SCHRIFTENREIHE

SOZIALE ÖKOLOGIE

BAND 24

PURPOSIVE INTERVENTIONS INTO LIFE PROCESSES:
A Neglected "Environmental" Dimension of the Society-Nature-Relationship

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WIEN, 1992

PAPER TO
THE 1st EUROPEAN CONFERENCE OF SOCIOLOGY, VIENNA 1992

Impressum
Medieninhaber, Verleger, Herausgeber:
Interuniversitäres Institut für interdisziplinäre Forschung und Fortbildung (IFF),
Abteilung Soziale Ökologie, A - 1070 Wien, Seidengasse 13
Tel.: 0222-526 75 01-0, FAX: 0222-523 58 43

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Purposive Interventions into Life Processes: A Neglected "Environmental" Dimension of the Society–Nature Relationship

Marina Fischer–Kowalski and Helmut Haberl[1]

1. Introduction

What can a sociologists' professional task regarding "environmental problems" be? The most obvious approach is insinuated in the title of this section of the European Conference: "Environmental problems". Sociologists like to deal with "social problems", and as soon as environmental issues give rise to social struggles of some kind or other, sociologists feel apt to deal with such struggles as they may deal with social struggles over any other issue. They are treated as an intra–society event, involving different consciousnesses, interests, groups, habits and social experiences that interact in some ways as is the case with all other "social problems" ready to be analyzed by sociologists. This in no way is a fundamental challenge to sociology. It is equivalent to political science's treatment of environmental policies and politics in analogy to other policies, and equivalent to economist's analysis of environmental protection expenditures as corrigenda to the national product such as welfare expenditures may be.

Might sociologists ask more fundamental questions? And might they be able to provide some theoretical and methodological framework to analyze the interaction between society and nature?

Well a decade ago Catton & Dunlap (1978) suggested it would require a new paradigm within sociology to successfully deal with the relationship society–

nature. They accused the social sciences and sociology in particular to follow a "human exceptionalism paradigm" (HEP) that would not allow human beings and society to be viewed as "one among other" forms of life on this planet, as part of the "web of nature". They outlined some general features of what they called the "new environmental paradigm" (NEP) required for a fundamentally different approach. Such a paradigmatic change has not taken place, as far as I can see (see Dunlap & Mertig 1991; Devall 1991). And I can well understand how highly uncomfortable such a paradigmatic change for sociology would be: as uncomfortable (if not irreconcilable) as a "no growth"-perspective is for modern economics.

The vantage point for a paradigmatic change is a preconception that there is something going wrong in the society-nature-relationship, that society behaves in a way that destroys the natural basis it rests upon. It is a matter of debate, how radical this "wrongness" ought to be conceived: whether it is a matter of minor amendments or of imminent danger to survival, whether it is something that will more or less regulate itself or will require massive intervention or cannot be regulated by society at all anyway – all these conceptions exist, among sociologists as among all other people, and there seems to be no professional consensus among sociologists about the means and ways to approach truth.

2. Distinguishing between "harmful" and "harmless" exchanges between society and its natural environment

There exists a variety of conceptions to distinguish between what is "good" (or at least harmless) and what is "bad" (harmful) for the "natural environment". These conceptions vary according to scientific discipline and according to political (or ethical) understanding of the man-nature relationships.

We think this variety of conceptions can be ordered into four basic paradigms:
- "poison paradigm"
- "natural balance paradigm"
- "entropy paradigm"
- "conviviality paradigm".

Each of them is guided by a specific reference concept, and each of them is able to catch important aspects of the possible meaning of "damages" society causes to its natural environment. The paradigms are not mutually exclusive in the sense that one specific aspect of environmental damage might not occur in more than one of them. But they cannot be reduced upon one another, nor can they be merged into one single "grand paradigm".[2] Each has its specific structure of reasoning, its own scientific and political tradition, and its audience. But all four paradigms taken together permit a complete scanning of what can be meant if people talk about the socio-economic system "causing environmental damage".

The "poison paradigm" is probably the most widespread one in common understanding of "environmental problems". It is derived from the scientific understanding of medicine and chemistry. This paradigm views society as producer of (chemical) substances which emitted into the environment cause disturbances that directly or indirectly act back upon society in a noxious way, mainly in a way endangering human health. Environmental regulation is then basically understood as control for noxious emissions.

The "natural balance paradigm" is rooted in the scientific traditions of biology (also shared by agricultural scientists, climatologists, and most nature-protection agencies). In this line of reasoning society is viewed as an agent who – intentionally or not – intervenes into the functioning of natural systems in a way detrimental to their self-regulation. Thus society is suddenly confronted with a situation in which some natural systems do not function any more in the way society is accustomed to and has learned to rely upon. In this paradigm environmental regulation is understood as protection of the sensitive aspects of biosystems against human intervention. This is quite a different understanding than within the framework of the "poison paradigm". The environment is seen as an ensemble of selfregulating systems in which chemical substances play one part among many other. The very same substance can work once as a nutrient, and at another time (and place) as "poison". And many other interventions apart from chemical substances count: be it the regulation of rivers, the importing of alien organisms or the use of heavy machines. There cannot be distinguished between "harmful" (e.g.noxious) and "harmless" interventions, since this depends entirely upon the sensitivities of the systems concerned.

The "entropy paradigm" is founded in theoretical physics, the so–called laws of thermodynamics, and at the same time relates well to economics. All processes are processes in which energy is used; it is not "used up" though, but only changed in quality: it becomes dispersed, less concentrated. In other words, its entropy increases. In an isolated system each process can only increase, but never decrease entropy – and finally all processes stop (see Prigogine 1990). Within this paradigm society is viewed as s system that exessively contributes to the production of entropy by not confining itself to the use of energy provided by the sun, but by using up energy reserves of this planet stored up for ages. The central environmental question according to this paradigm is therefore the speed with which society uses up (or rather: devaluates) resources in relation to the speed with which they are being reconstructed. Does society live upon natural "income" or upon natural "capital"?

The "conviviality paradigm" is founded in philosophical and ethical traditions that don't consider the human species entitled to exert its rule over all other species on this planet. Nature is not simply viewed as an "environment", but rather as "Creation" to be respected. Society (or often more simply: mankind) is regarded as an apparatus that increasingly dominates more parts of this planet and more life processes of other species and functionalizes them according to its own needs without respecting the needs of others (e.g.Devall 1991). The environmental question to be asked is the following: By which activities does society (unneccessarily) destroy, harm or dominate the living conditions of other species? How can the degree to which mankind lives at the cost of others be reduced?

Let us illustrate the functioning of the four paradigms for a special case: the damages caused by car traffic.

(1) In the "poison paradigm", the main argument would be: Car traffic causes about 60% of the toxic gaseous emissions to the atmosphere (CO, NO_x, C_xH_y). Thus limiting volumes for the exhaust should be issued. Catalytic converters are a good solution, since they reduce toxic emissions by 80% or more.

(2) In the "natural balance paradigm", it would be said that car traffic contributes with about 15% to the destabilization of the earth's climate, and also affects several ecosystems severely. Catalytic converters would not do, since they cannot reduce CO_2, but maybe electric or solar cars could.

(3) In the "entropy paradigm", it would be argued that car traffic requires about 50% of the end-consumption of liquid fossil fuels. Thus we need a technological innovation towards solar cars, for example, while catalytic converters are relatively irrelevant or even counterproductive since they require platinum, a very rare resource.

(4) In the "conviviality paradigm" attention would be drawn to car traffic as a major cause of unintentional and useless animal killing (insects, birds, rodents, amphibious animals etc.). It would also draw attention to the road system cutting the living space of many species into areas too small for a decent life and exposing them to all kinds of disturbances. Solar cars wouldn't help.

We think that an adequate understanding for environmental impacts of the socio-economic system should bear reference to all these four paradigms and should contain information concerning the central set of variables in each of them. It should not deprive any one line of reasoning of its possible empirical basis, or priviledge one over the other. Political discussion and the political decision making process would then have to weigh arguments and to solve existing contradictions.

