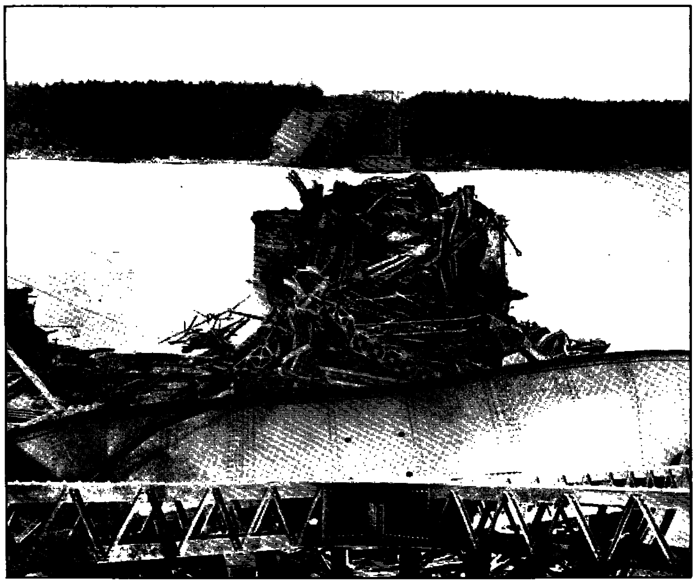

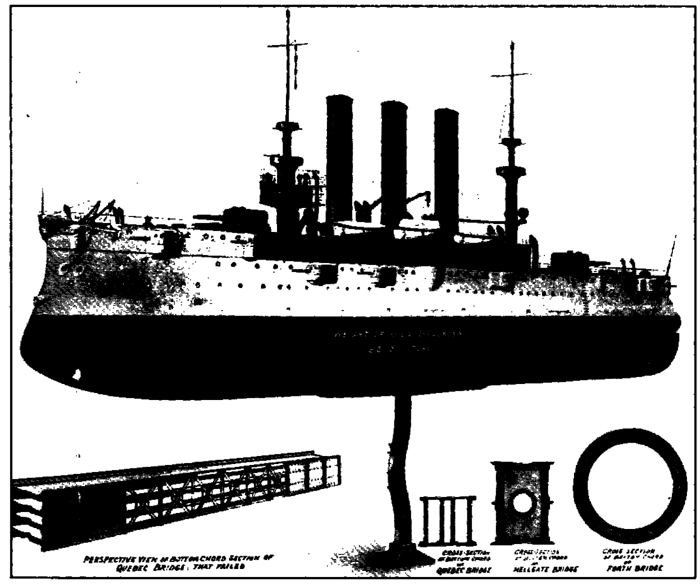

Aftermaths of the failure of the Quebec City railroad bridge, which collapsed during construction in 1907. *Left*, the remains of the bridge, which "fell straight down onto itself, leaving an amazingly compact line of wreckage." An early report published in *Engineering News* and that of a year-long Canadian government inquiry agreed that the reason for the collapse was that "one of the members in the bottom chord of the landward ('anchor') arm of the cantilever truss buckled." *Right*, a "lesson" on buckling published in *Scientific American* after the collapse. "The weight of the cruiser *Brooklyn* was about the same as the calculated axial load on the chord girder that failed at Quebec City. The perspective drawing of the girder reveals inadequate bracing." [From *Engineering and the Mind's Eye*]

The next step is to convert mental images into drawings and specifications. Ferguson describes how this happens, from the "thinking sketch," to the "talking sketch," used in the collaborative process of design, to the "prescriptive sketch," used to direct the drafting of a finished drawing. Ferguson suggests that drawings "changed radically the balance of power between managers and workers," shifting the locus of decision-making from the shop floor to the drafting room.

Engineering drawings may look precise, scientific, and "true," but, like the design itself, they conceal "many informal choices, inarticulate judgments, acts of intuition, and assumptions about the way the world works." Ferguson does not claim that technology is "socially constructed," a creature of economic, political, and social forces, as more radical historians and sociologists of technology insist. Indeed, there's not enough analysis in the book of the ways larger cultural and social forces influence engineers' work. For Ferguson, engineering design is a social process, but he sees this mostly as a function of engineers looking over each other's drawing boards or talking over projects at lunch.

