Epilogue

A Vision of the Future

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If conservationists, together with demographers, economists, earth scientists, anthropologists and politicians, could put forward a positive and persuasive vision of the future, they could lead billions of nonscientists to look to conservationists as helpful allies in their search for better lives. They could also give direction and meaning to the daily research that occupies many scientists. Without a positive vision of the future, conservationists are doomed to fight, and probably lose, a series of rearguard actions. So I shall propose an outline of a vision of the coming century—a century that is sure to be very exciting.

A century from now, humankind will live in a managed—or mismanaged—global garden. Most people will live in cities, surrounded by large, thinly populated zones for nature, agriculture, and silviculture. Worldwide, between 100 and 1,000 cities of 5 million to 25 million people each will serve their inhabitants' wants for food, water, energy, waste removal, political autonomy, and cultural and natural amenities. Some cities will serve people who want to live only with people ethnically and culturally like themselves; others will serve people who are attracted by ethnic and cultural diversity. Different cities will gain shifting reputations as being favorable for young people, childrearing, working, or retirement. The efficiency and quality of services that cities provide will depend on the quality of their managements and on the behavioral skills (including manners) of their populations.

As feudal rights and obligations to labor were replaced by individual and collective markets in labor, other present rights and obligations will increasingly be replaced by markets. For example, there will be a worldwide market in permits for permanent residence in cities. The prices of these permits may be tacked on real estate or rental prices, as city managements compete to command market

rewards for the public goods that they are able to provide. Countries that insist on a person's right to leave his or her country of birth will have to decide if that implies a person's right to go somewhere else.

Women around the world will demand and receive education and jobs comparable to men's education and jobs. Better education and jobs will accompany increased autonomy for women in the family, economy, and society. This autonomy will lead to increased power in all these domains, from the sexual and psychological to the political. Partly as a consequence of women having attractive alternatives to childbearing and childrearing, the number of children that women bear in a lifetime will decline globally to the replacement level or below. As childbearing will occupy a falling fraction of most women's lengthening lives, women will intensify their demands for other meaningful roles.

Although global human population growth will have ended, some regions will be net exporters of people, whereas others will be net importers. Rising pressures for migration from poorer to richer countries will strain traditionally xenophobic countries like Germany and Japan, as well as traditionally receptive countries like the United States, Australia, and Argentina. Migrations will bring culturally diverse populations into increasing contact. The result will be many frictions as humans learn manners and tolerance. Intermarriages will make a kaleidoscope of human skin colors.

The elderly fraction of the population will increase greatly, and the absolute numbers of elderly still more dramatically. Among the elderly, women will outnumber men by as much as two to one. New social arrangements among the elderly will arise.

The continental shelf, especially off Asia, will be developed to provide food, energy, and perhaps living space. Oceanic food sources will be largely domesticated. The capture of any remaining wild marine animals will be managed like deer hunting now.

The tropical forests that will have survived the onslaught of rapid population growth and economic exploitation between 1950 and 2050 will be preserved as educational and touristic curiosities, like the immensely popular John Muir Woods north of San Francisco. Many forests will be meticulously managed for fiber, food, pharmaceuticals, and fun (that is, recreational exploration). Today's simplified agricultural ecosystems will be replaced by synthetic ecosystems of high complexity. Biological controls and farmer intelligence will maximize yields while nearly eliminating biocidal inputs like today's pesticides and herbicides. Required agricultural inputs of energy and nutrients will be derived from human, animal, and industrial wastes rather than from today's fertilizers and fossil fuels. Unwanted effluents like eroded soil or pesticides and fertilizers in runoff will be eliminated or converted to productive inputs for industrial and urban use.

The atmosphere will also be managed. Rights to add carbon dioxide, methane, and other climatically significant trace gases and particles to the atmosphere will be traded in global markets for ecosystem services. Governments will by then

have recognized the potential of atmospheric and many other ecosystem services to generate taxes in support of other common goods. The production of gases will be manipulated as part of food production and wildlife management. For example, lake managers will control the ratio of plankton-eating fish to piscivorous fish to regulate the level of primary productivity in lakes. Genetic engineering of bacteria and farming practices will be used to manipulate agricultural methane production.