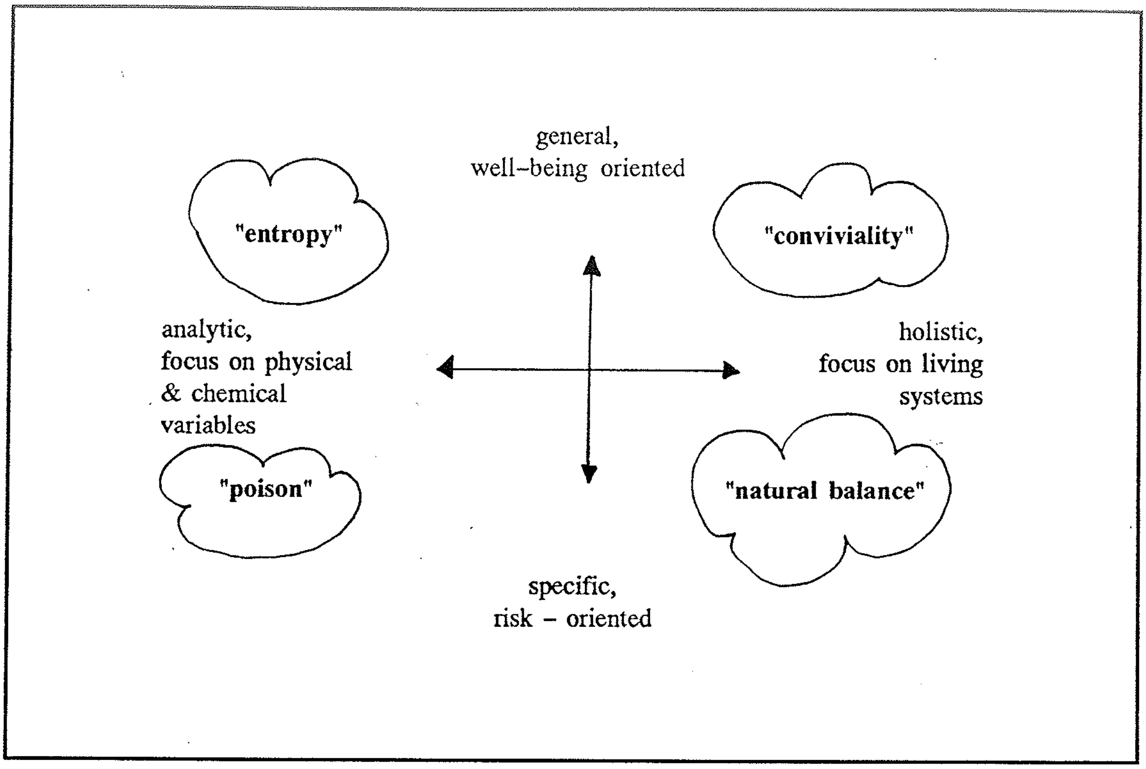

Figure 1: Epistemological qualities of the four paradigms

This recommendation can also be supported by considering the empistemological qualities of the four paradigms (see **figure 1**). Regarding the horizontal dimension, the "poison paradigm" and the "entropy paradigm" are more closely related to established ways of analytical thinking in chemical and physical dimensions, whereas the "natural balance paradigm" and the "conviviality paradigm" present holistic views referring to living systems. These two are more recalcitrant to relate to analytical systems such as economics – but holistic approaches may be the ones to come. The vertical dimension, specific vs. general, and at the same time risk–oriented vs. well–being oriented, also has implications for the possible acceptability of the paradigms. For the time being it is easier to argue for political measures in defense against specific risks than in favour of long term well-being. But this (hopefully) may change within the next decades, and an information system now created should be open for such changes.

3. The question for sociology: How can society regulate its exchange processes with its natural environment?

Let us try a view upon the socio–economic system as a huge *physical* system, driven by energy flows. Such a conception is irritating, since main stream social sciences tend to view social processes rather as a system of communication (see Luhmann 1986), and not in physical terms. The same is true for economics: In neo–classical theory the economic system is a system of stocks and flows of money, and it's only the monetary side of reality that counts. Physical concepts are discussed only as tools for the development of monetarization, not as autonomous concepts.[3]

As a physical system society is part of the biosphere; a part of the global eco-system. So why not view the socio–economic system as a special type of physical system in relation to other, "natural" physical systems (e.g. ecosystems). It is as all other physical systems – except for the biosphere as a whole – an open system with respect to material and energy flows. In terms of energy flows, socio–economic systems, particularly their industrial version, are systems with a very high energy density. In other words, they need a very high amount of energetic and material input and produce a very high amount of output. There exist other examples of ecosystems with a high energy density, which seem to follow one of two alternative patterns:

(1) "Closed cycle systems" have fast and rather closed cycles for all important nutrients. They manage to gain control over most environmental conditions necessary for their survival. An example for this pattern are tropical rainforests. They are able to continuously recycle their own nutrients. Provided that sun is shining they can practically go on forever as long as none of their highly interdependent parts are destroyed by external forces (such as men chopping thousands of trees). They create and reproduce the environment they need.

(2) "Flow systems", for example floodplains and updwelling regions in oceans, depend upon an external nutrient supply that they cannot themselves reproduce. They can only exist as long as this nutrient supply is sustained. Thus, they are vulnerable to environmental changes.

Obviously, today the industrial mode of production follows the second pattern. In principle there are three ways how such a system may survive in the long run:

Either it remains fairly small compared to the larger system, the biosphere of which it is part, so that neither its inputs nor its outputs matter much for the larger system (see **figure 2**). Then its survival depends only upon "stochastic" environmental changes (e.g.volcanic activity or major climatic changes). This (theoretical) possibility is long past human society, regionally speaking several thousand years (early Mesopotamian, Egyptian or Chinese cultures), and globally speaking since the colonization processes of the New Age, i.e. for about fivehundred years (see Crosby 1990).

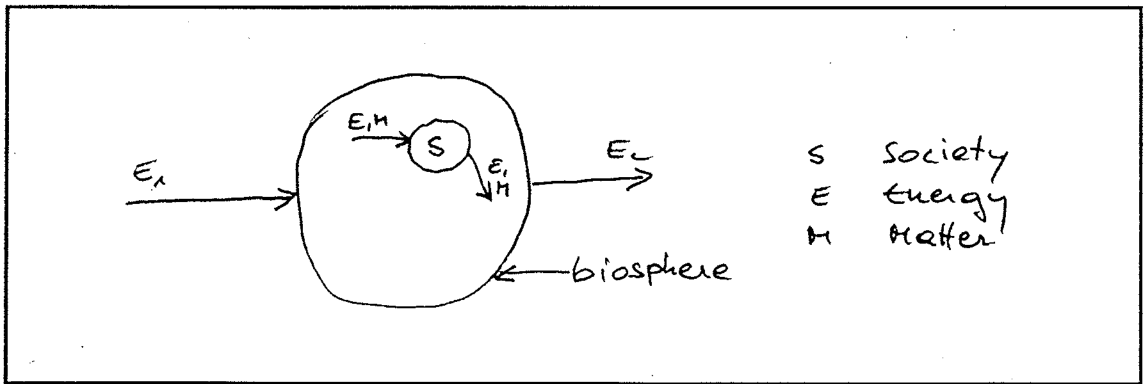

Figure 2

Secondly, if socio-economic systems of the "flow-type" become larger and larger, they have to start regenerating and regulating their environment so that this environment would be able to host the voracious systems. This means interventions of the type of "colonization". This was the core of the so-called neolithic revolution: the invention of agriculture and animal husbandry. Such purposive interventions into natural systems created "colonized" natural environments that remained self–supporting but much more exploitable for human needs than the original natural environments. Were these natural colonies exploited beyond reproduction though, they rendered "useless" and had to be "given up" (almost completely, as in the extreme case of desertification, or for certain functions), were re–naturalized and new colonies sought (**figure 3**). As long as the socio–economic systems remains mobile and adaptive, and as long as re–naturalized colonies regenerate in due time so they may be colonized again, this process may continue for a very long time.

