PART I: OUR CONVERGING CRISES

Depletion

Imagine you're at a big party. The host wheels out a tub of ice cream—the big ones they use at ice cream parlors—and yells, "help yourselves!" A few people grab scoops, spoons, and bowls from the kitchen and start digging into the frozen top. As they work the tub and it warms up, the ice cream becomes easier to scoop; more people bring spoons and bowls, and ice cream flies out of the bin as fast as people can eat it. When the ice cream is over half gone, it starts to get harder to get at; people have to reach in farther to scoop, and they're bumping into each other. The ice cream isn't coming out as fast anymore, and some people lose interest and turn their attention to the cake. Finally a small group of the most intrepid scoopers are literally scraping the bottom of the barrel, resorting to small spoons to get the last bits of ice cream out of the corners.

That's depletion. The faster you scoop, the sooner you arrive at the point when there's none left.

Like our hypothetical tub of ice cream, Earth's resources are subject to depletion—but usually the process is a little more complicated.

First, ***material resources*** come in two kinds: ***renewable*** and ***non-renewable***. Renewable resources like forests and fisheries replenish themselves over time. Harvesting trees or fish faster than they can replenish will deplete them, and if you do that for too long it may become impossible for the resource to recover. We're seeing that right now with many global fish stocks[1].

[1] Source: FAO 2016: http://www.fao.org/3/a-i5555e.pdf

Non-renewable resources—like minerals, metals, and fossil fuels—on the other hand, don't grow back at all. Minerals and metals can often be recycled, but that requires energy and sometimes the resources gradually degrade as they're cycled repeatedly. When we extract and burn fossil fuels, they are gone forever.

Another complicating issue is ***resource quality***. Our hypothetical ice cream is the same from top of the barrel to the bottom. But most non-renewable resources vary greatly in terms of quality. For example, there are rich natural iron deposits called **magnetite** in which iron makes up about three-quarters of the material that's mined. At the other end of the spectrum is **taconite**, of which only about one-quarter is iron. If you're looking to mine iron, guess which ores you'll start with. High-grade resources—the "low-hanging fruit"—tend to be depleted first.

Defining which resources can be considered "high-grade" is also a little complicated. We've just discussed ore grades. But there are also issues of ***accessibility***: how deeply is the resource buried? And ***location***: is it nearby, or under a mile of ocean water, or in a hostile country on the other side of the planet? There's also the issue of ***contaminants***: for example, coal with high sulfur content is much less desirable than low-sulfur coal.

Okay, let's see how issues of resource quality play out in the case of one of the world's most precious resources, crude oil.

Modern oil production started around 1860 in the United States, when deposits of oil in Pennsylvania were found and simple, shallow wells were drilled into them. This petroleum was under great pressure underground, and the wells allowed that oil to escape to the surface. Over time, as the pressure decreased, the remaining oil needed to be pumped out. When no more oil could be pumped, the well was depleted and abandoned.

Exploration geologists soon discovered oil in other places: Oklahoma, Texas, California, and later in other parts of the world, particularly the Middle East.

During the century-and-a-half that we humans have been extracting and burning oil, hundreds of thousands of individual oil wells around the world have been drilled, depleted and abandoned.

Oil deposits are generally too big to be drained from a single oil well; many wells drilling into the same underground reservoir are called an ***oil field***. Oil fields are geological formations where oil has accumulated over millions of years. Some are small, others are huge. Smaller oil fields are fairly numerous. The super-giant oil fields—like Ghawar in Saudi Arabia, which in its glory days of the 1990s yielded nearly ten percent of all the world's oil on a daily basis—those are very rare. Like individual oil wells, *oil fields* also deplete over time.