People will revalue living nature because they will realize that they do not know how to make old forests, coral reefs, and the diversity of living forms grow as fast as they can multiply machines. Conservation movements will gain renewed force. People will increasingly value nature for its genetic resources and for its aesthetic amenities.

To make intensive management of continents, oceans, and the atmosphere possible and effective will require massive improvements in data collection and analysis and especially in our concepts.

A century hence, we will live on a wired earth. Like the weather stations on land and the observational satellites that now monitor the atmosphere, the oceans of the next century will have a three-dimensional lattice of sensing stations at all depths. The crust of the Earth will receive the same comprehensive monitoring now devoted to weather. Earth, air, and sea will be continuously sensed and their interactions modeled to predict major events such as El Niños, hurricanes, earthquakes, volcanos, megaplumes of hot water from oceanic vents, shifts in major ocean currents, and climatic fluctuations.

Millionfold improvements or more in computing power over the next century will improve the resolution and scope of global models. These models will integrate the atmosphere, crust, and oceans; geochemical and geothermal flows; human and other biological populations, including domestic animals, trees, cereal crops, and infectious diseases; economic stocks and flows, accounting intelligently for the welfare-generating potential of natural resources; informational stocks and flows, including scientific, literary, artistic, and folk traditions; and familial, social, institutional, and political resources and constraints. These comprehensive models will have external forcing factors that remain beyond human control, such as solar flares, and will explicitly represent, though not predict, human decisions.

In spite of improvements in information, concepts, and management, the Earth will still bring surprises. Geophysical surprises will arise from the improved awareness made possible by better planetary monitoring, from inherent instabilities in geophysical systems that are described by the mathematics of chaos and from rising human impacts. Surprising infectious diseases will continue to emerge from the infinite well of genetic variability. Historically, each factor-of-10 increase in the density of human settlements has made possible the survival of new human infections. As more humans contact the viruses and other pathogens of previously remote forests and grasslands, dense urban populations and global travel will increase opportunities for infections to spread.

Economies will be increasingly integrated. Megalopolises will concentrate the talent and resources required for international business. Hardly any complex product will be conceived, financed, engineered, manufactured, sold, used, and retired within the boundaries of a single political unit. Governments will find that a growing fraction of the power to control the economic well-being of their citizens lies outside their borders. Economic integration will give profit to those who can recognize the comparative advantage of other societies and can negotiate mutually beneficial exchanges. Information will become an increasingly valuable commodity. Those who can create it, analyze it, and manage effectively on the basis of it will be at a premium. Information technology and global economic integration will grow hand in hand.

An international common law—not a world government but rather international standards of behavior—will grow stronger and more comprehensive in a progression from technical to commercial to political law. International agreements on vaccination and on metric measures work because they benefit all who abide by them, and many who do not. Growing investments by multinational corporations will force the development of international contract law. Once the regional and global economic customs, institutions, and laws are firm, it will become too costly for nation-states or their successors to ignore them. Legal and economic resolutions of political conflicts will become more efficient than violent ones.

As the peoples of Asia, Latin American, and Africa approach the levels of wealth of Europe and North America, their environmental fatalism and modest demands for food will be replaced by impatience with the accidents of nature, intolerance of environmental mismanagement, and refusal to eat less well than their neighbors. The need for careful global management—particularly management of the living resources that are the focus of our material and altruistic concerns—will become irresistible.

Perhaps I am dreaming when I speculate that geophysical and biological surprises, the revaluation of living nature, our greater dependence on people all over the world, our growing determination to act lawfully and our own aging (individually and as a population) will increasingly inspire in many of us a greater awe for the world, for others, and for ourselves. The problem for scientists is how we can provide the factual and theoretical foundations needed to achieve a managed, wired, and beautiful global garden a century from now—a prospect, as Matthew Arnold (1867:708) put it, "which seems to lie before us like a land of dreams, so various, so beautiful, so new."

The Ecological Basis of Conservation

Heterogeneity, Ecosystems, and Biodiversity

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