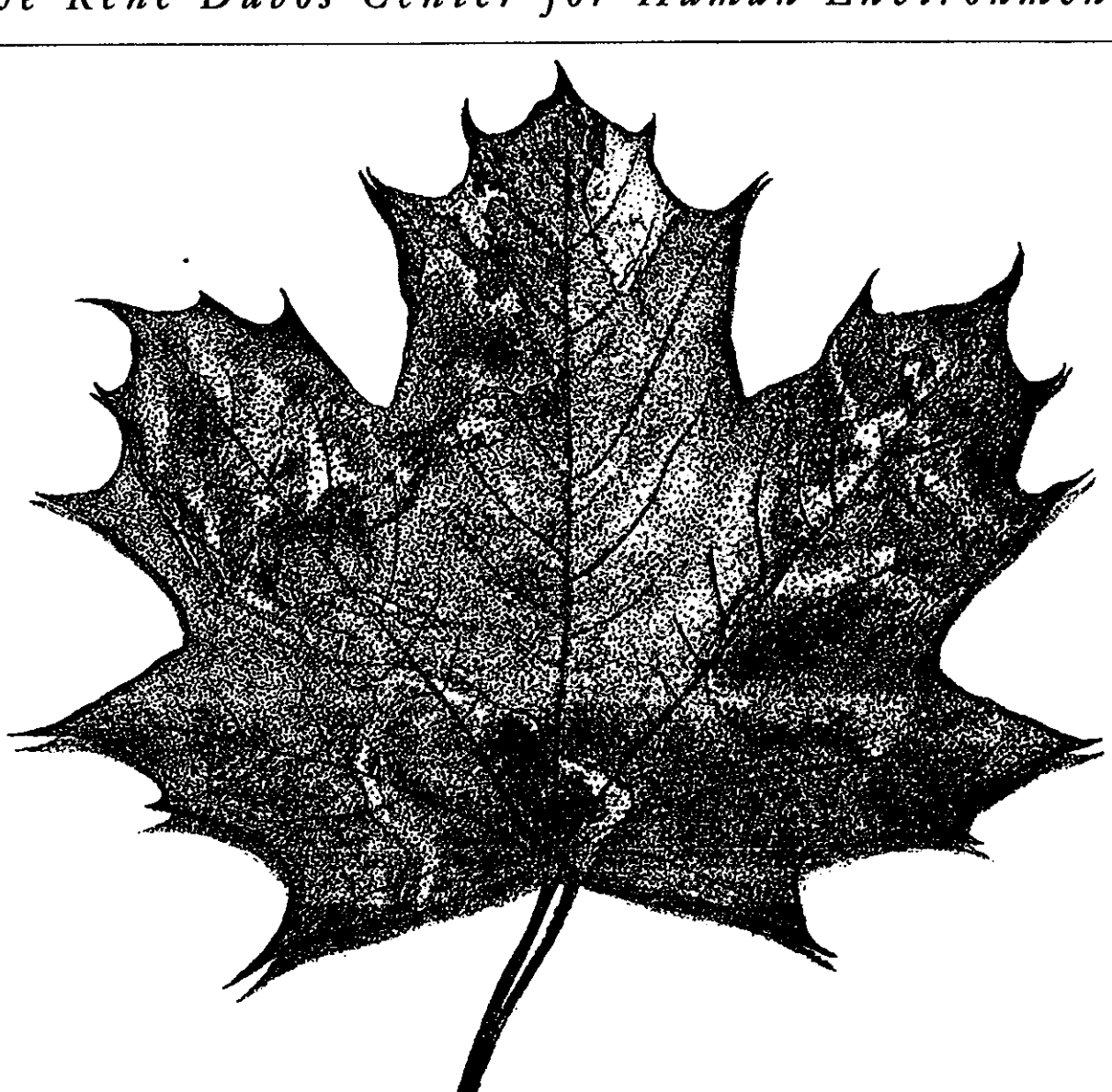
THE

ENCYCLOPEDIA *of the* Environment

The René Dubos Center for Human Environments



Ruth A. Eblen and William R. Eblen, Editors

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quire that the product be made entirely of recovered paper, with at least 10% post-consumer recycled content.

