Show Transcript
Deconstructing Dinner
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The Erosion of Civilizations (w/ David Montgomery & Ronald Wright)

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Jon Steinman: Welcome to Deconstructing Dinner, produced in Nelson, British Columbia at Kootenay Co-op Radio CJLY. I'm Jon Steinman.

Recently here on the show we've been reflecting quite a bit on the model of agriculture itself as the primary source through which most people on earth access their food. From our exploration of ethnobiology, to recent topics on permaculture, it's clear that there are *other* models that, for some people, are a substitute for agriculture, and for others, a complementary practice to agricultural dependence.

But what, within that dependence on agriculture, are *we* all dependent on? Is it multinational corporations? The chain grocery store down the road? Perhaps the microwave?

But behind those dependencies, which are precarious at best, is a more deeply rooted dependence – soil – a dependence whose once deep roots have been demonstrated over time to have become progressively shallower, as agricultural practices deplete soils' depth and nutrients.

On today's broadcast we explore once again the evolution of agriculture alongside civilization and narrow our focus on soil. Lending their voice to the show today - David Montgomery of the University of Washington and the author of *Dirt: The Erosion of Civilizations*, and British Columbia's Ronald Wright, the author of *A Short History of Progress*.

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Jon Steinman: "If we look at the relationship of societies to the land, the way people treated the land helped set the longevity of major human societies." That's a quote from David Montgomery, who we'll listen in on for the final three quarters of today's broadcast. But with Montgomery's focus on soil and its relationship to agricultural practices, let's first step back many millennia to a time *before* agriculture, and more specifically, that era between our hunter gatherer roots and our current agricultural dependencies.

One of the most notable books tracking this evolution is Ronald Wright's *A Short History of Progress*, released in 2004. The book is a series of five lectures delivered as part of the 2004 CBC Massey Lecture.

Born in England, Ronald Wright lives in British Columbia and is an established author and writer. His latest literary work is titled *What is America?: A Short History of the New World Order*. In his 2004 work, *A Short History of Progress*, Ronald Wright titles his second chapter (or lecture) "The Great Experiment," in which he summarizes some of the key shifts that humanity took from hunting and gathering our foods to domesticating them much like we see today.

Here's Ronald Wright and a short segment of his 2004 Massey Lecture recorded at the University of Alberta in Edmonton, perhaps not so coincidentally being the closest major urban center to the Alberta tar sands, one of the most telling *current* examples of humanity's ability to strip the earth of our most precious resources.

Ronald Wright: Among hunters there'd always been a large number of non-hunters - the gatherers - mainly women and children we suppose, responsible for the wild fruits and vegetables in the diet of a well-run cave. Their contribution to the food supply became more and more important as the game died out.

The people of that short, sharp period known as the Mesolithic, or Middle Stone Age, tried everything: living in estuaries and bogs; beachcombing; grubbing up roots; and reaping wild grasses for the tiny seeds, a practice with enormous implications. So rich were some of these grasses, and so labour-intensive their exploitation, that settled villages appear in key areas before farming. Gatherers began to notice that seeds accidentally scattered or passed in droppings would spring up the following year. They began to influence the outcome by tending and enlarging wild stands, by sowing the most easily reaped and plumpest seeds.

Such experiments would eventually lead to full agriculture and almost total dependence on a few monotonous staples. But that was several thousand years away. At this early time, the plant tenders were still mainly gatherers, exploiting a great variety of flora as well as any wild game and fish they could find.

At Monte Verde in Chile, for example, a permanent village of rectangular wooden huts was in place by thirteen thousand years ago, sustained by hunting camels, small game, and soon to be extinct mastodon. But the remains also include many wild vegetables, not least potato peelings. Although Monte Verde is one of the earliest human sites anywhere in the Americas, it shows a mature and intimate knowledge of local plants, several of which would eventually become the founding crops of Andean civilization.

Like the accumulation of small changes that separated us from the other great apes, the farming revolution was an unconscious experiment, too gradual for its initiators to be aware of it, let alone to foresee where it would lead. But, compared with all earlier developments, it happened at breakneck speed.

Highly important for what it tells us about ourselves is that there was not one revolution but many. On every continent except Australia, farming experiments began soon after the regime of the ice released its grip.

Older books, and some recent ones, emphasized the importance of the Middle East, or Fertile Crescent, which stretched from the Mediterranean shore to the Anatolian Plateau and the alluvial plains of Iraq. All the bread-based civilizations derived their staples from this area, which gave us wheat, barley, sheep and goats.

But it's now clear that the Middle East was only one of at least four major regions of the world where agriculture developed independently at about the same time. The others are the Far East, where rice and millet became the main staples; Mesoamerica, which means Mexico and neighbouring parts of Central America, whose civilizations were based on maize, beans, squashes, amaranth and tomatoes; and the Andean region of South America, which developed many kinds of potato, other tubers, squash, cotton, peanuts, and high protein grains such as quinoa.

In all these heartlands, crop domestication appears between eight and ten thousand years ago. Besides these big four, there are also about a dozen lesser founding areas around the world.

Unconnected people sometimes develop the same plants. Cotton and peanuts are each of two kinds developed simultaneously in the New World and the Old.

Animal domestication is harder to document but at about the same time people were developing crops, they learned that certain herbivores and birds could be followed, corralled and killed at a sustainable rate. Over generations these animals grew tame enough, and dim-witted enough, not to mind the two-legged serial killer who followed them around. (*audience:* laughter) Hunting became herding just as gathering grew into gardening.

