Humans measure things to understand the past, to document the present, and sometimes to predict the future. But humans neither measure everything nor measure things at random. Industrialized humans measure some things because they give pleasure—batting averages of favorite baseball players, for instance—and they measure other things because they are assumed to reflect individual or collective well-being—a person’s cholesterol level or annual income, a community’s crime or unemployment rate. In short, we humans measure what matters to us, and, conversely, we come to value the things we measure.

The natural world—including seasons, weather, growing patterns of food plants, animal migrations, locations of water sources, and so on—undoubtedly mattered to early humans, and so they likely monitored these aspects of their surroundings. For the past century, however, economic growth has been the overarching priority and dominant idea (McNeill 2000), and so the dominant measures, or indicators, for monitoring societal well-being have been measures of the economy. Closely watched economic indicators like the Dow Jones industrial average, gross domestic product (GDP), or gross national product (GNP) dominate the news. But the focus on these economic indicators has masked social, moral, and ecological ills that also matter to societal well-being (Davidson 2000, Manno 2000). Although people may be aware of such ills, the relentless dominance of economic indicators allows policymakers to make decisions that ignore those ills.

As a result, humanity now faces a paradox. The economic indicators we watch most closely suggest that all is well. Yet less-watched indicators show that the state of the biosphere is worsening. If we picture the key components of Earth’s living systems and their relationships to one another as a layer cake, human social systems rest atop the foundation layer of the natural, or ecological, system (Figure 1), and the human economic system is the
frosting, taking its shape from the social and ecological systems supporting it. Human prosperity for thousands of years has depended directly on what societies take from the supporting natural system. As human economic activity has intensified, the layers of the cake have begun to erode, progressively impoverishing the biosphere and threatening the very foundations of society. Such biotic impoverishment now takes many forms, including degraded soils, declining biodiversity, failed fisheries, changing climate, rising asthma rates, food insecurity, stress syndromes from overcrowding and the pace of modern industrialized life, mounting numbers of refugees fleeing ecological degradation, and the cumulative impacts of many simultaneous and mutually reinforcing events (Figure 2).

Humans face yet another paradox. Writings from Mesopotamia and South Asia 4500 years ago reveal awareness of biodiversity, the relationships among living things, and knowledge of natural order in the biosphere and of the consequences of disrupting it (Chew 2001). Since then scientific advances confirm the importance of those concerns, making modern society the best informed society in history. But our collective willingness to use that knowledge seems little better than it was 4500 years ago.

To reverse the erosion of living systems, society needs a new generation of indicators that no longer disguises the state of economic, social, or ecological things that matter to human well-being. If we watch such new-generation indicators as closely as we watch the Dow, perhaps we will again come to value the state of all Earth’s living and nonliving systems and so reverse the harm.

Better Economic Indicators. As a sign of societal well-being, GDP is as flawed as it is influential, and it illustrates the problem with conventional economic measures (Cobb et al. 1996). Rising GDP, typically viewed as a sign of prosperity (i.e., total human welfare),
measures economic throughput, the amount of money that passes through the economy. But it ignores other important aspects of that economy, including income distribution, unpaid work, and the black-market. Blind to “good” or “bad,” GDP does not account for social or environmental costs, such as pollutants, resource depletion, cancer, crime, or auto accidents, or, perversely, it counts these costs as benefits when money changes hands. The state of Earth’s ecosystems are left completely out of GDP accounting, as are nonmonetary contributions to human fulfillment, such as health, education, freedom, security, and peace. When society pays attention only to GDP and its companion econometrics—the Dow, the index of leading economic indicators, the consumer price index—the resulting balance sheet is incomplete, and biotic impoverishment worsens.

Better economic indicators would refocus attention on the connections between humans and their environments. They would take into account the fact that our planet itself develops over time without growing; likewise, development of the human economy must reflect increasing efficiency instead of ever expanding throughput (Daly 1991).

Efforts to improve econometrics include the genuine progress indicator (GPI) and the index of sustainable economic welfare (ISEW). ISEW, for example, adjusts GNP for negative impacts on the natural systems it regards as “natural capital,” wealth disparities across classes, the effects of pollutants, and other long-term social and environmental damage (Costanza et al. 1997b). A number of other efforts aim to clarify the relationship between economic and natural systems (Figure 3). Some researchers, for example, catalog the flow of goods and services from natural systems to human society (Daily 1997); they may even calculate their economic value (Costanza et al. 1997a, Pimentel et al. 1997). Others convert the rate of human consumption to land-area equivalents, estimating the size of humanity’s ecological footprint (Wackernagel and Rees 1996). A central tenet of
microeconomics is the presence of the “invisible hand,” the assumption that individuals seeking their own benefit will inevitably serve the common good. Ecological footprint analysis stops assuming the benevolent operation of an imaginary invisible hand (Stiglitz 2002) as it stops ignoring the very real footprint of human industrial metabolism (Rees 2000). Still others express the influence of humans by determining the proportion of Earth’s annual production consumed by humans (Pimm 2001). None of these approaches, however, explicitly measure the condition of natural biological capital—human and nonhuman—that is the sustaining wealth of the world.

*Beyond Economic Indicators.* Economic indicators alone, even better ones, cannot give a complete accounting of the social and ecological things that matter to contemporary society. For such an accounting, society needs comprehensive, integrative, and easily interpreted indicators of both social and ecological well-being, that is, indicators reflecting the health of living, biological systems, human and nonhuman. In essence, society needs indicators of the world’s biological capital. Many scholars, citizens, and institutions are working on such indicators, although governments, businesses, and people on the street have been slow to embrace their findings or watch the indicators as they watch the Dow.

