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# ENVIRONMENTAL RESEARCH BRIEF

## Emergy and Its Importance

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In ordinary commercial dealings among people, the value of a product or service within the economy of a state or nation is determined by what someone is willing to pay for it. Payment is usually made with money, for example, dollars when U.S. currency is used. Markets and agreements between people on prices govern these economic exchanges. The governance of small-scale economic transactions in markets is not affected by this discussion; however, the value of the environment needs to be considered in a different way when setting public policy.

People know that money is paid for their work and that money is not paid to the environment. Yet the environment does important work that is essential for all economic activity. When people take products from the environment, such as water, wood or animals, they do so without paying for nature's work in providing those products. Anything taken without payment becomes a debt or liability on the financial balance sheets used by all human enterprises. At present modern society owes a tremendous debt to the environment, but this debt is not entered on the books kept by government, industry, and commerce. As a result our present environmental debt is not being counted, controlled, and serviced in a reasonable way. One problem is that up to this time, we have not had an adequate method of accounting for these debts.

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Only people can accept money for products and services, so the environment can not and does not use money as a measure of value. Value in an ecosystem is measured not by money, but by flows of available energy. Available energy is energy with the potential to do work. All natural systems maximize flows of available energy to compete effectively for resources. The capacity to maximize current energy flow is determined by innovations and changes that have occurred in the past. Changes, which result in higher energy flows in the present, are often carried forward into the future. When everything required for an energy flow is considered, scientists find that it is actually the sum of the flows of the past and present available energy within a system that is maximized. However, both the available energy used in the past to make the inputs required for a product and the available energy transformed in the present during its production must be measured using a common unit to account for the fact that energies have different qualities, i.e., different ability to do work when used in a system.

The truth of the statements in the last paragraph can easily be verified by each individual by considering their own past. We all know that what we do today and what we get paid for doing it, in large part, depend on what we have learned and what we have experienced in the past. Without our past use of food, shelter, books, and without our families to support our learning and teachers to impart their knowledge to us we would not be what we are today or be able to do the work that we do in our jobs.

In the latter part of the 20th century, H.T. Odum and his colleagues found and tested a way to quantify the past use of available energy of all kinds on a common basis. They defined the new quantity that accomplished this and called it ***emergy***. Emergy is all the available energy of one kind used-up both directly and indirectly in the past to make a product or service that exists in the present (Figure 1). Emergy is expressed in its own unit, the emjoule, which connotes the energy (joules) used in the past, as compared with joules of energy available in the present in those products and services. For most evaluations of environmental systems, we use solar joules as the base unit. The solar energy used in the past to make a joule of available energy in the present is called the transformity of the product. Transformity is the amount of energy of many kinds that is used-up in making a unit of available energy in something else. It has units of solar emjoules per joule of available energy (sej/J).

The definitions of emergy and transformity above give rise to the Fundamental Equation of Emergy Evaluation:

**Emergy (solar emjoules, sej) = Transformity (sej/J) x Available Energy (J)**

Emergy allows the work that the environment contributes to economic activity to be quantified; and since all activities are based on the transformation of available energy in some process, economic and social quantities can also be documented in terms of their emergies. When all environmental, social, and economic quantities are expressed in emergy and placed on a single balance sheet, they are directly comparable and we have a comprehensive measure of the condition of the system. The balance of these factors will tell us whether our current system is operating in a sustainable manner, i.e., the emergy assets of the environment, economy, and society of a nation, region or business must exceed their liabilities for the entity to be healthy and sustainable.

In summary, emergy can be thought of as a kind of energy memory that is carried forward in the capacity of each individual thing to do work, when it is used for its intended purpose within a system. It is important because maximizing emergy flows is hypothesized to be the criterion that determines success in evolutionary competition. Therefore, we must understand and use nature's value system if we hope to assess the environment fairly for accounting purposes and discover the information that we need to make wise public policy decisions.

