Environmental Trends

Jesse H. Ausubel

In the United States in 1900, environmental hazards still caused about half of all deaths. Stagnant, contaminated water was a happy home for cholera, typhoid, and other waterborne diseases. In 1833, when Ralph Waldo Emerson was working on his first book, *Nature*, a cholera pandemic killed 5 to 15 percent of the population in many localities. Even more killers came by air, including diphtheria, tuberculosis, and whooping cough, as people crowded into poorly ventilated homes and workplaces. Henry David Thoreau, the author of *Walden*, was only 45 when he died of bronchitis and tuberculosis in 1862. As late as 1876, diphtheria accounted for about 10 percent of all deaths in Massachusetts.

By 1940 the combination of water filtration, chlorination, and sewage treatment stopped most of the aquatic killers in the United States. Refrigeration in homes, shops, trucks, and railroad boxcars took care of much of the rest. Replacement of hovels, tenements, and sweatshops with larger, better heated and ventilated buildings downed most of the aerial killers.

Now, increased longevity, high incomes, and large populations have been achieved in every class of environment on Earth. We manufacture computers in hot, dry Arizona and cool, wet Oregon. We perform heart surgery in humid Houston and snowy Cleveland. Year round we grow flowers in the Netherlands and vegetables in Belgium. The metro runs in Budapest regardless of the mud that slowed Hungarians for a thousand years. In Berlin and Bangkok we work in climate-controlled office buildings.

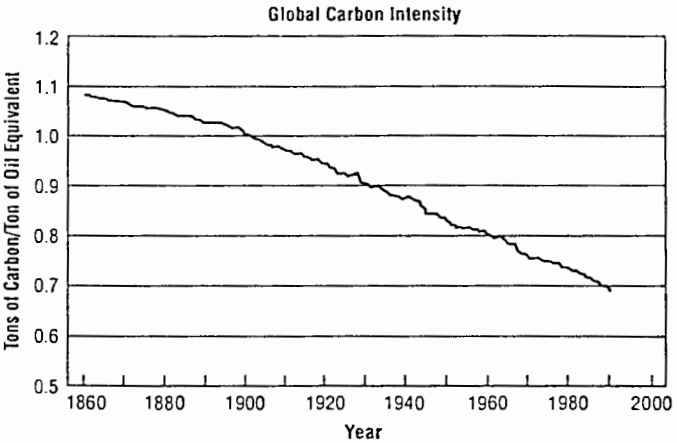
For most of history thick forests and arid deserts, biting insects and snarling animals, ice, waves, and heat slowed or stopped humans. We built up our strength. We burned, cut, dammed, drained, channeled, trampled, paved, and killed. We secured food, water, energy, and shelter. We lost our fear of nature, especially in the aggressive nations of the West. But we also secured a new insecurity. Having liberated ourselves from the traditional challenges to our survival, we now wonder must human ingenuity always slash and burn the environment? What will remain if we continue to grow? Can humans live here *with* others, as part of nature?

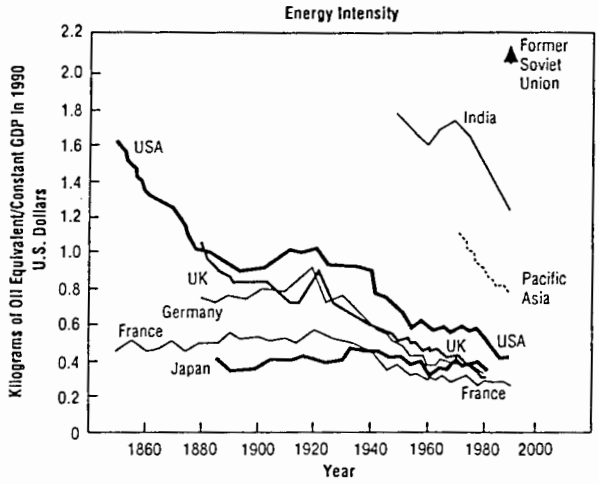
My answer is yes. Human culture, utilizing its most powerful tools, science and technology, which have brought us our present paradoxical freedom, can dramatically decouple our goods and services from demands on planetary resources. In fact, they are already doing so. Well-established trends, raising the efficiency with which people use energy, land, water, and materials, will cut pollution and leave much more soil unturned.

