Oklahoma farm yard in 1936, deep dust covering fences.

5

Drought's Slippery Slope

Suppose that I told you that, even without global fever, the chance of twenty-first-century America suffering a century-long, widespread drought is one in four. Speculation? No, such chances are what history tells us—the type of history written in thick or thin tree rings.

Even without global fever's rearrangements, the Great Plains and the West have often suffered century-long droughts, far more widespread and long-lasting than the more familiar Dust Bowl of 1932–38. Droughts provide a common setup for famine, so let me show how the slippery slope works in a regional drought. Drought also illustrates the role of random events in what is otherwise deterministic.

Drought watchers define drought as a moisture deficit severe enough to have social, environmental, or economic effects. That's a *what*-based definition, and it often suffices for lawyers and policy types.

I prefer to focus on *how* a drought gets going because it shows how slippery slopes are created. And how you can "get stuck" in a drought, seemingly unable to pop out.

Slipping on the proverbial banana peel is bad enough. Slippery slopes, however, are where things get bad and, because of that, automatically get worse. This repeats and repeats, creating an increasingly rapid descent into hell. Or thereabouts. Take, for example, the time that I slipped on an unseen layer of thin ice outside the back door. Quick reflexes didn't save me, and so I sat down hard. Then, astonished, I bounced down two flights of slippery steps, gaining speed with each additional bump.

That's similar to what goes on in a drought: a moisture omission that achieves a slippery slope, a chain of events that kills off plant life, roots and all, forcing it to start anew. It's like a computer crash and reboot. The crash is fast, the reboot is slow. So here's my slippery slope view of drought. It's more about the how—the underlying mechanisms—than it is about the what.

Usually by chance, the storm tracks skip over a region for several years running. So the topsoil gets a little dry and plants grow slowly. And then a few weeks of really hot weather bakes all of the ground that isn't shaded.

The result is that leaves droop. Evaporation from the leaves is what pulls more water up from the roots, what makes a leaf fill out and the plant stand upright. No more water around the roots, and the leaves wilt. Result: no more shade.

And now the feedback: The ground which was still shaded now bakes as well. The plant may no longer stand at attention (indeed, fire may prune it). The topsoil gets

much drier. This, by itself, does not seem to have a slippery slope: once the shade is reduced to nothing, it cannot get less shady.

But now another mechanism kicks in. Over a tropical forest, about half of the rainfall comes from what recently evaporated from the leaves upwind.

Less evaporation diminishes future rainfall by reducing the humidity. Think of it as recycling or, better yet, as priming the pump. To get mere humidity (water vapor) to coalesce into the little water droplets that we see suspended in steam and clouds, it takes a certain minimum amount of water vapor. This varies with temperature, measured as the dew point. Such droplets may condense to form the larger drops, finally becoming too heavy for buoyancy to keep them aloft. In short, it rains.

So the plant-generated humidity helps to harvest any passing water vapor by boosting it up into raindrop mode. It builds up the clouds. No evaporation means less rain. Once again, things get worse in a drought, almost automatically.

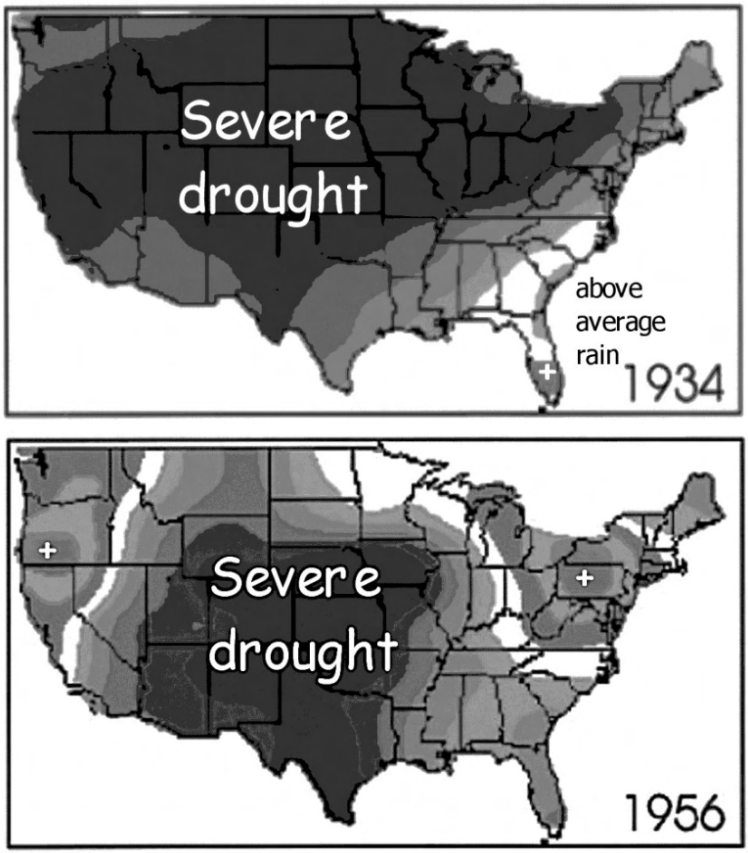
Now the water table drops significantly, and so the roots can't reach it. No plants grow the next spring. Surviving plants may now die, roots and all. Then, what rain that does fall is likely to run off quickly, since dead plants no longer extract water from the topsoil.

