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Hidden Value in the Steers of Argentina’s Pampas

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ABSTRACT

The internal trade of steers and culled cows in Argentina’s Pampas Region was evaluated from an emergy perspective, a process that can provide a measure of resource use efficiency of grazing cattle. The goal was to quantify the environmental contribution embedded in the product that is not measured in the current marketplace and to discuss the need for different actions by policy makers to recognize the true value of this product. The complete cycle of a grazing system in the pampas was evaluated using data from published national research and environmental publications. Emergy analysis was based on transformities adjusted to a 1996 global emergy baseline of reference. An Emergy Exchange Ratio was calculated as the total emergy inputs divided by product emergy outputs measured in market receipts. Results from the analysis show that farmers invested ten times more emergy from their natural resources and management than they received from the market for steers, and invested eighty-five times more emergy than they received for culled cows due to their low market value. Reasons for this disparity are discussed and new insights are provided regarding how better market policies could be established to promote a more sustainable agriculture and rural landscape.

INTRODUCTION

As with any product, the total value of inputs embedded in Argentina’s steers is much more than the cost of purchased inputs and services and the price in the marketplace reflects apparent social desirability. There is a direct and indirect dependence on “free” environmental contributions that we do not always perceive that are considered external to conventional accounting. Nature provides “life support services” at virtually every scale; many are free of charge or not captured by markets, and many are irreplaceable by technology (Costanza et al. 1997).

An example of the “free” work that the system is providing is ecosystem functions and services. Ecosystem services can be defined as “the benefits human populations derive, directly or indirectly, from ecosystem functions” (Costanza et al. 1997). Ecosystem functions derive from ecosystem structure and process, and are defined by De Groot (1992) as “the capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly.”

Putting value on environmental contributions is controversial and challenging, but necessary (Daily 1999, 2000; Björklund 2000; Cork and Shelton 2000; and Hau and Bakshi 2004). According to Costanza (1994), until now the role of natural resources within the mainstream of neoclassical economics has been deemphasized. However, this role should be addressed because when natural resources are eroded family farms and regional welfare are jeopardized and there are high costs that everybody in society must pay for restoration, as well as for products that depend on these resources.
Emergy methodology seems to be suitable for this valuation and analysis since emergy values embody the services provided by the environment, which are outside the money economy (Brown et al. 2000). Moreover, emergy analysis overcomes the inability of many existing approaches to adequately consider the contribution of ecological processes to human progress and wealth (Hau and Bakshi 2004).

Studies where an emergy analysis has been used include those of Cuadra and Rydberg (2000, 2005), Bardi and Brown (2000), and Rótolo (2005). These are examples where the contribution of natural resources to the production process can be easily identified.

As natural resources strongly support Argentina’s national economic development, the aim of this work is to quantify the environmental contribution embedded in the outputs from grazing cattle systems (steers and culled cows) and to discuss the need for actions by decision makers to enhance and assure the future availability of this resource. For a complete analysis we are missing an emergy evaluation of the slaughterhouse subsystem and international trade. However, the partial analysis presented here provides direction for thinking about what goes into product values from another perspective and contributes insight into valuing life support contributions that are currently ignored or taken for granted. These could be called “hidden values” in the cattle industry from Argentina’s Pampas Region.

**MATERIAL AND METHODS**

This paper is based on the results of an emergy evaluation of the complete cycle operation of a grazing cattle system in the Pampas Region (Rótolo 2005). The general concept and methodology for emergy evaluations are grounded in many publications (Odum 1996; Brown and Ulgiati 1997; and Brown et al. 2000) and thus very brief explanations are given here. Emergy is a systems concept and it cannot be completely understood outside of systems (Brown et al. 2000). Thus it is necessary, as a first step, to determine the window of attention and to diagram the system under study. A diagram in energy system language allows elucidation of the relationships among the units and the overall net outcomes of the system, as well as the resource flows. The second step is to construct emergy evaluation tables based on the diagrams. The final step includes calculation of indices that relate emergy flows of the system to those of society and the environment.