Efforts to produce social indicators measuring the condition of living human systems are gaining ground. Concern about our inability to monitor public human services the way we monitor financial markets stimulated the state of Connecticut to develop an annual social index (Miringoff and Miringoff 1999, Stille 2002). The social index of leading indicators combines 16 measures of social health, including child poverty, teenage suicide rates, average weekly wages, income inequality, homicide rates, health insurance coverage, and alcohol-related traffic deaths. When examined on a national scale and aggregated at state
levels, three indicators in particular—child poverty, high school completion, and health insurance—were bellwethers of overall social health (Stille 2002). The Miringoff study showed that although GDP continued to grow over 30 years, Americans’ social health simultaneously plummeted, as problems like child poverty, average wages, teen suicide rates, income inequality, and health insurance coverage all worsened. Infant mortality rate, another important indicator of societal well-being, increased in the United States in 2002 for the first time since 1958; 41 countries had lower infant mortality rates. An infant born in Beijing or Havana, for example, was less likely to die in the first year of life than one born in the United States.

Beginning in the 1970s, at least eight European nations formalized “national social health reports”; other nations including Canada, Cyprus, Hungary, Turkey, and Australia joined these countries in the 1980s and 1990s. In 2002 the ruler of Bhutan mandated production of a “gross national happiness” report. As of early 2005, the United States had not joined the nearly 20 countries explicitly mandating systematic evaluation of social well-being, despite, or perhaps because of, the very different picture from the one based on GDP that such an evaluation paints (Figure 4).

Development of indicators to improve our knowledge of the condition of Earth’s nonhuman living systems is also under way. Perhaps the farthest-reaching project of this kind is the Millennium Ecosystem Assessment, an international undertaking intended to supply decision makers with scientific information on the consequences of ecosystem change for human well-being and on the available options for mitigating undesired change (Kaiser 2000, Reid 2000, Gewin 2002). Although much work has been done to develop the assessment’s concepts and approaches, few data are yet available to guide decision makers.
Four U.S. efforts aim to understand the state of the nation’s ecosystems (Heinz Center 2002), biological resources (Mac et al. 1998, LaRoe et al. 1995), or the current state of the environment at the national level (USEPA 2003). The Heinz Center endeavor, a private initiative, identifies more than 100 specific indicators of physical, chemical, and biological condition of the nation’s ecosystems and human uses of those systems, provides data on current conditions and past trends, and highlights significant gaps in our ability to adequately describe key characteristics of these systems. In the 1990s, the U.S. Geological Survey (Mac et al. 1998) and the fledgling U.S. Department of Interior’s National Biological Service (before it was moved to the Geological Survey; LaRoe et al. 1995) were directed to improve information about the nation’s living resources. The Geological Survey reports, by geographical region, on factors affecting biological resources and resource trends. The National Biological Service report focuses on selected species and ecosystems. Neither agency explicitly focused on developing a coherent set of indicators and neither seems to have had much influence on natural resource or environmental policy to date.

As of early 2005, the only specifically biological indicator project to make it into the policy arena was the index of biotic integrity (IBI). Begun in the U.S. Midwest soon after passage of the 1972 Amendments to the Water Pollution Control Act (a.k.a. the Clean Water Act), it was the first effort to measure directly and in biological terms the unraveling of living aquatic systems caused by human activities (Karr and Dudley 1981, Karr 1991, Knoopman and Smith 1993). The goal was to shift water resource agencies’ focus away from chemical indicators and engineering solutions. The index, analogous to multimetric economic indexes, combines biological measures into a single index of biotic condition. (For more on biological integrity and its measurement, see Box XXX.) In the 30 years or so since its development, this index has been used worldwide to assess the biological condition of water bodies,

Better biological and social indicators are long overdue. By leading us to value mainly the things money can buy, narrow economic indicators have implicitly endorsed unsustainable lifestyles and blinkered us to the effects of our actions on noneconomic entities. Until we have comprehensive social and biological measurements of well-being, we will not fully perceive the erosion of the base two layers of Earth’s living-system layer cake, and our policymakers will lack the crucial foundation for informed decision making. If we do not develop, use, and watch broad indicators of well-being, we will not fully understand the status of and trends in living systems, how human actions influence those trends, or how we can avoid trends that threaten the well-being of life on Earth. If, on the contrary, we couple improved biological indicators with carefully defined social indicators and better economic indicators, we may improve the state of the biosphere as well as our own lives.

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Figure 1. The world can be depicted as a two-layer cake with frosting, whose foundation consists of the Earth’s natural living systems. Both the human social system and the economic system take their shape from the underlying “natural system.” In modern times the influence of human economies is eroding the underlying social and natural systems, threatening their ability to sustain human society.

Figure 2. The many faces of biotic impoverishment resulting from humans’ taking from Earth’s ecosystems. (modified from Karr and Chu 1995 and Chu and Karr 2001).

Figure 3. Selected indicators of system condition for each level of the conceptual layer cake, including some that monitor the interactions of layers.

Figure 4. Differing views of “progress” from 1970 to 2000 in the United States based on three measures of well-being indexed to 1.0 in 1970: GDP, gross domestic product; GPI, genuine progress indicator; and ISH, index of social health.
Ecological system

Social system

Economic system
Humans take from ecosystems

Biotic impoverishment

Indirect effects of altered physical and chemical systems
- Water degradation
- Soil depletion
- Chemical contamination
- Global climate change
- Altered biogeochemical cycles

Direct alteration of nonhuman living systems
- Overharvest
- Habitat fragmentation and loss
- Biotic homogenization
- Genetic Engineering

Direct alteration of human living systems
- Epidemics, diseases
- Lost cultural diversity
- Reduced quality of life
- Environmental injustice
- Political instability

Cumulative (interactive) effects