There's even more to drought's slippery slope. Dry out the ground and it gets a hard crust, thanks to the wind removing the softer bits. Thus when rain does fall, it splashes. Most runs off sideways on the hard surface

rather than sinking into the soil. And so the water table drops even further.

This can be reversed by enough rain, but it takes more than one good year for storm tracks.

This chain of events can be created, on a much faster timescale, in your own back yard. You may not be able to activate all of the feedback loops by failing to water the garden all summer, but you can see most of the chain except for evaporative rainmaking.



William H. Calvin, GLOBAL FEVER: How to Treat Climate Change (University of Chicago Press, 2008)

River sediments, tree-ring growth records, and the bathtub ring around lakes are the easy measures of earlier droughts, and sometimes the archaeologists can add the dates when settlements are abandoned. On top of that, you want to know the territory occupied by the drought and typical durations.

> People who remember the 1930s Dust Bowl might think they have seen the worst drought nature can offer. In the toughest Dust Bowl years, between 1934 and 1940, millions of acres of Great Plains topsoil blew away in colossal dust storms…Hundreds of thousands of people, including 85 per cent of Oklahoma's entire population, left the land and trekked west. All it took was an average 25 per cent reduction in rainfall.
>
> —the writer Mark Lynas, 2007

The Dust Bowl drought was before my time, but my mother said that when it did rain in Kansas City, it rained mud.

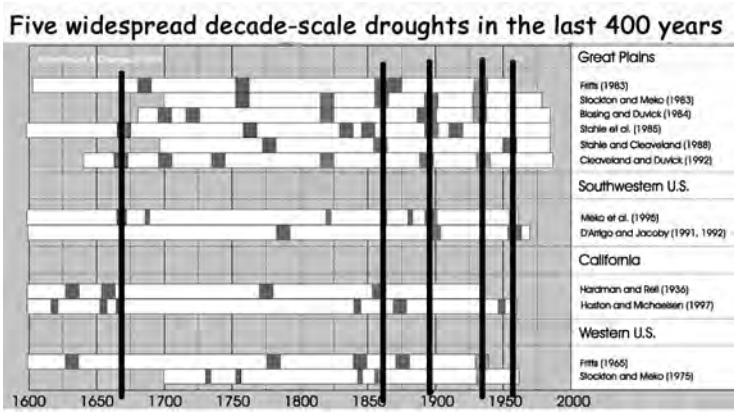
The Dust Bowl affected much of the western half of the U.S, magnifying the effects of the economic depression that began several years earlier when a speculative bubble crashed the stock market. In 1934, almost the entire United States was in severe drought.

And it wasn't as if the rain fell elsewhere. Only southern Florida got more rain than usual. In contrast, the big drought of 1956 was associated with extra rainfall in the Northwest and Northeast.

The computer models of climate (more in chapter 15) give some cause-and-effect insight into the rainfall patterns of 1934. If you force the model to follow the

observed temperatures in the Pacific Ocean—cool since a La Niña was in progress—it produces a rainfall map that looks very much like the actual 1934 rainfall map.