Data sources from several publications, databases, and national environmental institutions were utilized. The system was defined by references from some authors and personal communications with specialists in the field (see Rótolo 2005 for details). The system studied consisted of a cattle herd with a stocking rate of 1.5 EV/ha/year (G.Bavera, Univ. Nacional de Córdoba, personal communication 2005), where one EV (Equivalent Vaca/cow equivalent, or Animal Unit) is a cow weighing 400 kg that produces and raises a calf until weaning at 160 kg (including the hay for the calf). It could also be equivalent to a steer (410 kg) that puts on weight at an average of 500 grams/day on a pasture (Cocimano et al. 1975). The cattle leave the production system for the slaughterhouse with an estimated weight of 400 kg. Animals in the cow-calf operation of the system were fed with 80 percent natural pasture, 10 percent hay, and 10 percent maize stubble. The wintering-fattening phase of the system was based on 70 percent grazing on sowed pasture (mix of legumes and grasses), 20 percent winter annual cereal grazing while in the vegetative stage (system named verdeo), five percent hay, and five percent maize stubble. This last subsystem is supplemented with maize grain during two or three months at an average of 0.7 percent of animal living weight. Horses are used to manage the herd. Emergy analyses of natural and sowed pasture, verdeo, maize, cow-calf operation, wintering-fattening operation, and horse subsystems were prepared and the transformities of their outputs were calculated.

For the calculation of emergy flows, transformities utilized from previous studies were adjusted to a 1996 global emergy baseline of reference (Odum 1996) and the transformity for labor and services was based on a report from Ferreyra (2001), who evaluated the emergy/money ratio for the economy of Argentina during 1996. As the prices were obtained from 2002 and 2005, an index was applied to convert these values to 1996 according to INDEC (1996).
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The Emergy Exchange Ratio (EER), emergy inputs divided by emergy money paid for the marketed product, is the index used for this report. The emergy money is the price of the product times the emergy money ratio. When a product is sold money is received in exchange and both flows are converted into emergy units. The ratio of this index is always expressed relative to one or the other trading partners and is a measure of the relative trade advantage of one partner over the other (Brown and Ulgiati 2004).

RESULTS

An aggregated diagram of the complete cycle of grazing cattle for meat production using energy system language is shown in Figure 1. The contribution from “free” environmental inputs (renewable resources, R) comes from the left in the diagram and accounts for 7.64E+14 sej/yr, which represents 64.5 percent of total emergy yield. Purchased inputs (P) enter from the top, while inputs from the economy (labor and services, S) come from the right side in Figure 1 and also include some contribution from the environment, but from another external system. Soil organic matter (N) is considered a non-renewable, internal resource, at least in the short term, and is internal to the system. Outputs of fatted animals and culled cows (Y) are quantified as they leave the system in the lower right. Of course, all real and sustainable wealth ultimately comes from an environmental system somewhere (Odum and Odum 2001).

Table 1 shows a summary of the main driving forces for the system coming from society and from nature, highlighting the raw values of outputs in both energy and economic terms, and emergy calculations for the outputs. A complete analysis is given in detail elsewhere (Rótolo 2005).

It was assumed that the two outputs of the system carried the same emergy (they are co-products), since they are products of the same sources of inputs, but have different transformities. We did not merge the output as one product (kg of cattle) because they have different final destinies and they are sold for different prices. Besides, the numbers of culled cows (52 kg/ha/yr) and steers (200 kg/ha/yr) that leave the system are different due to the different functions that cows performed within the system before they were culled. When the energy used to make a product is divided by the energy
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Table 1. Summary of emergy table of grazing cattle for meat production.

