more new grants than subsequent budgets have allowed the agency to sustain. At the same time, in response to pleas from the scientific community for more stable funding, the average length of grants was growing from 3.4 years to the current 4.3 years. This means less money has been available for new grants and those up for competitive renewal. To suddenly award thousands of new grants would solve the short-term problem but set the stage for the same kind of crisis a few years down the road.

So what can be done? NIH has already begun to shift available money around. Ruth Kirschstein, head of the National Institute of General Medical Science, said that her institute will sometimes go out of its way to help the desperate—denying extra funds to a scientist with more than one grant to fund someone who has no other support, even if that person received a lower ranking from a study section. NIH has also used "downward negotiations," a euphemism for cuts, to take money from continuing grants to free money for new grants.

But researchers feel available money just won't do the trick. Some say it is time to mount a massive, grass-roots lobby campaign to convince Congress that more money should be put into biomedical research. William Brinkley of the University of Alabama described efforts by the Biophysical Society and the American Society for Biochemistry and Molecular Biology and the American Society for Cell Biology to educate Congress on the importance of biomedical research. Such efforts, he maintained, had already helped create a more favorable budget climate.

But John Holmfeld, science consultant to the House Committee on Science, Space, and Technology, warned that scientists could lose their credibility on Capitol Hill if they run to Congress every time they faced what he described as a "mini-crisis." "Rather than start a lobbying campaign to solve this immediate problem," which he estimated would have less than a 50–50 chance of success, he said, "you ought to think, as others have suggested, in strategic terms," such as establishing goals and priorities for spending. "Not only do we need a better idea of what's happening," said David Baltimore, the new president of Rockefeller University, "but we need a model of what ought to happen."

Some strategies have already been developed. Floyd Bloom said an upcoming report from the Institute of Medicine that he helped write will recommend testing a sliding scale for funding. Instead of funding some grant seekers fully and giving nothing to others, Bloom said the report will recommend providing graduated amounts of money depending on study section rankings. "In our calculations for the current year this might permit an additional 350 grants to be supported," he said. Other recommendations will be to give early, informal reviews for young scientists so that they will have a better chance of winning renewal, and creating a mechanism to support research teams during transitional periods as they finish one project and want to head in a new direction.

Whatever long-term solutions the Bush Administration and the NIH devise, they are not likely to bring short-term relief, and times will continue to be tough. Acting NIH director William Raub asked last week's forum audience to look for the silver lining: "Some of the strongest advocates of biomedical research . . . in private go so far as to say a bad year now and then reinvigorates our advocacy and helps in the long run." And some, he added, would say that "we should look to the fruits of this anguish rather than simply bemoan it." But a moan went up from the audience even as he spoke.

■ JOSEPH PALCA

Multidisciplinary Look at a Finite World

Fledgling field of ecological economics seeks to imbue ecology with more theoretical rigor and bring economics down to earth

HOW DO YOU ASSESS THE FUTURE VALUE of the spotted owl? Quantify the "gross national waste product"? Model the intergenerational impacts of the greenhouse effect? Determine the earth's human carrying capacity?

These are questions of almost unimaginable complexity, and they are usually ignored within conventional economics and ecology. But they are the kinds of things experts puzzled over at the first meeting of the International Society for Ecological Economics, held in May at the World Bank in Washington, D.C.

The meeting marked the debut* of a "trans-discipline"—ecological economics—designed to supply a bridge between the natural sciences and economics. And it seemed to have tapped a need—about 150 participants were expected; 372 showed up. The attendees came to see if it made sense to bring under one umbrella work that has been conducted in recent years in resource and environmental economics, systems ecology, energy, applied physics and mathematics, operations research, and anthropology and sociology. What they had in common, says economist Ralph d'Arge of the University of Wyoming, is that they are "a whole group of people with interests in a revised macroeconomics consistent with physical and biological laws."