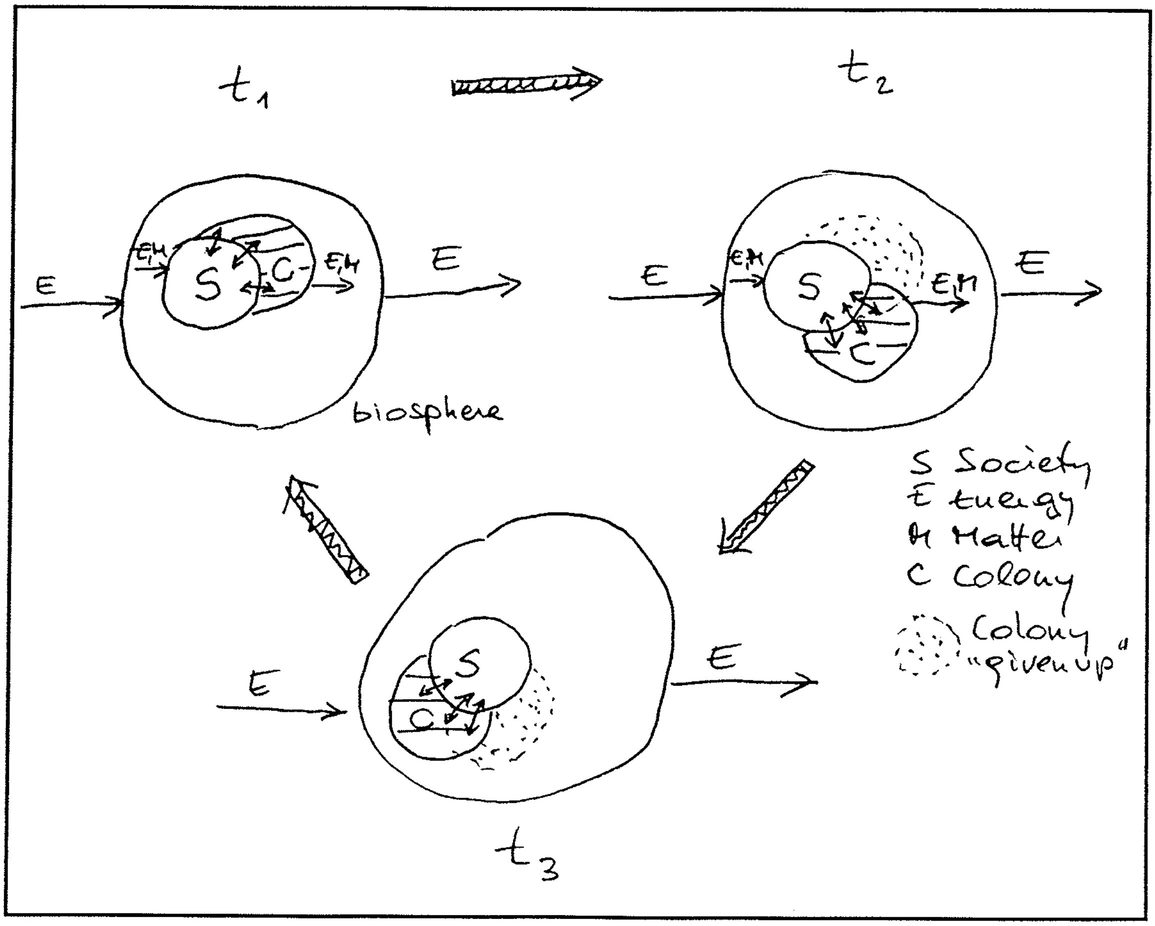

Figure 3

It comes to its limits though, if the system continues to expand, continues to exploit natural colonies beyond reproduction and at the same time destroys their capacities to regenerate naturally, resp. extends the time horizon of regeneration excessively. One answer to this situation, which seems to be the situation we are in now (see e.g. Meadows et al. 1992), is the idea to internalize the "natural environment", at least our biosphere, into the socio-economic system. This is equivalent to the creation of a mega socio-economic system that socially, economically and technically manages and controls the former "natural environment" (at least the bio-environment) as a part of itself. At the same time this means the transformation into a closed cycle system as described above, able to create and to reproduce its own nutrients. All possible damages according to paradigms 1-3 (see above) would have to be treated as damages within society. All of nature would be owned by specific social subjects for specific purposes (not neccessarily for profit purposes though), and damages caused by one subject would be damages to someone elses property to be persecuted within civil law. All "natural resources" would be represented within economy as (not neccessarily private) capital stocks. The socio-economic system would have to establish all mechanisms for distribution and exchange (**figure 4**), and not only on a contemporary, but also on an intertemporal (between generations) basis. This would mean the full mastery over nature, the perfection of the project of the Enlightenment.

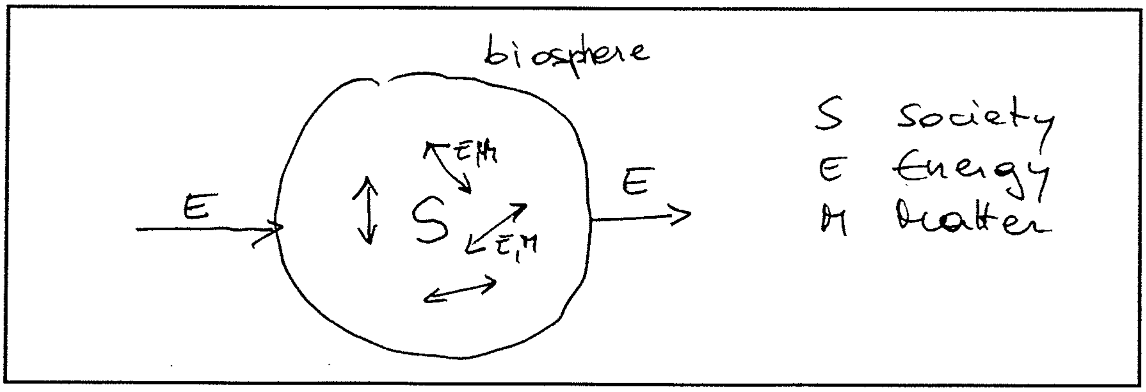

Figure 4

Even if this vision were technically feasible (which environmental economists, for example Immler 1989, and technicians tend to assume, whilst biologists tend to deny), it would be a huge social task. For the time being the (fully developed) industrial mode of reproduction feeds no more than 13% of the planet's human population properly, and its side effects keep about 50% starving. Mechanisms of exchange and distribution are not solved satisfactorily, not within societies and let alone between societies. And there could not even be reached an agreement that this is on its way to improvement – many would claim the contrary. Can one reasonably entrust the improvement of nature to the management of the industrial world?

We are very sceptical. So it seems worthwhile to consider another basic model of relationships between societ*ies* and natural systems, pinpointed in **figure 5**.