The increasing ability to capture visual images on paper and to make copies for others to see was a turning point in the rise of modern technology. The invention of pictorial perspective and printing in the 15th century changed engineering. For the first time, the exact visual information essential to technological knowledge could be communicated widely. Ferguson discusses the two traditions of technological picture books. "Theaters of machines," Renaissance compilations of illustrations of mechanical ideas such as Agostino Ramelli's *Le Diverse et Artificiose Machine* (1588) described technological possibilities, suggestions that an engineer might use where he saw fit. These, Ferguson suggests, were "simultaneously disruptive and progressive." They suggested the possibility of new ways of doing things. Detailed descriptions of existing technical processes, such as Agricola's 1556 *De Re Metallica*, on the other hand, had a more conservative effect; they diffused established techniques.

Ferguson's most interesting case study is his discussion of the art and science of fortification. In response to improvements in cannon in the late 15th century, military engineers developed a new kind of fortress design, a regular polygon with gun platforms at each corner to protect the walls with gunfire. For hundreds of years military engineers were fascinated with the "ideal form" of a fortress. In their attempts to make the perfect fortress—to make it in reality as it was on paper—they decreed that the area of the fortress must first be turned into a flat plain. The environs of a fortress (and by extension, of any engineering design), according to this scheme, must be predictable and controllable, uncluttered with people or nature. This "fortress mentality," Ferguson suggests, is the mind-set on which modern engineering is based.

Engineering and the Mind's Eye is full of interesting suggestions like this, historical vignettes that are mined for their bigger implications about the nature of engineering. Ferguson fears that engineering has changed for the worse. To revive it, he recommends that engineers be taught more about the real world, and less mathematics; that common sense play a greater role in engineering; that there be more hands-on management of engineering; and that the engineering profession be more accepting of outside criticism. This is good advice. Thoughtful engineers will find Ferguson's historical essays fascinating and his ideas about engineering education worthy of consideration.

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Biotic Prognostications

Global Warming and Biological Diversity. ROBERT L. PETERS and THOMAS E. LOVEJOY, Eds. Yale University Press, New Haven, CT, 1992. xxii, 386 pp., illus. $45. From a conference, Washington, DC, Oct. 1988.

Since 1920 the average temperature of the earth has increased about 0.5°C relative to the 1861–1900 average. This trend is correlated with a parallel increase in the concentrations of carbon dioxide, methane, and chlorofluorocarbons in the atmosphere. These "greenhouse gases" come from a variety of sources related to the relentless demands placed on the planet by a human population in log-phase growth, and they represent both the effluents of affluence (industrial production and automobiles) and those of poverty (burning tropical vegetation). Although there are still some who question that the observed temperature rise is a result of the increase in greenhouse gases, several global circulation models (GCMs) predict that a doubling of preindustrial CO_2 concentrations will cause an overall average warming of 1.5°C to 4.5°C or so within the next century.

The effects that such a warming trend will have on agricultural production and coastal regions have received much discussion. The primary goal of this book, which emerged from a symposium on the topic in 1988, is to focus attention on its impacts on biological diversity and natural ecosystems. To this end, the editors have brought together a stellar assemblage of authors. Following a foreword by Michael Soulé and a preface by Thomas Lovejoy, Robert Peters provides overviews of the problem from two different perspectives. George Woodwell follows with a revealing chapter on government attitudes to the climate change problem, and Stephen Schneider and coauthors discuss the general conclusions—and deficiencies—of present GCMs.

The next section, with chapters by Thompson Webb and Russell Graham, describes the impacts of past climate changes on the world's biota. This is followed by reviews on the effects of climate on vegetation (Ian Woodward), soils (Walter Whitford), wildlife diversity (Herman Shugart and Thomas Smith), animal physiology (William Dawson), ecology (Richard Tracy), behavior (Daniel Rubenstein), and migration (P. J. P. Myers and Robert Lester), and parasites and diseases (Andrew Dobson and Robin Carper).