<table>
<thead>
<tr>
<th>Note</th>
<th>Item/Unit</th>
<th>Data (unit/yr/ha)</th>
<th>Energy per unit (sej/unit)</th>
<th>EMERGY (E+12sej/yr)</th>
<th>% total</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>Renewable Resources (rain + groundwater)</td>
<td>764</td>
<td>64.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>Non-renewable Resources (soil organic matter)</td>
<td>103</td>
<td>8.69</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>Purchased inputs</td>
<td>239</td>
<td>20.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>Labor &amp; Services</td>
<td>78</td>
<td>6.56</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>Output</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>Fatted cattle (J)</td>
<td>2.67E+09</td>
<td>4.43E+05</td>
<td>1184</td>
<td>100</td>
</tr>
<tr>
<td>Y</td>
<td>Fatted culled cow (J)</td>
<td>6.85E+08</td>
<td>1.73E+06</td>
<td>1184</td>
<td>100</td>
</tr>
<tr>
<td>Y</td>
<td>Economic output</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>Fatted cattle (US$)</td>
<td>57.62</td>
<td>1.94E+12</td>
<td>112</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>Fatted cow rep. (US$)</td>
<td>7.04</td>
<td>1.94E+12</td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>

Footnotes: in appendix A

remaining in the product we can derive the transformity of that product. In culled cows there is less available energy remaining per hectare and per year than in steers, so they have different transformities. However, both products have the same emergy because it was necessary to account for almost the same contributions of the total inputs to the process to obtain the outputs.

Cows in the herd have the ability of producing calves, thus all the environmental contribution goes not only to feed the cows, but also to keep the herd going. Therefore, as cows are valuable animals for the system and the herd must be kept young and productive, about 20 percent are replaced each year. Cows have a higher transformity than steers. Both cows and steers are important to circulate nutrients in the system and to maintain soil structure and soil quality, and both are consuming most of the same resources.

The emergy values of the money paid for steers and culled cows that are replaced are drastically different because each product has a different market price (0.48 US$/kg for steers and 0.25 US$/kg for culled cows, Agromercado 2002) and they are commercialized in different quantities/hectare (200 kg/ha-yr for steers, and 51 kg/ha-yr for replaced cow due to the low replacement rate of cows per year). Culled cows usually leave the system as “old” cows according to the market standards. These animals have a very important function for maintaining the production system; however, the market pays less money for that type of animal because they are frequently used for the processing industry instead for fresh meat, which is the fate of most steers. Thus the culled cows require another processing step that needs more energy transformations to obtain a product and is also cheaper in market value.

In emergy values, the results of the transaction between farmer and slaughterhouse showed that eleven and eighty-five times more emergy were delivered in steers and culled cows, respectively, to the buyer than was available in the buying power of the monetary payment (Figure 2).

DISCUSSION

In the Pampas grazing system, the farmer is harvesting and selling energy that has been transformed throughout the process. He utilizes and manages the flows of energy coming from the environment, those coming from society as purchased inputs and services, and also his own energy and converts these into the final product (steers and culled cows), which are transformed into money. The
product obtained, after further processing requiring energy transformations outside farms, is converted by consumers into nutrients represented in their food. Thus we can see that everybody in society utilizes resources and the work coming from the environment, even though this is scarcely accounted for in our contemporary financial transactions. When trading, usually the money received by the farmer is used to pay those who have supplied the necessary inputs and services from the economy. No money is paid to the environment for its work (Figure 3, as adapted from Odum 1996).

**What Is Included in the Market, and What Does the Market Not Value?**

In emergy terms, within any output is embedded all the contributions previously done by nature and people to obtain the product. Then the value or wealth of that product is derived from what goes into it from nature and society, in contrast to what society gets out of it in the conventional way of accounting (Brown and Ulgiati 1999). Emergy results in Table 1 show that embedded in production of steers there is 73 percent contribution from local natural resources (renewable and non-renewable) and 27 percent contribution from purchased input and services. The latter include environmental contributions from outside the system under study. Thus, an emergy evaluation accounts for the flows from any market input and service that contribute to a product, but adds in the vital “free” work that our system is continually doing through ecosystem services and functions.