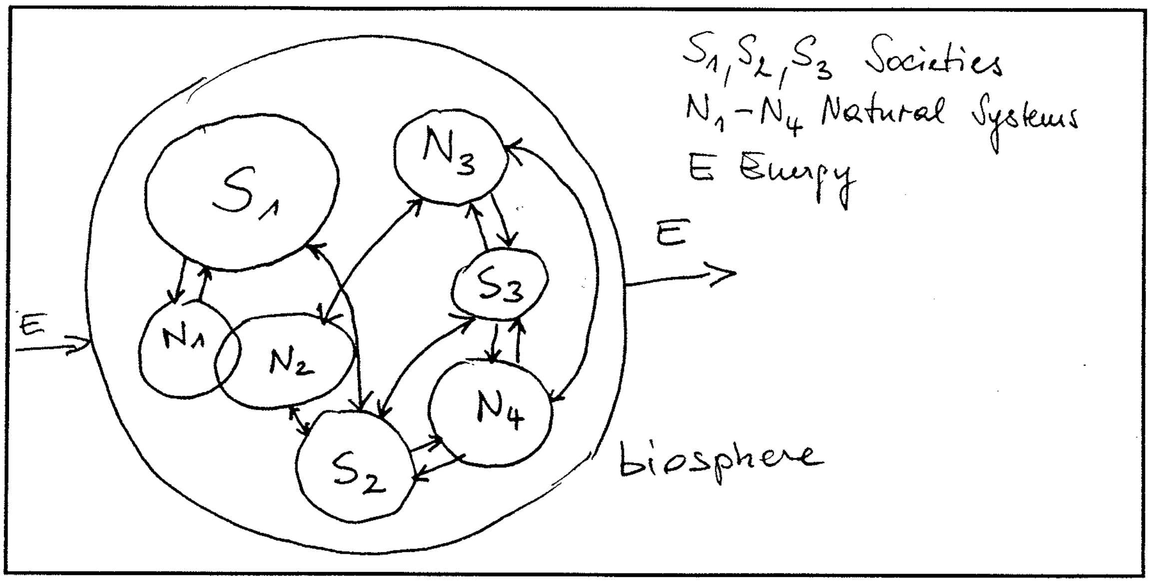

Figure 5

The story of **figure 5** reads as follows: Let us assume human societies (not neccessarily *one* unified socio–economic system) to share the biosphere with one another and with many other (natural) systems, systems of different logical and evolutionary status. Between these systems various exchange relationships exist. They have co–evolved, they are (to a varying degree) interdependent, and they all are to a certain extent self–organized, adaptive and contingent (Nicolis & Prigogine 1987; Kratky & Wallner 1990).

Let us use the metaphorics of a neighborhood upon which one depends: In order to survive, and even more in order to get along well, you have to know a lot about your neighbors – much more than what you might get from them. You will have presumptions about their habits, about the language they speak, about their character, you will learn on whom and on what they depend, and you will try out what you must do or not do in order tó get from them what you need or to avoid to get from them what you don't like to get. You might find out you could intimidate and dominate some of them, probably with the help of others, but you'd better not foster the illusion you could control them all. And if you are tempted to such an illusion, remind yourself of your limited knowledge and the contingency of the game. And be careful not to make real enemies, because to fight them will keep you busy all the time and distract your energies from more rewarding enterprises. And be loyal to your allies, but never rely completely upon them. Be aware: if you become a real nuisance for your whole neighborhood, they'll extinguish you. They learn about you just as much (at least almost as much) as you about them. So institutionalize ambassadors to warn against deviation from fair terms of trade, don't load too much responsibility upon your back (so let them live their way if possible) and keep proper records on your neighbors (particularly on your own part in the various deals, since you'll harvest what you've sowed), so you won't be taken by surprise.

Such a "communicative" (or anthropomorphic) view upon the exchanges not only between societies but also between societies and systems within their natural environment supposedly appears very strange to natural scientists accustomed to a rather mechanic paradigm of nature. It should not appear all that strange to social scientists though, and it is as least as useful as a practical guideline for information systems and systemic behavior as the "global control" model, as we shall attempt to demonstrate further down.

4. How to describe physical exchanges between the socio-economic system and its natural environment

If you conceive of the socio economic system as a physical system, drawing physical inputs from its natural environment, processing them internally, and generating physical outputs to this environment, you have to define a boundary between the "system" and its "natural environment": you have to be able to tell what is "inside" and what is "outside". This boundary is both omnipresent and fugitive. It certainly cannot be a "physical" or topographical boundary: The same physical elements will be both part of the social system and part of its natural environment, depending on the point of view. There can only be constructed a functional boundary, and this has to be done with care. Two approaches may be chosen:

(1) An apriori theoretical approach would discuss the possible functional labels of physical entities and processes that should define them as "inside" or "outside" the social system; this might be their function as goods and services on markets (a narrow approach that would leave aside the so-called "free goods", and could not easily be applied to elements of subsistence economies); it might be their function for "humans" in terms of a biological species (which would be a very broad approach, difficult to connect to a specific concept of the economy). We feel the most promising approach would be the functional link to property: property is specifically human and it constitutes a functional connection between physical entities and social "subjects". But we will not pursue this discussion in our contribution any further. We would like to encourage such a discussion, though.

(2) Another approach is a "constructivist" one. It presumes that society "constructs" its boundary towards its natural environment by the methods and tools it uses in order to describe it's behavior towards nature. The methods

themselves define what is to be considered as part of the system, and what is to be considered as an element of its (relevant) "natural environment". Practically speaking this is the approach we chose within this paper. It leads to an implicit definition of the boundary between the socio–economic system and its natural environment.

We chose an approach of causer–related environmental indicators in order to describe the behavior of the socio economic system towards it's natural environment. The set of indicators we have developed builds up an environmental information system, which can be used to describe the environmental performance of the socio economic system. It is self–referential, this means that we do not investigate the degradations or changes within the natural environment induced by social activities, but the indicators mirror environmentally relevant properties of the socio–economic system and it's physical exchanges with the environment. The indicators are compatible to economic statistics (namely to the design of the System of National Accounts, SNA) and can be linked to economic data by means of input–output analysis.

Let us come back to the conception of society as one among different systems on this planet (chapter 3). Then our information system can be characterized as an attempt to describe the behavior of (e.g. the Austrian) society towards it's natural "neighbor" systems. As it seems impossible to describe all possible aspects of this behavior, a selection had to be made according to the four basic paradigms (chapter 2).

The explicit connection to economic reporting systems as the SNA and the causer related approach led to an information system which describes the society–nature relationship "from the inside", from the point of view of society, but using properties that relate to the neighbor systems (namely *physical* entities as Joule, tons etc., and not *monetary* parameters).

The information system consists of the following three parts, which are listed in **figure 6** in greater detail:

1. ESIs: Ecologic–economical System Indicators

Materials balances
- materials consumption (primary, secondary, total / tons)
- materials wastage (tons)
- materials intensity (tons/AS)

Energy consumption
- net consumption – renewable / not renewable (Joule)
- net consumption of electricity (Joule)

Transport
- passenger kilometers (road / railway)
- ton kilometers (road / railway)

2. EMIs: Emissions

Gazeous emissions
- effect parameter "global warming potential" (CO_2–equivalents)
- effect parameter "ozone depletion potential" (F21–equivalents)
- effect parameter "toxicity" (?)

Liquid emissions
- effect parameter "oxygen consumption" (BSB–5)
- effect parameter "eutrophication" (tons phosphorus)
- effect parameter "toxicity" (?)

Solid emissions
- total waste (tons)
- ?

3. PILs: Purposive Interventions into Life Processes

Interventions into biotopes
- appropriation of net primary production (NPP / Joule)
- interventions into the water household of rivers (Joule.km)
- appropriation of water (m^3)
- release of anorganic fertilizers (tons of N, P, K) and of pesticides (tons)

Violence towards animals
- animal husbandry below a minimum standard for the quality of life (number of animals)
- animal killing below a technical minimum standard / animal experiments (number of animals)

Interventions into evolution
- breeding techniques (?)
- genetic engineering (?)

Figure 6: Proposal for a set of environmental indicators to be connected to the Austrian SNA (Fischer Kowalski et al. 1991a)

(1) Economic–ecologic system indicators (ESIs), these being indicators which describe ecologically relevant physical properties of the socio–economic system. They are designed in order to measure the "ecological efficiency" of the economy.

(2) The concept of Emissions (EMIs), which can be defined as the unintentional release of obtrusive physical entities over the border society – nature, is the most obvious and established concept within causer related environmental information systems.

(3) Purposeful Interventions into Life Processes (PILs) are no unintentional side–effects of production (like emissions), but are made in favor of a particular social use. These indicators are to portray the socio–economic actions causing biotope–destruction, violence towards animals and interventions into evolution.