Green Seal has also issued standards for tissue and re-refined engine oil. It is developing standards for compact fluorescent light bulbs, household cleaners, coffee filters, and house paint.

Scientific Certification Systems (SCS), a California company that has applied for non-profit status, also verifies manufacturers' environmental claims for their products. However, they verify on a case-by-case basis, rather than across a whole product type. If the company's claims, most of which involve recycled content, are verified by SCS, the company is allowed to display the SCS "Green Cross" logo along with its environmental claims.

SCS has also begun to examine products with an eye toward their overall effect on the environment. The company then produces an "Environmental Report Card" that lists the resources going into a product in comparison to those going into a "typical" product in that line. The first "Environmental Report Card," issued for a brand of plastic trash bags made of recycled material, included the information that the recycled bags required about one-fourth of the electricity needed to produce "normal" trash bags. SCS does not follow the environmental impact of a product after it is made.

Some experts have pointed out that one cannot determine which products are less harmful to the environment than others without looking at the full impact of the product, from creation to destruction. This "cradle-to-grave" look at a product is known as "life cycle assessment."

Most scientists feel that life cycle assessment cannot be accurately done until some scientific debates are resolved. For example, while many experts argue that paper packaging is better for the environment than plastic, others say plastic actually does less damage to the environment, especially if it is recycled.

JEFFREY R. LEVINE

For Further Reading: *Consumer Reports*, "Selling Green" (October 1991); Bradley Johnson and Christy Fisher, "Seals Slow to Sprout," *Advertising Age* (April 20, 1992); Alex Pham, "It's Not Easy Being Green: FTC Issues Some Guidelines," *Washington Post* (July 29, 1992).

ECOLOGICAL ECONOMICS

A new field of study, *ecological economics*, considers the unified systems of the environment and the human economy. Policies for management are sought which can make the economy and the environment symbiotic. Ecological economics began among intellectuals in the mid-18th and the 19th centuries who considered energetics and land as the basis for value. Measures of resource value were sought in estimates of nature's work. But in the 20th century when economic growth based on abundant fossil fuels was accelerating, there were only sporadic contributions and concerns with the environmental basis for the economy. When environmental life support was taken for granted, ideas of unlimited human creativity were prevalent. Human willingness to pay became the main concept of value.

Following the oil shortage crisis of 1973 the energy basis of economic wealth was recognized as fundamental by a few economists. People of many backgrounds were drawn to the task of revising economics to include the unpaid part of the system of humanity and nature. A sustainable economy requires human society to adapt to the environment following principles derived from the study of ecological systems. Sustainability requires recycling materials, adapting to the pulsing of earth processes, designing with nature's hierarchy of many scales in organizing the landscape, preserving essential information and genetic diversity, and optimizing efforts in order to increase productivity.

Among many new approaches are five subject areas for study and application:

(1) Understanding the combined system of the environment and the economy (for example, unifying landscape ecology and geographical economics): Sustainable prosperity depends on mutual reinforcement between nature's systems of resource production and the human economic processes. Each stimulates the other. By contributing to the environmental production processes, the human economy causes more resources to flow into the human prosperity. One of the main ideas in ecological economics, Lotka's 1924 "maximum power principle," is:

> In the process of self organization, those system designs and policies are reinforced and sustained which draw in more resources and develop more efficiency in their use.

In the long run, fitting the human economy to help the environmental resource production will make the human economy more sustainable and prosperous. Rather than a competition between human jobs and environmental protection, it is a symbiosis that maximizes environmental and human welfare together. Finding economic and environmental management policies that will develop the mutual reinforcement is one of the main concerns of the field.

(2) Identifying principles and designs common to both ecological and economic systems: Although of-

ten discovered independently, many principles in ecology and economics are similar, such as equations and models for production, limiting factors, recycling of materials, utilization of by-products, dependence on energy laws, and input-output. There is now active reorientation underway to learn and share concepts.

(3) Understanding and managing the interface between environmental and economic systems: Forestry, fisheries, agriculture, and tourism are examples of ecologic-economic interface (Figure 1). The interface shows contributions from the environment without payment, as money is only paid to people for their work and the contributions of the assets they "own," including environmental assets. Unless special arrangements are made to reinforce the environmental production system (reinforcing pathway in Figure 1), the free market tends to drain stocks and reduce environmental production that is useful to the economy.