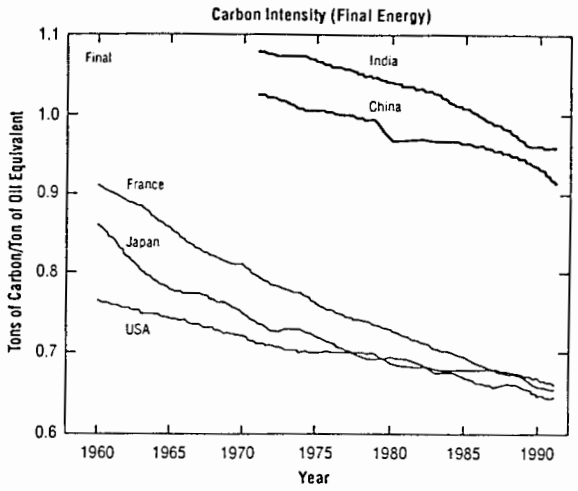
Energy

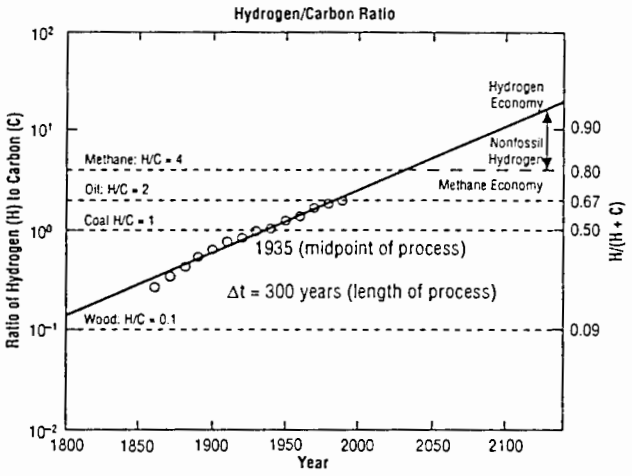
In energy the key trends are "decarbonization" and rising energy efficiency. Per constant dollar, the United States has pared its carbon intensity of gross domestic product per capita from about three kilos in 1800 to about three-tenths of a kilo in 1990. Carbon matters because burning it to release energy can change the global climate as well as harm the local air. Carbon enters the energy economy in wood, coal, oil, and gas, all of which in fact consist of blends of carbon and hydrogen atoms. Fortunately, the truly desirable, clean element in these fuels for energy generation is not carbon, but hydrogen, and the historical record reveals that for two hundred years the world has progressively lightened its energy diet by favoring hydrogen atoms over carbon in our hydrocarbon stew. The outlook for the next several decades is that we will rely heavily on natural gas, which is trim in carbon and rich in hydrogen, before turning to pure hydrogen fuels, generated by nuclear or solar means.

The displacement of carbon remains the largest single environmental challenge facing the planet. The good news is that in a few decades most of our devices and practices will change, and that major new energy systems can become pervasive in fifty to one hundred years. It is also good news that latecomers to technological bandwagons can learn from the costly experiments of pioneers and that no society need be excluded from the learning. The present carbon intensity of the Chinese and Indian economies resembles those of the United States and Europe at the onset of industrialization in the 19th century, but even they are on the path toward decarbonization and improved efficiency.









Agriculture

Agriculture is the greatest transformer of the planet. Cities, paved roads, and the rest of the built environment cover less than 5 percent of the land in the 48 contiguous states of the United States. Crops occupy about 20 percent of this land, pasture 25 percent. Agriculture has consumed forests, drained wetlands, and voided habitats.