The indicators follow two basically different concepts. Partly, they describe the "socio–economic metabolism": Matter and energy are "ingested", processed internally, and released into the environment. The "ESI" and "EMI"–indicators (and some of the PILs–indicators) follow this logic. The second concept is basically different. The socio economic system not only has a metabolism, but it also intervenes into it's neighbor systems and changes their functioning – in other words, colonizes them. If you look at the surface of the earth from an aeroplane, you will easily be able to see to what extent this colonization has altered the biosphere in the past few hundred years. Most of the PILs–indicators are designed to describe this colonization.

5. The metabolism approach

Just two months ago, the debate on sustainable development and possible limits of growth culminated at the UN Conference on Environment and Development (UNCED) in Rio de Janeiro. The variety of conceptions reaches from the "Beyond the Limits" perspective of Meadows et al. (1992) to the "only economic growth can guarantee sustainability" point of view (see for example Schmidheiny / BCSD 1992). We perceive the current debate as a "tour de force" of misunderstandings and theory–mismatch. Maybe the following concepts can open up the floor for better mutual understanding of fundamentally different points of views, such as economic ("unifying principle": money), social ("unifying principle": communication) and natural sciences ("unifying principles": energy, matter).

Obviously, if there are limits to socio–economic growth, they are *physical*, not *monetary* limits. Therefore you have to know something about the physical metabolism of the socio–economic system and it's physical exchange processes with it's environment, if you want to identify limits to growth or develop strategies for sustainable development.

We think that energy– and materials flows are the ecologically most relevant properties of the socio–economic metabolism. Therefore we included energy consumption and materials balances in the ESI–module (empirical example below). In a way, these indicators are an attempt to measure the physical size of the socio–economic system vis a vis it's natural environment in certain functional contexts. For example, the industrial energy turnover in Austria is of the same order of magnitude as the turnover of photosynthetically fixed energy in the Austrian terrestrial ecosystems (Fischer–Kowalski et al. 1992).

The physical outputs are not equally "harmful" to the environment. Moreover, they can be harmful in different functional contexts of the environment. For example, CO_2 is not toxic (and therefore not harmful within the poison paradigm), but it is capable of changing the global climate (and therefore harmful within the "natural balance" paradigm). So it is useful to aggregate the "outputs" of various chemical sustances into the environment to "effect parameters".

As Ayres (1991) showed, humankind currently influences the natural turnover of the carbon–, nitrogen–, sulfur– and phosphorous–cycle between 5 and several hundred percent. Thus, industrial metabolism has reached a considerable size compared to the natural metabolism of the biosphere – a fact, worthwile to be thought about.

6. Empirical example: Materials balances

We regard the materials–intensity of economic processes as one of the basic general criteria for their environmental impact. Most of the current environmental damages are significantly connected to the extraction and transportation, the processing and using of materials. Therefore we suggested to establish materials balances, which trace the material flows from the environment through the economy and back into the environment.[4]

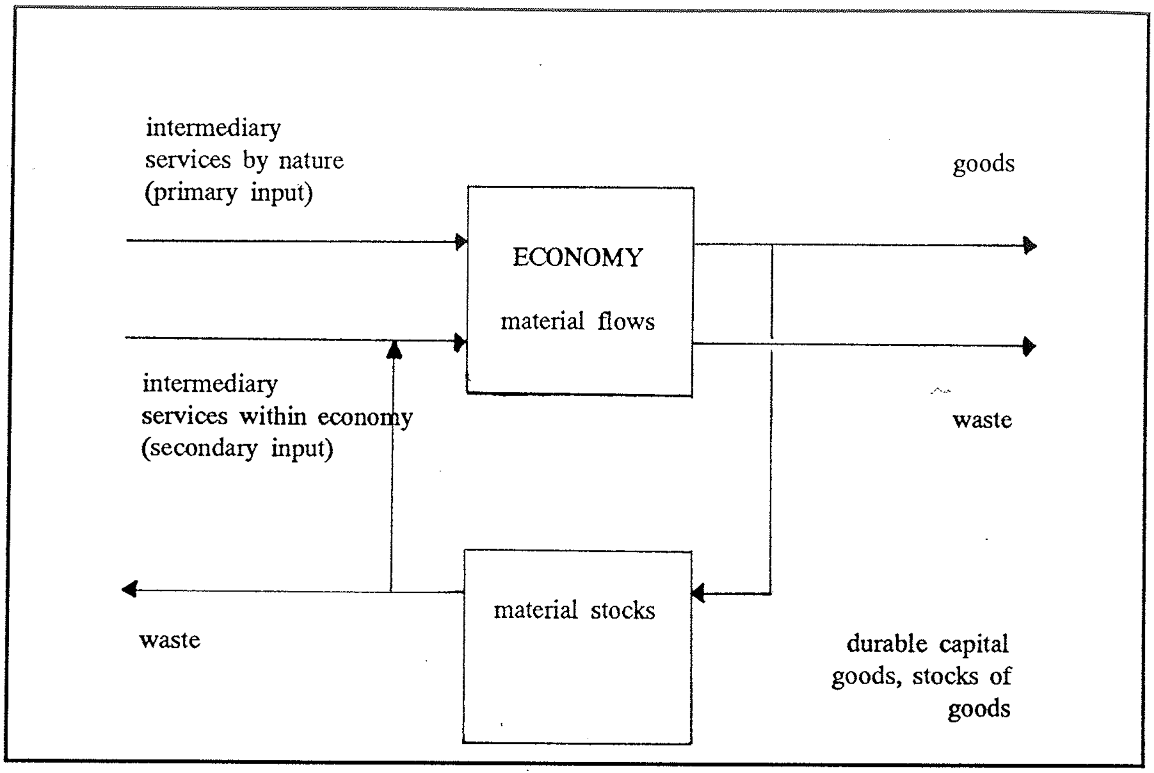

Figure 7: The concept of materials flows and stocks

The materials balances include the total material throughput of the economy in million tons (as measure of mass) per time period. **Figure 8** shows empirical materials balance–sheets for four selected branches of the Austrian Economy, namely extraction of crude petroleum and natural gas, manufacture of refined petroleum products, manufacture of pulp and paper, and electrical industry. The balances are differentiated into primary input, secondary input, output in the form of goods, and output in the form of non–reused wastage.

Primary inputs are directly extracted material inputs from nature usually not counted for in economic statistics. They contribute the major part of total input, particulary in basic industries. The portion of primary input in the form of water is extremly high in all industries regarded – it varies between 44% and 97% of the whole material input (see **figure 8**). So it makes some sense to distinguish between materials–intensity indicators inclusive and exclusive of water. It is indeed interesting to see that the role of water as primary input to the industrial

		Extraction of crude petroleum and natural gas	Manufacture of refined petroleum products	Manufacture of pulp and paper	Electrical industry
INPUT					
primary input (intermediary services of nature)	directly extracted resources	2,153	–	–	–
	water	1,761	12,598	220,700	13,811
	oxygen and nitrogen	?	?	?	?
	other resources	–	–	–	–
secondary input (intermediary services of economy)	energy carrier	0,063	0,664	0,386[1]	0,041
	other[2] secondary input	0,005	8,247	5,427	0,686
	(thereof: reused waste materials)	–	–	3,825[3]	0,005
	(thereof: direct packaging input	0,000	0,000	0,051	0,035
Sum		**3,982**	**21,509**	**226,513**	**14,538**
OUTPUT					
goods		2,153	8,129	4,105	0,607
total material wastage[4]		1,829	13,380	222,408	13,931
total material wastage (excl. water)[4]		0,068	0,782	1,708	0,120
Sum		**3,982**	**21,509**	**226,513**	**14,538**
employees (annual average)		2.813	3.391	12.474	72.379
production value in billions of AS		2.916	16.571	36.446	60.415

[1] excl. combustible waste material
[2] incl. deliveries of unprocessed primary inputs by other branches
[3] incl. combustible waste material
[4] as balance of total inputs less goods

Source: Own calculations

Figure 8: Material balances for four exemplary branches of the Austrian economy (1988, millions of tons)

system is about as dominant as for ecosystems. A high fraction of total input is also primary and consists of oxygen and nitrogen, which are particulary consumed in all processes of combustion. However, that part of the primary input we have not calculated for this empirical presentation.[5]

Secondary input are all material intermediary services within the economic system (from one branch to another). Secondary input can be divided into reused waste–material, renewable resource input, and direct packaging–input. Secondary input in the form of durable capital goods or stocks of goods is not defined as material flow and therefore stays out of regard within the flow concept, but would have to be part of material stock balances.

