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Water: the bloodstream of the biosphere

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Water, the bloodstream of the biosphere, determines the sustainability of living systems. The essential role of water is expanded in a conceptual model of energy dissipation, based on the water balance of whole landscapes. In this model, the underlying role of water phase changes—and their energy-dissipative properties—in the function and the self-organized development of natural systems is explicitly recognized. The energy-dissipating processes regulate the ecological dynamics within the Earth's biosphere, in such a way that the development of natural systems is never allowed to proceed in an undirected or random way. A fundamental characteristic of self-organized development in natural systems is the increasing role of cyclic processes while loss processes are correspondingly reduced. This gives a coincidental increase in system efficiency, which is the basis of growing stability and sustainability. Growing sustainability can be seen as an increase of ecological efficiency, which is applicable at all levels up to whole landscapes. Criteria for necessary changes in society and for the design of the measures that are necessary to restore sustainable landscapes and waters are derived.

Keywords: sustainability; water regime; subsistence; autarky; cellular structure; society

1. INTRODUCTION

Water is the basis of our nature: the most important liquor of life is the most precious agent also to mankind. No wonder that this mysterious agent is compared to blood. Ubiquitous and appearing in the form of vapour, of a liquid and as frozen ice, forming the most wonderful crystals as Emoto has recently photographed (Emoto 2001).

We will try to elaborate some of the most interesting properties of water and deal with the important processes that appear to occur at the interfaces of water with solid objects such as our earth and its lithosphere, organisms and the gaseous atmosphere. The interaction between the sun as an energy source of excessive mass and our much smaller water based planet as a sink creates a basic dynamic system. The sun tries to reduce energy flow density and cools its rapidly moving matter as much as possible by its interaction with the planets and thereby accelerates the molecules on the surface of the much smaller planets. A liquid medium like water at the earth surface dissipates this life-giving energy, distributing it in space and time. This process leads to damping temperature and creates thermal conditions supporting all natural processes. Evaporation and precipitation form a water cycle almost without loss of matter, which cools hot spots and warm cooler areas.

(a) *Water has shaped the face of our planet*

The solar-driven, dissipative water and matter cycles—with water as the most important dynamic agent—have shaped the face of our planet Earth and constitute the key for life. The various energetic properties of water to dissipate energy as, for example, the cyclic processes of evaporation and precipitation, of dissolution and crystallization, and finally—water in the biological cell—of disintegration of the water molecule and recombination of water (carbon fixation and respiration), coupled in a recursive way, are together the three most essential cyclic water processes damping the solar pulse. Water maintains the transport of all reactants and reaction products; it is involved in stabilizing reaction conditions and providing the energy concept of reactivity, as is the pH concept. Together with the above-named properties, the dynamic agent water sorts solid and dissolved matter by controlling buoyancy under hydrodynamic conditions and the solubility properties of practically all compounds in water. There are hardly any structures that cannot be considered as hydromorphic in a direct or indirect way. Like the bloodstream, water maintains coherency in energy partition, in transport processes, in temperature distributions and reaction processes at water–solid interfaces, in all organisms and over the whole planet (Ripl 1992, 1995; figure 1).

We may proceed therefore with our analogy of water as the bloodstream in the biosphere and look at the primary role of the water cycle for stabilizing the gaseous atmosphere with respect to temperature, composition and distribution. Further on, we may inspect the interface between the lithosphere and the vegetation cover under the local conditions of the water cycle, which is usually considered as the soil. For life support, fertility and the self-organization of living structures as organisms and assemblages of ecosystems establishing the biosphere, water also plays a predominant role. Finally, we will examine the role of water for the most recent evolutionary invention of the process nature, as is humankind, society and the dynamics of social structures.

However, since humankind has ruled the fate of this Earth, the natural way of self-organization—by feedback—

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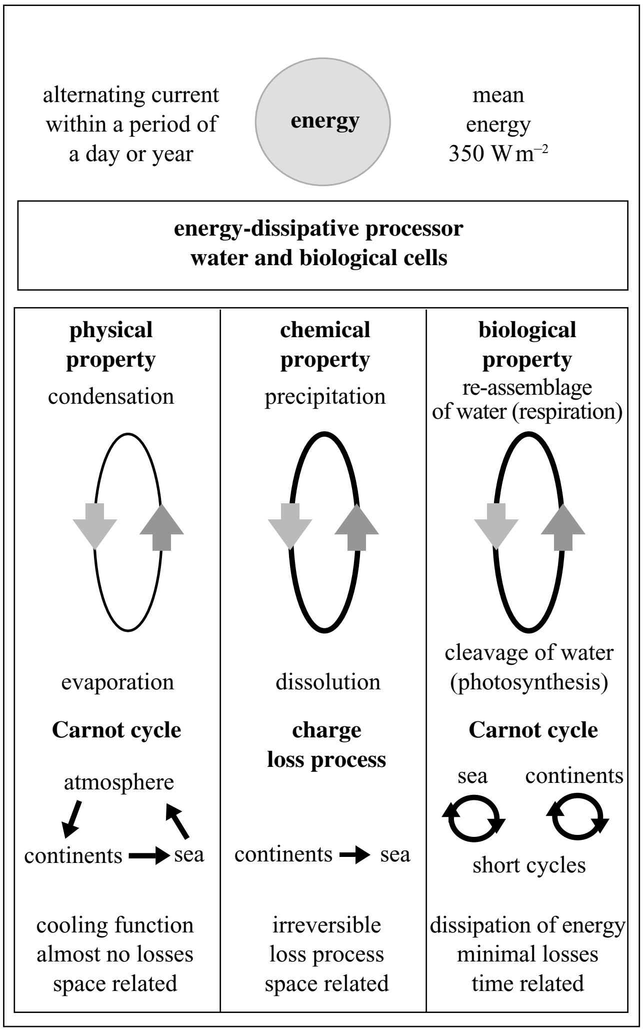

Figure 1. Processor properties of water (Ripl & Hildmann 2000).

owing to limitations, has been steadily disrupted in a stepwise fashion. Some improvement in the human control of water cycles and material transport processes therefore seems inevitable—if sustainable development is to be ultimately desired by societies and believed to be the main goal of humankind. The randomization of previously ordered matter and processes—mainly through the use of non-renewable energy and the distortion of the global cooling system through interference with the water cycle and vegetation cover—characterizes the present situation. Accelerated, irreversible, base cation-flow processes to the sea, from localities originally fertile and covered in vegetation, are still increasing.

(b) *Natural development of energy-dissipating structures*

The situation at present indicates a thorough misunderstanding between the game rules of nature and the economic rules of the game our 'advanced' societies play. Nature has always changed its strategy when physical limitations have been imposed and feedback control has shifted the priorities of net productivity into the maintenance of locally closed, short-circuited, water and matter cycles. Processes in nature were altered from productivity and reproduction of the most energy-efficient (pioneer) organisms to a community-based diversity of organisms, closing matter cycles locally *in situ*, and thus producing sustainable structures by minimizing losses (Odum 1983). The local and more loss-free recycling of water and material, as minerals and nutrients needed by the biosphere, provided the prolonged development of energy-dissipative structures *sensu* Prigogine (Nicolis & Prigogine 1989). Open systems turned into more closed and stable systems owing to more resource-economic adaptations to local and phase-related behaviour. These better optimized structures could grow and spread, whereas less efficient processes with more open structures and higher losses were forced to shrink. Society has hitherto failed to realize that the most crucial stabilizing process is the short-circuited water cycle—between evapotranspiration and precipitation. To a large extent this process already takes place under and within the tree canopy. The control of local material flow takes place mainly within biota. Locally, water cycles that are more completely closed—in part internalized within organisms and ecosystem structures—are thus controlling localized, short-circuited, matter management.