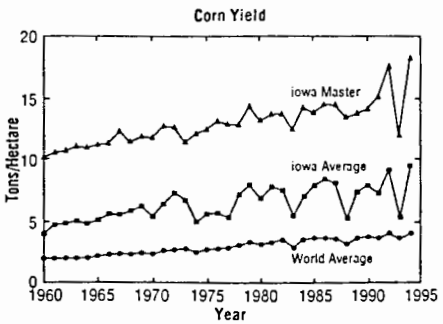
Yet since mid-century the amount of land used for agriculture globally has remained stable, and the stage is set for further reductions. A shift away from eating meat to a vegetarian diet could roughly halve our need for land.

More likely, diets will increase in meat and calories. Under such conditions, the key will be the continuation of gains in yield resulting from a cluster of innovations including seeds, chemicals, and irrigation, joined through timely information flows and better-organized markets. In fact, US wheat yields have tripled since 1940, and corn yields have quintupled. The world on average grows only about half the corn per hectare of the average Iowa farmer, who in turn grows only about half the corn of the top Iowa farmer. Importantly, although the performance of all has risen steadily for decades, the ratio separating them has not changed much. Even in Iowa the average performer lags more than thirty years behind the state of the art.

When the state of the art becomes routine, however, the effects accumulate dramatically. By raising wheat yields fivefold during the past four decades, Indian farmers have in practice spared for other purposes an area of cropland roughly equal to the area of the state of California.

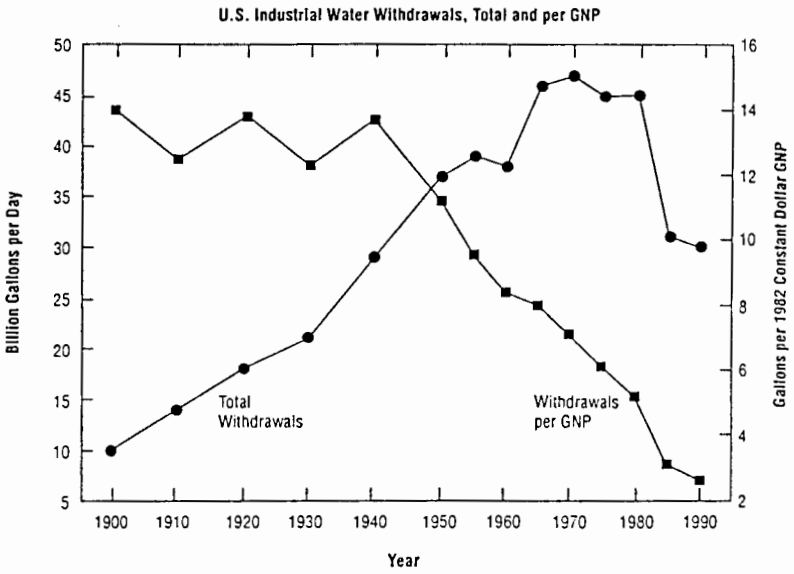
What is a reasonable outlook for the land used to grow crops for ten billion people, a probable world population sixty or seventy years hence? Per hectare, world grain yields rose 2.15 percent annually between 1960 and 1994. If farmers can lift the global average yield about 1.5 percent per year over the next six to seven decades, their productivity will equal that of today's European wheat farmers. That would make it possible for ten billion people to enjoy a diet with the caloric intake of today's average American and still spare close to a quarter of the present 1.4 billion hectares of cropland. The quarter spared, fully 300 million hectares, would equal the area of India.

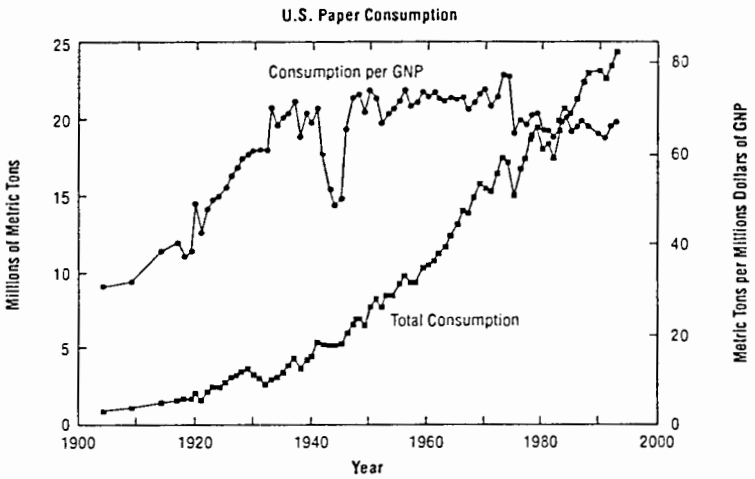
The present reality is that large amounts of land in Europe and North America are reverting from farm to woodland, and high public subsidies keep cropland in production. In any case, rising yields and the spatial contraction of agriculture are powerful antidotes to the current losses of biodiversity and related environmental ills.

