanding how we influence our environment and the biological productivity of all terrestrial life. As I've traveled the world studying landscapes and how they evolve, I've come to appreciate the role that a healthy respect for dirt might play in shaping humanity's future.

Viewed broadly, civilizations come and go—they rise, thrive for a while, and fall. Some then eventually rise again. Of course, war, politics, deforestation, and climate change contributed to the societal collapses that punctuate human history. Yet why would so many unrelated civilizations like the Greeks, Romans, and Mayans all last about a thousand years?

Clearly, the reasons behind the development and decline of any particular civilization are complex. While environmental degradation alone did not trigger the outright collapse of these civilizations, the history of their dirt set the stage upon which economics, climate extremes, and war influenced their fate. Rome didn't so much collapse as it crumbled, wearing away as erosion sapped the productivity of its homeland.

In a broad sense, the history of many civilizations follows a common story line. Initially, agriculture in fertile valley bottoms allowed populations to grow to the point where they came to rely on farming sloping land. Geologically rapid erosion of hillslope soils followed when vegetation clearing and sustained tilling exposed bare soil to rainfall and runoff. During subse-

quent centuries, nutrient depletion or soil loss from increasingly intensive farming stressed local populations as crop yields declined and new land was unavailable. Eventually, soil degradation translated into inadequate agricultural capacity to support a burgeoning population, predisposing whole civilizations to failure. That a similar script appears to apply to small, isolated island societies and extensive, transregional empires suggests a phenomenon of fundamental importance. Soil erosion that outpaced soil formation limited the longevity of civilizations that failed to safeguard the foundation of their prosperity—their soil.

Modern society fosters the notion that technology will provide solutions to just about any problem. But no matter how fervently we believe in its power to improve our lives, technology simply cannot solve the problem of consuming a resource faster than we generate it: someday we will run out of it. The increasingly interconnected world economy and growing population make soil stewardship more important now than anytime in history. Whether economic, political, or military in nature, struggles over the most basic of resources will confront our descendants unless we more prudently manage our dirt.

How much soil it takes to support a human society depends on the size of the population, the innate productivity of the soil, and the methods and technology employed to grow food. Despite the capacity of modern farms to feed enormous numbers of people, a certain amount of fertile dirt must still support each person. This blunt fact makes soil conservation central to the longevity of any civilization.

The capacity of a landscape to support people involves both the physical characteristics of the environment—its soils, climate, and vegetation—and farming technology and methods. A society that approaches the limit of its particular coupled human-environmental system becomes vulnerable to perturbations such as invasions or climate change. Unfortunately, societies that approach their ecological limits are also very often under pressure to maximize immediate harvests to feed their populations, and thereby neglect soil conservation.

Soils provide us with a geological rearview mirror that highlights the importance of good old dirt from ancient civilizations right on through to today's digital society. This history makes it clear that sustaining an industrialized civilization will rely as much on soil conservation and stewardship as on technological innovation. Slowly remodeling the planet without a plan, people now move more dirt around Earth's surface than any other biological or geologic process.

Common sense and hindsight can provide useful perspective on past experience. Civilizations don't disappear overnight. They don't choose to fail. More often they falter and then decline as their soil disappears over generations. Although historians are prone to credit the end of civilizations to discrete events like climate changes, wars, or natural disasters, the effects of soil erosion on ancient societies were profound. Go look for yourself; the story is out there in the dirt.