One strategic gap of the material flow balances is the difference between total input and total output in the form of goods. That difference is identical with the total material wastage (in gaseous, liquid or solid form) of production, which will not be delivered to further steps of any socio–economic processing and is deposited in the environment in one form or another. The amount of that difference, respectively the total wastage, has a high information value with regard to the checking, controlling and completion of emission–data, whose current availability in Austria is very limited. According to **figure 8** the total material wastage amounts to 46% – 98% of the total input (if water is included), respectively from less than 3% to 31% (if water is excluded).

7. The colonization of nature

Since the beginnings of agriculture and husbandry ("neolithic revolution"),[6] societies intervene into natural living systems: They clear forests, build dams and irrigation systems, breed plants and animals, build houses and streets and the like. This type of exchange processes between society and nature is quite different to simple "input", e.g. intake of plants or meat as nutrition. And it is specifically human, at least as specifically as making use of tools. It cannot be conceptualized with the notion of metabolism, but it is similar to colonization.

Emissions are by–products of the industrial mode of production: Nobody is interested in the release of sulfur dioxide, which a coal power plant produces. If it were easily possible, everyone would be glad to do without it. As the sulfur produces negative effects for humans and animals (lung diseases) and plants (dying forests syndrome), discussions concerning problems of this type focus on weighing costs (environmental costs versus costs for filters).

The colonization of nature follows another logic: A dam is built in order to use the energy of the river to drive turbines instead of eroding the riverbank and inundating floodplains. Although a water power plant normally does not produce emissions, it strongly affects the ecology of rivers, floodplains and wetlands (Goldsmith & Hildyard 1984). Thus for the purpose of a water power plant one has to intervene in the structure of a natural system, change its functioning, or, in other words, colonize it. Interventions of this type are made purposively in favor of human benefits, and to a large extent, their disadvantages are no detriments to society, but to natural systems. Therefore, we called this type of society–nature relationship "purposive interventions into life processes" (PILs).

According to Moscovici (1990), historically three basic paradigms of nature can be distinguished: *"organic", "mechanical", and "cybernetic"*. The first, *"organic"* paradigm, beginning with the neolithic revolution and ending with the beginning of industrialization, is typically represented by the art and philosophy of the old greeks. Within this type of man–nature relationship, human control over nature is enhanced by improved skills of handicrafts.

The dominance of mechanical and chemical methods and the industrial mode of production characterize the second, *"mechanical"* paradigm. Metabolism–like problems, like emissions, are a typical problem caused by this mechanical mode of economic production (Oechsle 1988). But, as a new, *"cybernetic"* paradigm is arising, the necessity to reduce emissions is broadly accepted, and in the long run their importance will diminish in relative terms.

This *cybernetic* mode of economic production (and paradigm of nature) is characterized by qualitatively new and enhanced possibilities of human control over nature. There are many examples for this cybernetic paradigm. The application of analytical–chemical methods in ecology yielded new possibilities of directing and utilizing natural processes in order to meet human demands (Korab 1991). New biological technologies are developing rapidly and are politically strongly promoted – last but not least because it is hoped that they will be the urgently needed "clean technologies". These tendencies can be described as a strategy of replacing EMIs with PILs, for example using biological instead of chemical techniques (Fischer–Kowalski et al. 1991b). Thus it seems that PILs will gain more importance in the future.

This type of society–nature relationship can be analyzed with sociological categories such as Galtung's(1975) distinction of "direct" and "structural" violence. For example, the human appropriation of nearly 40% of the global terrestrial products of photosynthesis (see empirical example below) are a "deprivation of nutrition" for all heterotrophic organisms, living in these ecosystems. "Direct" and "structural" violence are also ovious in animal husbandry. As Galtung's theories on direct and structural violence are actor–oriented, they were a valuable heuristic guideline for the development of the indicator system described below.

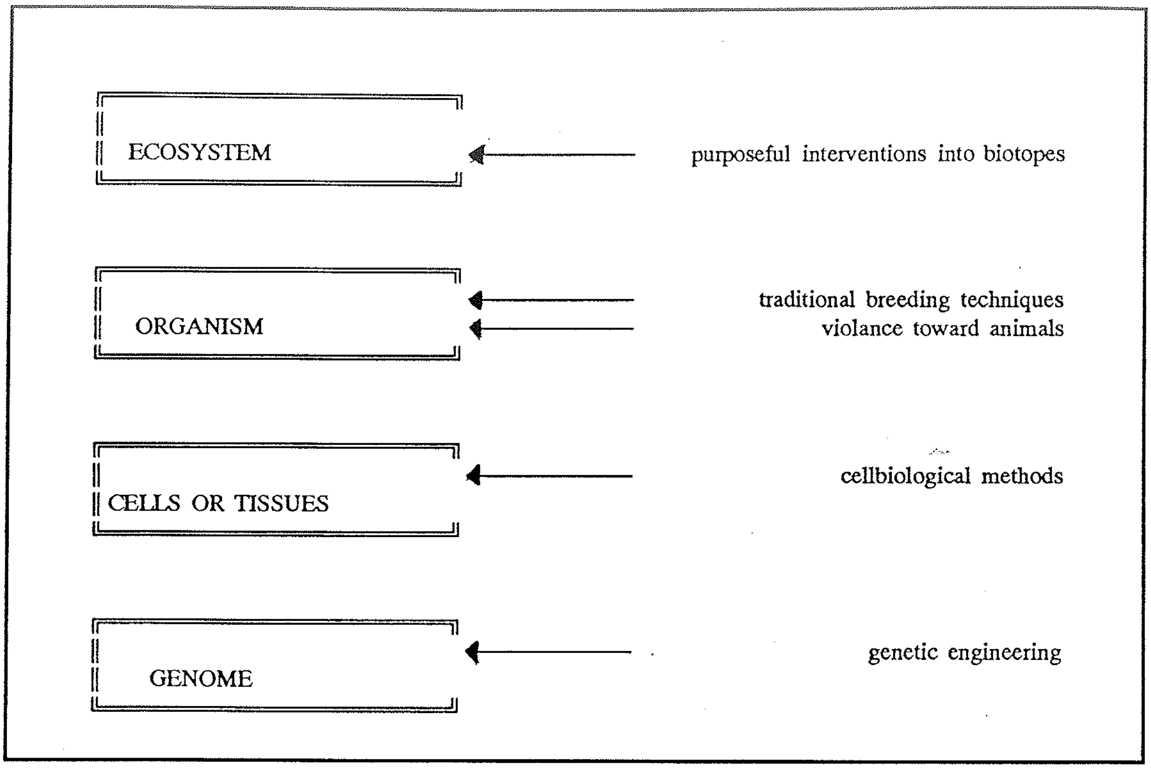

Figure 9: Systematics of PILs refering to the level of intervention (Fischer-Kowalski et al. 1991b)

PILs can be systematised according tothe different biological hierarchical levels on which the interventions take place (**figure 9**): Ecosystems, organisms, cells,

genes. We developed the following modules of indicators in order to mirror relevant processes with which the socio-economic system intervenes into life processes in favor of particular social uses (Fischer-Kowalski et al. 1991a, Haberl 1991, Wenzl & Zangerl-Weisz 1991):

1/ *Interventions into biotopes:* Indicators for socio-economic efforts to change the structure of natural ecosystems. The most important general efforts of this kind are interventions into water systems, the appropriation of photosynthetically fixed energy (see below) and the input of technically produced substances (fertilizers, pesticides).

