# Ecological economics – Towards a synthesis of two disjunct disciplines

*M. K. Pandit*

*The basis of all human activity is the use of natural resources, which also constitute the basic life support system. All economic activity, directly or indirectly, derives its sustenance from the environmental resources. The correlation between economic growth and natural resource depletion has of late attracted the attention of economists, but they form only a minority. The present article addresses basic issues leading to differing perceptions among ecologists and economists as far as economic growth is concerned and also tries to explore how this gap could be narrowed. The paper also reviews in brief some of the most recent international debates relating to ecological economics. The intricate problems of economic evaluation of ecosystems and the difficulties encountered in this process have been highlighted.*

THOSE of us who were fortunate to have gone through the special issue of *Ecological Economics*[1] would agree how a meaningful dialogue between ecologists and economists has attempted to bridge the wide gap between the two most dominating disciplines of the twentyfirst century. This process had, however, started much earlier with the works of Costanza and Daly[2], Costanza[3], and Maxwell and Costanza[4]. The Asko meeting, organized by the Beijer International Institute of Ecological Economics in September, 1994 in the archipelago outside of Stockholm, was an important landmark in further concretization of this process of dialogue and consenus. The participants included eminent economists and ecologists and the dialogue resulted in a joint article by the distinguished scholars, led by Kenneth Arrow, which got published in *Science*[5]. However, Robert Costanza, a co-author of the Arrow *et al.* article, in his introductory essay on 'Economic growth, carrying capacity, and the environment' in the special issue[1] has outlined the reason that 'like any consensus statement, Arrow *et al.* leave many things vague and only scratch the surface of many others[6]'. It was, therefore, logical to elicit further response to the paper from a group of invited scholars, who could feel free to offer positive, negative or both responses which is not possible in a consenus group. These responses were slated to be published in three separate journals and one of them is *Ecological Economics* which is being discussed here. One of the commentators[7] in the issue pointed out that the article by Arrow *et al.* was some sort of 'dog bites man story', in the context of 'the article's authorship, novelty of the concept and the journal's prestige and readership'. That was perhaps the reason it initiated a debate and a discourse which could have academic implications on one end and possibly political on the other. However, in terms of the novelty, it does not seem to be a 'man bites dog story' as was said to be. There are indications of such a thinking in economics much earlier. Here it would be interesting to refer to an obituary essay by Herman E. Daly[8] who, while paying tribute to his distinguished teacher, Nicholas Georgescu-Roegen, mentioned that there was a great need for introspection among economists, who refuted Georgescu's revolutionary ideas not by reasoning, but rather by keeping silent or making 'the lame remark' that his recent work was 'not really economics'. The revolutionary ideas were contained in Georgescu's *Entropy Law and the Economic Process*[9] and *Analytical Economics*[10], but even after three decades standard economics textbooks have ignored these reformist ideas of Georgescu-Roegen. Daly in this essay has drawn the readers' attention to Paul Samuelson's Preface to *Analytical Economics* in which he referred to Georgescu-Roegen as a 'scholar's scholar', an 'economist's economist' and eulogized him elsewhere by saying, 'I defy any informed economist to remain complacent after meditating over this essay'. But what was preached was never practised. Samuelson's 'influential textbooks', to quote Daly, have not contained a trace of Georgescu's ideas. Why, for example, was it not possible for the concept of 'entropic flow' to occupy the core of economic theory? The 'circular flow' continued to have sway over economic policy because in this path it was theoretically possible to achieve a continuous economic growth through abstract exchange value (debt, purchasing power) which has no physical dimension[8]. For example, the circular flow diagram conveys the meaning of the economic process as an iso-

M. K. Pandit is in the Centre for Inter-disciplinary Studies of Mountain & Hill Environment, University of Delhi South Campus, Benito Juarez Road, New Delhi 110 021, India.