Sheep and goats were the first true domesticates in the Middle East, starting about 8000 B.C. Domestic camelids, early forms of the llama and alpaca, used for pack trains and wool as well as meat, appear in Peru during the sixth millennium B.C., about the same time as cattle in Eurasia, although neither camelids nor early cattle were milked. Donkeys and horses were tamed by about 4000 B.C.

Craftier creatures, such as dogs, pigs and cats, had long been willing to hang around human settlements in return for scraps, slops, and the mouse boom spurred by granaries. Dogs, which may have been tamed for hunting back in the Paleolithic, are found with human groups throughout the world. In cold weather they were sometimes used as bed warmers, which some experts believe accounts for the expression "three dog night." (*audience:* laughter) Actually, that's not a joke, it's true. (*audience:* laughter)

In places such as Korea and Mexico special breeds were kept for meat. The chicken began its sad march towards the maul of Colonel Sanders as a gorgeously-feathered Asian jungle fowl (*audience:* laughter), while Mexico developed the turkey. Along with the llama and alpaca, Peruvians kept Muscovy ducks and the lowly but prolific guinea pig, which even made a cameo appearance on the menu of Christ's last supper in a Colonial Peruvian painting.

As the eating of guinea pigs and chiguaguas suggests, the Americas were less well endowed with domesticable animals than the Old World. But the New World compensated by developing a

wider and more productive range of plants. Peru alone had nearly forty major species. Such plants eventually supported huge native cities in the Americas, and several of them would transform the Old World's nutrition and economics when they were introduced there.

The more predictable the food supply, the bigger the population. Unlike mobile foragers, sedentary people had little reason to limit the number of children, who were useful for field and household tasks. The reproductive rate of women tended to rise, owing to higher levels of body fat and earlier weaning with animal milk and cereal baby food. Farmers soon outnumbered hunter gatherers - absorbing, killing or driving them into the surrounding wilderness.

At the beginning of the Upper Paleolithic, when our modern subspecies emerged by fair means or foul as the earth's inheritors, we numbered perhaps a third of a million all told. By 10,000 years ago, on the eve of agriculture, and after settling all habitable continents, we'd increased to about three million. And by about 5,000 years ago, when farming was established in all the founding regions and full civilization had already begun in Sumer and Egypt, we may have reached between fifty and twenty million people worldwide.

Such figures are merely educated guess work and everything else I've just said is, of course, an oversimplification. But change to full-time farming took millennia. And early results were not always promising, even in a core zone such as the Middle East. Neolithic Jericho was tiny, a mere four acres in 8000 B.C., and took another 1500 years to reach ten acres. The Turkish site of Catal Huyuk, the largest settlement in the Fertile Crescent between 7000 and 5500 B.C., covered only one-twentieth of a square mile, or thirty-two acres, and its inhabitants depended on wild game for much of their protein.

As any rural Canadian knows, hunting continues among farmers wherever it's fun or worthwhile. And this was especially true in the Americas and parts of Asia where domestic animals were scarce.

Nevertheless, the pace of growth accelerated. By about 5,000 years ago, the majority of human beings had made the transition from wild food to tame.

In the magnitude of its consequences, no other invention rivals farming except, since 1940, the invention of weapons that can kill us all.

The human career divides in two: everything before the Neolithic revolution; and everything after it. Although the three Stone Ages – Old, Middle and New – may seem to belong in a set, they don't. The new Stone Age has much more in common with later Ages than with the millions of years of stone toolery that went before it. The farming revolution produced an entirely new mode of subsistence which remains the basis of the world economy to this day.

The food technology of the late Stone Age is the one technology we cannot live without. The crops of about a dozen ancient peoples feed the six billion on earth today. Despite more than two centuries of scientific crop breeding, despite the so-called "Green Revolution" of the 1960s and the genetic engineering of the 1990s, not one new staple has been added to our repertoire of crops since prehistoric times.

Although the new Stone Age eventually gave way to metal working in several parts of the world, and to the Industrial Revolution in Europe, these were elaborations on the same theme, not a fundamental shift in subsistence. A Neolithic village was much like a Bronze Age or an Iron Age village, or a modern Third World village, for that matter.

The Victorian archaeological scheme of classifying stages of human development by tool materials becomes unhelpful from the Neolithic onward. It may have some merit in Europe, where technology was often linked to social change, but is little help for understanding what happened in places where a lack of the things our technocentric culture regards as basic - metal, ploughs, wheels, etc. - was ingeniously circumvented or where, conversely, their presence was inconsequential.

For example, Mesopotamia invented the wheel about 4000 B.C. but its close neighbour, Egypt, made no use of wheels for another two thousand years. The Classic period Maya, a literate civilization rivalling classical Europe in mathematics and astronomy, made so little use of metals that they were technically in the Stone Age.

By contrast, sub-Saharan Africa mastered iron working by 500 B.C., as early as China did, yet never developed a full-blown civilization. The Incas of Peru, where metal working had begun about 1500 B.C., created one of the world's largest and most closely administered empires, yet may have done so without writing as we know it, 'though the evidence is growing that their quipu system was indeed a form of script.

Japan made pottery long before anyone else, more than 12,000 years ago. But rice farming and full civilization did not appear there for another 10,000 years, adopted wholesale from China and Korea. The Japanese didn't begin to work bronze until 500 B.C. but became famous for steel swords by the sixteenth century. At that time, they acquired European firearms, then abandoned *them* for three hundred years.

We should therefore be wary of technological determinism, for it tends to underestimate cultural factors and reduce complex questions of human adaptation to a simplistic, "We're the winners of history so why didn't others do what we did?"

We call agriculture and civilization "inventions" or "experiments" because that is how they look to hindsight. But they began accidentally, a series of seductive steps down a path leading, for most people, to lives of monotony and toil. Farming achieved quantity at the expense of quality. More food and more people but seldom better nourishment or better lives. People gave up a broad array of wild foods for a handful of starchy roots and grasses. As we domesticated these plants, the plants domesticated us. Without us they die, and without them so do we.

