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Running out of resources

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Pls. Note that this is a first (un-edited) version, with references.

Running out of resources was one of the most forceful claims of the early environmental movement, and a claim that provided the backdrop for many of the environmental movement's most enduring contentions: the call for recycling, the contention that small-is-beautiful and the justification for the need to restructure society away from its obsession with resource-consuming production. While the idea has held a powerful sway over the past 30 years of popular thinking, it is also one of the environmental claims that have been demonstrated most clearly to be incorrect. Although the scare of resource depletion gets its run through the media every so often,[1] even many environmentalists today disavow their previous worries of running out.

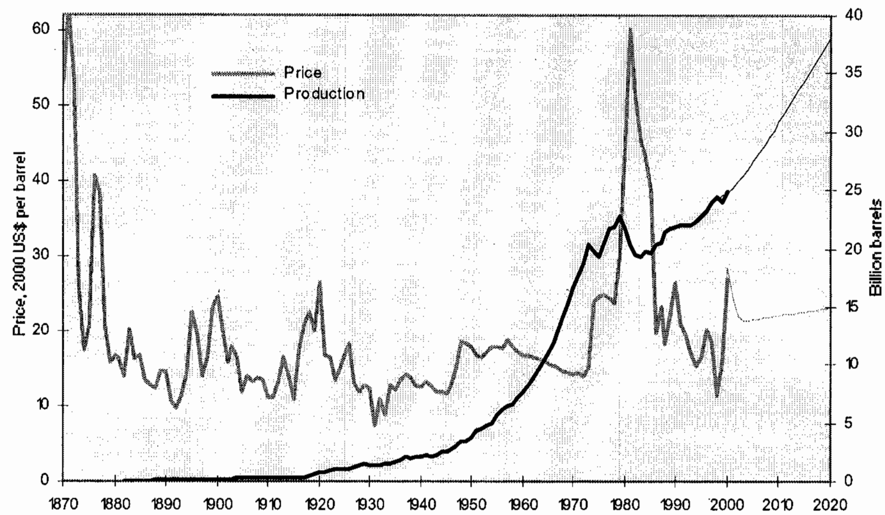

Figure 1 Oil price 1871-2020 in 2000 US$, and world production 1882-2020, US Energy Information Agency prediction from 2001-20. Source: Simon et al. 1994, EIA 1999c:63, 273, 2000e:127, 153, 2001a:117, 137, 2001c:13, CPI 2001.

Worrying

For many, the first oil crisis in 1973 was the initial proof of the scarcity of resources. Actually, we have always worried about running out of all kinds of resources. In antiquity grave concerns were voiced about running out of copper and tin. And the best-seller *Limits to Growth* from 1972 picked up on the old worry, claiming that we would run out of most resources. Gold would run out in 1981, silver and mercury in 1985, and zinc in 1990.[2] But, of course, this hasn't happened yet.

Economists had from the very outset pointed out that these fears were erroneous, and yet the idea of running out held an almost magical grip on intellectuals in the 1970s and 1980s. Even today most discussions seem to be played out against a backdrop of arguments pointing back to the logic of *Limits to Growth*.

Frustrated, the economist Julian Simon in 1980 challenged the environmentalists with a bet. Since increased scarcity would mean higher price, he offered to bet $10,000 that any given raw material – to be picked by his opponents – would have dropped in price at least one year later. The environmentalists Ehrlich, Harte and Holdren, all of Stanford University, accepted the challenge, stating that "the lure of easy money can be irresistible."[3] The environmentalists staked their bets on chromium, copper, nickel, tin and tungsten, and they picked a time frame of ten years. In September 1990 not only had the total basket of raw materials but also each individual raw material dropped in price. Chromium had dropped 5 percent, tin a whopping 74 percent. The doomsayers had lost.

Truth is they *could not* have won. Ehrlich and Co. would have lost no matter whether they had staked their money on petroleum, foodstuffs, sugar, coffee, cotton, wool, minerals or phosphates. They had all become cheaper.[4]

The case of oil

Oil is today the most important and most valuable commodity of international trade. Moreover, our civilization is based on the use of energy. Thus, the plausibly most important threat seems to be the recurrent worry that we are running out of oil. In 1914 the US Bureau of Mines estimated that there would be oil left over for only ten years' consumption. In 1939 the US Department of the Interior projected that oil would last only 13 more years, and again in 1951 it was again projected that oil would run out 13 years later.[5] As Professor Frank Notestein of Princeton said in his later years: "We've been running out of oil ever since I've been a boy."[6]

Again, measuring scarcity means looking at the price. Even if we were to run out of oil, this would not mean that oil was unavailable, only that it would be very, very expensive.[7] The chart shows that the price of oil has not had any long-term upward trend.