(c) *Breaking up short-circuited matter cycles*

The opening up, by humankind, of the course that processes will take, as, for example, the conversion of local evapotranspiration processes into the passage of water through the soil, along with the increased use of groundwater—both being responsible for the losses of nutrients and minerals—have proved to be adverse to sustainable life processes. The enhanced transport of life-supporting matter from top-soils (minerals and nutrients taken away in drainage ditches and with one-directional sewage-treatment plants) in an irreversible manner to the sea (recycling from the sea only occurs after a couple of hundred million years when the seabed is eventually converted again into continents) constitutes a most efficient factor in the widespread breakdown of vegetation cover and successive desertification; it is the beginning of ageing landscapes and the ceasing of societies' subsistence.

Some changes in the way that water should be managed in our societies will be shown. Efforts to control the water cycle and thereby regulate the transport and distribution processes can improve, to a large extent, the efficiency and sustainability of our human environment. With intelligent management of the water cycle, the indispensable material resources for fertility, and their availability in the top-soil at the surface of continents, can be gained and controlled for future generations.

2. WATER: THE MYSTERIOUS BASIS OF LIFE

One most dazzling property of water to determine the lifespan of structures at several different levels of organization and of the water cycle, is caused by water's chemical dissipative property: namely, the dissociation of water into protons and electrons involved in pH- and redox reactions and the reactivity of water with various substances. Dissociation or partial charge separation in the water molecule is temperature dependent and is based on the molecular properties of water and its dynamics at various interfaces and between liquid–liquid, solid–liquid and liquid–gaseous phase boundaries. This property is responsible for almost all dissolution reactions but also for the central role in the genesis of life.

Close examination of the water molecule shows an angle of *ca.* 105° between the two hydrogen atoms and the oxygen atom. The anomalous property of water, in which water's structure improves and gains density when the temperature increases from freezing point at 0–4 °C can be explained by the partial coherency and formation of water clusters.

Water is a polar agent and the most abundant solvent for salts, and even organic compounds. When salts are dissolved, anions and cations are evenly distributed in the solvent water. The clusters become more determined in time and space, which further improves the structure, increases the boiling point and decreases the freezing point, thus gaining coherency. The mole fraction tells how many water molecules are coordinated to one ionic couple. All this happens under dynamic conditions at temperatures between the point of freezing and boiling. The clusters in salt solutions turn more alike and movement in the clusters is to a large extent polarized (moving in the same ordered direction) and coherent. This is even more true for those molecules within clusters than for those at the interface between clusters, which still are less ordered. Water molecules show paramagnetic properties, and ionic solutions show electric properties, thus alternating electric and magnetic fields are to be expected with a natural frequency depending on the mass of the clusters. The temperature, however, will influence the amplitude of the cluster oscillations. Amplitude, however, influences the dissociation of the water molecules into H^+ and OH^-. With higher temperature, influencing cluster amplitude, pH is lowered and reactivity gained. Such necessarily oscillating water cluster systems within an enclosure (e.g. capillaries, crevices or cells) develop, through interference with the limiting enclosure, standing wave patterns—thus causing a discrete distribution of reactivity in space and time ruling the probabilities for chemical reactions, dissolution of solids, formation of crystals and the distribution of energy.

(a) *Formation of carbohydrate radicals and polymerization into glucose*

These wave patterns within a salt solution (water cluster–ionic structure) can be modulated mechanically or electromagnetically and are, with the highest precision in space and time, increasing or damping reactivity. If one water cluster is pumped with energy in positive feedback with its own frequency, the probability increases for certain molecules in the water cluster to break their dipole (pH reaches 0 as in the standard hydrogen electrode) and the hydrogen atoms in *status nascendi* may combine with, for example, a coordinated CO_2 molecule to form a carbohydrate radical (CH_2O) with a very low stability. At this very moment, the energy level drops in the reaction centre and the radical is moved to a space at the lowest energy density, which could be the less-ordered interface between clusters.

There this carbohydrate radical might meet additionally five other such radicals from neighbouring clusters and polymerization into glucose might occur at an even lower energy density and stabilize the resulting reaction product. This reaction system could even react with coordinated nitrogen ions and continue reacting to give long-chained fibre structures of, for example, cellulose or, say, starch, filling the less-ordered interface between clusters with stable organic matter which brings increased order to this space and increases synthesis efficiency and precision. Preferentially, molecules containing C and N form long-chained complex molecules with hydrogen and oxygen. These reactions could proceed until the build up and decay of these molecules are precisely in dynamic equilibrium. The organic products absorb different wavelengths of light according to their electronic configurations and distributions. Absorbed energy is usually dissipated by transformation of the light into longer wavelengths (fluorescence) or by mechanically modulating the coherently oscillating cluster medium. Such molecules modulate the mechanical standing wave patterns with their inherent electromagnetic fields in the cluster medium within their adapted enclosures (membranes) until the highest stability of compounds under these dynamic conditions is achieved. It seems likely that this is the key for the evolutionary development of all kinds of structural molecules like amino acids, proteins and all kinds of biocatalysts such as enzymes. The complexity of living matter is a result of the dissipation properties of water and the living cell as an energy-dissipative structure (Prigogine 1980).

(b) *Role of energy-dissipative medium water*

This kind of self-organization makes the dissipative process of life and its development a necessity rather than a result of chance. The energy-dissipative medium water in interaction with the solid interface, driven by the energetic interaction of the sun with our biosphere would be sufficient to explain how living metabolizing structures are created under dynamic conditions (Ripl & Wolter 2000).

A more function-oriented view among scientists could probably bridge the very structure-oriented, 'scientific', reductionist viewpoint and result in an improved identification and better understanding of biological processes. This is especially true in the fields of so-called 'scientific medicine', and the various alternative approaches, which seem more and more to complement rather than contradict each other.

3. THE ROLE OF WATER IN SELF-ORGANIZING ECOSYSTEMS: THE CONCEPT OF THE DISSIPATIVE ECOLOGICAL UNIT

According to Odum (1969), ecosystem development is a two-phase process.

(i) An establishment phase, where pioneer plants cover the space and prove to be the most efficient in utilizing nutrients and water for the most rapid reproduction, and thus covering the available empty surface or space. However, when space becomes filled up and limitations occur, a change of strategy forced by negative feedback has to take place.
(ii) A maintenance phase, where assemblages that develop matter-recycling capabilities occur, characteristic of 'mature' ecosystems. Assemblages of organisms, which are able to close matter cycles and develop short-circuited and, in part, internalized

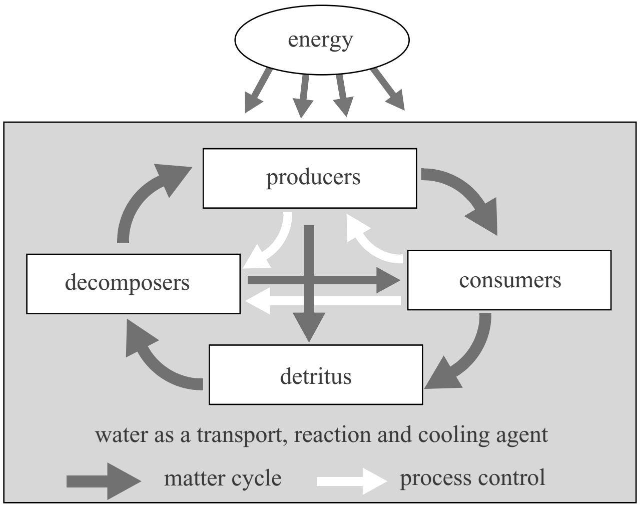

Figure 2. The DEU (Ripl & Hildmann 2000).

water and matter cycles, are energetically favoured (*k*-strategists) and replace the *r*-strategists (pioneer organisms with high reproduction rates).