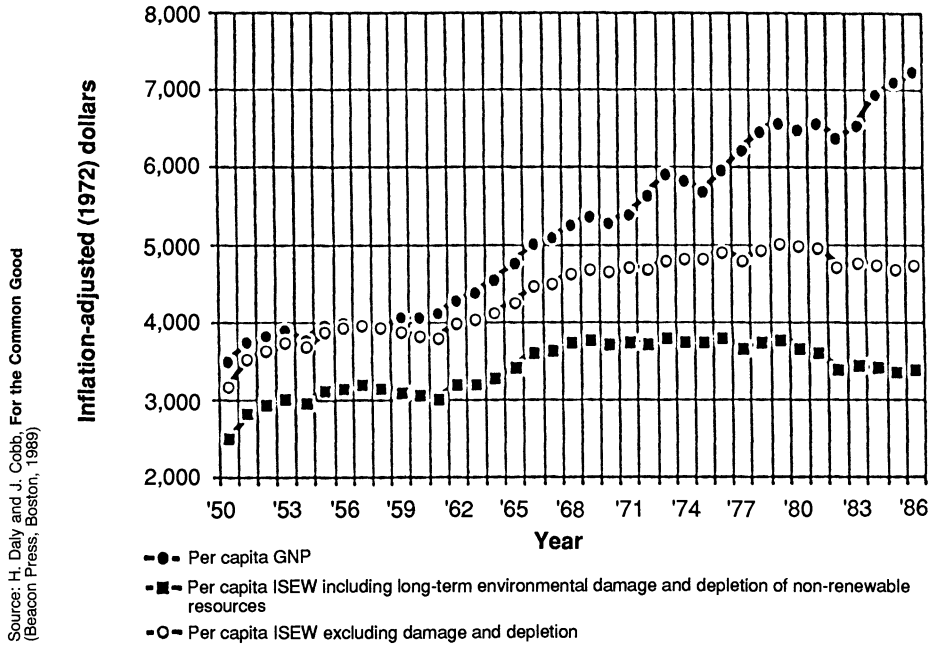
That means they believe there are limits to growth, and some think the limits have already been reached. Many see the time as ripe for an economics based not on growth, but on "sustainability." According to World Bank economist Herman Daly, one of the organizers of the conference and a maverick in his trade, this calls for replacing the old paradigm of the economy as a self-contained system with one that treats it as a subset of the biophysical system.

At present, said Daly, "There is no point of contact between the macroeconomics and the environment." He said leading economics textbooks do not even contain entries on such topics as natural resources, pollution, and depletion. That's because most economists treat environmental functions as "externalities." Ecologists, for their part, have little understanding of economic constraints, said conference co-organizer Robert Costanza, an economist at the University of Maryland's Chesapeake Biological Laboratory. They tend to stick to natural systems and leave out the human angle.

People working in ecological economics are inclined to be technological pessimists. They start with the premise that there is no getting around the First and Second Laws of Thermodynamics: since energy/matter can't be created or destroyed, resources are finite; and that once dissipated they can't be reused (entropy law). Most do not believe new technologies will be sufficient to avert major human and ecological disasters if current trends continue. They see no alternative to slowing population growth and the "throughput" of environmental goods and services.

Sustainability has become the rallying cry for development experts in recent years, but the term is nonspecific. What level of eco-

* The Society for Ecological Economics was formed at a meeting in Barcelona in 1988. It has its own journal, *Ecological Economics*, edited by Robert Costanza.



Source: H. Daly and J. Cobb, **For the Common Good** (Beacon Press, Boston, 1989)

Index of sustainable welfare. *Herman Daly of the World Bank and John J. Cobb of the Clarement School of Theology have devised a substitute model for the U.S. GNP that includes a measure of distributional equity in an "index of sustainable economic welfare" (ISEW). Adjustments are made for a variety of factors including services, costs of pollution, loss of wetlands and farmland, and "defensive" government expenditures that do not add to wealth. The result is an economy that has declined somewhat since the 1970s—in contrast to one continuously gaining, as reflected by GNP.*

nomic production can be sustained, for how long, and for how many people? Daly believes the first task is to come up with some parameters for sustainability by establishing an "optimal scale" for the world economy. One macroindicator, he said, has been offered by Paul Ehrlich and Peter M. Vitousek of Stanford University who have estimated the proportion of the world's output from photosynthesis that humans presently use or preempt. Currently, it is 25% of the earth's total photosynthetic capacity and 40% of land-based capacity.