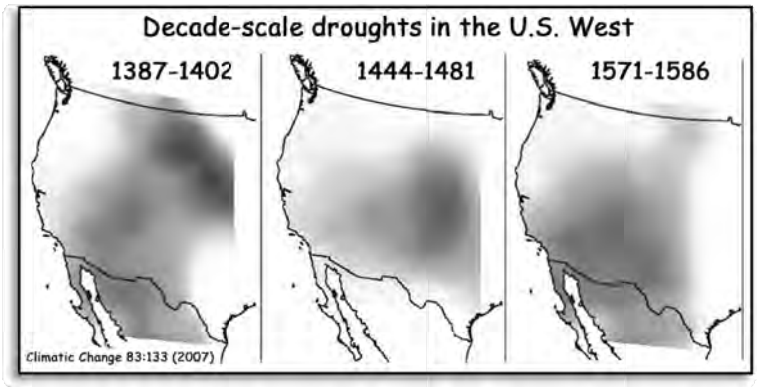
The previous decade-scale drought was back in the 1890s. There was another in the 1850s, just before the U.S. Civil War, and another back in the 1660s, when Isaac Newton was contemplating falling apples. They too covered a lot of territory at once. Three of the four happened during the warm up after the Little Ice Age ended about 1850.



Notable droughts (dark boxes) west of the Mississippi River in the last 400 years. Of the five widespread decade-scale droughts (connected by vertical lines) comparable to the Dust Bowl, four have occurred since the earth began warming up after the Little Ice Age ended in about 1850. (Data compiled by Woodhouse and Overpeck 1998. The light horizontal ribbon represents the time span of the data at the location.)

Humans, of course, can make natural drought cycles worse. The longer I hang around a medical school, for instance, the more stories I hear about common patient behaviors that just exacerbate the problem.

There's a big market out there for denial. "This is not happening to me" is one stage of grief. I hope we don't see the other two: anger ("How dare God do this to me") and bargaining ("Just let me live to see my daughter get married"). Some remind me of what seems to be going on with the Earth's fever.



All of these Little Ice Age droughts in the American West were worse than the Dust Bowl of the 1930s, even though there were fewer century-scale droughts then.

With global warming will come additional denial, certainly by some of the naysayers and procrastinators of the past. While denial has been encouraged by disinformation campaigns, it's already common enough for climate problems. Take the 1930s Dust Bowl. Drought wasn't the only cause of the black blizzards. Not only had

the farmers done away with the grasses that held the topsoil in place, but growing wheat had exhausted the topsoil. Overgrazing by cattle and sheep had stripped the soil further. So when the rains failed, the land just blew away.

Dusty dune formed after 1935 dust storm.

Starting in 1935, federal conservation programs tried to change the business-as-usual farming practices by seeding grass, rotating crops, strip and contour plowing, and planting trees as windbreaks. But the farmers were in denial about their traditional careless practices. For many of them, it took the incentive of the government paying them a dollar an acre to get them to grudgingly adopt the new methods.

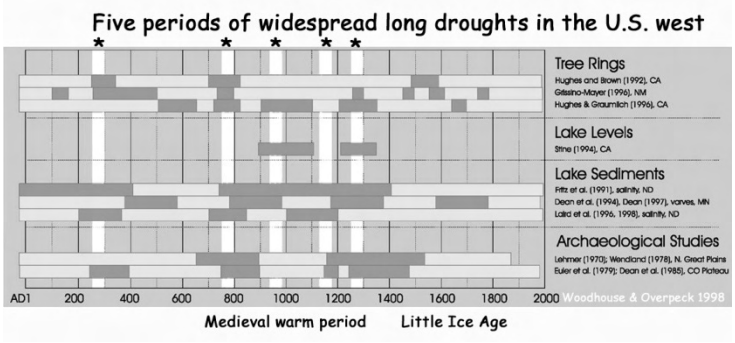
The denial went deeper than that, reflecting something about national traits as well. As the historian Robert

Worster wrote, "The ultimate meaning of the dust storms of the 1930s was that America as a whole, not just the plains, was badly out of balance with its natural environment. Unbounded optimism about the future, careless disregard of nature's limits and uncertainties, uncritical faith in Providence, devotion to self-aggrandizement—all these were national as well as regional characteristics."