(a) *The matter recycling ecosystem cell or dissipative ecological unit*

Considering ecosystems in the maintenance phase, which are analogous to organisms designed in a cellular way, we will call them DEUs. Five functionally defined components prove to be necessary to form a DEU (figure 2). The components consist of three types of organism, as

- (i) green plants (primary producers);
- (ii) bacteria and fungi (decomposers);
- (iii) the food chain (all kind of animals as grazers and predators of all kinds of organisms, thus opening up space for growth and reproduction, and thus keeping the system efficient); and two non-living components, as:
- (iv) dead organic debris, serving as a stock of energy, nutrients and minerals; and
- (v) water, serving as the cooling, transport and reaction medium.

(b) *Double function of the green plant*

The green plant usually has a double function, which is, on the one hand, the production of energy sources for all kinds of organisms and, on the other hand, the function of an active water pump sucking water through the roots to the leaves and maintaining the process of transpiration. By active transpiration, which is coupled to the photosynthetic processes, in the root zones by way of feedback, regulation of redox conditions is largely controlled. Waterlogged layers of debris and root zones rich in water-retaining capillaries are lacking in oxygen supply and retard the decomposition–mineralization processes. Evapotranspiration coupled with net production lowers the water in the soil zone capillaries and enables air access to the debris layer, thus enhancing the activity of decomposers and providing mineralized nutrients for the production process, just at the time when it is needed, and almost without energy, nutrient and mineral losses.

The selection criteria in the maintenance phase rely on the matter-recycling performance of the whole organism assemblage within the domain of one DEU (the ‘cellular’ unit of one ecosystem) and a maximum decoupling from the evaporative water cycle, rather than relying on a single pioneer species as in the establishment phase.

Mutants and new organisms introduced to such an assemblage become selected according to their ability to improve localized matter cycling and to reduce the irreversible losses from the habitat; thus, by doing this, prolonging the usage of the habitat and retarding the process of ecosystem ageing. Less energy is used for weathering minerals and for acidifying the habitat than occurs in highly net productive systems. More energy for spatial growth facilitates the expansion of such assemblages, while any surrounding, less resource- and energy-efficient, structures have to shrink.

4. THE EMERGENCE OF ECOSYSTEMS AND SUSTAINABLE DEVELOPMENT IN NATURE

Sustainable development with the least material losses is achieved if almost all water is evaporated and not percolated through the soil. Surface run-off, low in matter transport, together with the higher probabilities for precipitation in wetlands and floodplains (and providing higher heat capacities and better temperature control), is still able to feed rivers and streams with sufficient water. At the same time, importantly, the movement of groundwater to rivers and streams is minimized. A high water-retention capacity in the landscape is accomplished in the biosphere, in the vegetation and in the debris and humus layers of the upper soil zone—and not by percolation to the groundwater. The store of groundwater (‘the permanently saturated soil zone’) in natural landscapes was always kept at a maximum and situated in the lower floodplain and river margins, usually as close to the soil surface as possible. Groundwater transport would always be successively minimized in nature.

(a) *Closing and short-circuiting as the stabilizing principle*

Groundwater is not the dominant source of water for living organisms. Rather, they control the water cycle more and more by short-circuiting their internal and external water cycle. The external cycle, in particular, has been optimized by the foliage of trees serving as both evaporating and cooling structures in these finely tuned processes. The spatio-temporally phased adaptation of the organism assemblages under dynamic conditions, as described in § 3b, is the origin for the observed species diversity in mature ecosystems. The adaptation process provides ‘cellular’ structures, characterized by increased resource efficiency and cyclic processes, with a minimized openness for matter and heat transfer. Here, again, water is the most important dissipative dynamic agent—and the water cycle determines the dynamics and sustainability of each DEU ‘cell’.

The course of the evolutionary process at the ecosystem level becomes clear when the very precise energy pattern of the sun’s radiation, modulated by the Earth’s rotation and its skewed axis, is taken as the primary structuring information. The habitat, with its energetic and material prerequisites, provides the second set of structuring boundary conditions (time and space limiting) for the local development of the various living communities (biocoenoses). The dynamic process eliminates initial randomness and replaces it with ordered, metabolizing structures—the result of the most optimal local lowering of energy flow density, i.e. the dissipation of energy. The stabilizing principle is closing and short-circuiting the water cycles locally, internalizing matter cycles, and thus minimizing irreversible material losses from the habitat. Sustainable development ('the most reduced rate of ageing') of the biocoenosis ('organisms') and the habitat are the results of this dynamic process. After an initial phase of establishing vegetation cover wherever possible, and filling up the space with rapid-growing pioneer species, negative feedback due to space and/or matter limitation initiates the second phase of development.

An improved coupling and integration of processes becomes necessary. This is accomplished by an improved 'socialization' ('working together') of organisms and improved short-circuiting of material flows in space and time, providing better resource utilization within the confines of the habitat; here, the limiting pulsed energy flow of the sun serves as the 'balance wheel' of the coupled 'clockwork mechanism', determining and regulating the course of parallel and sequential processes. Again, water as the cooling, transport and reaction medium serves as the process-carrier in the ecosystem's successional and evolutionary processes. This means that evolutionary probabilities are rather high initially in simple biocoenotic structures, and then decrease with the degree of self-organization towards improved efficiencies for resource utilization.

(b) *Short-circuited water cycles within vegetation structures*

The increased performance of optimized and phase-adapted structures is shown by an increased evapotranspiration and the localized temperature damping between day and night. At night time, the water vapour produced during the preceding day is condensed, thereby warming up the night period around vegetation. Supersaturated water vapour is immediately condensed on hairs, needles or any sharp-edged structures, thus building up droplets that lower surface tension, and warming up such structures at night—as can be seen with spider-webs or similar structures. Extremely short-circuited water cycles in nature are probably the most abundant water cycles within vegetation structures. Field experiments showed high range of evapotranspiration rates, up to 27 mm a day through the advection effects (Kucerova *et al.* 2001) whereas the evaporation and precipitation as measured in various sampling devices represents only a more or less small fraction of these energy-dissipative water cycles. This view is supported by close inspection of satellite pictures: showing the distribution of black body radiation of vegetation structures in, for example, Landsat TM channel 6 imagery. The more evaporation processes at and within the surface and foliage of vegetation per area that takes place, the more even the temperature is distributed and the cooler are vegetation structures—markedly so at times with high-energy flow (midday in summer).

Energy-dissipation processes by the energetically discretely distributed and formed water cycles, within a large range of frequencies, are to a large extent controlling the microclimate, the provision of necessary water for plants, and preventing large thermal differences in the landscape. A random mosaic of overheated and cooled areas results in highly turbulent, dynamic convection and advection processes in the atmosphere, close to the soil and vegetation-covered surface. Convective turbulences are generated and dust carried high into the atmosphere serves as nuclei for condensation processes that occur in areas of wetlands, rivers and lakes—areas that are mostly better-cooled and show lower atmospheric pressure than the overheated surroundings. It is easy to understand that these small local areas lacking any means for an efficient temperature-regulating system are channelling energy into global weather systems and thus modulating them. Areas with an even cover of vegetation, with sufficient evaporable water, have more predictable weather events than do damaged areas without proper vegetation cover.

