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SUSTAINABILITY

by

Joel E. Cohen

Black Rock Forest Consortium
Cornwall, New York 12518

Sustainability

Remarks for the opening of the Center for Science and Education at Black Rock Forest 17 October 1999

Joel E. Cohen[1]

It is a great honor to participate in the opening of the Center for Science and Education at Black Rock Forest. Bill Schuster asked me to talk about sustainability, and I will.

First I want to join the friends of Black Rock Forest in honoring Bill Golden on this occasion. The Black Rock Forest Consortium, and this Center for Science and Education, and many other works of Bill Golden, convey in living form the kernel of the idea of sustainability: the importance of preparing now for an uncertain, but certainly challenging, future. More than most people, Bill Golden has a vivid sense of the future. He proves it through his investments in enabling people to prepare for the future. Thank you, Bill, for envisioning the Black Rock Forest Consortium. Thank you for making it and this beautiful Center a reality. I also thank Bill Schuster and the staff of the Forest and all the friends of Black Rock Forest who have helped to create this happy occasion, and Sibyl R. Golden and Paul E. Olsen for improving this talk.

Let me summarize my message about sustainability. We can have a more sustainable future if we accelerate change in four areas: population, economics, the environment, and culture. We can slow population growth by encouraging voluntary reductions in fertility. In economics, we can replace the old model of economic activity as a linear process — from resource to waste — by a new network model in which all forms of matter and energy and information are resources. In our relations with the environment, we can move toward an intelligent, wired earth. We can stop destroying parts of the biosphere before we know what they do. Finally, in culture, we can make it possible to achieve all of the previous goals by educating well all of the world's children between the ages of 6 and 16 years old.

Now that you know where I hope to end, let me begin at the beginning.

What is sustainability? Most definitions are variations on the definition of the 1987 Brundtland Commission report called Our Common Future: sustainability means meeting "the needs of the present without compromising the ability of future generations to meet their own needs."

This definition refers to the abilities of future generations, and it refers to the needs of future generations. To know whether what we are doing today is sustainable, we need information about the abilities and needs of future generations. The difficulty in making decisions today about sustainability is that we can be sure that the future will be different from the present and the past.

To show the difficulty of assessing sustainability, let me review some major transitions in the history of life and in the history of humans.

[1] Joel E. Cohen, Abby Rockefeller Mauze Professor, Rockefeller and Columbia Universities, winner of the 1999 Tyler World Prize for Environmental Achievement.

Life was adapted to an atmosphere with little or no oxygen for perhaps two billion years, from shortly after the origin of the earth about 4.5 billion years ago until about 2.1 billion years ago. Starting about 2.1 billion years ago, plants began to excrete oxygen as a waste product of their metabolism. With the rise of oxygen in the atmosphere, anaerobic modes of life that had been sustainable for two billion years became unsustainable.

Six or seven hundred million years ago, about 1.5 billion years after the rise of the oxygen atmosphere, suddenly organisms evolved hard body parts. Modes of life with soft body parts that had been sustainable for one-and-a-half billion years suddenly lost primacy in the struggle of Darwinian evolution.

The dinosaurs and many other species became unsustainable around the time when a meteoric impact darkened the skies 65 million years ago, though the extinctions may not have been due simply to the meteorite itself.

In these examples, the sustainability of a given mode of life turned out to be temporary. So far, life has proved sustainable only through adaptations and transformations to radically new forms.

Now we fast-forward through biological history to humans. Modern humans have lived on the earth for approximately 150,000 years, roughly one part in thirty thousand of the history of life on earth. For most of modern humans' existence, immense glaciers covered much of the northern and southern hemispheres. At the end of the most recent ice age, around 12,000 years ago, earth probably had between 2 million and 20 million people. There were certainly fewer people on earth than the 28 million people in metropolitan Tokyo today. Humans had roughly the same average population density over the earth as a typical carnivorous or omnivorous terrestrial mammal with the adult body weight of a human being.

As the earth warmed and the glaciers retreated, peoples in West Africa, the Middle East and Southeast Asia independently invented agriculture. The time required for the human population to double contracted sharply from tens of thousands of years to a mere 15 or 20 centuries. Between 10,000 BC and the early 1800s, the human population grew to a billion people, a number completely unsustainable by pre-agricultural technology. This is an early example of what I would call a knowledge-based unsustainability transition.

If the first agricultural revolution began 12,000 years ago, it ended in 1960. In 1960, the population reached 3 billion, a decisive turning-point. Up to 1960, humans increased the area of arable land in proportion to population size. Three billion or fewer people could be fed from traditional agriculture, for example by cultivating 2 billion hectares, half in cereals at a yield of one ton of grain per hectare.

Since 1960, the arable area has remained virtually constant. Instead, global average cereal yields have roughly doubled, in close proportion to population size. Two discoveries made it possible for yields to rise. One was the Haber-Bosch industrial process to fix atmospheric nitrogen for nitrogenous fertilizers. Fritz Haber discovered that process in 1908. The other was the development in the 1960s and later of so-called miracle varieties of rice, wheat and corn by plant breeders. These new varieties could take advantage of fertilizers and irrigation.

Since 1960, the number of people on earth has doubled to 6 billion. Never before the second half of the 20th century had any human being lived through a doubling of the human population. Now, anyone who is 39 years old or older has seen the human population double in his or her lifetime. Today's population is unsustainable using only the agricultural technology of 1960. Three-quarters of a billion people still do not get enough calories to avoid chronic hunger and under-nutrition, and perhaps two billion people do not get enough of all essential nutrients.