So anyone who would tackle our current addiction to fossil fuels is going to have to maneuver around denial. But there is another not uncommon patient behavior to bear in mind as well: aversion to experts. In medicine, "too late" is often heard. In many parts of the world, that's because of the poor availability of medical care. Where that isn't the case, you still see the patient who overgeneralizes about herbs, assuming they can fix anything. Or the patient who finally sees a nurse-practitioner but resists referral to a specialist because "I just don't feel comfortable with fancy specialists."

There are a lot of people out there like that, and I fear they will react to climate experts in a similar way. Even if education might eventually reduce such problems, climate may require much quicker action than several generations of education. The urgency about climate change really calls for politicians and cultural leaders to interpret the warnings. They will be heard in a way that the climate experts may not.

It's called leadership.



Century-scale droughts (*gray boxes*; the more brief droughts are omitted here) over the last 2,000 years, west of the Mississippi River. The ones that were widespread are connected by the *white vertical bars*. There were five such widespread century-scale droughts in the last twenty centuries, but four of them occurred in the span of the Medieval Warm Period. None occurred in the Little Ice Age that followed.

We have obviously survived a number of climate changes already. Some of them even sped up the evolution of *Homo sapiens*, as I discussed in *A Brain for All Seasons*.

However, 99 percent of Americans no longer live on farms and are instead crowded into cities and their suburbs. Most are unable to feed themselves without food on the shelves at the local grocery. This inherently unstable situation makes us much more vulnerable. When I was born in 1939, 20 percent of Americans still lived on farms. Now it's 1 percent.

So what are the odds of collapse from climate problems? We naturally focus on the next one, when it comes to natural disasters, but you also have to think about how often something happens.

Besides floods, we can give the odds of drought conditions. We now have a lot of data on past droughts. Some areas, such as present-day North Dakota, stayed in drought for 700 years at a time. So let's focus on century-scale droughts (say, lasting at least ten times as long as the Dust Bowl). Furthermore, let us restrict ourselves to the occasions when most of the western half of the U.S. was simultaneously in drought conditions.

Such a drought (shown as a vertical white line), covering the same territory as the Dust Bowl but lasting a century, has indeed happened. If it happened again, it would be a disaster, and not only for the farmers. Even if famine were not our fate, a country weakened by such a problem may be taken over by some other country—making drought a serious national security concern. Not only did such a widespread, century-scale drought happen once but it has happened five times in twenty centuries. One century in every four, on average.

That track record for the western half of the U.S., even without global fever, suggests that it has a 25 percent chance of getting hit by a thoroughly disastrous century-scale drought in the twenty-first century. If you count less widespread droughts or ones that last less than fifty years, the chances of serious disruption are much higher.

The now-revealed unstable climate lacked our current rate of global warming. We can get some clues about the consequences of warming, however, from when the five century-scale droughts occurred.

Though there were serious decade-scale droughts (page 47), no century-sized droughts occurred in the U.S. during the Little Ice Age (from roughly 1315 to 1865) when Europe and some other parts of the world were generally about 1°C cooler.

Four of the five long American droughts during the last twenty centuries happened during the so-called Medieval Warm Period of anomalous climate.

So instead of one century in four, perhaps our chances are closer to four chances in five of the twenty-first century having a major climate disturbance as some regions warm more than others. An 80 percent chance of having to live in a vastly disrupted United States is so close to a sure thing that Americans ought to insist that their government treat it that way as a precaution.

Fifty years ago, climate scientists didn't know most of this history and didn't know much about the feedback loops. Thanks to science, we now know the chances. Furthermore, we know the mechanisms that create the

drought's slippery slope, and that may someday help us to intervene and limit the damage.

Wall of dust in April 1935 approaching Stratford, Texas.

No one seems to know this American drought history, despite the media's well-known appetite for disaster stories. And fewer people realize what is arriving on climate's fast track. Most of the models agree in predicting that the dryness of the 1930s Dust Bowl will return to the American Southwest by midcentury—and for good.

Yet it's business as usual for most of our leaders. While they should of course be better informed, it's really we citizens who need to know this history and, at the least, some metaphors for how it happens. Without our expressed concerns, politicians will continue to "study the problem further," not realizing the dangers of the slippery slope.