The oil price hike from 1973 to the mid-80s was caused by an artificial scarcity, as OPEC achieved a consistent restraint to production.[8] Likewise, the present high oil price is caused by sustained adherence to OPEC agreed production cutbacks in the late 1990s.[9] Thus, it is also expected that the oil price will once again decline from $27 to the low $20s until 2020.[10] This prediction lies well in the middle of the $17-$30 stemming from eight other recent international forecasts.[11]

The reason why it is unlikely that the long term trend will deviate much from this price is that high real prices deter consumption and encourage the development of other sources of oil and non-oil energy supplies. Likewise, persistently low prices will have the opposite effects.[12]

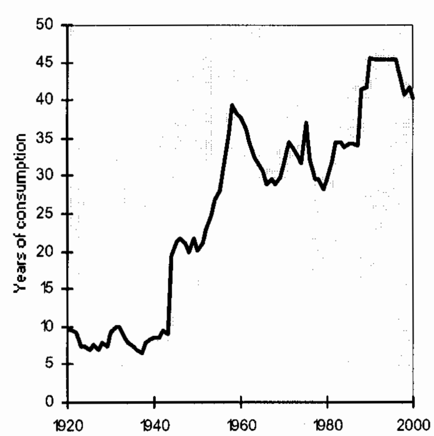

Figure 2 Years-of-consumption: world oil reserves compared to the annual production, 1920-2000. Source: Simon et al. 1994, EIA 1997b:Table 11.3, 11.5, 1999c:271, 2000d:277, 2000a:109, 2000c:136, 2001a:137, 2001b:113, . Total reserves until 1944 are only American, since 1944 for the entire world.

Actually, if we look at the real price of gas at the pump (the consumer price) excluding tax, it stands at $1.10 in early 2001, at par with the lowest prices before the oil crisis. This is because most of the gas price consists of refining and transportation, both of which have experienced huge efficiency increases.[13]

At the same time the chart demonstrates that we have had ever more years-of-consumption, despite increasing consumption. This is truly astounding. Common sense would tell us that if we have 35 years' consumption left in 1955, then we should have 34 years' supply left the year after.[14] Yes, actually we should probably rather have 33 years' worth left because we consumed more oil in 1956 than in 1955. But the chart shows that in 1956 – contrary to what common sense would indicate – there were *more* years of reserves even at a *higher* annual consumption.[15]

The development for non-fuel resources has been similar. Cement, aluminium, iron, copper, gold, nitrogen and zinc account for more than 75% of global expenditure on raw materials.[16] Despite an increase in consumption of these materials of between two- and ten-fold over the past 50 years, the years-of-consumption have grown, just like with oil.[17] The increasing abundance is also reflected in an ever-decreasing price: The Economist's price index for raw materials has dropped some 80% since 1845.[18]

How is this possible?

How can we have used ever more and still have even more left? The answers to this question point to the three central arguments against the limited resources approach.

1. "Known resources" is not a finite entity. It is not that we *know* all the places with oil, and now just need to pump it up. We explore new areas and find new oil. But since searching costs money, new searches will not be initiated too far in advance of production. Consequently, new oil fields will be continuously added as demand rises. This is part of the reason why we see years of consumption increasing and not decreasing.

Actually, it is rather odd that anyone could have thought that known resources pretty much represent what is left, and therefore predict dire problems when these have run out. It is a little bit akin to glancing into my refrigerator and saying: "Oh, you've only got food for three days. In four days you will die of starvation." No, in two days I will go to the supermarket and buy some more food. The point is that oil will come not only from the sources we already know but also from many other sources which we still do not know.[19] US Geological Surveys have regularly been making assessments of the total undiscovered resources of oil and gas, and writing in March 2000 they state: "Since 1981, each of the last four of these assessments has shown a slight increase in the combined volume of identified reserves and undiscovered resources."[20]