One of the ways the reinforcement can occur is with recycling of materials. Rather than allowing the by-products of the human economy to accumulate in great dumps (landfills) that divert land from useful purpose and often leak toxic substances into ground waters, the materials can be returned to environmental processes in places and concentrations where they assist environmental productivity. For example, return of nutrient-rich waters from treated sewage to wetlands was tested in many kinds of ecosystems in Florida and is now becoming a worldwide practice in fitting cities to their environments. This was practiced on a smaller scale in older cultures.

(4) Development of appropriate measures of environmental value and understanding their relationship to market values: Figure 1 shows nature's work on the left generating, for example, a contribution of wood to the economy. Nature receives no flow of money (the dashed lines). As the wood is brought into the economy, human services are contributed and these do receive money. For example, the dashed line in the middle of the diagram brings the money from sales to the landowner and forester. They send the money back to the economy (to the right again) buying goods and services for investment and consumption. Environmental valuation measures the work of nature in generating the real wealth (the wood). Energy measures of this work do not change and are not affected by the use or non-use of the wood, in contrast to economic valuation.

Market values are what people and businesses are willing to pay. Market prices make the human part of the system efficient. Market values respond inversely to the environmental resource, prices being least when the environmental system is contributing most. Market value of restoring natural capital (resource reserves in nature) has been suggested as a resource value (dashed lines in Figure 1), but such values don't include the work of nature. If only market value is used for decisions about the environment, the environmental resource system tends to be used up so that its further production is lost. Weedy systems take over. Examples are the many failed fisheries of the world where free markets caused the resource to be overfished. Other examples are the scrubby vegetation that replaces over-harvested tropical forest. In order to have sustainable environmental production by forests and fisheries, work from the human economy must be put back into nature to reinforce the desired system, as in Figure 1.

Market value and environmental values are very different and should not be confused. People and businesses have to use market value to guide their buying and selling. But for deciding how to manage the environment, to judge pollution impact, or decide what land use is best for the economy overall, environmental valuation is necessary.

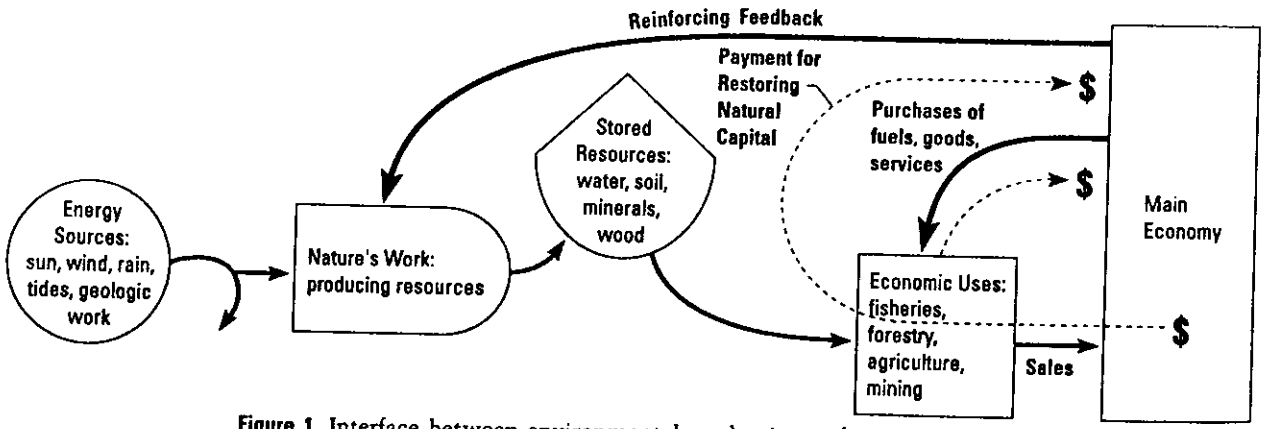

Figure 1. Interface between environmental production and economic use.

Much of the research in ecological economics concerns new measures of environmental contribution. Some evaluate the "energy embodied" in the previous work of nature in generating a product or service (solid lines in Figure 1). One method assigns input energies to pathways of a network according to the input-output data on some circulating quantity such as money. Another measure, Emergy—spelled with an "m"—calculates environmental work and human work on a common basis. It is the available potential energy, expressed in energy units (emjoules) used directly and indirectly to make a product or service. The maximum power principle implies that public policies to make a vital economy should be those that maximize the emergy production and use for the coupled system of the economy and the environment working together.