There is no escape from agriculture except into mass starvation and it has often led there anyway with drought and blight. Most people, throughout most of time, have lived on the edge of hunger and much of the world still does.

Jon Steinman: This is Deconstructing Dinner. That was British Columbia author and writer Ronald Wright speaking in 2004 in Edmonton, Alberta. That was just a short segment from his 2004 Massey Lecture, an annual public event. Ronald presented his work titled *A Short History of Progress,* which is also published in print form by House of Anansi Press.

Today's show is titled "The Erosion of Civilizations," a title taken from the 2008 work by Professor David Montgomery of the University of Washington. Taking off from where Ronald Wright just left off, David's work has in part involved studying the soil, which so many civilizations throughout history and today have relied upon and manipulated for our agricultural purposes.

David is a Professor in the School's Department of Earth and Space Sciences with an interest in geomorphology. In 2008 University of California Press published his work titled *Dirt: The Erosion of Civilizations*. It explores the idea that we are, and have long been, using up earth's soil. Once bare of protective vegetation and exposed to wind and rain, cultivated soils erode - bit by bit, slowly enough to be ignored in a single lifetime but fast enough over centuries to limit the lifespan of civilizations. *Dirt* traces the role of soil use and abuse in the history of Mesopotamia, Ancient Greece, the Roman Empire, China, European colonialism, Central America, and the American push westward. David believes the recent rise of organic and no-till farming lends hope for a new agricultural revolution that might help us avoid the fate of previous civilizations.

In September 2009, journalist Tom Allen interviewed David in Seattle for the weekly radio show "One World Report," a production of KBCS Bellevue, Seattle.

Tom Allen: The history of agriculture is written in the dust. From the stripping of Ancient Greece down to the bedrock, to the spectacular gullies of Italy's Le Crete, and America's Piedmont Plateau, poor farming practices have forced migrations, caused wars, famine, disease, and even threatens modern agriculture.

David Montgomery: Soil really is the one crucial resource that humanity depends on and yet that we systematically undervalue and treat like dirt.

Tom Allen: And that was Dr. David Montgomery, Professor of Geomorphology at the University of Washington. His recent book, *Dirt,* is strong medicine. I interviewed him in the garden of his Seattle home, a very pleasant example of urban horticulture. And you'll hear some stark reminders of the industrial civilization surrounding it.

In your book, *Dirt*, you describe an agricultural system that's on the verge of collapse, vulnerable to interruption of inputs of fertilizer, fuel, and especially long-term soil degradation. Am I overstating the case to say that these disruptions in agriculture could take civilization with it?

David Montgomery: No, I don't think you are overstating the case, but I think that it would be overstating the immediate hazard to portray that as something that faces us in the next few years or few decades. It's a challenge that society faces over the next century, maybe two centuries. In my view, it's *the* big challenge facing humanity, just over the horizon from how we deal with climate change.

Tom Allen: Dr. Montgomery says that the lifespan of most civilizations can be predicted by the depth of their soil. And when that's gone so is the civilization. Mesopotamia exhausted its soil by about 1800 B.C. and Baghdad, its centre today, sits in little more than a desert.

Closer to home, the American Dust Bowl was a tragedy that played out over a decade rather than centuries. The dramatic photo on the cover of his book, *Dirt*, shows a Dakota farmyard with wagons buried to the wheel tops.

David Montgomery: It's a striking photograph, and the publisher loved it. And I also liked it because it shows essentially the aftermath of a very local technological collapse. And it relates to the way the people treated the land. And if we look at the relationship of societies to the land, the way people treated the land ended up setting the longevity of many major human societies. And that photograph to me sort of captured the elements of that overall story, but with a modern twist.

Tom Allen: So the Dust Bowl was not just an Act of God then?

David Montgomery: No, it was not just an act of God. There have been many droughts, equally severe as the one that caused the Dust Bowl, over the last several thousand years on the Great Plains. And the soil didn't blow away.

What was different about the drought that caused the Dust Bowl was that the farms of the Eastern Plains - the areas overlain by the Buffalo Prairie, where the grass was literally holding the soil together - once that was aggressively ploughed and opened up, so that there was nothing holding the soil, once it was exposed back to desiccation and drying and drought and the power of the winds, it quite literally blew away.

Tom Allen: In your book, *Dirt*, you give us example after example of societies who essentially survived until their soil played out. What's that, on average, a couple thousand years, or is it less than that?

David Montgomery: Well, if you want to take sort of the encompassing view, it's eight hundred to two thousand years.

Tom Allen: So, we've got a long ways to go before we have to worry about anything like that then?

David Montgomery: Well, we do where we are sitting now in Western Washington, because agriculture arrived here a century ago or so. But there's parts of the world today that have already played through their natural endowment of soil. And, given that society is now a relatively integrated global affair, and we don't have any other planets to go to and no new continents to take over, colonize or reshape, the problem may start to manifest for our global society well before it becomes a problem everywhere.

So there are parts of the world that are very resilient to the problem of soil loss because they are naturally endowed with a great reservoir of dirt. But most of the planet is not that way. If we

look at Africa, we look at most of South America, most of Asia. So there are places around the world today that are very close to the edge already.

Tom Allen: While Dr. Montgomery cautions against an immediate overreaction, he does say that given the globalized markets for food, shortfalls anywhere will impact prices and availability of food. Within the Pacific Northwest region, there is a grassroots push to improve food security.