2. We become better at exploiting resources. We use new technology to be able to extract more oil from known oil fields, we become better at finding new oil fields, and we can start exploiting oil fields that previously were too expensive and/or difficult to exploit. An initial drilling typically exploits only 20 percent of the oil in the reservoir. Even with present-day, advanced techniques, using water, steam or chemical flooding to squeeze out extra oil, more than half the resource commonly remains in the ground unexploited. It is estimated that the ten largest oil fields in the United States will still contain 63 percent of their original oil when production closes down.[21] Consequently, there is still much to be reaped in this area. In the latest US Geological Survey assessment, such technical improvement is expected to yield more than a 50 percent increase of identified reserves.[22]

At the same time we have become better at exploiting each liter of oil. The average US car has improved its mileage by 60 percent since 1973.[23] Likewise, home heating in Europe and the US has improved 24-43 percent.[24] Many appliances have become much more efficient – the dishwasher and the washing machine have cut about 50 percent of their energy use.[25]

Most nations actually exploit energy better and better: We use less and less energy to produce each dollar, euro or yen in our national product. Since 1880 the UK has almost tripled its production per energy use, and for the world at large, almost twice the amount of wealth was produced in 1992 per energy unit compared to 1971.[26]

We also exploit other raw materials ever better: today, your car contains only half as much metal as a car produced in 1970. Super-thin optical fibers carry the same number of telephone calls as 625 copper wires did just 20 years ago – and of better quality.[27] Newspapers can be printed on ever thinner paper because paper production has been much improved. Bridges contain much less steel, both because steel has become stronger and because we can calculate specifications more accurately.[28] Moreover, information technology has changed our consumption – we buy fewer things and more bits. Programs worth several hundred dollars will fit on a CD-ROM worth only 2 cents in plastic.[29]

3. We can substitute. We do not demand oil as such but rather the services it can provide. Most often we want heating, energy or fuel, and this we can obtain from other sources. Therefore we can swap to other energy sources if they show themselves to be better or cheaper. This happened in England around 1600 when wood became increasingly expensive (because of local deforestation and bad infrastructure) and prompted a gradual switch over to coal.[30] During the latter part of the nineteenth century a similar substitution took place from coal to oil.

In the short run, it would be most obvious to substitute oil with the other commonly known fossil fuels such as gas and coal.[31] Like oil, both have increased their years-of-consumption, and for the same reason. Moreover, shale oil could cover a large part of our longer-term oil needs. At $40 a barrel (less than one-third above the current world price), shale oil can supply oil for the next 250 years at current consumption,[32] and in total, there is enough shale oil to cover our *total* energy consumption for the next 5,000 years.[33]

In the long run, renewable energy sources could cover a large part of our needs. Today, they make up a vanishingly small part of the global energy production, but this can and probably will change. The cost of both solar energy and wind energy has dropped by 94-98 percent over the last 20 years such that they have come much close to being strictly profitable.[34] Renewable energy resources are almost incomprehensibly large. The sun leaves us with about 7,000 times our own energy consumption[35] – in principle, covering just 2.6 percent of the Sahara Desert with solar cells could supply our entire global energy consumption![36]

In the longer run, it is likely that we will change our energy needs from fossil fuels towards other and cheaper energy sources – maybe renewables, maybe fusion, maybe some as-of-yet unthought technology. As Sheik Yamani, Saudi Arabia's former oil minister and a founding architect of OPEC, has pointed out: "the Stone Age came to an end not for a lack of stones, and the oil age will end, but not for a lack of oil."[37] We stopped using stone because bronze and iron were superior materials, and likewise we will stop using oil, when other energy technologies will provide superior benefits.[38]

Biodiversity SIDEBAR

The threat of biodiversity loss is real, but exaggerated. Most early estimates used simple island models that linked loss in habitat with loss of biodiversity. A rule-of-thumb indicated that loss of 90% of forest meant a 50% loss of species. As rainforests seemed to be cut at alarming rates, estimates of annual species loss of 20,000-100,000 abounded. Many people expected the number of species to fall by half globally within a generation or two. [Former US vice-president Al Gore repeats the figure of 40,000 species in his *Earth in the Balance*,[39] the popular science magazine *Discover* tells us that half the species we know today will be extinct within the next 100 years,[40] and the famous Harvard biologist E. O. Wilson points out that we are losing between 27,000 and 100,000 species a year.[41] Not to be outdone, professor Paul Ehrlich even estimated in 1981 that we lose some 250,000 species every year, with half of the Earth's species gone by the year 2000 and all gone by 2010-25.[42] These assertions of massive extinction of species have been repeated everywhere you look.[43]]