Different authors describe and classify ecosystem services and functions from different points of view (De Groot et al. 2002; Norberg 1999; and Daily 2000). Utilizing the classification given by De Groot et al. (2002), examples of ecosystem functions are soil formation, nutrient regulation, pollination, atmospheric gas regulation (beneficial to humans and other land-dwelling creatures), climate regulation, biotic regulation, photosynthesis, food, water supply, and examples of regulation and services such as drainage and natural irrigation, storm protection (e.g., coral reef), prevention of damage from erosion, and enjoyment of scenery. The natural resources evaluated in the grazing system studied here contribute to a great extent to many of those services as Daily (1997) clearly explains in the book entitled “Nature’s Services: Societal Dependence on Natural Ecosystems.”

If we focus our attention on the internal Emergy Exchange Ratio for steers, the calculations showed a relation of 11:1 (Figure 2), thus the farmer is sending out much more emergy than he receives in exchange. For example, when the buyer (slaughterhouse) purchases a steer it is paying for the work of the farmer and the people along the line in supplying goods, but it does not pay for the air, water for the cattle and pastures, or the earth for fuel. It does not pay for erosion control in a pasture over five years or for the cycling of nutrients by animals. Since the slaughterhouse receives a product, that is a result of free contributions of nature plus purchased human services, it receives more real

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**Figure 2. Emergy value sent out and received by the farmer.**
wealth than it pays for. Agricultural products contain much more emergy than is usually paid for because money only accounts for the human services and tangible inputs and not for the work of the environmental systems (Odum 1987). Therefore, with an emergy evaluation it is possible to account not only for the contribution coming from society but also for that of coming from the environment, which includes those function and services that are usually underestimated by traditional economic analysis.

In this study, the emergy value of the output (112E+12 sej/yr for steers and 14E+12 sej/yr for replaced cows) includes the emergy value of ecosystem and services as a whole, since our intention was not to discriminate among them. However, we did estimated that 73 percent of total emergy of steers and thus of total emergy value represent local environmental contribution from natural renewable and non-renewable resources where are embedded important functions and services provided by the local agro-ecosystem. All these functions and services have a complex and dynamic connectivity over time following the system principles described by Odum (1996). One function could influence the availability of other functions and their associated services (De Groot et al. 2002). It is not our intention to go deeply into specific functions or services of ecosystems. However, it is necessary to highlight connectivity as a starting point for future discussions to promote environmental actions or programs considering the rural-urban system as a whole. Meanwhile, studies may focus on specific functions or services in the system that are jeopardized. Recognizing this net of complex connections could help us understand the importance of our intervention in the process (i.e., role of steers in the overall system) since each single action will affect more than one ecosystem service, and the consequences often are not immediately visible.

How are these complex questions addressed?

Specialists from different orientations have been dealing with the questions presented above and offer different alternatives (Daily 1999; Brown and Ulgiati 1999; Odum and Odum 2001; Patterson 2002; Cuadra and Rydberg 2005; Cork and Proctor 2005; and Kumar 2005). Even though there are neither agreements nor unique solutions, care of the environment is an issue we all must face if we to be responsible for our future. In this study, the gap between the emergy sent with cattle and the endollars received by the farmer (Figure 2) demonstrates an unfair trade and incomplete accounting.
since an important amount of local environmental contributions are not even being discussed or included in the conventional analysis.

The self-organization of systems explains and shows the links among flows and levels of the system studied. The feeding back and reinforcement of lower units are crucial so that the system can continue to operate (Odum 1987). According to the principle of reinforcement for maximum performance, if those resources from the environment into the production system are harvested and sent without reinforcement, the system is not sustainable in the long run (Odum and Odum 2001). So it is necessary to include reinforcement from the main economy (government, consumers, industries, educational and research institutions) back into the environmental processes (Figure 4).

We have shown the unfair trade in emergy terms where the buyer receives much more wealth than he pays for and suggested that adequate feedback or reinforcement does not occur. To find ways to reinforce local renewable and non-renewable resources embedded in the product is a vexing and difficult challenge. However, this analysis raised issues that we need to discuss for the future welfare of farm families, the region, and the country.