David Montgomery: There has been a huge shift in the base of the food chain that we draw from on this planet. One of the great tragedies of industrial agriculture has been the destruction of great amounts of soil life and the basis for natural soil fertility on many of the great agricultural regions in the world. Something like a third of the carbon that's in the atmosphere now that was added after the Industrial Revolution came not from fossil fuels but from the degradation of soil organic matter.

Tom Allen: Critics of the Green Revolution point out that using chemical fertilizers is a losing game.

David Montgomery: It's kind of like trying to run your agricultural fields on meth.

Tom Allen: As time goes on, more and more chemicals must be added just to maintain crop yields.

David Montgomery: The real problem I see with the Green Revolution approach of trying to rely on genetically engineered crops and on very high nitrogen inputs to maintain soil fertility are that, what do we do at the point when the processes that we use to develop nitrogen-based fertilizers become so expensive they are not usable for food? We are going to have to rely on native soil fertility. It doesn't make a whole lot of sense to me to systematically poison the bottom of a food chain when you're drawing your sustenance from the top of the same food chain.

If we really wanted to grow as much food as is humanly possible on the smallest space as possible, we would shift our agricultural practices to small-scale farms in labour-intensive organic manners.

Tom Allen: In the world of permaculture one of the tenets has been agroforestry, or food forests. And I am looking around your garden here where we sit and I am seeing that there is not a rectilinear display of basil all in one place, and beans all in another, and tomatoes in a third place. It's all sort of mixed together. And there's some things that are tall, and other things that are short, growing in the shade of the tall things, and so on and so forth. Are you familiar with the terms?

David Montgomery: Yes, and in terms of credit for garden design, I deserve none. My wife deserves the entire credit for it. She's the gardener.

Yeh, she has a mixed environment. Things at a different canopy level are essentially behind what's she's been able to grow. And I've been amazed at how much food she is able to grow in

two fairly small vegetable plots in our backyard, in the middle of a city. Now, we're not feeding ourselves. We're not trying to be sort of the poster urban farmers. But the amount of food we are able to get seasonally out of a backyard garden in Seattle - not the part of the world most known for its sunshine and great ability to grow all kinds of stuff - it's truly phenomenal what we are able to wring out a small piece of ground, with no fertilizers and no chemical help.

Tom Allen: No fertilizers and no chemical help. Well, let's see. Fertilizers and chemical help aren't necessarily the same thing. (*David Montgomery:* laughs) There's something going on there in the soil. I mean, you are obviously not using this as a substrate for chemicals.

David Montgomery: What Anne discovered is the power of essentially investing in soil life. She's been invested in soil soup, putting biota back into the soil fairly aggressively, putting organic matter back into the soil, and taken what was the ratty lawn of a hundred-year-old Seattle house and invested in the soil. When we bought the place it was just lawn everywhere, and you could dig down into it. It was just dry, dusty soil - very little life. After about eight years returning organic matter to the soil, adding soil microbes, and putting beneficial biota back into the soil, the ground is full of life, and that life helps cycle the fertility and promote life in the plants that we then harvest to eat.

Tom Allen: This has been Part II of a conversation with Dr. David Montgomery, author of the book, *Dirt: The Erosion of Civilizations*. While the garden we sat in uses many cutting-edge techniques, it's a private garden feeding a single family. There are thousands of such gardens across the Pacific Northwest. Next time, we will look at some community gardens whose productivity makes large-scale commercial farms pale by comparison. For One World Report, this is Tom Allen.

Jon Steinman: This is Deconstructing Dinner, a syndicated radio show and podcast produced in Nelson, British Columbia at Kootenay Co-op Radio CJLY. I'm Jon Steinman. Today's episode is archived on-line at deconstructingdinner.ca, where you can also help support this weekly not-for-profit program by making a donation or becoming a voluntary monthly subscriber. Information on how to do so is linked to from the main page of the website.

That was an interview with Professor David Montgomery of the University of Washington. David was interviewed by Tom Allen of KBCS's One World Report. A thanks to Tom for making that interview available.

But it was also only months before that interview that David Montgomery was also hosted at Oregon State University in Corvallis. Montgomery spoke about his book, *Dirt: The Erosion of Civilizations*, and was hosted by the PAGES project, which stands for Past Global Changes. The organization is an international effort to coordinate and promote past global change research, with their primary objective being to improve our understanding of past changes in the earth system in order to improve projections of future climate and environment, and inform strategies for sustainability. For the remainder of today's broadcast, we'll listen in on that talk when David expanded on the many topics that he raised in that last segment. Here's David Montgomery speaking in July 2009.

David Montgomery: Those of you who are familiar with looking at the interaction of human societies and the environment and reading environmental histories have no doubt run into the argument and the idea that environmental influences and soil erosion resulting from deforestation in particular has been proposed as an idea to explain the demise of civilizations around the world. That whole set of societies over there on the right, from Mesopotamia, the Minoans, Greece, Rome, sort of Bronze Age Europe, up through the Roman Empire, stuff in Asia, stuff in Mesoamerica, are places where people have made the argument.

And, as a geomorphologist who is trained – I literally cut my geomorphological teeth out on the Oregon Coast range not all that many miles from where we are sitting today - the argument that deforestation per say could lead to the wholesale soil loss that has been implicated in the fates of many ancient societies was something that just didn't really resonate very well with me. Because we have been able to document that you do get a very large increase in soil erosion following forest clearing in the kind of environment that we are in here today. But it lasts a very brief time, and occurs over a very small portion of the topography, in part because trees left to their own devices grow back and reforest fairly rapidly. And the idea that simply clearing trees as a one-off could actually lead to the wholesale loss of the soil just didn't really add up.