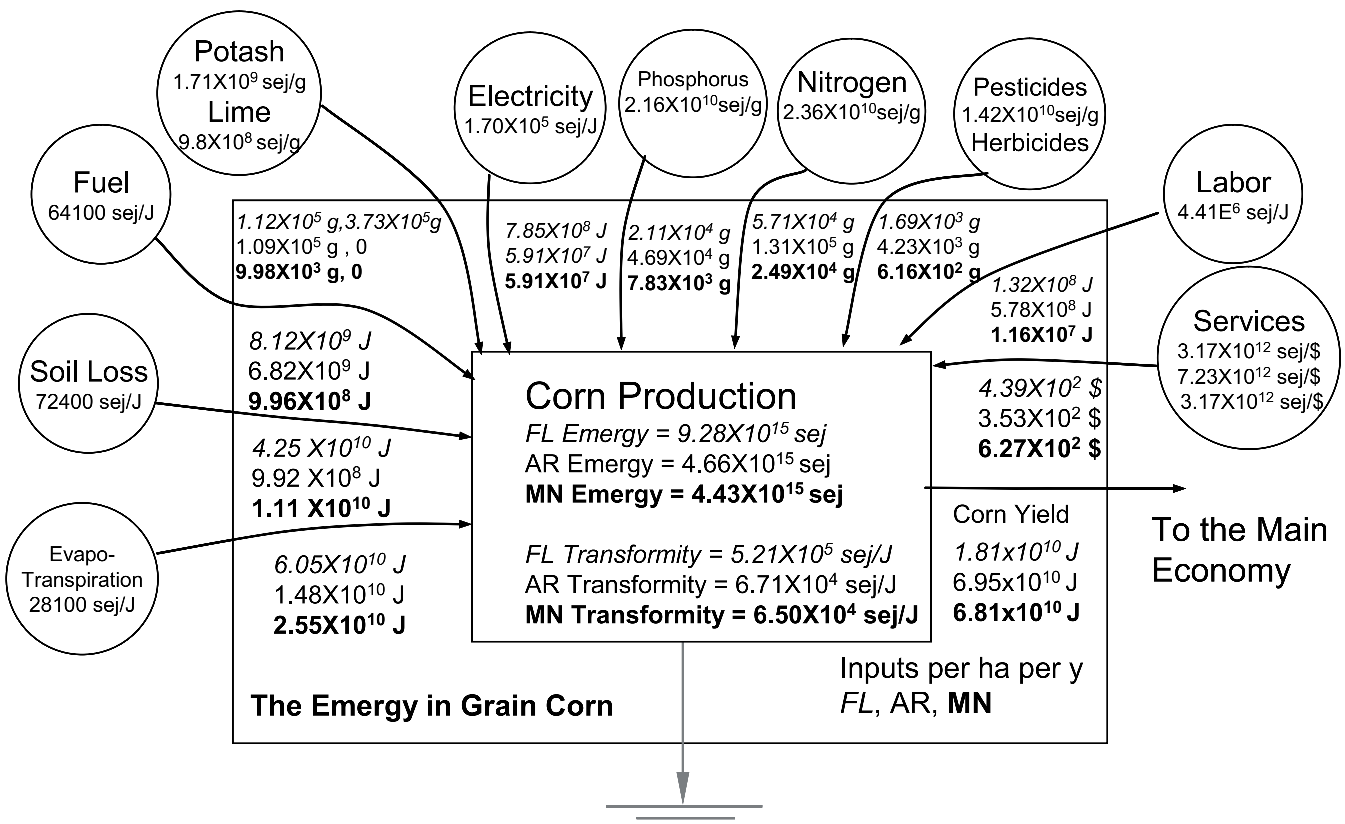


***Figure 1.*** *Emergy can be calculated for anything for which the production process is known. The main emergy inputs required for grain corn produced on a hectare of land in Florida, Arkansas, and Minnesota are given along with the energy yield of corn and the emergy (sej) and transformity (sej/J) of the yield. Florida and Minnesota use Brandt-Williams (2002) as a template. Arkansas uses Odum et al. (1998) as a template, and thus a few inputs are summed but not shown for this state.*

**References**


Brandt-Williams, S.L. 2001 (revised 2002). *Handbook of Emergy Evaluation. Folio #4. Emergy of Florida Agriculture.* Center for Environmental Policy, Environmental Engineering Sciences, University of Florida, Gainesville, FL. 40 p.

Odum, H.T., Romitelli, S., Tigne, R. 1998. *Evaluation Overview of the Cache River and Black Swamp in Arkansas.* Center for Environmental Policy, Environmental Engineering Sciences, University of Florida, Gainesville, FL, 1998.