lated circular flow from the manufacturers to the users and back again, without any inlets or outlets. In sharp contrast is the Georgescu-Roegen's view of one-way flow which begins with resources and ends with waste. He called it 'entropic flow' and highlighted its role in the maintenance of economic process. In his analysis he brought out clearly that the entropic flow necessarily induces changes in the environment on which it depends, because what is released as waste is qualitatively different from what is taken in[8]. Georgescu also explained that inclusion of physical dimension in the circular flow of economic process had not been considered at all by economists. Georgescu-Roegen used the second law of thermodynamics or the entropy law to explain the matter–energy flow in economic process by relating it with the environment in terms of resource utilization and production of waste. Consider conversion of soil (clay) into bricks which are then used for construction of a building and one can in no way retrieve soil from the concrete mass. Also add to the process amount of energy used up in converting clay into bricks. The system, therefore, ends up with taking in low entropy energy-matter and producing high entropy energy-matter. Daly argues that growth in entropic flow encounters physical barriers like depletion, pollution and ecological disruption. Since, in mainstream economics, growth in GNP has been treated as synonymous with the economic growth, it has been impossible to set limits to which resources can be exploited and converted into capital. Georgescu-Rogen considered substituting capital for resources, an idea propounded by the neoclassical school, as the cardinal sin of economics. He therefore, could not perhaps expect a better deal from his peers. So much for the 'disciplinarian' attitudes.

## Ecology and economics

There is a highly striking similarity between physical sciences and economics, of course via mathematics, in achieving results through submission to experimental data and their verification by empirical evidence. Also that when 'economic phenomena are analysed thoroughly they display existence of regularities which are just as striking as those we find in physical sciences'[11]. It is this virtue of economics which has been exploited in the past and also in the present day neoclassical thinking. For instance, the theory that the resource constraints of entropic flow can be overcome by substituting capital for resources owes its origin to the Cobb-Douglas type production functions. But in reality how much substitutability is possible between fund and flow remains a moot question! Conversion of resources into capital would follow that not only more capital is required for the purpose, but also more resources are needed to generate fund flow. More production to generate capital would also result in depreciation, depletion, pollution and disruption. In the words of Daly, 'to conceive of capital as a near-perfect substitute for resources, as is frequently done under the influence of Cobb-Douglas type production functions, is to believe that one can make the same house with twice as many saws, but half the lumber. Not to mention the problem that more saws require more resources for their production[8]'. It is on this count of over-mathematization of economics and the elevation of technique over substance[12] that has, in a way, led to the wedge between ecology and economics.

Biology in general and ecology in particular, compared to other scientific disciplines, seem to exhibit lesser regularities/generalities which could be analysed and forecast. 'Ecology has deep-rooted characteristics that make its problems more difficult to solve than, for example, those of physics[13]'. Therefore, modelling exercises and projections, derived through mathematical equations, for solving ecological problems, more often than not, fall flat while dealing with the intricacies of life phenomena. Since problem solving is a difficult task in ecology, some authors have defined it as 'the most intractable legitimate science ever developed[13]'. Consider extrapolation of an observation made on one organism to all organisms inhabiting the same ecosystem. For instance, temperate forests in Alps and Himalaya harbour *Sorbus aucuparia*, cannot be generalized to mean that biotic communities of the two biomes are similar. Similarly, populations of a species, distributed in time and space, may have similar genetic make up, but differ greatly in their ecological properties. Prediction of likely habitats of these species-populations, using analytical tools, simply does not work because populations of same species may inhabit extremely contrasting habitats. A practical weakness of the approach, using regularity or generality as a basic criterion in problem solving in ecology, is that predictions generated are not sufficiently precise to answer specific questions about specific individuals and localities. Similarly, theories like sigmoid population growth equation, also known as logistic or Verhulst-Pearl equation, are 'pedagogically useful but not applicable to specific situations, because they ignore such complications as age distributions, time lags and nonlinear interactions that characterize actual populations[14,15]'. The problem is further complicated when equations and the analyses derived from these are applied to complex life-form situations like ecosystems.