However, the data simply does not bear out these predictions. In the eastern United States, forests were reduced over two centuries to fragments totalling just 1-2% of their original area, yet this resulted in the extinction of only one forest bird.[44] In Puerto Rico, the primary forest area has been reduced over the past 400 years by 99%, yet "only" seven of 60 species of bird has become extinct.[45] All by 12% of the Brazilian Atlantic rainforest was cleared in the 19th century, leaving only scattered fragments. According to the rule-of-thumb, half of all its species should have become extinct. Yet, when the World Conservation Union and the Brazilian Society of Zoology analysed all 291 known Atlantic forest animals, none could be declared extinct.[46] Species, therefore, seem more resilient than expected. And tropical forests are not lost at annual rates of 2-4%, as many environmentalists haven claimed: the latest UN figures indicate a loss of less than 0.5%.[47] Moreover, it is likely as the developing world gets ever richer that that it – just like the developed world – increasingly will set aside parks and begin reforestation.

Thus, the current professional understanding, backed by the UN,[48] centres around an estimate of 0.7% lost species over the next 50 years.[49] And this loss will not escalate but more likely abate within the next hundred years. True, the loss of 0.7% of biodiversity is a problem – one among many mankind still needs to solve – but it is nowhere near the catastrophe of losing 25-50% of all species, which is still so commonly claimed.

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[1] Motavalli 2000, CNN from 1996, Mattingly 1996.

[2] Meadows *et al.* 1972:56ff.

[3] Simon 1996:35-6.

[4] WRI 1996a:170

[5] Simon 1996:165.

[6] Simon *et al.* 1994:325.

[7] Simon 1996:24ff.

[8] Greene 1997. Although it is often claimed that OPEC is a monopoly, oligopoly or a cartel, there is actually obvious evidence against this – 1) OPEC lacks the clout since non-OPEC production constitutes the majority of the world output, 2) only since 1983 has OPEC attempted to set production quotas and it has never agreed on price, and 3) OPEC has no mechanism for punishing members for defecting from any OPEC agreement. Instead, empirical evidence seems to point to Saudi Arabia as the dominant producer, with its production *negatively*

correlated to the rest of OPEC, allowing the price to increase beyond the competitive price (Alhajji and Huettner 2000).

[9] IEA 2000b:25.

[10] EIA 2000e:58.

[11] EIA 2000e:102.

[12] EIA 2000b:26.

[13] Adelman 1995:287; cf. EIA 1997b:table 3.3, when measured in real prices, table D1.

[14] This argument is used in, e.g., Ehrlich and Ehrlich 1974:48.

[15] Be aware that part of the increase in the reserve estimates for the OPEC countries in the late 1980s could be caused by the fact that these figures are also used in negotiations for OPEC quotas. This is suggested by CRS (1995b) and Ivanhoe (1995:82). Nevertheless, it is generally estimated that reserves did go up, also in the 1980s (USGS 1997a).

[16] Lomborg 2001:139, USGS 1998a.

[17] Lomborg 2001:141.

[18] Annon. 1999h:147.

[19] It should be added that more advanced models like the Hubbert curve try to predict future discoveries, but although these models have been successful with countries like the US, using up its resources early, it is not at all clear whether these models will work with the much bigger and more important oilfields. It is still possible that the low rates of new discoveries primarily are reflections of low prices and very high oil reserves. See Campbell 1997 and Ivanhoe 1995.

[20] USGS 2000b.

[21] Craig *et al.* 1996:134. In Denmark it was estimated that less than 20 percent of the oil is exploited, *JyllandsPosten*, 15 May 1998:E5.

[22] USGS 2000b.

[23] From 13.4 mpg to 21.4 (EIA 2000c:17).

[24] Europe uses 24 percent less energy per square meter in 1992 than in 1973; the US uses 43 percent less (Schipper *et al.* 1996:184).

[25] Schipper *et al.* 1996:187. In Denmark electric home appliances have become 20-45 percent more effective over the last ten years (NERI 1998A:238).

[26] World Bank 1994:171; see also EU 2000a:36.

[27] Meadows *et al.* 1992:83.

[28] Hille 1995:329-30.

[29] Ausubel (1996) points out, how a few compact discs now can contain all the phone numbers of all U.S. homes and businesses, an amount of information in telephone books which formerly weighed five tons.