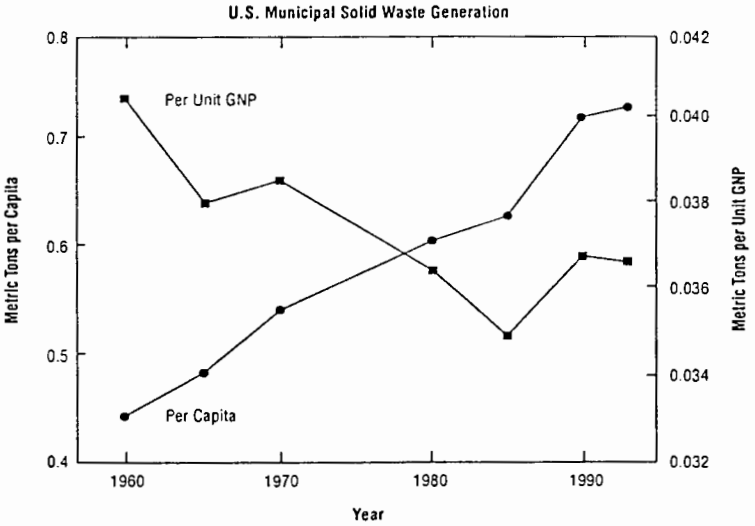


Water

Water saving goes with land sparing. Water saving is evident in industry and among consumers as well as on farms. Industrial withdrawals of water in the US have dropped steadily since 1940. Then, 14 gallons of water flowed into each dollar of output. Now the flow is less than three gallons. Better management of demand reduced water use in the Boston area from 320 million gallons per day in 1978 to 240 million gallons in 1992. Absolute U.S. water withdrawals peaked about 1980. Since 1975, per capita U.S. water use has declined at an annual rate of 1.3 percent.







Materials

We can reliably project decarbonization, food decoupled from acreage, and fewer drops of water yielding more value. What about an accompanying dematerialization—the decline over time in the weight of materials used to meet a given economic function? This, too, would spare the environment.

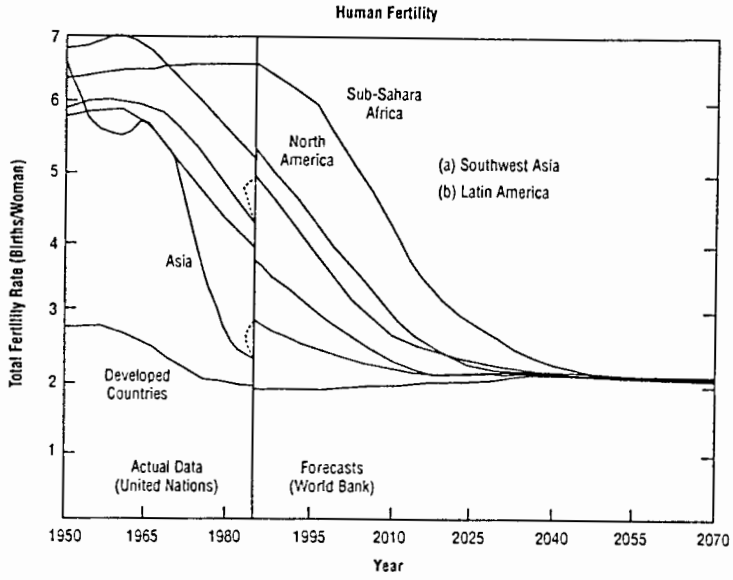
In fact, the intensity of use of diverse primary materials has plummeted over the 20th century. Lumber, steel, lead, and copper have especially lost importance. Products as different as computers and beverage cans have become lighter and often smaller. A few compact discs contain the phone numbers of all U.S. homes and businesses, equivalent to the content of telephone books formerly weighing five tons. Although the soaring numbers of products and objects, accelerated by economic growth, raised municipal waste in the United States annually by about 1.6 percent per person in the last couple of decades, trash per unit of GNP dematerialized slightly.