Beyond the general goal of sustainability, there was little consensus at the conference on how to get from here to there. A lot of the talk was general, highly technical, or heavy on macro-theorizing (some people want to trash neoclassical economics; others want to merely modify it). But some clear themes emerged.

"Intergenerational equity"—making decisions that will not compromise life for future people—is one. "All decisions over time have been treated by economists as investment questions, as if all resources were always this generation's resources," said economist Richard Norgaard of the University of California at Berkeley. The discount rate has been a long-disputed example. The use of discount rates, applied to assess cost and benefit flows of particular resource or development decisions, is based on the fact that humans value the present over the future. In practice it means, for example, that a slow-growing timber stand can't compete with a dam that provides immediate payoffs. Daly supplies an analogy with the goose that laid the golden eggs: at some point, the assessed future value of the egg flow gets close to zero, and the "efficient" course is to kill the goose for its meat.

But changing discount rates scarcely begins to address a much larger dilemma: how to set values on environmental goods and services. Currently, said mathematician Colin Clark of the University of British Columbia, "much of apparent economic growth may in fact be an illusion based on a failure to account for reduction in natural capital." Resource economists have been trying for years to devise ways to incorporate the "real" costs of resources and pollution in systems of national income accounting to improve gross national product (GNP) estimates. Economist Henry Peskin of Silver Spring, Maryland, described several ways of revising accounts to reflect this, including separate identification of pollution abatement expenditures and keeping a balance sheet of stocks of natural resources. Governments might tax depreciation of mineral and petroleum reserves to slow down depletion, he added. Whatever the strategy, said Peskin, "the environment has to be treated as a productive sector."

A far more radical approach to grounding economics in physical reality is offered by a group of researchers who want to replace conventional economics with an "energy theory of value." Biologist Howard Odum of the University of Florida has devised a system for reducing all economic transactions to common energy units called "emergy" (for embodied energy), defined as the solar energy that went into a product. Using Ecuador's shrimp industry as an example he said when the raw energy that goes into shrimp exports is converted to emergy, the country exports ten times as much as it receives. At the other end of the scale is a country like Japan, which is getting a free ride emergy-wise.

Odum's approach is controversial, to say the least. Perhaps more representative of current efforts is an assessment of the "real" dollar value of Louisiana wetlands done by biologist Costanza and economist Stephen C. Farber of Louisiana State University. They combined conventional estimates of commercial and recreational values of the wetlands with calculations of the solar energy used by plants in the system. The gross primary [energy] production was converted into fossil fuel equivalents, which were in turn stated in dollars, using a ratio of GNP to total economy fossil energy use. Costanza concluded that if Louisiana were looking to its long-term future, it would be charging $17,000 an acre instead of the $300 to $500 (exclusive of mineral rights) the market does now.

It is through painfully complex studies such as these that people working on the border between biology and economics want to chart sustainable paths for development. So far, few decision-makers are paying attention to these models, which are not even understood by most conventional economists, says d'Arge. But they are far more substantive, say this group, than are the speculations that went into the old "limits to growth" scenarios that economists helped shoot down as "empty models."

Indeed there are already signs that ecological economics is becoming institutionalized: new institutes are being formed by the Swedish Academy of Sciences in Stockholm, the University of Siena, and the University of Ottawa. Costanza said the University of Maryland is also seeking funding for a graduate research training program.

"The big challenge in the coming decade," he said, is "to redesign the playing field at the local level" in accordance with long-term global goals. Then Costanza offered a hard-headed assessment: Because of the enormous uncertainties to be faced, he said, "we have to construct the best models that we possibly can and then not believe them."

■ CONSTANCE HOLDEN