How might global climate change affect specific regions? Vera Alexander provides informed speculation on arctic marine ecosystems, Carleton Ray and coauthors on coastal marine zones, Gary Hartshorn on tropical forests, and Dwight Billings and Kim Moreau Peterson on the arctic tundra, Jerry Franklin and coauthors on the northwestern North American forests, Walter Westman and George Malanson on the Mediterranean ecosystems of California, Dennis Murphy and Stuart Weiss on the Great Basin, and Larry Harris and Wendell Cropper, Jr., on Florida. Potential changes in eastern North American forests are treated in papers by Daniel Botkin and Robert Nisbet and by Margaret Davis and Catherine Zabinski. Finally, indirect linkages and synergisms among climate change, biodiversity, the geosphere, and various anthropogenic stresses are addressed in contributions by Norman Myers and John Harte *et al.*

What do all these papers tell us? First, all predict that the consequences of global change for biodiversity will be dramatic and disastrous. Many ecosystems will be fundamentally altered as a result of changes in abundance and local extirpations of more common species, extinctions of geographically restricted species, expansion of exotics and disease vectors, increases in catastrophic storms, fires, and seasonal extremes, and unknown interplays among all these events. These in turn are likely to result in irreversible losses of germ plasm, reductions of forest yields, and declines in the quantity and quality of freshwater resources. Clearly, such impacts not only will alter natural resources but also human economic futures.

Aside from providing "creative speculation" on the qualities of a changing world, few of these papers are able to make specific, unequivocal predictions. The complexities of the real climate system still vastly exceed the comprehensiveness of today's GCMs, and the grid size of these models is too large to predict local conditions very accurately. Climate can affect almost every conceivable aspect of plant and animal biology, so we have only rudimentary ideas about how species' tolerances may respond to climate change. We know even less about how the loss of species can affect basic ecosystem processes. While we do know a bit about the relationship between past climates and community composition, extrapolation to the future from this information is risky. The rates of change are likely to be much faster than previous onsets of natural greenhouse conditions, and the flora and fauna must respond to this change in landscapes highly modified and fragmented by human activities.

The most serious consequence of our current inability to generate specific predictions is that it provides a grand excuse for continued inaction. As Woodwell points out, the "concept of a large and resilient world open to infinite compromise persists." However, the take-home lesson from this book is that the changes likely to be wrought by global warming are not going to be very convenient, pleasing, or profitable to its human inhabitants and that the time available for altering its course is growing short. The prudent action is to follow Woodwell's advice and take immediate steps to "restabilize the human habitat and preserve opportunities for our children to live in it." Perhaps the first step is to buy this book and give it to your favorite politician for Christmas.

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Vignettes: Divine Terminations

Saddam Hussein had styled himself the heir of Nebuchadnezzar and Hammurabi, but, in truth, he was a modern-day Sennacherib. . . . [Sennacherib] invaded Judea and besieged Jerusalem. Like Hussein, his forces were shattered by air power—allegedly suffering 185,000 dead at the hands of the Angel of Death.

—*Richard P. Hallion*, in *Storm over Iraq: Air Power and the Gulf War* (Smithsonian Institution Press)

The direct influence of prophecy belief on nuclear decision making surfaced as an issue in the 1980s as the eschatological interests of several Reagan-administration officials became known. Secretary of Defense Caspar Weinberger, asked about the subject in 1982, replied, "I have read the Book of Revelation and yes, I believe the world is going to end—by an act of God, I hope—but every day I think that time is running out." Interior Secretary-designate James Watt, questioned at his confirmation hearing about preserving the environment for future generations, forthrightly replied, "I do not know how many future generations we can count on before the Lord returns." Reagan's Surgeon General, C. Everett Koop, attended a 1971 prophecy conference in Jerusalem and reported on it for a leading premillennial journal.

—*Paul Boyer*, in *When Time Shall Be No More: Prophecy Belief in Modern American Culture* (Harvard University Press)

Books Received

The Archaeology of William Henry Holmes. David J. Meltzer and Robert C. Dunnell, Eds. Smithsonian Institution Press, Washington, DC, 1992 Variously