One such analysis, based on equations and extrapolations, which has of late attracted great attention among economists and biologists alike, relates to environmental and natural resource accounting. A plethora of literature is now available on the subject of system of national accounts (SNA) and a review of the debate was published by UNEP in 1993 (ref. 16). In the majority economic view, the basic assumption in the whole SNA analysis revolves around the GNP as the index of growth, which in turn is based on the quantification of goods and services, and stocks and flows. There is, however, a growing realization among economists that if the welfare of future generations is to be kept in mind then the net national product (NNP) is a better index than GNP. These economists[17] are of the view that 'changes in stocks of natural resources have typically not been included in the SNA. As many of these resources generate essential life supporting services, their exclusion may severely distort the NNP estimates. It should be of highest priority to try to include changes in the complete asset base in the accounts'. Even for estimation of NNP, in the ecological context, the evaluation will embrace the natural capital, which is an ecosystem or the species therein. For estimation of NNP, it is natural that, while taking care of the ecological constraints, we must resort to shadow pricing of goods and services of an ecosystem. To achieve this sub-goal it is necessary to build demand supply curves for the various ecological functions. A number of methodologies are being attempted internationally to evaluate ecological functions in terms of services, but agreement on these seems a remote possibility, even among economists[16]. It is extremely difficult to build demand supply curves, precisely because we are unable to know how and which functions to quantify in an ecosystem. Applying economic tools of shadow pricing would involve methodologies like opportunity cost, revealed preferences, willingness to pay and accept, travel cost and many more. All these methodologies suffer from one basic flaw – they are all anthropocentric and thus ignore all real natural functions of an ecosystem. It can be argued here if there can be any other view than 'anthropocentric' in economics. At the outset it seems extremely difficult and impracticable, but in long range view, economics cannot escape from the reality that the resources, which form the feed of economy, cannot be exploited unsustainably for long. Economics has to be on the lookout for alternate development paths, which are sustainable. Carrying capacity based development and the holistic context of institutional economics are some of the useful approaches for achieving sustainability[18,19].

On a somewhat transformed note the neoclassical school believes that after all one can quantify most of the variables operating within an ecosystem and model the effect of different scenarios that could arise and, therefore, select a development path that could be termed as sustainable. As stated above, whatever be the methodology this analysis cannot escape the basic bias towards human species and the subservience of all other life to it. Let us take an example of a terrestrial ecosystem and consider whatever could be natural functions of a pristine ecosystem and then let us also find out what are human aspirations linked to this ecosystem (Figure 1).