So what actually might have been to blame? I started to look into the idea. First of all, one has to ask the question, was extensive soil erosion associated with ancient societies and did it have anything to do with their demise? This essentially forms the first half of the book. I am going to give you a brief taste of that today.

The question I wanted to ask in this book, therefore, could agricultural soil erosion limit the lifespan of civilizations? It seems like a fairly simple question to ask. I am not going to advertise that I am the first person to have asked it. By no means am I. And nor am I the first person to really write a book based on soils and their relationship to civilization. It's in fact sort of my attempt to update a wonderful book called *Topsoil and Civilization* that was written in the 1950s. But since then, a lot has been learned about soil loss in ancient societies. Recent archaeological studies in the past several decades have showed that soil erosion played a role in the demise ancient civilizations and Neolithic Europe, Classical Greece, Rome, southern United States, Central America - in society after society around the world where one would care to look.

I am going to spare you most of the archaeological details of that today but invite you to think about soil the way a geomorphologist like myself does. Think of it as a system that's produced and is lost. For most of the scientists in this audience that is going to be a fairly simple kind of concept. Soils are produced from the breakdown of rocks mixing with organic matter. They are stored on hillsides as the soil sits there and they are lost through erosion. If you have almost any kind of a sloping surface to topography, soil will be moving down slope at some rate.

The balance between soil production and soil erosion under whatever the climate – the vegetation, the topography, the geology, what it's in - will lead to the development of a typical soil profile. Soils are very diverse, very rich, amazing phenomena. I'm obviously not going to go into detail what those are today around the world.

The key point that I want to make is perhaps the simplest point one can make about soils. And that is, over time, the change in soil thickness is going to be reflected as the net balance of the difference between soil production and soil loss. This may not be a terribly great revelation to anybody in this audience, but when you go out and talk to people in a general audience, most people do not think about soils as things that are produced and lost and changed. They don't think of topography as something that evolves over time. And it would be different if they were able to come back in a thousand years and look at it. It's something that I have been trying to essentially convey to a general audience for the last few years with this argument.

And how does this relate to the longevity of civilizations? Well, fundamentally the invention of the plough fundamentally altered the balance between soil production and soil erosion. Why? Well, when you clear the land and expose it to wind and rain for some portion of the year, if it's not protected by vegetation for that time you're commensurately increasing the rate of erosion. And if there is no commensurate increase in the breakdown of rock in the production of soil then essentially you are losing soil faster than it's being made.

And many studies - many of which I have summarized in the book - have shown that conventional plough-based agriculture has increased soil erosion often by more than an order of magnitude. I'll show you the data behind that assertion later in the talk.

But what I want to do first is give you a very brief introduction to the flavour of some of the kind of geoarchaeological data that one can put together to try and make this argument. Because obviously back in Neolithic Europe, or Bronze Age Europe, or many ancient societies, there were not geomorphologists running around with buckets trying to collect sediment yield out in the real world.

The couple of geoarchaeological studies that have been done in Greece, for example, have shown that cycles of erosion and soil formation began with the Bronze Age erosion event right after the introduction of plough-based agriculture. van Andel and Runnels, back in 1987, argued that when the plough arrived in the immediate deglacial world from points East, the Greek landscape underwent a transition from open Oak woodland. Cultivation spread essentially right up through the hillsides. You can see the sort of the thin soil overlying on bedrock. And grain was cultivated essentially throughout the Classical Greek landscape. And this resulted over time, they argued, in erosion of the soils and stripping of the upland environments down to relatively thin, relatively bare rocky slopes. And that much of the soil that had been up in the areas that were extensively cultivated in Classical times is now found down on top of the original alluvium in the valley bottoms. And that there are areas where you can find agricultural implements on rocky slopes where you really couldn't grow wheat anymore.

How did this potentially affect the population density in Classical Greece? Again, van Andel and Runnels did something that I have seen very few archaeologists or geologists be brave enough to do. And that is attempt to reconstruct population density through time, going back from about 6000 B.C. up to about the present in this region. And what they found is essentially sort of three cycles of population rise, first in the Bronze Age. A collapse in the vernacular. Some people throw out this kind of phenomena, or a low population, shrinking of population density. A rise in

the Classical Age, in Classical Greece. Another low point in the southern Argulic. And in the modern age where the population rebounded.

I don't think you have to think very hard to imagine explanations for the amplitude of those three different kinds of peaks. A bunch of guys with digging sticks in the Bronze Age are not going to be able to support the population density as people with fertilizers and John Deere tractors. Technology obviously plays a role.

But what sets the periodicity? Why three cycles? Why approximately a thousand or two thousand year kind of time scale between successive societies at this place? And, indeed, if you look through the archaeological record, many societies last on the order of about a thousand years or so, unless if you are looking at flood-plain based agriculture, where soils are replenished from erosion of upstream areas and the arguments that are to follow in this talk simply don't apply. Other arguments apply there.

Well, the problem of extensive erosion in Classical Greece was noted by Plato. You could call him the first geomorphologist if you want - some of the earliest literature that we have surviving in the Western world. And he essentially noticed the evidence for extensive Bronze Age erosion in the period of erosion before the Classical Age in Greece. And he wrote that, "The rich, soft soil has all run away leaving the land nothing but skin and bone. But in those days the damage had not taken place, the hills had high crests, the rocky plain of Phelleus was covered with rich soil, and the mountains were covered by thick woods, of which there are some traces today."

Not many people believed him until van Andel and Runnels started their work in Greece in the 1980s. Why? Well, he wrote this in his dialogue in which he discussed Atlantis, and it's not viewed among most scientists as a terribly credible source. Yet he even estimated the time scale of the Bronze Age erosion event about right. He said that it had happened a couple of thousand years before his own day. It makes for very interesting reading

Skipping all the other societies that I talked about in the book in the interest of time, that will try to catch us up here a little bit, Colonial America essentially started as an agricultural colony, from investment bankers if you will, in London. Their mandate was to return a profit on the people backing them to go to Jamestown.