2/ *Violence towards animals:* Indicators with reference to causing suffering and pain with animals. This subset contains two indicators, one for the circumstances of keeping animals (long-term aspect) and one for short-term aspects, killing animals and animal experiments.

3/ *Interventions into evolution:* Indicators for direct (genetic engineering) and indirect (breeding techniques) influences on the gene pool (for reference see Wenzl & Zangerl-Weisz 1991).

Within each information module we seek to operationalize the intensity of intervention from the part of the socio-economic system into natural living systems. "Intensity of intervention" is a very general notion, and it does not automatically imply a value-judgement concerning the consequences. The background assumption to this might be spelled as follows: The higher the intensity of intervention, the more the living conditions of other species and their evolution are determined by man. This may be interpreted in terms of responsability, in terms of sustainability of man's economy, or in terms of control resp. imperialism. This should be open to political debate: In all cases it seems reasonable to generate periodical informations that provide society with an awareness of its own interventions.

8. Empirical example: Socio-economic appropriation of photosynthetically fixed energy

Energy not only is the motor of industrial economy, but also for natural ecosystems. Ecosystems can be conceptualized with compartment models, in which more or less closed materials' cycles between the compartments are driven by a flow of free energy. In fact the development of ecology as a theoretically integrated discipline of natural science began with the investigation of energy flows by Eugene P. and Howard T. Odum (see Odum 1983, 1991). Today the following concept – reported here in rather simplified terms – is broadly accepted: The green plants convert radiant energy from the sun into chemical energy in the process of photosynthesis. The accumulated energy is available to all other organisms: The heterotrophic organisms (animals including man, fungi, micro-organisms) depend upon consuming energy–rich substances in order to sustain their metabolism. Consequently, "photosynthetically fixed energy ultimately supports the great diversity of species that inhabit the world's ecosystems" (Wright 1990, p.189).

Therefore we consider the degree to which society appropriates photosynthetically fixed energy as an important indicator for the intensity of intervention into natural living systems.

Net primary production (NPP) is the photosynthetically fixed energy, accumulated by green plants in a certain period of time (usually one year). It is an important figure because of several reasons. First, empirical studies show that energy flow can be related to numbers of species with species–energy curves (Wright 1990, p. 189). This means that if the amount of energy remaining in the ecosystem is reduced, the number of species living in this ecosystem will diminish (see **figure 10**).

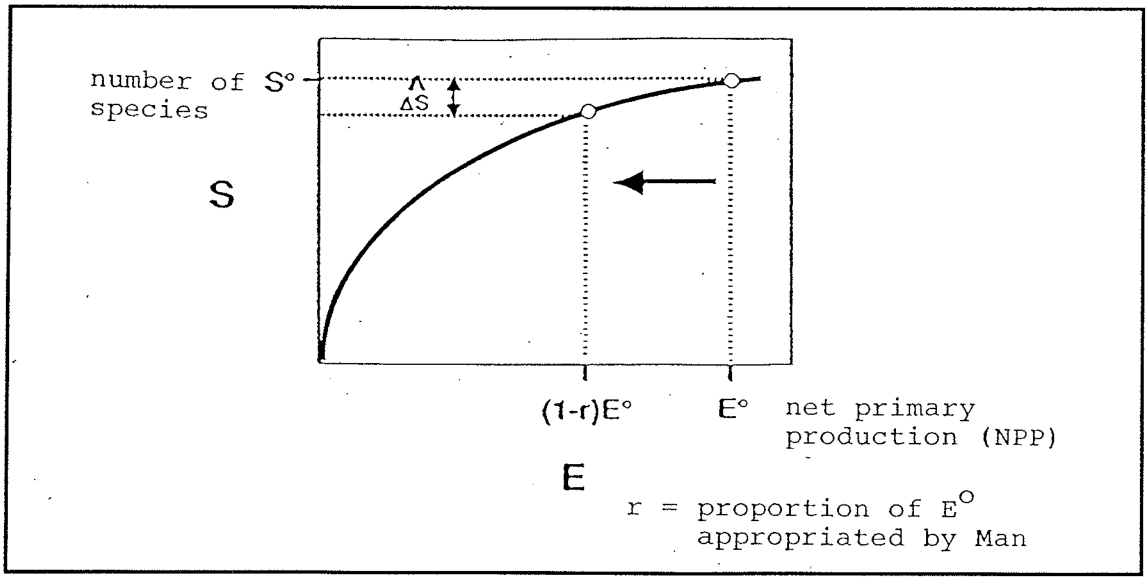

Figure 10: Example for a species–energy curve (Source: Wright 1990)

Secondly, there are limits to the fraction of NPP which can be used in a sustainable manner. The human appropriation of the NPP currently is estimated to lie between 20 and 40% of the total terrestrial global NPP (Vitousek et al. 1986, Diamond 1987, Wright 1990, Max-Neef 1991). Even if it is not clear at which percentage of human appropriation of NPP the limits of sustainability are reached, the current amount already is considerable, and obviously cannot be increased without further speeding up the extinction of many other species. We therefore propose to use the appropriation of NPP by the socio-economic system as (one of three) indicators for purposeful interventions into biotopes (Haberl 1991). The indicator is formulated as the difference between the hypothetical NPP of the undisturbed eco-system and the actual NPP.

socio-economic uses	area concerned	photosynthet. fixed energy[1]		distribution
		hypothetical	appropriated by man	of approp.
	km^2	NPP_h (PJ/a)	NPP_a (PJ/a)	NPP (%)
agriculture[2]	15.900	370	250	40,4
grassland, alpine pastures	21.000	280	180	29,0
forests (logging)	34.300	580	110	17,7
gardens	1.700	40	20	3,2
traffic zones	1.600	40	40	6,5
buildings	700	20	20	3,2
other[3]	8.000	40	0	0,0
total	83.200	1.370	620	100,0

[1] first estimates based on international literature
[2] including wine
[3] indcluding waters and wasteland

Sources: Bundesamt für Eich- und Vermessungswesen 1989; BMLF 1989a; BMLF 1989b; ÖSTAT

Figure 11: Appropriation of NPP in Austria 1988 – first estimation (Source: Own calculations)

What does this mean? The hypothetical NPP_h (per space unit and year) depends upon morphological and climatic circumstances. Under Austrian conditions it may vary from about 5 $TJ/km^2.a$ (alpine grasslands) to 50 $TJ/km^2.a$ (floodplains).[7]

Would man not intervene, this biological energetic basis would be available to all other species. Man, or speaking more technically, the socio–economic system, may intervene in qualitatively different forms, but they can basically be boiled down to two mechanisms:

(1) It may build structures (such as highways or buildings) that prevent or reduce the NPP in a certain area drastically (the very same road prevents a certain NPP_h each year by its very existence[8]).

(2) Consumption: Certain amounts of NPP are harvested (or grazed off by cattle) and serve as inputs to the socio–economic system, thereby being no more available to the ecosystem.

What is shown in **figure 11** as NPP_a appropriated by the socio–economic system is therefore the sum of "prevented" NPP and "consumed" NPP.

The hypothetical NPP on Austrian territory is estimated to be around 1.370 PJ/a. Thus the socio–economic appropriation of the products of photosynthesis in Austria (with 620 PJ/a) amounts to about 45% of the total production.[9] This means that the socio–economic system produces and reproduces environmental structures that permit little more than half of the current photosynthetically fixed energy for all other species but human beings. This certainly is highly relevant both from the viewpoint of the "natural balances paradigm" and from the "conviviality paradigm".

9. Conclusions

The current debate on environmental problems is characterized by fundamental misunderstandings. There are different groups of actors, which have completely different perceptions of environmental problems, rooting in different "unifying concepts" within the different scientific traditions. We think that only interdisciplinary approaches are useful to find common points of view and new solutions.