In pristine alpine regions, for example, the cloud and fog distribution shows very precise patterns, which indicate where the evaporation and condensation occur, showing the energy-dissipative process in its spatio-temporal distribution mediated by the water cycles. Recently, a Czech study showed that different management practices in small catchments result in different matter losses and different temperature distributions (Procházka *et al.* 2001). Similarly, restoration of spoil heaps through re-vegetation can be accomplished in direct feedback to matter losses and temperature fluctuation (Pecharová *et al.* 2001).

Most of these short-circuited water cycles are, to a large extent, decoupled from matter cycles. They occur at the various levels of natural organization as inherent parts of the system and, to a high degree, are internalized. Groundwater, however, is practically stationary in an optimized natural landscape. During the earliest stages of vegetation development, after, for example, the last glaciation phase had ceased, groundwater flows still occurred in significant amounts. However, the growth of trees, with their large amounts of evapotranspiration, slowed down the vertical flow of water—and fine material from the soil surface was deposited, along with rising saturated carbonaceous or siliceous solutions that were precipitated, close to the root zones of these trees. This process seals the underlying parts of the trees, which accumulate debris on top of the root horizon and create a layer of water-retaining debris that acts as a moist 'swamp'. Studies in alpine virgin forests have revealed the large layers of organic debris, with trees using decaying trunks as a substrate, especially as a 'tree nursery'. The tree roots are extremely flat close to the 'soil' surface—trees mostly grow with hardly any direct contact with the lithosphere. This moist-debris swamp usually has a large water-retention capacity, so that *ca.* 30 mm of precipitation or more are needed until the first run-off occurs.

(c) *Alpine virgin forest as an illustration*

Within these alpine virgin forests, the passage of water through the underlying layers is successively minimized. The rivers are partly fed by water running off from areas above the tree boundary line and are partly fed by direct precipitation into the river bed or riparian zones. In winter, of course, when snow is melting, surface flow to the lower river beds occurs. Matter transport out of such pristine virgin forest areas is extremely low in dissolved matter and organic humic substances. In the dolomitic part of this alpine landscape, rivers can show conductivities of *ca.* 150–200 $\mu S\ cm^{-1}$ at 20 °C, which is roughly in accord with the solubility product with an atmosphere containing 0.3% carbon dioxide. At the same time, snow analyses in this region have revealed a pH range of 6–6.5, with extremely low sulphate, nitrate and base cation content. These observations show that an intensive local water cycle prevents and dilutes the wet–dry air deposition material carried by long-distance water cycles. A structural proof of these conditions was the occurrence of a belt of native beech (*Fagus silvatica*) at the tree limit boundary (at 1600 m a.s.l.). Below this beech layer, the forest contained substantial numbers of coniferous trees.

However, these observations should not be taken as an example of what we should try to achieve in rural management and a sustainable landscape. A virgin forest (Rothwald in Austria, size 350 ha (1 ha = 10 000 m^2)) is a lost paradise (i.e. never to be regained) that has taken about 2000 years to establish (as shown by peatcore dating) and could not sustain human societies. However, studies in this virgin forest reveal the play rules of nature; play rules that are cleaning water through evaporation (distillation) processes, using the latent heat of water for determining the microclimate of habitats, and sealing the landscape against matter losses with any possible groundwater flow, which would otherwise lead to matter being transported out of local habitats. The highest efficiency is achieved by internalizing most subsistence processes at the cellular level, and if this is not possible, at the organism or ecosystem level. A study of the intensity and distribution of these water-bound processes reveals the origins of ecosystem stability or sustainability. This rise of stability relies on the ecosystem reaching its final evolutionary stages with a minimum of material losses to rivers and thus to the sea. This is the ever-improving natural resource management by ecosystems; for instance, in a virgin forest, adopting the evaporative water-pump of trees that can control, in an integrated way, the cleaning of water, the maintenance of an optimum energy dissipation and temperature damping, and the control of mineralization processes and irreversible matter flow (W. Ripl, unpublished data).

5. THE ADVERSE ROLE OF SOCIETY IN THE PROCESS OF NATURE: INTERFERENCE WITH THE BLOODSTREAM

As man became initially integrated into the process of nature, man was controlling ecosystems as a top predator by raising resource efficiency, through his removal of biomass and the opening up of space. Man helped ecosystems to increase gross productivity while net productivity was kept close to zero. The change in 'socialization' ('system connectedness') through the introduction of agriculture also changed man's relationship with nature. The optimized water and matter cycles were partly opened up, resulting in increased losses of matter from habitats.

(a) *Agriculture introduced loss processes*

However, in the initial phase, the increase in losses was only slight and the first few hectares of cultivated land resulted in much smaller losses than did the last few. The progressive covering of landscapes with increasingly cultivated areas has resulted in a shift to highly nonlinear ('unpredictable') loss processes. Initially, interference with the water cycle was negligible—until the cultivated landscape was complemented with small settlements. In these settlements, the administration, culture, market-trading and defence were done in a centralized way. However, man considered the cultivated areas as his own property and the defence of this property was best managed in a centralized way. The self-sufficient economies of the farms were developed into bartering and trading goods. The local recycling of matter seemed no longer possible and material losses further increased. When the settlements grew into small cities, nearly always situated close to rivers to enable transportation, the demand for increased harvests grew inexorably and even larger cities developed.

Historically, water played an eminent role in practically all kinds of ancient cultures. The sustainability of early cultures was to a large extent coupled to the use of vegetation elements in agricultural practices and in the way that water was supplied to increase productivity. Large differences can be seen in the span of different cultural periods depending on the manner of cultivation. In the Far East tradition, rice paddies (utilizing wetlands, recycling faecal matter and adopting a bacterial food chain in fish and chicken production) were the main nutritional basis, markedly low in matter losses for a relatively long-lasting cultural development (4000–5000 years). There is evidence that the carrying capacity of dike and pond systems in former China reached up to 120 persons per hectare (Korn 1996). Contrast this with the Western tradition (Babylonians, Egyptians and Romans) where 'dry' steppe-originated plants were domesticated and used as the basis for cereal production. To enhance the productivity of cereals in these cultures it was far better to have water in control, by way of artificial water supply and irrigation; however, the material losses from production areas were considerably increased. Quite soon, growing cities developed, and losses were further increased because of the lack of recycling—until cultural succession became necessary. Already, at this stage of development, less-closed matter cycles were being opened up even more and, despite the permanent procession of military campaigns to conquer more 'living space', these cultural assemblages lasted at most 2000 years.

(b) *Landscape degradation mediated by water*

In agricultural practices, water management and irrigation were introduced to gain productivity in cultivated areas. Larger means of transport to and from the cities became necessary. Warfare was invented to secure the existence of growing cities, resulting in still ever more increasing demands, until such high resource and control inefficiencies had developed that these ancient cultures broke down—leaving only desert. This happened with the cultures of Babylon, Egypt and of such Mediterranean societies as the Greeks, Romans and Carthage. It is worth mentioning that the vegetation and the local water cycles were lost concomitantly at the same time. This indicates that the local cooling structures of vegetation were responsible for the distribution of precipitation and temperature. Since those times, the Mediterranean landscape has been highly degraded—to a large degree, forests have been replaced by scrub vegetation. But, even in more recent times, large continental areas have been dried out and damaged systematically by so-called 'ameliorative' actions, with the aim of increasing local productivity. Within a relatively short time-span, large areas of the American continent, the Ukraine and by the Aral Sea (Russia) were turned into deserts. Even in central Europe the landscape has been dried out by these measures. The opening up of top-soils and the lowering of water tables were aimed at increasing mineralization and the productivity of cereal crops, which are still the original domesticated 'steppe-like' plants inherited from our ancient cultural predecessors.