The thing that they actually figured out that would actually support them was tobacco. And tobacco growing, though, turned out to be a very highly erosive crop. After about a hundred years of tobacco growing, Hartwell, Blair and Chilton, in describing the present state of Virginia, wrote that, "So it is at present, that Tobacco swallows up all other Things, every thing else is neglected. By that time the Stumps are rotten, the Ground is worn out; and having fresh Land enough, they take but little Care to recruit the old Fields with Dung."

Essentially, soil management in North America in Colonial days was tailored around optimizing tobacco cultivation. And you could only get about three to five years of crop out of, or high production, out of land before it was extensively eroded because of the way that tobacco was cultivated and grown. It also exhausted soil fertility but I am not going to talk much about that today. I go into that in the book. But that would take even more time.

But essentially the whole phenomena of how tobacco growing influenced Colonial society is a really interesting one. I will skip the details today about how it set the stage for the rise of plantation agriculture, thereby setting the stage for the Civil War. But by George Washington's time, in the late eighteenth century, he was very concerned about the problem of extensive agricultural soil erosion in the Colonies. He wrote that, "A few years more of increased sterility will drive the Inhabitants of the Atlantic States westward for support; whereas if they were taught how to improve the old, instead of going in pursuit of new and productive soils, they would make these acres which now scarcely yield them anything, turn out beneficial to themselves."

Washington was basically arguing that the extent of erosive degradation of Colonial soils in North America would drive the United States westward, not because of some sense of manifest destiny. That came a century later. But simply because people were interested in the fresh soils on the other side of the Appalachians after having exhausted the soils along the Eastern Seaboard.

To what extent did this happen and how might this shed some light on the potential for soil erosion to have influenced ancient societies like Classical Greece is shown by this map, that again is not my work, it's based on the work of others. But it shows the extent of historical soil erosion in the Piedmont region of the Southeastern United States, going from about Virginia to Alabama, in this noodle here, that is the Piedmont. It's not the Appalachians. It's not the Coastal Plain. But it's the upland hilly landscape where this kind of argument about progressive soil loss under cultivation applies fairly well.

And you'll notice that something like four to ten inches of soil had been lost through a couple of hundred years of Colonial agriculture in this region. Well, is this a big deal or a small deal? Well, when you think that the original top soil thickness in this region has been estimated at having been about a foot, having lost a third to more than two-thirds of that in a couple of hundred years really puts in perspective what the Greeks could have done with a thousand year run at it, what the Romans did in Central Italy, and etcetera in other societies.

Now I like to show this figure simply to make the point that who in their right mind would think that you could sustainably plough a forty five degree hill slope. This is not something that could be sustained terribly long. You can imagine that soil erosion would be racing ahead of soil production in such an environment. And obviously I show it because it is an extreme example.

The other example of soil erosion that could be viewed as fairly extreme is obviously the North American Dust Bowl. I am not going to talk a lot about that today but to share the quote from the first Chief of the Soil Conservation Service, Hugh Bennett, who wrote in 1941 that, "I suspect that when people along the seaboard of the eastern United States began to taste fresh soil from the plains 2,000 miles away, many of them realized for the first time that somewhere something had gone wrong with the land."

The problem of soil erosion during the Dust Bowl, the problem of eating Nebraska soils on your bagels in New York and in Boston, really brought the problem of soil erosion to the forefront of

thinking in mid-twentieth American society and it led to the development of the Soil Conservation Service. And just in case you might suspect that the establishment of a Federal Agency dedicated to soil conservation would solve the soil erosion problem in the United States, I want to disabuse you of that notion.

This is a wheat field from about forty years after the establishment of the Soil Conservation Service out in the Palouse in Eastern Washington. And you will notice all these small channels, which geomorphologists call rills. And it illustrates the fundamental problem of plough-based agriculture. At some time of the year, the crops are not going to be back in. And if you get rainfall on a erodible soil at a time of year where it's not covered, soil erosion can race ahead of soil production.

The key question, though, is by how much? Well, this slide from the Palouse from a 1961 paper by Verle Kaiser shows that it can actually add up to quite a lot. This fence up here on the right is a fence around the farmer's cistern. The field was up at this level in 1911, at the level of the cistern when the sod was broken for the first time, and it had only been ploughed under conventional wheat production for fifty years, 1911 to 1961. And this cliff resulted as a result of the erosion from the agriculture.

And this, which you can't see very well, but there's that little black thing there. It's actually a survey rod. It shows up pretty well on the negative in the sunlight. But that's a foot. So you have five feet of soil loss in fifty years. That's a foot a decade. That's an inch a year. There is really no where on earth where soils are forming about an inch a year unless you count places where volcanic soils are being added from above.

Jon Steinman: This is Deconstructing Dinner. You're listening to Professor David Montgomery of the University of Washington speaking in July 2009 at Oregon State University. David is the author of *Dirt: The Erosion of Civilizations,* released in 2008 by University of California Press. As David continued his talk, he suggested that the problem is not "that" we farm, it's "how" we farm.

David Montgomery: Well, if you look back at the archaeological record you can kind of triangulate the argument that there was a lot of soil loss associated with many ancient societies, but it's really hard to make the causal connection because the things were not measured or observed that way. So one of the things that I want to do before trying to make the argument that agricultural soil erosion might indeed set the limiting time scale for the life span of civilizations was to do that thing that has become, at least in my experience, incredibly hard to get at least undergraduates to do. And that is I went to the library. And I went there for three weeks. And I just got all the data that I could possibly find on contemporary and long-term or geological erosion rates, and also on agriculture erosion rates in particular.