Problems start with the fact that everybody believes to know, what an environmental problem is, but everybody implicitly uses his own concepts. We think that it is necessary to explicitly discuss this point, and to accept the legitimacy of basically different points of view (we called them "paradigms"). This is a precondition for a rational and democratic political bargaining process.

Current discussions are dominated by an implicit concept of "metabolism". Natural resources are "ingested", processed internally and released into the environment. Obviously, paths toward sustainable development have to rely on a good picture of this metabolism: It must be ensured that resources are not being overexploited and the sinks are not destroyed.

This picture completely neglects another dimension of the society–nature relationship: the colonization of nature in favor of particular social uses. These purposive interventions into life processes (PILs) are historically the oldest form of modification of the environment in order to sustain socio–economic reproduction. PILs characterize the beginnings if agriculture and animal breeding, and they are specifically human.

The focus on metabolism–like problems bears the danger of a strategy of replacing EMIs by PILs. But, whereas the consequences of noxios emissions have been investigated and are widely accepted, the possible negative consequences of PILs are to a large extent unknown.

References

Ayres, R.U.(1991): Industrial Metabolism. Theory and Policy. Manuscript (Will appear in: R.U.Ayres, U.E.Simonis (eds.): Industrial Metabilism. New York forthcoming)

Catton, W.R.Jr. and Dunlap, R.E.(1978): Environmental Sociology: A New Paradigm. The American Sociologist vol.13, pp.41–49

Corniere, P. (1986): Natural Resource Accounts in France. An Example: Inland Waters. In: Information and Natural Resources, Paris (OECD)

Crosby, A.W. (1990): Die Früchte des weißen Mannes. Ökologischer Imperialismus 900–1900. Campus: Frankfurt / New York.

Diamond, J.M. (1987): Human use of world resources. Nature Vol. 328, 479–480:

Devall, B. (1990): Deep Ecology and Radical Environmentalism. Society and Natural Resources vol.4, no.3, pp.247–258

Dunlap, R.E. and Mertig, A.G. (1990): The Evolution of the U.S. Environmental Movement from 1970 to 1990: An Overview. Society and Natural Resources vol.4, no.3, pp.209–218
Fischer–Kowalski, M; Haberl, H.; Payer, H.; Steurer, A.; Zangerl–Weisz, H. (1991a): Verursacherbezogene Umweltindikatoren – Kurzfassung. Research Report iff / Ökologie–Institut: Wien.

Fischer–Kowalski, M.; Haberl, H.; Wenzl, P.; Zangerl–Weisz, H. (1991b): "Emissions" and "Purposeful Interventions into Life Processes" – Indicators for the Austrian Environmental Accounting System. Presented paper to the Conference on "Ecologic Bioprocessing" of the Österr. Gesellschaft für Bioprozeßtechnik (ÖGBPT), Graz, Oct. 1991.

Friend, A. (1988): Natural Resource Accounting: A Canadian Perspective. In: Y.J.Ahmad, S. El Serafy and E.Lutz (eds.), Environmental and Resource Accounting and their relevance to the measurement of sustainable development, Washington D.C. (World Bank)

Galtung, J. (1975): Strukturelle Gewalt. Beiträge zur Friedens– und Konfliktforschung. Rowohlt: Reinbek.

Goldsmith, E. & Hildyard, N. (1984): The Social and Environmental Effects of Large Dams. Vol 1: Overview. Wadebridge Ecological Centre.

Haberl, H. (1991): Gezielte Eingriffe in Lebensprozesse. Research Report: iff / Ökologie–Institut: Wien.

Immler, H. (1989): Vom Wert der Natur. Zur ökologischen Reform von Wirtschaft und Gesellschaft. Westdeutscher Verlag: Opladen.

Korab, R. (1991): Ökologische Orientierungen: Naturwahrnehmung als sozialer Prozeß. In: Pellert, A.: Vernetzung und Widerspruch. Zur Neuorganisation der Wissenschaft. Profil Verlag: München / Wien, 299–342

Luhmann, N. (1986): Ökologische Kommunikation. Westdeutscher Verlag: Opladen.

Max–Neef, M.A. (1991): Speculations and Reflections on the Future. Official document No.1 prepared for the Preperatory Committee of the Santiago Encounter, March, 13–15th, Santiago de Chile.

Meadows, D.; Meadows, D.; Randers, J. (1992): Beyond the Limits. Global Collapse or a Sustainable Future. Earthscan Publications: London.

Moscovici, S. (1990): Versuch einer menschlichen Geschichte der Natur. Suhrkamp: Frankfurt.

Nicolis, G. and Prigogine I. (1987): Die Erforschung des Komplexen. Auf dem Weg zu einem neuen Verständnis der Naturwissenschaften. München-Zürich

Odum, E.P. (1983): Grundlagen der Ökologie. Band 1: Grundlagen. Thieme: Stuttgart. 2.Auflage.

Odum, E.P. (1991): Prinzipien der Ökologie: Lebensräume, Stoffkreisläufe, Wachstumsgrenzen. Verlag Spektrum der Wissenschaft: Heidelberg.

Oechsle, M. (1988): Der ökologische Naturalismus. Zum Verhältnis von Natur und Gesellschaft im ökologischen Diskurs. Campus: Frankfurt/Main / New York.

Pearce, D., Markandya A. and Barbier E.B. (1990): Blueprint for a Green Economy. London

Prigogine, I. and Stengers, S. (1990): Dialog mit der Natur. München

Schmidheiny, S. / BCSD (1992): Kurswechsel. Globale unternehmerische Perspektiven für Entwicklung und Umwelt. Artemis & Winkler: München.

Vitousek, P.M.; Ehrlich, P.R.; Ehrlich, A.H.; Matson, P.A. (1986): Human Appropriation of the Products of Photosynthesis. BioScience Vol 36, No. 6, 368-373.

Wenzl, P.; Zangerl-Weisz, H. (1991): Gentechnik als gezielter Eingriff in Lebensprozesse. Vorüberlegungen für verursacherbezogene Umweltindikatoren. Research Report iff / Ökologie-Institut: Wien.

Wright, D.H. (1990): Human Impacts on Energy Flow Through Natural Ecosystems, and Implications for Species Endangerment. In: Ambio Vol 19. Nr.4, 189-194

Notes

1. Interdisziplinäres Institut für Forschung und Fortbildung der Universitäten Innsbruck, Klagenfurt und Wien (IFF), Abt. Soziale Ökologie, Seidengasse 13, A–1070 Wien und Österreichisches Ökologie–Institut für angewandte Umweltforschung, Seidengasse 13, A–1070 Wien.

2. The notion of "sustainability" claims to be such a "grand" paradigm. But inspite of its generality we think it cannot embrace all aspects these 4 paradigms encompass. It excludes the "conviviality"–reasoning (paradigm 4) completely, and it would rule out some of the more short–term processes in the "poison"–paradigm. It seems a close relative to the "entropy"–paradigm, also sharing its unspecificity.

3. Although attempts in this direction are becoming somewhat more common now, see for example Pearce et al.1990 and the international examples given there, or Ayres 1991.

4. The need for a supplementary system of physical accounting connected to the traditional SNA has gained understanding during the last years. Ambitious attempts have been started by the Norwegian, the French and the Canadian governments (see Corniere 1986, Friend 1988, OECD 1988). The model of material balances and intensities as represented below is a contribution to that discussion in progress.

5. The data bases to do so would be sufficient, if confined to processes of combustion (which makes for the major share of the total).

6. Some authors even argue the success in this primary colonization of plants and animals to be the major explanatory variable for the longterm dominance of European civilization over all other civilizations (e.g. Crosby 1986)

7. 1 TJ = 10^{12} J; 1 PJ = 10^{15} J

8. There may also be cases in which the intervention causes an increase of NPP above the "natural" level, such as by growing maize instead of wood. But in practically all such cases this surplus NPP is then extracted from the ecosystem by harvesting.

9. It is interesting to note that the amount of appropriated photosynthetically fixed energy corresponds quantitatively to the end use of (technical) energy, which for Austria is around 750 PJ/a.