Today, most of the world's onshore crude oil deposits—often called ***conventional oil***—have already been discovered and are in the process of being depleted. The oil industry is quickly moving toward several kinds of ***unconventional oil***—for example tar sands in Canada, deepwater oil in places like the Gulf of Mexico, and tight oil (it's also known as shale oil) produced by hydrofracturing, or fracking, in North Dakota and Texas. Unconventional oil resources are either of lower quality, like the tar sands, or are more challenging to extract or process, compared to conventional oil—therefore production costs are significantly higher, and so are the environmental impacts and risks.

As fossil fuels are depleted, their energy profitability generally declines. It takes energy to get energy—it takes energy to drill an oil well, to mine coal, or even to build a solar panel. But we expect an energy profit in the long run: our energy resource will give us much more useful energy than was required to develop it. But as we move to lower quality fuels or ones that are harder to extract, the ratio of ***Energy Returned on Energy Invested (or EROEI)*** falls. In the early days of the oil industry, energy returns of a hundred-to-one were routine; in today's petroleum industry, returns of ten-to-one are more common. That means more and more of society's overall resources have to be invested in producing energy. It also means oil prices are likely to become more volatile.

During the past century, our transportation systems were built on the assumption of continually low prices and growing supplies of oil, and the petroleum industry was structured to anticipate low extraction costs. Now that extraction costs are going up because we're relying more on unconventional resources, there is no longer an oil price that works well for both producers and consumers. Either the oil price is too *high*, eating into motorists' disposable income, reducing spending on everything else and thus making the economy trend toward recession; or the oil price is too *low*, bankrupting the oil producers.

This suggests that the free market may not be capable of managing non-renewable resources in a way that meets everyone's needs over the long run—especially those of future generations, who don't have a voice at the table. In theory, when a resource that's in high demand becomes scarce, its price rises to discourage consumption and encourage substitutes. But what if poor people need that resource, too? What if the entire economy depends on ever-expanding cheap supplies of that resource? What if a substitute is hard to find, or fails to match the original resource in terms of versatility or price? What happens to producers if costs of extraction are rising rapidly, but a temporary surge in supply or a fall in demand causes prices to plummet far below production costs? In just the last decade, we've seen all of these problems begin to play out in oil markets.

The main alternative to market-based resource extraction and distribution is for governments and communities to collaborate on some kind of program of ***resource management***. We've done this with renewable resources, for example by establishing quotas on fishing or by protecting old-growth forests. However, conservation efforts have seldom been undertaken in the case of non-renewable resources like fossil fuels. Humanity's collective plan evidently is to extract and use these resources as quickly as possible, and to hope that economically viable substitutes appear in time to avert a future economic catastrophe.

In agrarian societies the most crucial depletion issue is usually the depletion of ***soil nutrients—nitrogen, phosphorus, and potassium***, which together make soil fertile enough to grow crops. In farming societies, soil fertility largely determines population size. To avert population declines, successful agrarian societies like the ancient Chinese learned to recycle nutrients using animal and human manures. In contrast, modern industrial societies typically get these nutrients from non-renewable resources: we mine phosphate from large deposits in China, Morocco, Florida, and ship it around the world. And we produce artificial nitrogen fertilizers from fossil fuels like natural gas. Since both phosphate deposits and fossil fuel deposits will ultimately be depleted, industrial agriculture will have to find ways to break its dependence on these non-renewable resources to become sustainable over the long term. Meanwhile, our ability to supply plant nutrients artificially has enabled us to largely ignore the depletion of topsoil itself, of which we are losing over 25 billion tons per year globally.

In short, the depletion of renewable and non-renewable resources is a very real problem, one that contributed to the collapse of societies in the past. Today we consume resources at a far higher rate than any previous civilization. We can do this mainly due to our reliance on a few particularly useful nonrenewable and depleting resources, namely fossil fuels. Energy from fossil fuels enables us to mine, transform, and transport other resources at very high rates; it also yields synthetic fertilizers to make up for our ongoing depletion of natural soil nutrients.

This deep dependency on fossil fuels of course raises the question of what we will do as the depletion of fossil fuels themselves becomes more of an issue.