The processes involved in this degradation of landscape are again mediated by water; the land is now characterized by oscillating water tables. Air is introduced into the previously self-regulating soil system, thus increasing bacterial activity and oxidizing the acid-forming compounds such as organic material containing sulphur and nitrogen. In spring, when the water table is successively lowered because of increased evaporation, the activity of micro-organisms is enhanced and salts are formed in the aerated pore-spaces of soils. In autumn, when the maritime and the continental thermal climate regime changes—and precipitation increases over the European continent—the water table rises and the salts of nitric and sulphuric acid produced during the summer are now transported to the rivers and to the sea. High losses of base cations and nutrients are the result. The energy liberated by this process is, of course, converted into mineralized 'fertilizers' for the plants, but also into highly increased material losses. Measurements of these losses show that the material flow has increased by a factor between 50 and 100, compared with losses from optimized natural vegetation structures.

Originally, the soil was the dynamic interface between vegetation and the lithosphere—under the conditions of the local water cycle—and this soil was managed by the optimized plant cover in direct feedback to gross production; whereas, the soil in our modern society has been transformed to an optimized, homogenized substrate for maximizing net productivity. Percolation experiments in soil columns, one with a stationary water table up to the surface of the soil column, and a second similar column with the same amount of percolated water but in a wet and dry cycle, have shown that three times as many ionic charges were dissolved when the water table was successively oscillating up and down. This might explain how the East Asian agricultural practices, which adopted continuously wet rice paddies, have prolonged the period of land use, providing a relatively more sustainable cultural society. However, even these cultures have recently changed their agricultural practises towards more global agricultural practices, in accordance with European agriculture; resource efficiency has dropped with increased losses as a result.

(c) *Sustainability and the way we adapt to the play rules of nature*

From these examples, we can see that the way in which water and matter cycles are controlled in various societies is crucial for their sustainability—crucial for vegetation and desertification phases, and for the carrying capacity of their systems of agricultural subsistence. Before, it was claimed that virgin forests belong to a lost paradise. However, the way we adapt to the play rules of nature determines the sustainable development of our societies. Comparing the land management in our countries with the process of nature shows how little our agricultural practices have developed; how our food production, energy and water supply, together with the maintenance of the indispensable service functions of nature, all lack efficiency. If intelligence is defined by the ability to sense and trace phase conditions, and, in accordance with them, to act in an adaptive way, our collective intelligence dealing with the process nature seems highly underdeveloped.

The reason for this seems to be several severe malfunctions at the interface between the 'software' of our economic and social behaviour, and the 'hardware' requirements of the physical system. An important general failure seems to be the incompatibility of the separate centralized administrative control of vegetation, soil, water and conservation management, with the help of universal laws and rules. Nature, however, shows an energetically discrete distribution of water, energy and water-dependent natural processes.

Another basic bias results from converting ordered natural structures, which result from a developing optimized natural process and connectedness, into distributions of randomness. Further, the adoption of a structurally based conceptual framework, split into arbitrary administrative sectors, leads to highly inefficient and destructive control mechanisms being implemented by society; whereas, nature adopts a functional framework successively eliminating randomness.

(d) *Introduction of non-renewable energy*

One of the most destructive steps in our excessive devastation of nature was the implementation of non-renewable energy in society. The constraining, but structuring, feedback mechanisms of a very precise daily energy supply pattern, modulated by the seasons, in the spatio-temporally distributed process of nature were thus removed—thereby accelerating the ageing and degradation of the landscape and its ecosystems. Even the energy-based boundaries of city growth were thus removed—and all cyclic processes were transformed into unidirectional structures demanding ever-increasing transport facilities. A sudden large increase in the irreversible losses of structure, matter and energy came as a result. The natural water cycles were subjected to the largest distortions, followed by tremendous linear matter flows to the sea. The building of centralized power facilities, water supplies fed by the use of groundwater, miles of sewerage systems and water treatment plants, has resulted in the conversion of cities into malign cancer cells, whereas the overexploitation of top-soils on a global scale has resulted in the damage and overuse of the finely tuned local water cycles. Although societies believed in a large step forward in technical and social development, the process 'Nature' was thrown back into the early establishing phase—from communities of *k*-strategists to simple monocultures of *r*-strategists—thereby losing its valuable habitats and

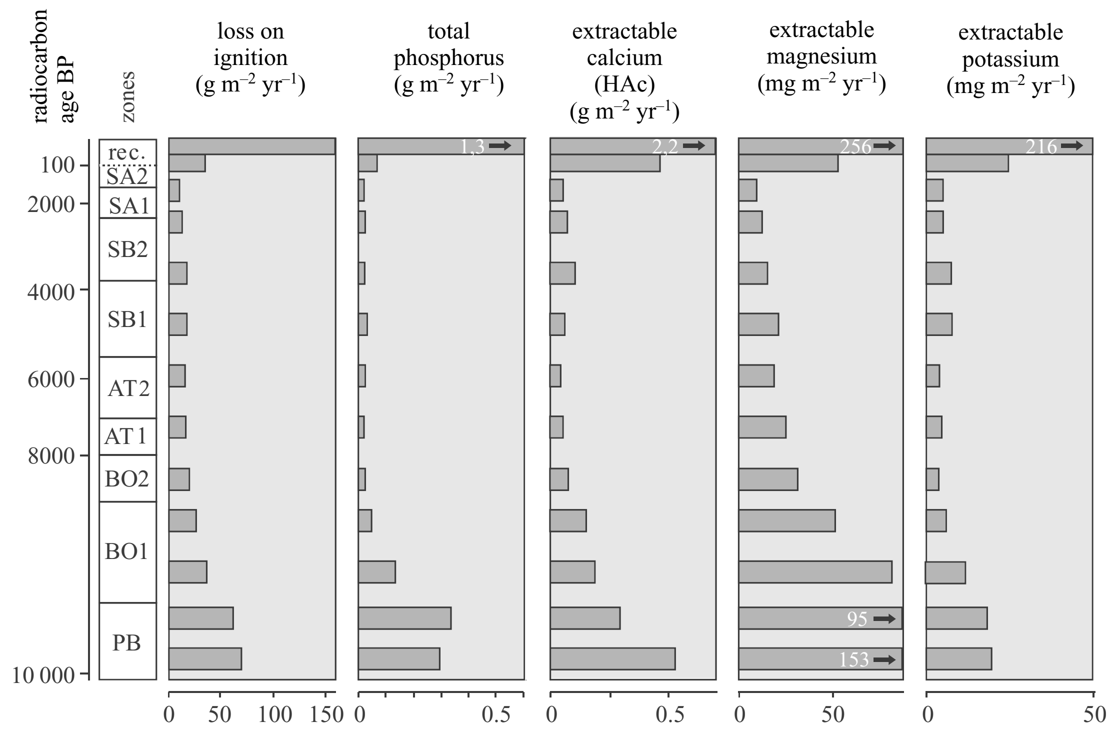

Figure 3. Postglacial development of Lake Trummen; annual deposition (modified from Digerfeldt (1972)).

diversity, the most valuable results of the self-organizing process we call 'Nature'.

(e) *Irreversible material losses: some examples*

The 'ameliorative' lowering of groundwater tables, which are still decreasing, has led to rapidly oscillating drying and wetting phases—both phases combining to acidify top-soils by the oxidation of organic matter and destruction of soil colloids, all of which are needed for matter and water retention. As already indicated before, this oxidation process has resulted—most often in summer when the water table decreases because of enhanced temperature and evaporation—in the production of strong nitric and sulphuric acids, thus weathering inorganic soil minerals into easy dissolvable salts which, in autumn, under conditions of rising groundwater tables and increased flow conditions, are transported through groundwater to the rivers, lakes and coastal areas, resulting in enormous non-point source eutrophication processes (Ripl *et al.* 1995).

