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Short communication

Ecological economics began on the Texas bays during the 1950s

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Ecological economics has grown to be an active field with annual conferences, a technical journal devoted to the subject and international professional societies. Graduate students are attracted to the field by the exciting new interdisciplinary ideas that are being discussed. For many the field is critical because it raises hope that rational and sustainable environmental policies are possible. One major challenge of ecological economics has been the development of a system that will properly account for values in both nature and human societies. While most ecological economists have struggled to accommodate conventional economic philosophy in working on this challenge, H.T. Odum developed a novel approach that uses energy as a common denominator and that is based on a "donor" system of value instead of a "receiver" system based on utility (Odum, 1996). His approach is significant because it does not use willingness to pay to establish value and as a result does not require having to make up markets for non-market goods and services. It is easily adapted to valuing environmental goods and services as it is to value goods and services within the human economy. The purpose of this note is to trace the origin of Odum's accounting system to some of his early research.

From 1956 to 1963, Odum worked as the Director of the Marine Institute of the University of Texas, on the Gulf of Mexico coast near Corpus Christi, Texas. These were very productive years in terms of developing many ideas, including new theories of energetics, but most of his time was spent recording and analyzing diurnal oxygen curves from the Texas bays (see enclosed paper by Swaney and Hall). Hundreds of such curves were generated for the calculation of ecosystem metabolism. Comparisons of curves taken in pristine areas with those from areas with human impacts often demonstrated the loss of metabolism due to the impacts. These comparisons probably allowed Odum to express human impacts in terms of the ecological energetics that he observed in the changed metabolism.

Somehow Odum got the idea (Odum et al., 1959) for the need for an economic assessment in relation to the negative impacts he was quantifying and in relation to the positive uses of the bays. He therefore helped fund thesis research of a graduate student from the UT School of Business to evaluate the "Marine Resources of the Corpus Christi Area" for the year 1958 (Anderson, 1960). In this work Anderson used conventional economic approaches to quantify dollar values for recreational use, commercial fishing, mineral extraction, use of cooling water, transportation, and effluent disposal. Odum included Anderson's data in several of his later publications (Odum, 1967, Table 3 on p. 148; Odum, 1971, Figs. 8–10 on p. 297, Odum et al., 1974, Table 1 on p. 143). These were just economic values and not ecological economic values, but they were ahead of their time and presaged future initiatives that were to combine ecology and economics.

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Anderson (1960) also went beyond conventional economics and calculated a "potential value of primary production per bay surface acre." He took Odum's average bay metabolism of 8 g organic matter/m^2/day, converted it to 71.2 pounds/acre/day, reduced it by 50% to account for ecosystem respiration and other consumption, and extrapolated it over a year to calculate a total annual value in units of tons/acre/year. He then multiplied by the local price of hay ($15/ton) in order to convert to dollars! His value was $97.46/acre/year. This was perhaps the first estimate of the potential dollar value of natural primary production!

In retrospect this appears to be a rather simplistic approach to ecosystem valuation but it represents a major intellectual leap. Odum helped in some way with this calculation since Anderson credits an interview with him in a footnote of his paper as the source for the 50% reduction factor due to ecological consumption. So Odum was involved to a greater or lesser extent in the first calculation of the value of an ecosystem service in 1958! However, he seems to have known this value was not quite correct because he only published it once (p. 147 in Odum, 1967) in discussing the value of ecological energy flows:

> For example, we can use a study done in Texas to realize the very great magnitudes of these flows on a dollar basis. That they are energetically vast on the scale of the bay's metabolism is obvious from the metabolic data and the rapid changes in the bay's systems. If one takes the grams per square meter of photosynthesis involved in bay processes and gets a dollar equivalent for it as forage for cows, the estimates of the bay's productivity by man's system is about $100 per acre per year. Man's drain of value from the bay is greater than that.

From the modest start in the late 1950s it seems to have taken another decade before Odum struck on a better approach to converting between energy and dollars, which he called the "money equivalent of work" (Odum, 1971, p. 182). He divided fossil fuel use by GNP at the national scale to estimate a ratio of 10,000 Cal/$. By dividing this conversion into ecological energy flow he calculated what he termed life support value. For example, he provided the following calculation in a general survey of US estuaries (Odum et al., 1974, p. 150):

> In addition to these dollar values we estimate the value of the work the ecological system is doing outside of man's dollar economy. With productivity and metabolism at about 5 g dry matter/m^2/day and 4 kcal/g there are about 29 × 10E7 kcal/acre/year of work processed in maintaining a useful part of the earth's life support. At our approximate rate of 10,000 kcal work per dollar, the equivalent money value is $29,000 per acre per year. As life support systems become scarce we might ponder the meaning of these high values.

He also used this approach to calculate the replacement value of a forest (Odum, 1971, p. 298):

> First consider the actual value in energy units and convert. The value as a public recreation and life-support system is its replacement cost. To replace complex, diverse, and beautiful forest requires about 100 years. The photosynthesis per square meter of a forest may be approximately 40 kcal/(m^2)(day). The dollar equivalent of work driven by organic fuels is about 10,000 kcal/dollar. With 4047 m^2/acre, the dollar value of replacement of an acre of this forest is $590,000 per acre. Losing the development value of 100 years for an acre of land is a major loss. A single tree of about 100 years of age is estimated in this way to be worth $3000.

Odum and Odum (1972) cite a similar calculation given by Lugo et al. (1971).