(5) Learning the way global international policies on trade and finance should drive the utilization of natural resources: Because market prices don't recognize the real contribution of resources, inequities of capital and foreign trade can cause unsustainable stripping of minerals, forests, soils, and fishery stocks in undeveloped countries to support overdevelopments in other countries. Currencies of rural undeveloped countries have high emergy/money ratios (8 to 48 solar emjoules per 1993 dollars) compared to the urban, developed nations' emergy/money ratios (0.5 to 3 solar emjoules per 1993 dollars). Large differences in this ratio cause inequity in foreign trade (2 to 30 times more EMERGY in raw resources traded than in the buying power of the money paid). When less developed countries borrow from developed countries they may pay back 5 to 10 times more EMERGY. Trade and borrowing would lead to mutual prosperity if price were based on emdollars (emergy-evaluated currency).

HOWARD T. ODUM

For Further Reading: L. C. Braat and W. F. J. Van Lierop, eds., *Economic-Ecological Modeling* (1987); R. Costanza, *Ecological Economics* (1991); J. Martinez-Alier, *Ecological Economics* (1987).

ECOLOGICAL PYRAMIDS

An ecological pyramid is a graph depicting (usually) the number of individuals of species at different trophic levels. For example, in Figure 1a, the energy which plants capture from the sun during photosynthesis may end up in the tissues of a hawk. It gets there via the birds the hawk has eaten, the insects eaten by the birds, and the plants on which the insects fed. The plant-insect-bird-hawk system is the food chain, and each stage, a trophic level. More generally the trophic levels are called producers (plants), herbivores or primary consumers (the insects), carnivores or secondary consumers (the bird) and top-carnivores or tertiary consumers (the hawk). The numbers of individuals at each level often drop dramatically. There are more

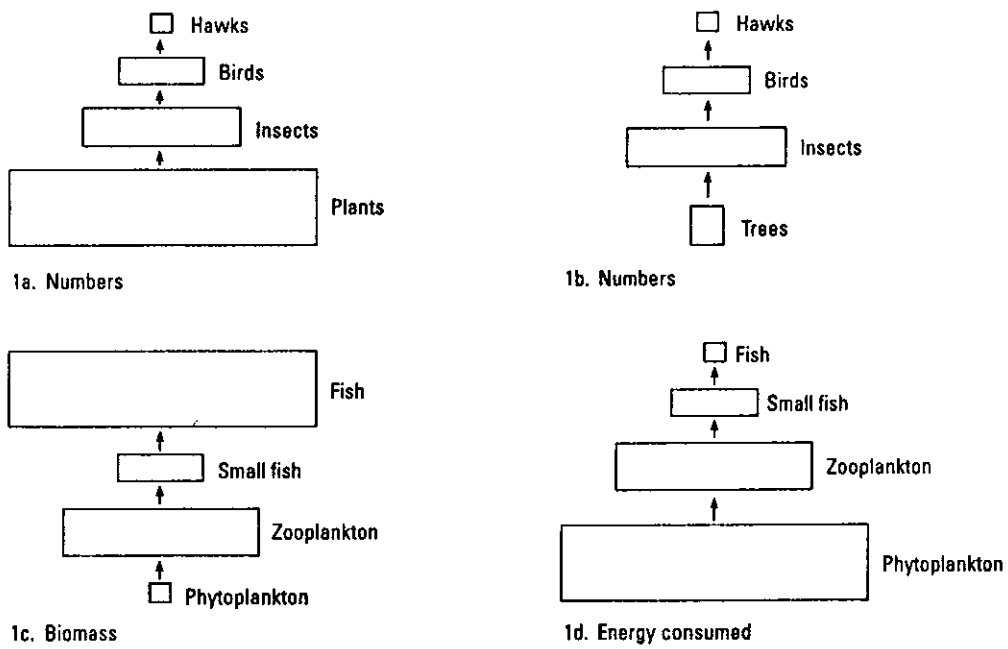

Figure 1. Ecological pyramids.