Ageing is increased dramatically as can be seen by the transport charts and patterns of increased irreversible charge flow and erosion. Digerfeldt (1972) showed in the small catchment of Lake Trummen, Sweden, the development of sediment deposition rates in the postglacial period (figure 3).

Since the time that groundwater tables were lowered, agricultural net productivity has been highly increased—however, at the cost of a nonlinear reduction of sustainable development and the rapid ageing of landscapes. Since the introduction of non-renewable energy, the irreversible material flow has increased, per hectare, for the whole area of Germany, by a factor of more than 50 and even up to 100 times. In total, 1000–1500 kg of total dissolved salts, calculated without including sodium chloride (NaCl, which is considered as almost always, nowadays, a direct anthropogenic contribution to water courses), are the net losses from each hectare of Germany every year. The losses from pristine natural mire and forest structures were *ca.* 10–20 kg per hectare per year, whereas calculations of matter transport in German rivers have revealed a weighted mean of over 1400 kg of mineral salt losses per hectare and year for the total area of Germany (Hildmann 2003; figure 4).

Calculated as proton equivalents liberated in the soil, this is roughly estimated to be 2.5 kg equivalents per hectare per year. Pokorny (2001) estimated that at a radiation input by the sun of 6 kWh m^{-2} and a peak energy flow of 800–1000 W m^{-2}, a wetland or forest dissipates some 70–80% of this energy by evapotranspiration, whereas only 5–10% is back-radiated to the atmosphere as heat. Drained agricultural fields, however, show an evapotranspiration of only 10–20% whereas back-radiation to the atmosphere is 60–70%. Just one tree, with a crown diameter of *ca.* 10 m, evaporates during a single sunny day *ca.* 400 l of water, equivalent to *ca.* 4 mm. By contrast, the photosynthetic process amounts to only a dissipation of 2–4 kWh, which is *ca.* 1% of the radiation input (Pokorny 2001).

The target functions for modern agricultural and water management are almost diametrically opposite to the target functions of nature and its self-organizing process. In our water and agricultural management, catchment runoff and the regeneration of groundwater are controlled with a high degree of modelling and data-measurement effort—however, only leading to the increased irreversible transport of matter (mineral and nutrient ions much needed by vegetation) and to a decreasing soil fertility.

Such management practices are further dependent on the composition of soils and their stock of weathered minerals. Floodplains of fluvial origin, and soils subjected to oscillating water tables in the lower parts of the catchments, seem to be much more sensitive to management

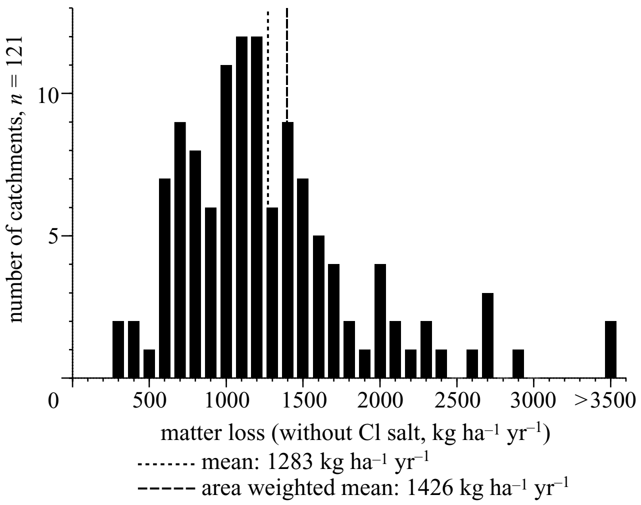

Figure 4. Salt loss with the rivers to the sea (Hildmann 2003).

practices than do the elevated headwater regions with their soils containing igneous or solid calcareous dolomitic components; weathering and erosion processes are expected to regenerate soils at these higher elevations. Floodplains of low-lying landscapes, as, for example, the northern part of Germany, by contrast, show a decreased base-cation exchange capacity and top-soils with increasing acidification in their vertical soil profiles.

The management of water and soil in many rural areas, therefore, shows over-exploitation: reducing their sustainable development and decreasing the possibilities for gainful land use when non-renewable energy sources become exhausted. In table 1, we find records of irreversible losses in various small catchments within the larger Stör River catchment area (Ripl & Hildmann 2000).

6. REMEDIATION OF THE BLOOD STREAM OF THE BIOSPHERE

(a) *Re-implementing dynamic structures to minimize irreversible losses*

As we have seen, process distribution and connectedness in nature is quite different from the production practices of our society. The main ecological processes are the water cycle with its transport cooling and reaction functions. Coupled to this water cycle are the matter flows. By changing between the liquid and gaseous phase, matter cycles are tightly bound to vegetation and thereby decoupled from the water cycle. It is important to note that vegetation keeps water in a litter-detritus 'debris' layer and buffers the external water cycle by an internalized water cycle. Groundwater flow is slowed down and kept close to the soil surface. Water vapour in the lower atmosphere close to vegetation, even without a single rain event, can be precipitated by leaves, needles and other structures with high surface to volume ratios. The result is a lowering of surface energy and a warming of these structures. We can see that, even without what could be measured and called 'rain', the water cycle can be closed by these energy-dissipative structures. The water cycle within forests is much higher in frequency than the long distance transfer of water vapour from the oceans to continents. The limiting factors in terrestrial ecosystems are, originally, space for growth and available nitrogen for plants.

Within our society, the naturally adapted water and matter cycles are highly distorted and opened up. Control of the cycles is still more neglected and irreversible matter losses from habitats to the seas occur. Based on these findings we have to revise our agricultural and land management practices. Before the use of non-renewable energy, closed matter cycles between society and agriculture were needed to achieve sustainability. The organized groups of small villages were coupled to farming and able to host much larger parts of the population; whereas, cities were limited by transport, supply of food, but mostly by the feedback mechanisms from metabolic products, which had to be transported and recycled to the fields. Labour sharing had not yet been developed far beyond any efficiency optimum and a part of labour was needed for earning local subsistence. The distribution of trade and craftsmen was adapted to this feudal society. The large advance of industrialism was founded on the belief that one could produce goods without needing land area.

Planning processes were centralized within cities and controlled by a centralized administration, ruled by laws. All kinds of feedback and hierarchical adaptation mechanisms were thus removed and/or randomized with respect to nature—resulting in increased inefficiency in the conservation of physical resources and energy dissipation. The so-called economic planning and distribution of processes and land use was to steadily replace the adaptive management of agriculture and the trades serving the agricultural-based society. The difficulty with solving our sustainability problems seems to be the transition from that of a net-production society into one whose strategy is characterized by the maintenance of the steady state, where water and matter cycles are to be closed and the function of ever-continuing 'growth' reduced to that of improving relations within society, life quality and sustainability. Planning that does not take into account temporal phases and system-immanent cycles has to be replaced by coupled spatio-temporal-related planning (time here being synonymous with energy), which means re-implementing dynamic structures that have minimized irreversible losses. These goals can be only achieved by respecting life cycles and adaptive resource management on managed land areas: locally providing the water cycles, the energy, the food and the necessary service functions of nature. Such service functions are that of soil fertility, short-circuited water cycles, the thermostatic ('thermal-damping') function, and the composition as well as distribution of matter in the atmosphere.