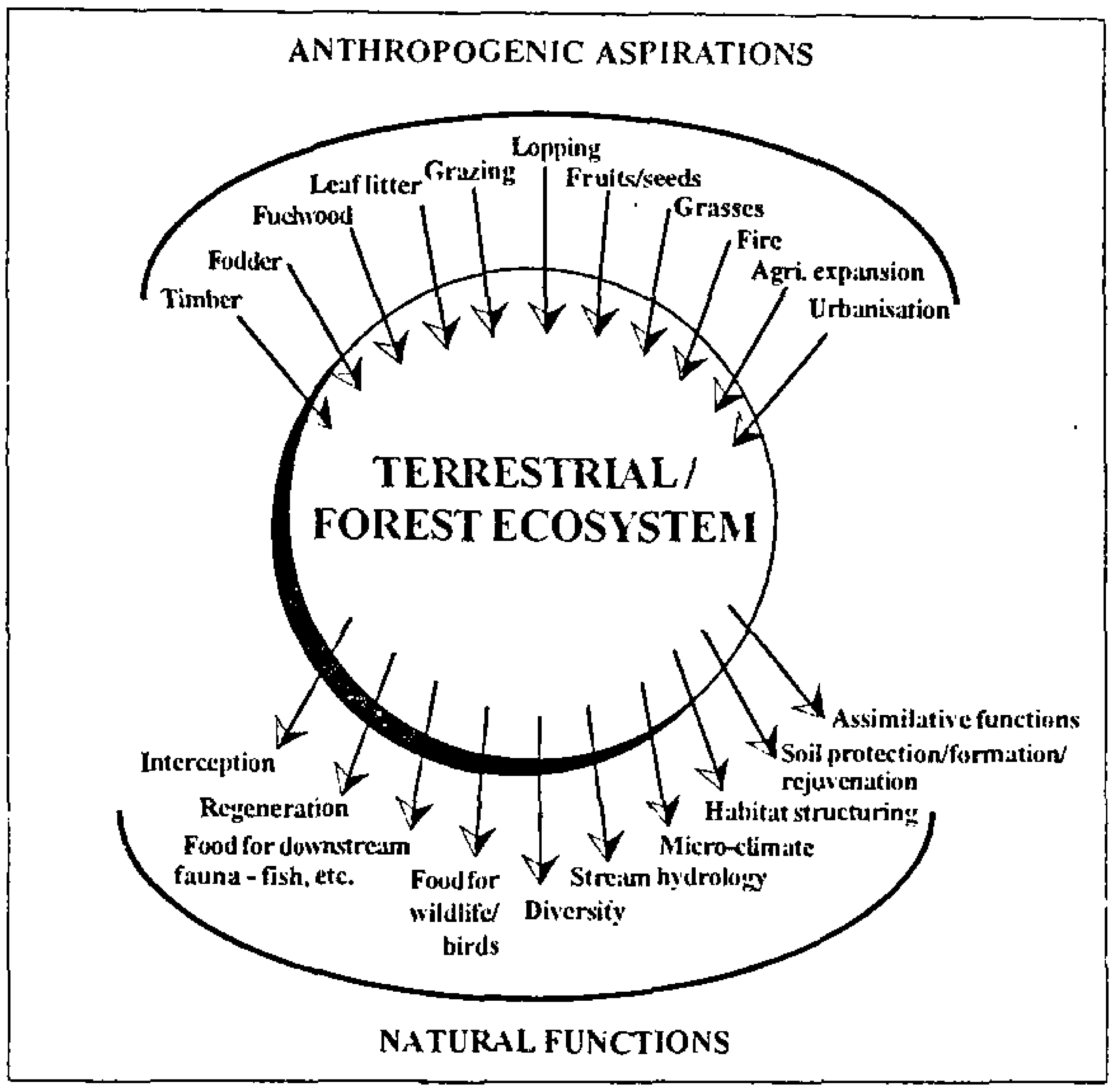


**Figure 1.** A simplified summary of anthropogenic pressures on a forest ecosystem and its natural functions. Note the diversity of natural ecosystem functions ranging from maintenance, regulation, habitat structuring, assimilation, etc. Any one or a mix of human activities as shown in the top of figure can severely damage or reduce the natural functions, which in turn would destroy the very base on which that human activity depends. Such natural functions, therefore, cannot be ignored while attempting natural resource accounting.

**Table 1.** Components included in modified forest accounts

| Yield | Maintenance | Stock |
|---|---|---|
| Timber | Maintenance | Forest inventory |
| Harvest of berries | | Berry-yielding herbs |
| Mushroom | | Mycelium |
| Meat (bag) | Game protection | Game population |
| Recreation | Various activities | Various |
| Biodiversity | Fauna/flora protection | Survival conditions |
| Effects on hydrological flows | Measures that affect run off | Forest inventory, bare lands, ditches, etc. |
| Fixing of carbon | Silviculture and boarding (non-harvesting) | Carbon pools |
| Buffering of acid rain, tree nutrition | Liming, fertilization | Content of exchangeable base cations in soil and vegetation |
| Nitrogen leaching | Construction of nitrogen sinks | Nitrogen-fixing capacity |
| Reindeer forage | | Lichen stocks |

Source: ref. 20.

From an economic analysis point of view, accounting in a natural ecosystem is done broadly for its functions like production/yield, maintenance and stock (see Table 1). When we try to understand the natural ecosystem

**Table 2.** Modified NNP accounts for income from Swedish forests, 1987

| | |
|---|---|
| Market value of timber | 18.63 |
| Inputs from other sectors | –3.14 |
| Stock growth | 3.8 |
| Silviculture | – 1.55 |
| *Subtotal 1* | 17.74 |
| Berries | 0.5 |
| Mushrooms | 0.55 |
| Meat from game | 0.47 |
| *Subtotal 2* | 1.52 |
| Biodiversity | – 0.6 |
| Carbon pools | 3.8 |
| Exchangeable cations in soil | – 0.6 |
| Lichen stocks | – 0.02 |
| *Subtotal 3* | 2.58 |
| **Total net income** | **21.84** |

Source: Adapted from ref. 20. The figures are in billion SEK.

functions as outlined in Figure 1, it would be clear how little justice we do to ecology by evaluating or accounting only that which is of direct benefit to *Homo sapiens*. The natural functions listed in the Figure 1 may again only be a miniscule of the total processes operating and products being generated within that ecosystem. The evaluation leaves no scope for assessment of countless interactive processes which operate on a time-scale varying from millionth of a second (at molecular level) to millions of years (at ecosystem level). Table 2 represents the results of an exercise some authors[20] in Sweden carried out based on the components selected for accounting as shown in Table 1. One can, almost instantly, see a dichotomy between the desired outcome and the actual outcome. It is only timber, berries, mushrooms and meat from game which are added to accounts. However, the most important part, the biodiversity, which has made all other functions possible is subtracted, as if it were a liability on the system. Timber, berries, mushrooms and meat all consumed by man, are therefore, not natural functions of an ecosystem to the extent that man has extricated himself from this ecosystem through a 'civilizational process'. His dependence on forest produce cannot be equated with that of a tiger, elephant or a reindeer. Man's relation with the forest is increasingly becoming a unidirectional process, while that of wildlife is dynamic and losses and gains flow both ways.