As currently practiced, agricultural subsidies and taxes intended to be allocated as payment for more sound agriculture appear to be an inadequate solution. According to Lingard (2002), agricultural subsidies planned to care for natural resources do not always benefit the environment. Likewise, the implementation of taxes may not only cause social disturbance if they are transferred as an increase in cattle prices, but also may not accomplish their objectives. Thus, money paid for system resource inputs goes largely to human extractors in exchange for their work in obtaining resources, rather than being used as a form of compensation for the free work of the environmental systems that produce the resources (Huang 1998). Thus, according to Odum and Odum (2001), money and market values cannot be used to evaluate resources from the environment since they account only for the human part of the work. Then an emergy analysis, involves both the environmental and socio-economic contribution to a product or service. Therefore, it seems to be a more objective method of valuation since it values the system, utilizing a common unit, from a donor point of view instead of the willingness of society to pay.

Farmers are usually the stewards of those natural resources that provide vital functions and services for humans and other life. They feed back into the system according to their understanding of management and responsibility for resource stewardship (Figure 3). Farmers have to bear the everyday challenge of making choices according to the traditional market fluctuation, sometimes being pushed to almost exhaust their resources, in order to maintain their family income and well-being. So farmers should be supported in their actions of taking care of those resources by enhancing the management of

Figure 4. Reinforcement of environmental process from the main economy (adapted from Odum 1996).
storage resources through crop-animal rotation, fields lying fallow, sowing legumes, promoting the use of minimum purchased inputs for the production systems, and enhancing research, education, information flow and the production of local technologies. This support should come from different sectors of the society in different ways (Figure 4) and should be decided through clear communication and networking among all those involved. This communication among sectors of society might be a challenging task, since according to Daily (1999) there should be first a scientific understanding about human – environment interaction because scientists’ initiatives are important to foster substantive communication on environmental issues with leaders in the social sciences, business and government. However, today there is an increasing number of scientists who are re-examining the man-nature links and attempting to make this clear to the public, as well as to their colleagues (Limburg and Folke, 1999).

The trade-offs in allocation of resources are difficult and controversial. They involve not only local, regional, and international levels, but also, according to Daily (1999), they involve “our most important ideals (such as ensuring a prosperous future for our children), our oldest tensions (such as between individual and societal interests) and sometimes our bloodiest tendencies.”

On one hand, education, information, interactive communication, techniques, and technology seem to be the ways to start addressing the question of acknowledging or placing value in some way on environmental functions and services hidden or not really taken into account in the market value of the products. On the other hand locality seems also to be the most suitable starting point since information, techniques, and technologies are easier to communicate and discuss in close spatial proximity. This provides a starting point to collaborate with higher decision-making levels (national and international) where we can provide some insight to policy makers. “Think globally, act locally” (Esteva and Prakash 1994). Each region has their own particular natural resources and it needs to feed them back with different information or technologies that are specific for certain context and society. For that reason, it could be reasonable that the actions taken for recognizing and restoring the function and services exported within the products or services produced by a region, are discussed and decided among the actors living in the region with a national scope and long-term vision. Thus, a way to recognize our dependence on nature and to start evaluating and caring for its functions and services is to gain understanding of the issue through a participatory community process. Cork and Proctor (2005), as part of the Ecosystem Services Project in Australia, have designed and implemented a multiphase interactive process among scientists, policy makers, land managers, and community representatives in order to broaden public understanding about the natural ecosystem in the country. The same authors obtained many interesting outcomes, among which they say that “many farmers understood immediately that their business is managing ecosystem services on behalf of society and that these new buzz words potentially gave greater recognition to the role of land managers in society.”

Therefore, one way that nature work embedded in the output of any process could be fed back by society is through finding local alternatives, inserted in a national framework, where society could participate. Understanding these mechanisms, we can be sure that actions are really targeting ecosystem function and services with a holistic point of view through the creation of local-regional environmental centers. According to Cork et al. (2001) a key issue raised by a focus on ecosystem services is the need to encourage investments in the full range of services rather than allowing imbalance to be introduced by haphazard investments in one or a few at a time.