(b) *Improving water and matter retention*

Man has to be reintegrated in ecosystems as the most suitable intelligent controller of water cycles and matter cycles. Responsibilities and control functions ought to be redistributed downwards to locally acting resource managers in self-sufficient 'cellular' structures which control to a high degree their water and matter cycles and internalized subsistence functions. These functions imply the local production of their required energy, water, food and maintenance of their local natural services. The efficiency of these 'cells' will be increased if these functions are achieved within the least possible area. A

Table 1. Overview of matter losses of several sub-catchments of the Stör River catchment (mean from 1992 to 1994). (The data are compared with the input by rainwater (last row, mean from 12/92 to 3/95; Ripl & Hildmann 2000.))

river or stream	location	catchment area (km^2)	precipitation (mm)	run-off (mm)	run-off ratio	total diss. loss	without NaCl	SO_4	Ca	K	Mg	total N	total P
						(kg ha^{-1} yr^{-1})							
Stör	Willenscharen	484	910	394	0.43	1324	1183	267	295	30.7	20.8	23.3	0.573
Stör	Padenstedt	203	890	405	0.46	1582	1413	304	352	33.2	21.9	27.3	0.562
Schwale	Brachenfeld	71.7	883	287	0.32	1175	1106	199	280	15.3	17.5	18.3	0.387
Schwale	Kerkwischholz	48.8	880	260	0.29	1032	971	160	247	13.5	14.6	19.2	0.423
Dosenbek	Tungendorf	28.1	889	247	0.28	831	774	147	195	14.6	13.1	15.1	0.566
Aalbek	Ehndorf	41.4	885	423	0.48	1618	1475	348	361	35.4	21.9	14.3	0.460
Bünzau	Sarlhusen	206	915	423	0.46	1174	1044	229	261	29.2	21.2	24.2	0.788
Buckener Au	Innien	58.8	943	456	0.48	1089	945	197	231	28.1	23.0	24.5	0.686
Wischbek	Ehndorfer Moor	5.7	891	453	0.51	1491	1343	350	319	37.6	25.2	12.8	0.431
Bredenbek	P16	10.7	893	434	0.49	1379	1256	334	312	32.9	20.1	10.7	0.493
Höllenau	Böken	61.3	888	364	0.41	1119	1026	223	260	23.7	17.5	19.7	0.694
Fuhlenau	Böken	34.3	939	588	0.63	1718	1540	335	394	13.1	33.2	54.4	1.402
Höllenau	Moorabfluß	17.6	886	329	0.37	1075	1000	151	256	16.8	15.7	20.4	1.591
Bramau	Föhrden	453	901	358	0.40	1056	905	191	224	27.4	16.4	17.0	0.580
Schmalfelder Au	Bramstedt	179	895	293	0.33	816	697	147	173	22.3	14.2	16.1	0.675
Ohlau	Bramstedt	72.3	913	383	0.42	861	759	165	192	27.0	17.9	26.9	0.613
Dreckau	Lentföhrden	13.5	911	347	0.38	538	445	136	111	29.6	16.8	33.4	1.354
Osterau	Bramstedt	168	908	394	0.43	1168	993	204	245	23.0	15.7	14.5	0.588
Osterau	Heidmühlen	86.8	932	318	0.34	971	898	194	226	18.3	12.0	12.0	0.445
Holmau	Kleine Au	17.1	891	621	0.70	1539	1383	243	344	34.3	24.1	27.4	0.748
Halloher Moor	P07	1.52	912	369	0.40	715	650	148	178	21.5	14.2	30.3	0.294
Brokstedter Au	Brokstedt	93.2	911	423	0.46	1533	1398	338	341	37.6	21.9	15.9	0.507
Brokenlander Au	Hasenkrug	53.1	903	387	0.43	1466	1332	331	325	32.5	20.8	9.9	0.409
Wiemersdorfer Au	Hasenkrug	35.9	906	431	0.48	1475	1347	312	335	39.1	21.9	24.7	0.767
Wegebek	Mühlenbach	9.47	952	591	0.62	1294	1168	245	304	30.7	24.5	37.6	1.011
Fitzbek	P4317	6.4	949	347	0.37	868	785	158	193	19.7	15.3	15.0	0.475
Mühlenbek	Kellinghusen	19	911	288	0.32	820	748	197	192	24.5	14.6	17.5	0.276
precipitation			965			161	90.4	46.8	7.64	5.36	3.34	21.6	0.598

coupling of these cellular structures at a secondary level of organization could further reduce irreversible losses. A maximum of space should be kept available for the process of nature—at least during the transition phase. This means that the functions of subsistence are to be intensified by gaining process density per area.

These approaches need to adopt both low-tech and high-tech solutions for harvesting solar energy and adopting internalized closed water cycles, by water distillation through steam formation, production of electricity, condensation of steam and using the latent heat produced during the condensation process. Warm, distilled water can be used in household machines, for showers and baths. Steam–water mixtures can be used in vacuum toilets for sterilizing. At the moment, water- and wastewater-free housing with separating vacuum toilets is being developed. The reuse and processing of nitrogen and phosphorus contained in urine, and the decentralized drying and combustion of the solid faecal matter, together with biological waste and organic wrapping material in block heating and small power plants is promising, especially if the excess heat produced enables the intensification of food production in integrated greenhouses. The use of biomass as an energy source from rapidly growing trees (willows (*Salix*) and poplars (*Populus*)), with a harvesting cycle of 5–8 years, would be additionally useful to increase landscape cooling, and water and matter retention in fallow land that has lost its fertility.

Particularly degraded land close to rivers can additionally be used as water retention areas in the case of flood events. Adapted land management can be improved by the adoption of agro-forestry concepts and a redistribution of land use—providing optimized temperature damping through evaporation and the recycling of nutrients and minerals wherever possible.

A localized, closed and internalized water cycle means that sewage systems and water-supply pipes, as well as water and sewage-treatment plants (sources of enormous material losses), can be avoided. The recycling concept could even be adapted to arid countries. Combined with reforestation using sludge from, for example, biogas production or still-working treatment plants, these localized, closed water cycles could provide water, nutrients and minerals for growing oases and winning back manageable land from the desert. Greenhouse facilities and the solar distillation of salt solutions, or seawater, by Fresnell-lens glass collectors for heating, create subsistence structures even for developing countries. The assemblage of such structures can be done at different stages: starting with low-tech solutions and successively replaced by high-tech ones. There will still be a certain need for additional water to cover the inevitable losses from an almost-closed water cycle. Collected rainwater, distilled brines and recycled grey water could be sources for refilling the water loop internally and to get the tree-vegetation cover to grow in desert areas. As nature shows highly nonlinear properties and the transition from sink to source regarding the water cycle cannot be evaluated in a simple deterministic model, feedback and heuristic pattern recognition will have to replace the excessive belief in and adoption of management based on modelling.

New types of professional are badly needed for this most important work. At the moment, all our efforts are taking place in cities in a highly inefficient manner, shown by the steadily increasing irreversible processes and already substantial growing negative feedback at both economic and social levels indicating lasting and severe limitations.

(c) *Society needs flexible and adaptive restructuring practices*

The rapidly changing conditions in the 'hardware assemblage' nature, and the software solutions of our societies, need flexible and adaptive practices to restructure our societies and to eliminate the sources of inefficiency—as there is too high a division of labour and the basis for planning is built exclusively on the will and imagination of society.

The modules for future self-sufficient structures can be developed in our countries and people trained at all educational levels. These hardware and software modules and structures have to replace the remnants of an industrial society built on eternal linear growth. The kinds of technology needed for this reconstruction should be easily adapted to the various climatic conditions, needs and phases of development. Such a direction for research and development is probably much more promising than the development of improved methods for forcing nature: with dams, large-scale irrigation and the development of ever-increasing amounts of treatment steps in sewage-treatment plants, as well as the additional sewerage and centralized burning facilities for wastes and sludge.