Is anyone concerned with public policy (say, a presidential commission) looking ahead at the major disruption problem? Are we studying how to create a more resilient economy, structured so that it can cope with such shocks? Examining models to see how the crisis economy might be stabilized to prevent market crashes and currency crunches? (The economists I've asked all say that they haven't heard of anyone working on the crisis economy problem.)

An Oklahoma main street.

Is anyone planning, perhaps, a subsidized conversion to drip irrigation or hothouse agriculture? Or making agriculture do more with less? Pigs are terribly inefficient. You only get back about 15 percent of the calories that you feed them. Chickens manage 25 percent, beef 20 percent.

Vegetarians entirely bypass the middleman with the three-fold markup.

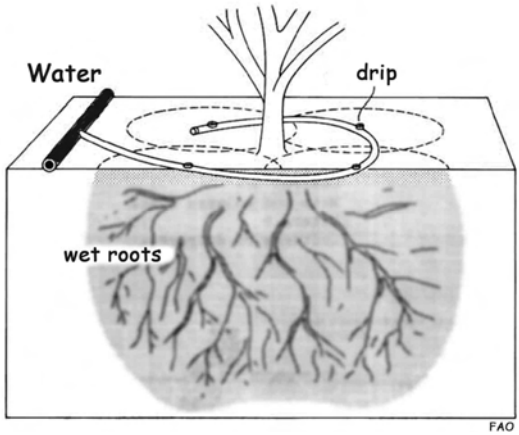
We can get trapped by our metaphors. Inadequate ones such as "gradual warming" produce tunnel vision, with all the dangers of being blindsided. So let us be on the look-out for handy metaphors, ones brief enough to use for a question to the speaker or in a letter to the editor. For example, there is a common assumption, both by some scientists and by many commentators, that the future is some gradual extrapolation of recent history. So remind them of the stock market's rise during the 1990s, when many people became accustomed to annual compounding of more than 10 percent. The people that projected this into the future soon discovered that many stocks could also fall by 75 percent. "I used to be retired," a friend quipped. "Now I'm merely unemployed."

Surprises happen. You may not know what and when and where, but you nonetheless can make sure that the infrastructure emphasizes stability. Just as we retrofit our old bridges to survive earthquakes, we should redesign our agriculture and our economy to survive hard knocks from climate surprises, pandemics, and economic panics. So far as I can tell, this isn't on anyone's agenda.

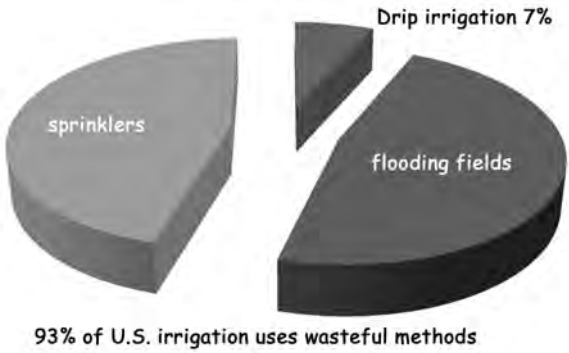
The water table is lowering rapidly in many places, another tragedy of the commons. Crops remove CO_2 from the air. However, irrigation not only raises the humidity (a heat-trapping gas) but reduces the amount of sunlight reflected back out into space via making the surface dark-

er. Water scarcity is going to be a major problem in many places as the planet warms and the winds rearrange. Given the high percentage of river flow that is used for such wasteful irrigation practices, conversion to drip irrigation and hothouses will surely be on the agenda. Cities without a reliable water supply will likely no longer tolerate the existing division of water resources—and have to pay higher food prices in consequence.

Doing something is, of course, expensive. Then too, everything is labeled expensive unless it's business as usual. We can no longer afford business as usual. But there will be great business opportunities for the countries that develop the expertise and the needed new technologies before others do.



Drip irrigation method wets only the individual plant and minimizes evaporation as well.



Agriculture now accounts for about 70 percent of world water use, industry for about 22 percent, and towns and municipalities for 8 percent.

GLOBAL
How to Treat Climate Change
FEVER

WILLIAM H. CALVIN

THE UNIVERSITY OF CHICAGO PRESS
CHICAGO AND LONDON

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