Today there are different alternatives for feeding back and recognizing nature’s work. Odum and Odum (2001) propose a series of actions and policies to slow down the disproportionate consumption of a sector of the society and to enhance nature’s contribution in everyday activities and everyone’s life. New Zealand’s government reinforces land productivity through aerial spreading of phosphate fertilizer over pastures (a kind of subsidy) (Odum and Odum 2001). Cork et al. (2001) refers to the Ecosystem Service Project where innovative ways allow investors to contribute to and benefit from regional environmental “banks” that are guided by strategic planning for balanced environmental outcomes.
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CONCLUSION

The emergy evaluation that we have conducted of Argentina’s Pampas grazing systems provides new ways to give more accurate accounting of the value of work by nature that end up in financial trade. The local environmental contributions in steers from natural renewable and non-renewable resources (73%) that are embedded in the cattle emergy value sent to the slaughterhouse represent some of the key functions and services on which production, food, and local community rely. Based on these calculations, the emergy value in steers is ten times their current value in the marketplace, and the emergy value in culled cows is eighty-five times their market value. Understanding the complex and dynamic connectivity among ecosystem functions and services, and the lack of recognition of the real emergy value of products in the marketplace, should compel us to think carefully before deciding on market, export, or environmental incentives for any specific practices.

This analysis provides us with useful information about the fate of real wealth of local communities and farmers. The results suggest that conventional financial accounting is insufficient to measure long-term sustainability of an agricultural system. This information could be useful for different actors in society and the food system, and all possible tools should be used to evaluate current systems and those proposed for the future. It is especially useful to remember that “nature could survive without me, but I could not survive without nature” (Odum and Odum 2001).

REFERENCES


Chapter 32. Hidden Value in the Steers of Argentina’s Pampas.


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APPENDIX A

**R: Renewable Resources:** (sun; rain; wind; earth cycle; groundwater); **N: Non-Renewable Resources:** (soil organic matter); **P: Purchased Inputs:** (foil; seeds; fertilizers; agrochemicals; machinery; buildings; minerals supplements; bull replacement; horse replacement; wood (sleeve, corrals, fences); wire (sleeve, corrals, fences); mill and Australian tank; drinking trough and bath and **S: Labor & Services:** infrastructure, goods, health; bull and horses (Rótolo, 2005).

**Y: Output:**

1. **Fatted cattle:** 400 kg (estimated living weight; Gonella, 2000; Agromercado 2002) x 0.5 EV/ha x 13.36 MJ/kg (Viglizzo et al., 2001) x 1 x 10⁶ J/MJ = 2.67 x 10⁹ J/ha-yr. Transformity from this study. 
2. **Culled fatted cow:** 420 kg (assuming final weigh culled cow - Agromercado) x 0.12 EV/ha-yr (20% of reproductive cows; assuming that they are 60% of the cargo – 1 EV/ha-yr - during 2month = 0.02EV/ha-yr) x 13.36 MJ/kg (Viglizzo et al., 2001) x 1 x 10⁶ J/MJ = 6.85 x 10⁸ J/ha-yr. Transformity from this study.

**Economic output:**

3. **Fatted cattle:** Source from Agromercado, 2002. (0.48US$/kg (average price among all categories) - 5.3% tax - 0.02 US$/kg for 200 km transport) x 200 kg/ha-yr (400 kg average weigh x 0.5 EV/ha-yr) x 0.67 factor conversion to 1996 US$ (INDEC) = 57.62 US$/ha-yr. Transformity by Ferreyra (2001).

4. **Culled fatted cow:** Source from Agromercado, 2002. (0.25US$/kg (average price) - 10% tax - 0.02 US$/kg for 200 km transport) x 51.24 kg/ha-yr (420 kg average weigh x 0.02 EV/ha-yr) x 0.67 factor conversion to 1996 US$ (INDEC) = 7.04 US$/ha-yr. Transformity by Ferreyra (2001).