Though many more people than necessary still live in poverty and misery, it is an amazing fact that a higher number and a higher fraction of people today eat better than ever before in history. The average length of life worldwide has risen from perhaps 30 years in 1900 to perhaps 66 years in 1999. People's nutrition and length of life might well have improved further and faster, had population growth been slower in the 20th century. Nevertheless, we could not have reached where we are today without the knowledge gained during this century.

We will need to gain much more knowledge if we are to make it happily through the next century.

In the 20th century, human withdrawals of fresh water from the hydrologic cycle increased 8-fold. People now withdraw between one-quarter and one-half of all the available renewable fresh water. If these statistics are correct, it is arithmetically impossible for the next century to see another 8-fold increase in human water withdrawals without some knowledge-based revolution in the technology for accessing renewable fresh water, for example, through desalination.

In the 20th century, average annual inputs of carbon into the atmosphere from combustion of fossil fuels rose from approximately half a billion tons of carbon per year to 7.3 billion tons of carbon per year. Many people believe that a continuation or acceleration of human carbon inputs to the atmosphere would cook the earth, humans included. If they are right, we will need a knowledge-based revolution in our technologies for producing and using energy.

We do not know enough to know whether people can continue to transform water, carbon, and many other elements and compounds at present and increasing rates without severe damage to the biogeochemical processes that support human and all other life forms.

What is true of the history of life in general has been, and probably will be, true of human life as well: sustainability is at best temporary. Change and adaptation are permanent necessities.

I conclude by offering four adaptations and changes that could help make the next century more sustainable. These are changes in population, economics, environment and culture.

First, we can help make every human birth a wanted birth. The growth rate of world population has dropped since 1965 by one-third, from about 2 percent per year to 1.3 percent per year. Currently 44 percent of the world's people live in countries where fertility is below the level required to replace the population in the long run. Nevertheless, the world's population continues to increase by about 78 million people per year. That is 150 additional people every minute. We can help the people in countries with continuing high fertility to achieve family sizes at or below replacement levels of fertility. We can do it by helping those countries to educate all girls and boys. We can help them to assure access to health services, including reproductive health and family planning services, for every man, woman and adolescent. Research shows that healthy, educated parents generally choose to have fewer, healthier, better educated children.

Second, we can organize our economic production efficiently. Until now, economic production has been a linear process: we extract some resource from nature, industry transforms it, consumers use it, and we throw what's left away. In the 20th century, the global economy is so big that this mental picture is obsolete. There is no longer any "away" to throw things away to. Industrial ecology presents a new organization of economic production. The by-products of one economic activity become the inputs and resources of another. Instead of linear, independent production processes, the economy becomes a network of activities that feed other activities, just as a food web in ecology links all species in a network of feeding and recycling.

Third, we can be more conscious and forward-looking in dealing with our physical, chemical and biological environments. An earth wired with sensors will make it possible to monitor the impact and consequences of our own activities. Existing worldwide networks of weather stations, tide gauges and seismic sensors are early steps toward instrumenting the earth. To understand better the earth's history and future and our place in it, we can install more instruments in the atmosphere, continents and oceans at all depths and elevations. The sensing and monitoring systems at Black Rock Forest are a crucial part of a global observing system.

In biology, we do not understand the functions provided by most species and ecosystems on earth, and we cannot replace the genetic information produced by the last 4 billion years of evolution. We can stop throwing out living parts of the earth before we read the instruction manual. Here, too, Black Rock Forest is extremely valuable as a protective haven.

Fourth, no one can anticipate the challenges humans will face one-quarter, one-half or a full century from now. But we can increase the chances that future generations are able to respond to whatever challenges come their way. Universal basic and secondary education would improve individual lives and would provide a reserve of competence to face surprising challenges. It would lower both birth rates and death rates. It would increase economic productivity and enterprise. It would facilitate environmental preservation. It would enhance human capacities to innovate and to adapt.

How big is the problem? There are 1.25 billion children between 6 and 16 years old. Hundreds of millions of them have no access to schooling. According to the World Bank, public expenditure on education in 1996 was nearly 5 percent of gross national product worldwide. The average cost was roughly $1,000 per child per year. The rich countries spent much more per child. The poor countries spent much less. Using information technology, we could probably educate all children better than we do now at lower average cost.

As much as any other single area of action, universal basic and secondary education would enhance our chances of a sustainable future. The educational role of Black Rock Forest is a step in this direction. If the challenges of population, economics, the environment and culture are serious, how can we afford not to educate all the children?

Thank you again to Bill Golden, to Bill Schuster and to each of you for helping to make this happy occasion.

The Black Rock Forest Consortium, founded in 1989, operates the 3,785-acre Black Rock Forest as a field station for scientific research and education. Current members are American Museum of Natural History, Barnard College, Boys Harbor, Brooklyn Botanic Garden, Browning School, Columbia University, Convent of the Sacred Heart, Cornwall Central School District, The Dalton School, Ethical Culture Fieldston School, Friends Seminary, New York Academy of Sciences, New York-New Jersey Trail Conference, New York University, Newburgh Enlarged City School District, Ocean of Know, Rensselaer Polytechnic Institute, The Ross School, Storm King School and Teachers College. A regular newsletter describes the activities of the Consortium. For further information, visit <www.blackrockforest.org>.

This most recent Black Rock Forest Paper, No. 32, reinaugurates this distinguished series on the occasion of the Consortium's 10th Anniversary.

Black Rock Forest Papers have been published by the management of the forest since 1930 and are available directly from the Consortium (129 Continental Road, Cornwall, NY 12518). Submission of papers based on research or other activities of Black Rock Forest is invited. Other publications from the Forest (more than 200 to date) are also available from the Consortium and in the peer-reviewed scientific literature.

To William T. Golden, in celebration of his 90th birthday on October 25, 1999