What is, therefore, important is the understanding that *the wood* is not timber alone. What is also important is that inventory of species, as outlined in Table 1, cannot be accounted separately; the *parts* cannot be summed up as a *whole*. A forest cannot be treated like a car whose chassis, engine, gear box, etc. can be accounted individually and then totalled into an entity called car. What needs to be appreciated is that a structure we term as an ecosystem is the product of millions of years of interactions and adjustments among its components, and its biotic and the abiotic characteristics. Therefore, evaluating only a tiny fraction of this vast organism, spread both in time and space, can only be a notional exercise. The results of such an exercise, based on half truths, are going to be grossly misleading. The argument that some data, which can be bad data, is better than no data[21] is bad in intent in the same way as bad economics cannot be better than no economics. The reason is preference, while accounting, to some data like timber or non-forest timber produce over other species of seemingly modest standing in a natural ecosystem. It leads us to a situation where it becomes terribly bad ecology. In a natural ecosystem there are no preferential treatments – the high and the lowly, the mighty and the meek, are allocated resources on an equitable basis. The evidence for this comes from the fact that in a climax natural ecosystem it is generally *K-selected* species, which co-exist with a high degree of species diversity, and leave enough resources and space for others to prosper. In sharp contrast is the situation of the highly-disturbed ecosystems where it is mostly *r-selected* species, which are weedy, allelopathic and dominate to oust others. Applying classical or neo-classical economic approaches to ecosystem analysis for resource accounting would sharply bring into focus that face of economics which will juxtapose human selfishness with the co-existing nature of ecology operating in natural ecosystems. It is here that the role of eminent and influential economists can bring about a positive transformation, which shall not be perceived as correction of current and prevalent economic thought, but its evolutionary responsibility.

Keeping in mind the long term goal of sustainable development, many seminal thinkers of this century have discussed the relation between economic growth and environmental quality, and the link between economic activity and the carrying capacity and resilience of the environment. The debate aimed at establishing a substantive dialogue among economists and ecologists or exploring the possibility of an interdisciplinary consensus on the issues of economic growth, carrying capacity and the environment is a well-directed step towards synthesis of the two disjunct disciplines[1,5]. These useful efforts have to be received with admiration, support and understanding, for that can help us in evolving a methodology that allows the coming generations of *Homo sapiens* and also our contemporary life-forms to feel secure and assured of life enjoyment as is intended in the best spirit of economic thought. It is in this context that economics can find ecology to be useful. Economics tends to assume that change takes place in a fairly continuous fashion, but change in an ecosystem may be of capricious nature resulting from the response to destabilizing factor/s rather than a process of graduated change[22]. From ecology we learn the lesson of 'holism'. In other words, if environmental responses to economic change have to be predicted, various interactions and links within and between ecosystems have to be fully fathomed. The concern – how can one dispense with the anthropocentric principle of value in economics and how can a 'holistic' state be accomplished – may be genuine. But if the aim of sustainable development has to be achieved, a realization must start in right earnest that 'ecologically bounded-possibilities of using natural resources are taken as a normative starting-point for the development of economic theory[18]'. There is a great and urgent need to strengthen the new school of thought based on an institutional framework. This framework shall neither be based on anthropocentric and close-ended mathematical models, nor on a reductionistic–mechanistic argument, but on a holistic, evolutionary, open-ended and pluralistic methodological paradigm. These reformist views[23] have started gaining acceptance among economists, though only in a limited way. If we fail in this endeavour then the existing imbalance of power in the society, which helps the 'vested economic interests to put their individual short-term aspirations ahead of the collective and long-term interests of a sustainable society', will continue to increase[18]. Our success will lie in forging towards an ecological-economics synthesis. Barbier *et al.*[24] have enunciated a number of steps to enable this synthesis. Better communication between different disciplines and development of inter-disciplinary approach have been suggested to be the first step towards this goal followed by improved research collaboration between organizations and individuals. This aim could be an achievable one. After all there are many common grounds of meeting in ecology and economics – equity, resource allocation, micro-economics (welfare of individuals/species), macro-economics (welfare of populations/communities/ecosystems/biosphere), stocks, flows, goods, services, etc. These are not merely semantic similarities, but real scientific regularities shared by the two disciplines. Ecology and economics are not such aliens to each other as many sceptics may think.

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