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Book Review

Harvesting the biosphere: What we have taken from nature. By V. Smil. 2013. The MIT Press, Cambridge, MA. ISBN: 978-0-262-01856-2, US$29.00, 320 pages.

'Trust but verify', former US President Ronald Reagan once enthused during bilateral negotiations with the Soviet Union[1]. This simple adage still rings true today, and it lies at the root of much of the dilettante Vaclav Smil's quantitative, rigorous and often contrarian scholarship on a vast array of different topics. In *Harvesting the biosphere: What we have taken from nature*, Smil does not disappoint his growing band of faithful acolytes as he moves beyond his frequent intellectual focus on energy, history, human population and food to systematically address humankind's withdrawals from our planet's natural stores. Many organisms have altered the Earth's biosphere, he contends, but none have imposed environmental transformation on any scale approaching that of contemporary humans. Covering topics ranging from the foraging of traditional societies in search of edibles to current concerns like harmful crop cultivation by-products, increasing population pressures and insatiable appetites for animal products, *Harvesting the biosphere* tackles a massive but understudied question: what are the numbers behind these accumulated anthropogenic impacts on the biosphere?

This book was so important that renowned businessperson and philanthropist Bill Gates[2] published an interactive review on his website. However, even Gates' incisive commentary could not fully encapsulate the depth and breadth of topics covered by Smil. Touching on biomass stores, biomass productivities, phytomass and zoomass harvests, crops, animals, foraging, fuels and changing land cover trends, the author meticulously assesses the ways and time periods in which humankind has re-configured the Earth's reserves. Helpfully (at least for this reviewer), he begins with introductions to many key biomass terms before plunging into the voluminous data underpinning what is ostensibly an overwhelming task.

It would be too taxing to summarize the astonishing plethora of statistics and factoids put forth by Smil in so brief a space; accordingly, this review captures a few of the most fascinating findings. Relative zoomass concentration discussions—along with associated explorations of broader animal populations—provide an excellent starting point. Smil notes that the highest zoomass means recorded in a study of the world's most herbivore-rich ecosystems put Uganda's Ruwenzori National Park at the top, with a density of 19.9 g/m^2, or nearly five times that of more famous African parks like South Africa's Kruger and the East African Serengeti. But even such superficially impressive relative numbers are lost in cumulative wild animal totals which, in turn, are dwarfed by domesticated livestock figures, as an illuminating section on annual meat intakes makes abundantly clear. Smil explains that by the year 2000 approximately '1.3 billion heads of cattle…900 million pigs…1.75 billion sheep and goats…(along with) more than 14 billion chickens and about 1.7 billion other birds (ducks, turkey, geese)' (p. 128–129) were required to meet humankind's demands.

These stupefying domesticated animal numbers make sense when evaluating the evolution of per capita consumption, as Smil finds that 'the best generalizations (for individuals living in antiquity or in the periods prior to intensive agricultural practices) would be as follows: even in the relatively well-off societies, average per capita meat intakes were…5–10 kg/yr' (p. 126), primarily due to a lack of the modern agriculture practices so essential for generating adequate animal feed. For context, it is worth noting that 5–10 kg/yr is at least one *order of magnitude* less than modern American demand[2] and only a few tens of kilograms less than the 35–40 kg/yr that medical evidence suggests is sufficient. His conclusion is clear; despite an undeniable role as 'a convenient source of high-quality, easily digestible protein…(as well as) an excellent source of vitamins A, B12, D and iron and zinc' (p. 126) and while acknowledging the likely role that meat plays in spurring human physical and mental development gains, an unfettered rise in meat consumption could exacerbate already grave environmental conditions, including (but not limited to) accelerating greenhouse gas emissions, declines in coastal wetlands and drastic changes in soil (the latter being a particularly acute worry if tropical rainforest integrity is further compromised for animal rearing). Answers, unfortunately, are in frustratingly short supply, as sustainable farming is no panacea without an unlikely global moderation in intake (at most, 'ethical' animal rearing could supply 70% of present consumption and a smaller fraction of anticipated increases to 2050 and beyond); neither are mass voluntary reversions to plant-based meatless diets, ubiquitous consumption of 'fake meat' or a ramp up in the use of muscle tissues from bioreactors.[3]

Equally engrossing is an analysis of biomass fuels, beginning with wood in preindustrial societies. Smil chronicles how charcoal emerged as 'a preferred choice for indoor combustion and…smelting metals' (p. 136), but

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could not match the power density of fossil alternatives as humankind's demands for metallurgical fuels expanded. Blast furnace output of iron is one example of this trend, as use of that input increased 20-fold from 1900 to 2010. Clean energy advocates are politely reminded that all-important coking coal has no viable renewable replacement, as Smil estimates that using the equivalent amount of high-yielding roundwood species—in an implausible scenario where charcoal wholly replaced coking coal—would require a land mass exceeding half of Brazil's portion of the Amazonian basin.

Examination into the sustainability of other potential renewable biomass fuels shows that transportation fuels are also hamstrung by an assortment of issues. Corn-derived ethanol—a fuel whose propagation remains dependent on costly US government subsidies—promotes less resilient monocultures, spikes water demand, leaches nitrates and expands anoxic zones in proximate bodies of water. Sugarcane is a superior feedstock for ethanol fermentation, argues Smil, with energy returns on energy invested that can exceed ten, but shortages in arable land availability make even this choice questionable. Food prices would invariably be affected, with the resulting impacts falling disproportionately on the poor and disenfranchised. Perhaps unsurprisingly, Smil remarks that a future energy scenario involving substantial growth in many biofuel production cycles has been called a 'crime against humanity' by at least one senior United Nations official.

So what lessons can be drawn from this volume? First, Smil continually reminds us that the uncertainties inherent in macro-level measurements of biomass remain staggering, even with advances in computational modeling and the deployment of innovative measurement techniques like the satellite-based Moderate Resolution Imaging Spectroradiometer. Recent inquiry into deep sea zoomass concentrations provides a telling example of these uncertainties, as researchers (publishing in the same year!) argued for both a food-poor marine zone and 'biomass densities 100 times greater than previously reported for depths below 500 m.' Broader quantifications of more readily accessible biomass—such as terrestrial phytomass levels—are also challenging (estimates over the past 80 yrs of the aforementioned category have varied wildly from 268 to 1395 Gt/C). Clearly, more readily accessible subject matter does not necessarily provide straightforward answers.

The second lesson follows from the first; specifically, that research into remaining biomass must not be delayed. Our knowledge of many of Earth's environments (and the autotrophs and heterotrophs that inhabit them) is embarrassingly fragmented; more research is urgently needed and, indeed, may be one of the most pressing issues facing environmental science. Encouragingly, the third lesson is that hope still remains. Human actions may have reduced or altered the biosphere's phytomass and zoomass, but—simultaneously—reversals or reductions have occurred in tropical deforestation, positive changes in carbon balances have appeared, and tree cover growth in developed countries has been surprisingly robust. Progress is possible, but whether it actually materializes quickly enough remains to be seen.

References

1 Abbott, K.W. 1993. Trust but verify: The production of information in arms control treaties and other international agreements. Cornell International Law Journal 26:1.
2 Gates, B. 2013. *Harvesting the biosphere*. Available at http://www.gatesnotes.com/Books/Harvesting-The-Biosphere (accessed December 2, 2014).
3 Smil, V. 2014. Eating meat: Constants and changes. Global Food Security 3(2):67–71.

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