[30] Hausman 1995.

[31] Lomborg 2001:127-8.

[32] EIA 1997c:37. See also USGS 1997b.

[33] Craig *et al.* 1996:159, The total energy in shale oil is estimated at 2.11e24J, while we consumed 4e20J in 1999.

[34] DOE 1997.

[35] 180 W/m^2 on the Earth's 5.1e8 km^2 gives an annual energy of 2,895e24 J or 6,951 times the energy consumption in 1997.

[36] With an average influx of 300 W/m^2 and an efficiency at 20 percent, 21,9961 km^2 would exactly produce an annual 416 EJ. 21,9961 km^2 is 0.147 percent of the Earth's land area of 1.495e8 km^2. The Sahara Desert takes up about 8.6e6 km^2, "Sahara," *Encyclopædia Britannica Online*, http://www.britannica.com/bcom/eb/article/5/0,5716,66425+1+64749,00.html?query=sahara.

[37] Greider 2000, although, as with all popular phrases, more people seem to claim ownership, Annon. 1999g, 2001a.

[38] Likewise, when *The Economist* asked in early 2001: "Will The Oil Run Out?" their answer was: "Eventually, yes; but by then it might no longer matter" (Annon. 2001a).

[39] Gore 1992:28.

[40] Diamond 1990:55.

[41] Wilson 1992:280; Regis 1997:196; Mann 1991:737.

[42] Using 10 million species, as in Myers. Cited in Stork 1997:62.

[43] In a summary chapter on biodiversity, Ulfstrand cites Myers' asserted reduction by half within 50 years and writes that "Ecologists and evolutionary biologists in general agree with this estimate" (1992:3). If no new nature management is instituted, the Brundtland report states that "over the longer term, at least one-quarter, possibly one-third, and conceivably a still lager share of species existing today could be lost" (WCED 1987:152). The internet site Web of Life tells us that 50,000 species die out every year, http://www.weboflife.co.uk/weboflife/press_centre/pr_0006006.html. The *UN Chronicle* carried an article claiming that "UNEP has predicted that up to 25 per cent of living species may become extinct within a single human lifetime" (Anon. 1992a:52). Greenpeace claimed on their website that "it is expected that half of the Earth's species are likely to disappear within the next seventy-five years." This document was removed at the request of

the Danish chairman of Greenpeace, after I criticized it in the Danish daily *Politiken* (18 February 1998, www.greenpeace.org/~comms/cbio/bdfact.html). This chapter is to a large degree based on Simon and Wildawsky 1995.

[44] Simberloff 1992:85. Simberloff writes here that three species of birds became extinct, but that forest clearance was probably not responsible in two of these cases.

[45] Lugo 1988:66.

[46] Brown and Brown 1992:127. Note, however, that the Mitu mitu, a large ground-dwelling frugivore bird, in the last decades only known from a few coastal lowland forest patches in Alagoas, northeastern Brazil, is probably extinct in the wild, with only a small private, captive population (Baillie and Groombridge 1997, http://www.wcmc.org.uk/species/data/red_note/18610.htm, Fog 1999:133).

[47] The loss of tropical forests is 9.2 Mha in the 1980s and 8.6 Mha in the 1990s (FAO 2001c:9). The total tropical forest area is 1810 Mha in 2000 (FAO 2001c:19), and using these deforestation figures to backcast total forest area, taking averages, gives 0.4689 percent for the 1980s and 0.4592 percent for the 1990s.

[48] "The rate of extinction today is hundreds, if not thousands, of times higher than the natural background rate" UNDP 1995:12. Using the invertebrate species lifespan of 11e6 years (May *et al.* 1995:3) and interpreting the quote to be from 200 to 2,000 times the natural background (the "if not thousands" means it *could* be thousands, not all the way up to 9,999): 200*(1/11e6)*50 = 0.09% and 2000*(1/11e6)*50 = 0.9%. The authors are not quite consistent, using a somewhat lower lifespan when comparing 1,000 times the background rate to 2 percent per 50 years (UNDP 1995:235), making the conclusion 0.4-4 percent over the next 50 years.

[49] Stork (1997:61) estimates that between 100,000 and 500,000 of 8 million insects will die out over the next 300 years. This is equivalent to a maximum of 0.208 percent/decade, and an average of 350,000 is equivalent to 0.729 percent every 50 years, the figure mentioned at the beginning of this chapter.