Why did I look at geologic erosion rates? Well, if you think about that early assertion, that in terms of soils coming into some kind of balance with their local environment, the long term rate of geologic erosion, of rock erosion, is going be approximated by the long term rate of soil erosion, or there wouldn't be soil left in the landscape to begin with and go out and measure. They will be somewhere comparable.

And this is what I found: essentially fourteen hundred measurements of agricultural and geological erosion rates. It's a one-dimensional plot. And the geologic data are shown in white. The agricultural data are shown in black. You'll notice several things. One, erosion rates are incredibly variable on this planet. Down from rates comparable to Mars on the cratonal environments - the flat, tectonically dead parts of continents. They go up to about a millimetre a year or so in steep soil mantled terrain, like the Oregon Coast Range, behind where you are sitting.

And I want to point several other things out. First of all, that alpine and glaciated terrain, things like the High Himalaya and the High Cascade, can erode at a millimetre or so or higher. Notice where the agricultural data plot here. That by agricultural data on this plot what I mean is conventional plough-based agriculture, modern conventional agriculture, ranging from the Third World to First World technology. A wide range. It also spans four orders of magnitude or so. But you'll notice a couple of things about it. First, that farms are eroding like alpine topography. Essentially if you just look at the spread of the data for modern agriculture, for plough-based agriculture, it's essentially at the very high end of the long-term geologic erosion rates. And in particular, if you sort of make the "which of these things is most like the other?" kind of comparison, we've managed to turn the places that we farm globally, places like Nebraska, into places that are eroding at rates like the High Himalaya. It's actually quite a trick when you think about it.

And the other thing I want to point out that this red bar here is the USDA soil loss tolerance values, which range from about 0.4 to 1 millimetre a year. Those are the range of soil erosion rates meant to define rates of sustainable soil loss. And I'd like to point out that they sit at the very far end of any kind of long term data for any of the kind of places that we actually farm. Therefore, conventional agriculture as practiced in the modern world is unsustainable. That may sound fairly bold but I think that it's fairly simple and well-defended.

The next thing that I want to share with you in terms of data before trying to move on to the end here is that, if you look at probability distributions for all the different kinds of data that I was able to find in this several week compilation, it's very instructive. What I have shown here in black are the two distributions that I just showed you previously. The geological data are the black line that runs through here. The conventional agriculture is the upper line. And it's a percentile plot and the erosion rate this time is on the y-axis. Those USDA sustainable, or unsustainable values, as the case may be, are shown again in red.

The new data that I have added are all the data that I could find on the rates of soil production. There has been a closet industry in quantifying rates of soil production over the last twenty years. And I was able to dig up a lot of numbers on that. Rates of erosion under native vegetation and rates of erosion under so-called conservation agriculture, or so-called alternative agriculture, no-till agriculture and terraced agriculture.

And the point that I want to draw your attention to is that, I can't tell you that there is any difference between these distributions given the nature of this data. But the one thing that really stands out is the conventional plough-based agricultural data.

Herein lies the good news as well as the bad news. The good news is that the problem is not in terms of accelerated soil loss. It's not "that" we farm, the problem is "how" we farm. Because conservation-based agriculture can reduce soil erosion rates to rates comparable to soil production rates.

In case you object to the idea of comparing the sort of broad distributions based on global data, which you should have concerns about, I want to show you the comparisons I was able to find in the literature about places where you compare the human increase factor due to agricultural erosion. So you if take the ratio of the erosion rate that you would find under conventional agriculture to the ratio of erosion rate for the same soil, same climate, same geology, native vegetation, that ranges from about ten up to a hundred. There are outliers on either end. But you get sort of a concentration in a box and whiskers plot.

And if you look at the no-till decrease factor - the ratio of erosion rate under conventional agriculture to the ratio under no-till on the same kind of plots, the same slope, and the same climate, and the same kind of underlying geology - it decreases erosion rates by about the same amount. So no-till practices can reduce soil erosion by about as much as conventional ploughing increases it.

Therein I think lies the good news. There is one other study to share with you in part because I think it is so clever. Bruce Wilkinson did a study where he looked at trying to reconstruct geologic erosion rates over all of geologic time, or at least the last half-billion years of geologic time, by looking at the distribution of sedimentary rocks in the geologic record.

What he found is that, for the last half-billion years, the average erosion rate in the continents is about an inch every fourteen hundred years. This compares to the average rate of soil erosion off of agricultural lands at present of an inch every sixty years or so, which itself is about ten times shorter than the USDA's estimate of rates of global soil production.

So virtually any way you cut it, whether from looking at modern studies, looking at rates of soil loss, to looking at soil loss over most of geologic time, or at least since land plants evolved, our agricultural soils are eroding at something like ten to twenty times at any kind of conceivable replacement rate.

You can put together a very simple model for estimating the time required to lose the soil, the thicknesses as a function of the difference between the erosion rate and soil production "p." It turns out to be a log-linear plot like many simple analytic models.

But if you basically take the idea that, on average, we're losing something like a millimetre a year of soil as the net difference between erosion and production rates - and you recall that's conservative according to the data that I have compiled. And you basically look at what that would mean for the loss of a half-meter thick or meter thick soil. These two lines here, you essentially go up to here, take it over here. And you are talking five hundred to fifteen hundred years or so as the predicted time scale for agricultural soil erosion, the way it's been practiced

around the world for millennia, to exhaust the soil physically. And we are not talking about soil fertility in this case. We are actually talking about conserving the soil itself.