By the mid-1970s Odum had developed a system of energy quality factors or transformities to refine the life support calculation but the basis of the method of converting between energy and dollars has remained the same through to the present state of emergy analysis (Odum and Odum, 2000). Much interesting ecological economics work grew from Odum's life support calculations. The important dialogue about the value of salt marsh wetlands (Gosselink et al., 1974; King et al., 1979; Lugo and Brinson, 1979; Odum, 1979a,b; Odum and Hornbeck, 1997; Shabman and Batie, 1978, 1980) can be traced back to these early calculations as can, to some extent, the whole notion of ecosystem services so popular today among ecological economists (Costanza et al., 1997).

Odum (1984) reviewed the contribution of the Texas work to his emergy analysis method as follows:

We became impressed with energy as a general measure of utility in the study of energy systems of streams, springs, ponds, forests, etc. in the 1950s. While dealing with public controversies over dredge and fill project in Texas in 1959, ways were sought to adequately represent the value of the rich turtle grass beds so they would not be eliminated by development projects which claimed to be more valuable to the economy than the ecosystems being displaced (Odum et al., 1959).

Our measurements of the gross photosynthetic productivity of the grass flats and other estuarine ecosystems provided direct measure of the work of nature that was contributing to fisheries, cleansing waters, and other life support functions supporting the economy without much conscious recognition. A dollar equivalent was developed for organic produce based on crops. Then a whole estuary, Corpus Christi Bay, Texas was analyzed as a system. With funds obtained from the Corpus Christi Chamber of Commerce a graduate student from the Bureau of Business Research in Austin was added to the project to evaluate the direct economic uses of the bay. The resulting publication (Anderson, 1960) included nature's work calculated with a dollar equivalent for organic production. We now see this result as an underestimate of nature's contribution because the dollar equivalents calculated from crop prices was much less than the embodied environmental contribution of crops to the economy. Nevertheless the Corpus Christi value study showed the work of the bays to be much more valuable than had been recognized at the time . . . .

Since Odum's and Anderson's early calculations occurred long before any of the other direct antecedents of the field (such as work by Daly and Georgescu-Roegen), the argument can be made that the field of ecological economics began on the "Gray-Green Bays of Texas" in the late 1950s.

References

Anderson, A.A., 1960. Marine Resources of the Corpus Christi Area. Bureau of Business Research, Research Monograph 21:1–49. University of Texas, Austin, TX.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., van den Belt, M., 1997. The value of the world's ecosystem services and natural capital. Nature 387, 253–260.

Gosselink, J.G., Odum, E.P., Pope, R.M., 1974. The Value of the Tidal Marsh. Center for Wetland Resources, Louisiana State University, Baton Rouge, LA.

King, W., Hay, M., Charbonneau, J., 1979. Valuation of riparian habitats. In: Johnson, R.R., McCormick, J.F. (Eds.), Strategies for Protection and Management of Floodplain Wetlands and Other Riparian Ecosystems. General Tech. Rept. WO-12. USDA, Forest Service, Washington, DC, pp. 161–165.

Lugo, A.E., Brinson, M.M., 1979. Calculations of the value of salt water wetlands. In: Greeson, P.E., Clark, J.R., Clark, J.E. (Eds.), Wetland Functions and Values: The State of Our Understanding. American Water Resources Association, Minneapolis, MN, pp. 120–130.

Lugo, A.E., Snedaker, S.C., Bayley, S., Odum, H.T., 1971. Models for Planning and Research for the South Florida Environmental Study. Final Report Contract 14-10-9-900-363 between the National Park Service and the Center for Aquatic Sciences, University of Florida, Gainesville, FL, pp. 120–130.

Odum, H.T., 1967. Biological circuits and the marine systems of Texas. In: Olson, T.A., Burgess, F.J. (Eds.), Pollution and Marine Ecology. Wiley, New York, NY, pp. 99–157.

Odum, H.T., 1971b. Environment, Power, and Society. Wiley-Interscience, New York, NY.

Odum, E.P., 1979a. Rebuttal of "economic value of natural coastal wetlands: a critique". Coastal Zone Manage. J. 5, 231–237.

Odum, H.T., 1979b. Principle of environmental energy matching for estimating potential value: a rebuttal. Coastal Zone Manage. J. 5, 239–241.

Odum, H.T., 1984. Energy analyis evaluation of coastal alternatives. Water Sci. Technol. 16, 717–734.

Odum, H.T., 1996. Environmental Accounting, EMERGY and Environmental Decision Making. Wiley, New York, NY.

Odum, E.P., Odum, H.T., 1972. Natural areas as necessary components of man's total environment. Trans. North Am. Wildlife Nat. Resour. Conf. 37, 178–189.

Odum, H.T., Hornbeck, D.A., 1997. EMERGY evaluation of Florida salt marsh and its contribution to economic wealth. In: Coultas, C.L., Hsieh, Y.-P. (Eds.), Ecology and Management of Tidal Marshes, A Model From the Gulf of Mexico. St. Lucie Press, Delray Beach, FL, pp. 209–230.

Odum, H.T., Odum, E.P., 2000. The energetic basis for valuation of ecosystem services. Ecosystems 3, 21–23.

Odum, H.T., Muehlberg, P.E., Kemp, R., 1959. Marine Resources. Texas Natural Resources. Report of the Research Committee of the Houston Chamber of Commerce, Houston, TX, pp. 39–52.

Odum, H.T., Copeland, B.J., McMahan, E.A. (Eds.), 1974. Coastal Ecological Systems of the United States, vol. 1. The Conservation Foundation, Washington, DC.

Shabman, L.A., Batie, S.S., 1978. Economic value of natural coastal wetlands: a critique. Coastal Zone Manage. J. 4, 231–247.

Shabman, L.A., Batie, S.S., 1980. Estimating the economic value of coastal wetlands: conceptual issues and research needs. In: Kennedy, V.S. (Ed.), Estuarine Perspectives. Academic Press, New York, NY, pp. 3–15.