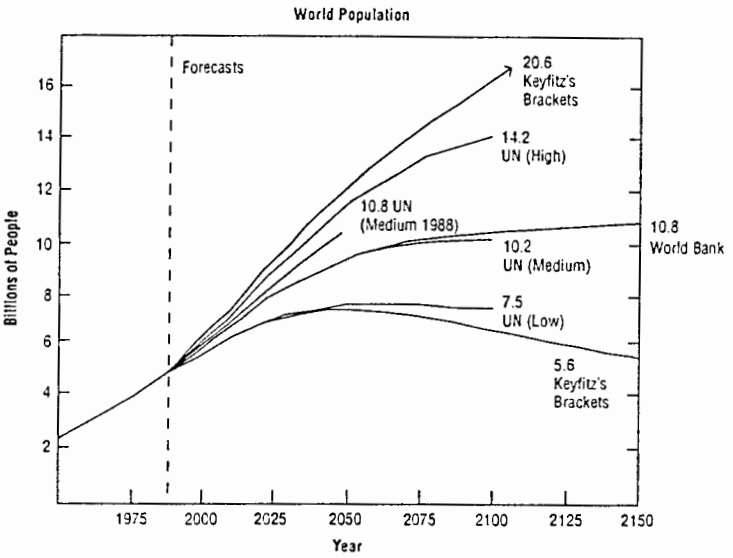
So far, trends of dematerialization are equivocal. But the potential exists to develop superior industrial ecosystems that reduce the intensity of materials use in the economy, minimize wastes, and use persisting wastes as inputs in redesigned industrial processes. Since 1990, recycling has accounted for over half the metals consumed in the United States, up from less than 30 percent in the mid 1960s. The trick is to make waste minimization a property of the industrial system even when it is not completely a property of an individual process, plant, or industry.

Population

But there is a catch for homo faber, the toolmaker. Our technology not only spares resources. If so, our footprints on Earth would simply become lighter and lighter. Technology also expands the human niche, allowing larger populations. Family and population size is ultimately a cultural choice, although technology makes the choices more reliable. Fertility rates have been falling in most nations and are below levels needed to replace the current populations in Europe and Japan, which may implode. Perhaps the idea of the small family, which originated in France around the time of the Revolution, will become the norm worldwide after 250 years.

Still, recent population growth, which peaked globally at about 2 percent per year around 1970, is unprecedented. The effect is that in the coming interval of a few decades human society will need to accommodate as many more people as already live on Earth. After a very long preparation, our science and technology appear ready to do so, to reconcile our economy and the environment. A highly efficient hydrogen economy, landless agriculture, industrial ecosystems in which waste virtually disappears: Over the coming century these can enable large, prosperous human populations to co-exist with the whales and the lions and the eagles and all that underlie them—if we are mentally prepared, which I believe we are.





Philosophy

Across the planet, attitudes toward nature, and perhaps inseparably toward one another as humans, are changing. "Green" is the new religion. Jungles and forests, commonly domains of danger and depravity in popular children's stories until a decade or two ago, are now friendly and romantic. The characterization of animals, from wolves to whales, has changed. Environmental saints, such as the Brazilian rubber tapper Chico Mendes, and environmental shrines, such as the Great Sarcophagus at Chernobyl, begin to sanctify the landscape.

So, our minds as well as our technology seem ready. We have liberated ourselves from the environment. Now it is time to liberate the environment itself.

Jesse H. Ausubel is the director of the Program on the Human Environment at Rockefeller University. An extended version of this essay appears in *Technological Trajectories and the Human Environment*, Jesse H. Ausubel and H. Dale Langford, editors (National Academy Press, 1996).