And that time scale reasonably approximates the time spans of most major civilizations. Can we quibble with this in detail? Absolutely. And can I basically rule out things like climate or natural disasters? No. In terms of their influence on the longevity of human societies. No, and I am not trying to.

The argument I am trying to make is that this long-term slow bleed of soil may be what is setting the long wave length periodicity behind the rise and fall of human societies. I don't think soil erosion actually terminally ended any society. It happens too slowly to actually do that. But in terms of setting the health and potential of societies, I think it actually is sort of the big underappreciated influence that has been acting throughout history.

I am also not the first person to argue this. I'll here, by quoting Walter Loudermilk, who wrote that, "Here in, a nutshell, so to speak, fifty years ago, we have the underlying hazard of civilization. By clearing and cultivating sloping lands - for most of our lands are more or less sloping - we expose soils to accelerated erosion by water or by wind and in doing this we enter upon a regime of self-destructive agriculture."

Jon Steinman: David Montgomery. That last comment is a powerful one indeed. That the collapse of civilizations because of the health of their soils is *not* a 'terminal' ending of civilizations but a *gradual* indicator of health and well-being. Well, if that suggestion proves to be true, then those signs are no doubt before us today, whether it be the rapid rise in poor health, malnutrition and disease both here and abroad; or the dead zone in the Gulf of Mexico, like others around the world; or the seemingly frantic pace of injecting off-farm inputs into the soil (both organic and non). Well, the predictions shared by David Montgomery and others don't seem like a suggestion at all, and instead an inevitability, unless we steward ourselves and our soil in another direction.

In this last segment from David's talk at Oregon State University, we listen in on two audience questions posed after his talk.

First Audience Member: Very interesting. You suggest that in order to preserve the soils we need to change farming practices. In the current world I don't know how much of the food supply is industrial farming but I assume a large fraction. So is it possible to supply the global population with enough food by changing the industrialized farming practices to practices that do not erode the soil?

David Montgomery: Thank you. That is an excellent question. And I am really glad you asked it because that's something that when I started doing the research for the book I would not have been able to answer. And it is a concern that I think is sort of the first one to think about.

What I have been really impressed by is how many studies there have been now, over the last ten years in particular, looking at crop yields under no-till versus under conventional agriculture. And they are pretty comparable. On some kinds of terrain, on some kinds of soils, one is higher

than the other. Now, the key thing with no-till is that it's not necessarily incompatible with large-scale industrialization. In fact, one of the critiques of it is that it is often associated with increased pesticide and herbicide use. And you can think of sort of organic agriculture and no-till as parallel tracks. In the book I argue we need to get both those together and figure out how to do organic agriculture in no-till fashion over the long run.

But of course the other potential answer to your question is, if you look at where the highest crop yields are on the planet are, they are not on large-scale industrial farms. They are on very small-scale, labour intensive organic things. Some of them are actually in cities, urban agriculture.

So in terms of how we would actually be able to feed the planet using so-called alternative agriculture, I think that it is perfectly feasible to do. Whether we would actually be able to do the political and economic transitions that it would take to enable that to happen is a much bigger question in my mind now than whether it is simply feasible to do. And organic agriculture can yield good comparable crop yields to conventional as well so there is just different ways to do it.

Second Audience Member: Thanks for the insight in your book. You talked about ancient societies which lasted on average a thousand years. So they lost their soil? Right. It's a rule of thumb. But, where do we stand today, in, say, recent societies? Have we already gone towards the end of that thousand year lifespan that we have, or are we just missing evidence of societal collapse during the last two thousand years?

David Montgomery: I think that, if you look around the globe, there is a real big differences in where we would sit with that. Where we standing today, the native forest here was cleared a little over a century ago. So we are just starting. If you look at the Middle East they've played through. And so, I think that the real message behind recognizing this as a phenomena that has affected regional societies in the past is not to get locked into the same practices globally for the next hundred or two hundred years because we don't really have anywhere else to go.

And if you look at the places where you could argue that you could find a lot of new agricultural land – the Amazon Basin, or the Tibetan Plateau, if you could get water to it - there's things that we could do that probably wouldn't be sustainable. In terms of the Amazon, with conventional agriculture, at least, we would get a decade of productivity out of it at best. And India might complain if China took the Tsangpo River and used it to irrigate the Tibetan Plateau.

So I think the key point is really not so much that we face an immediate crisis, or that any one particular place is at really high immediate risk, but that if we look globally and if we look through climate change, because clearly I think that's the much more immediate and pressing problem, we'll have to deal with the soil problem.

But if you look at the problem of how we would actually sustain agricultural production in a post-petroleum world, when nitrogen-based fertilizers might not be the optimal way to maintain soil fertility, simply from economic considerations, we ought to be thinking about alternatives. And the idea of being able to park more carbon back in the soil, which is a side benefit of no-till agriculture, is something that ought to be kind of thought about in terms of dealing with climate change because that would help with the next crisis which is, admittedly, a bit farther off.

Jon Steinman: And that was David Montgomery of the University of Washington's Department of Earth and Space Sciences. David was recorded speaking in July 2009 at Oregon State University in Corvallis, Oregon. The event was hosted by PAGES, a project of the Institute of Geophysics and Planetary Physics at UCLA. More information on today's topic and an archived copy of the show is available on our website at deconstructingdinner.ca and the July 29th, 2010 episode.

ending theme

That was this week's edition of Deconstructing Dinner, produced and recorded at Nelson, British Columbia's Kootenay Co-op Radio. I've been your host Jon Steinman. I thank my technical assistant John Ryan.

The theme music for Deconstructing Dinner is courtesy of Nelson-area resident Adham Shaikh.

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