Comparing the above-named development towards decentralized self-sufficient structures for subsistence with that of the developments proposed by private–public partnerships and global-water partnerships, it seems that sustainable development becomes even more likely with the sort of subsistence concepts proposed. Locally adapted best-management practices can only be done by well-trained and broadly educated resource managers able to integrate all subsistence functions within a certain managed area—thus replacing those many land managers and farmers who are directed by administrators under a planned economy and in a centralized manner.

The local remediation of fundamental water-based ecological functions is, however, coupled to policies based on the principle that the person causing damage must pay the cost ('the polluter must pay' principle). To start with, for restructuring societies, this principle could be taken and even applied to road transport processes. This would increase the costs for heavy transport by a factor of 50–100, as the axle pressures contribute to the fourth power in the formula relating road damage to repair frequency. This would mean that practically the whole road construction programme ought to be paid for by such heavy traffic. The result would be highly improved regional markets for locally produced subsistence products. Transport probabilities would decrease and local cycles become enhanced. It seems that the subsidies to agriculture are in reality subsidies towards cities, which, only by using cheap non-renewable energies can compete and spread. Economic models for a sustainable future have in the long run to be oriented along the lines of the 'bloodstream' water and its basic role in society.

(d) *Economic models for a sustainable future*

Undistorted market forces, even for labour developing under the constraints of limiting resources—as are human resources, renewable energy (time) and land with its material and energetic prerequisites (space)—reflect the evolutionary and self-organizing system. In the un-liked former feudal system, human resources and social responsibility were very poorly developed at the level of society. A modern post-industrial society, however, needs a basic right of elementary subsistence support. This could be for everybody a basic level of labour-free income together with basic healthcare support. Together with the other possibility for free income for everybody by right, at a certain age, to get an untaxed property value from his/her society, which could then be rented to resource managers and reduce the proportional resource taxes on property values that must successively replace individual labour and income taxes—especially if labour is no longer a limiting factor any more and therefore produces the new poverty of unemployment. However, why is this taken up in our treaty of the universal life-giving bloodstream?

The reason is that the process of nature shows that each organism has a basic access to a free-energy resource and a free-space resource for its life cycle. Water is never to be saved or protected in a functioning system. The different phases in individual development are highly embedded and linked to the adapted population and habitat matrices. I doubt that it should be possible for our societies to neglect the universal play rules—for the flow, efficient coupling and distribution of processes within the embedding process 'Nature'.

Man is probably the only process-controller who is enabled, with his natural and artificial sensors, to determine the space–time properties of the harmonic components in nature, to identify the irreversible sinks, and to trace and to regulate water and matter cycles—in such a way that the irreversible losses of the most limiting prerequisites of life can be minimized below a certain threshold, where they can be easily compensated for within the energetic framework of renewable energies. Again, this can only be achieved if water as the bloodstream, along with its connected irreversible processes, is put into the main focus of our concern and promoted to be the adapted regulating device for controlling stable localized society-cells by direct feedback forcing. The feedback could rely on continuously monitoring temperature distribution from

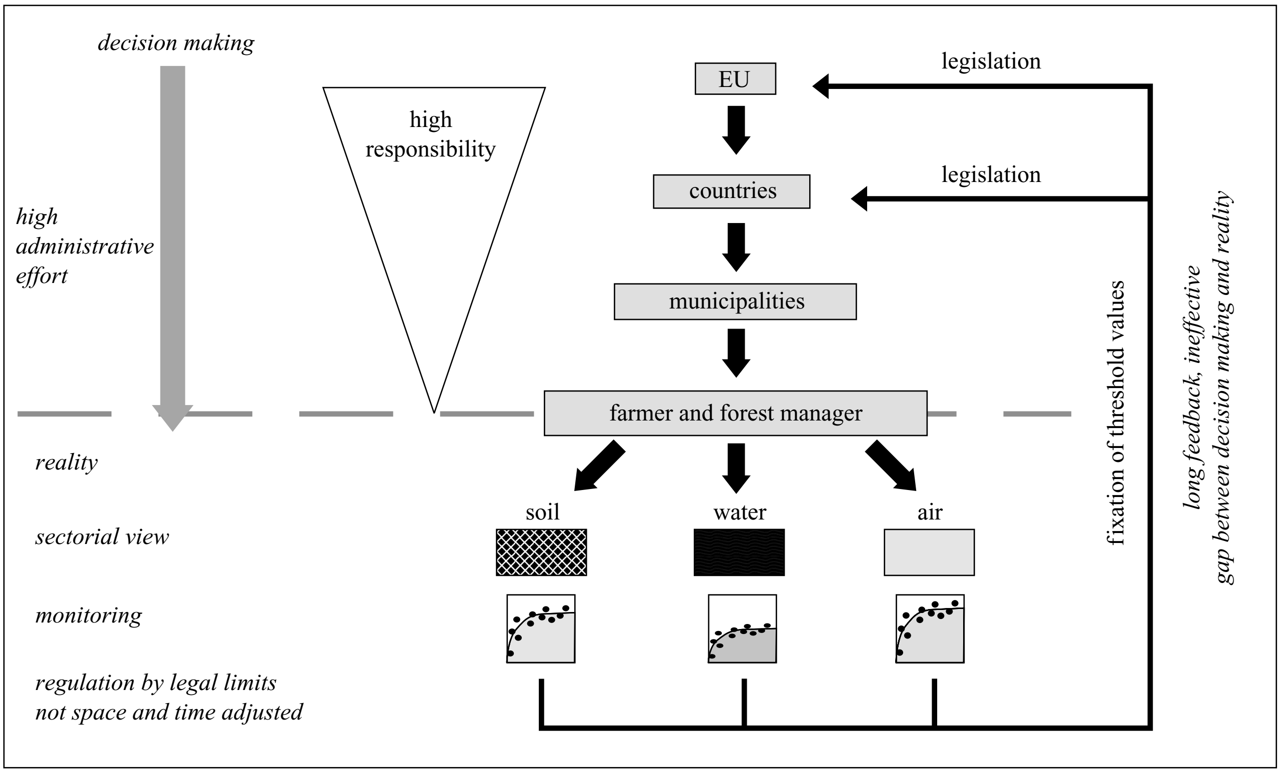

Figure 5. Present environmental politics: regulation by threshold values (W. Ripl and K. D. Wolter, unpublished data).

the satellite on managed land-properties and monitoring the charge-loss processes in catchments by automatic conductivity measurements. Transfer payments from people in cities to resource managers providing energy, food, water and the necessary service functions of nature all provided by the managed land area should replace the European subsidy system in an highly inefficient centralized plan-economic mode.

(e) *Resource managers to get back responsibility for land management*

The resource manager dealing with the subsistence of societies has to get back responsibility for land management where he can earn his money by providing the subsistence functions of societies in the most efficient way (figures 5 and 6).

The present inefficiency can be demonstrated by the city of Berlin, the capital of Germany. A city surrounded by landscapes which are highly endangered owing to their lack of minerals and nutrients. An extensive system of navigation canals for boats and barges was built for transporting freight. However, these canals are directly connected to the Rivers Spree and Havel, the recipients of all treated wastewater and discharge to the River Elbe. Drinking water is supplied by infiltration river water along the shores and pumping water in wells along the river shores. The 3.5 million inhabitants, who each use up to 6 m^3 of drinking water a day, are discharging treated purified water into the same rivers. A system of 'arteries and veins' was once proposed for separating the clean water in the rivers from the nutrient-rich water in the canal system, with the option to transport and recycle nutrients and minerals back to the exhausted surrounding landscape.

These proposals were turned down by the water management section of the senate. Instead, the technological treatment of water has been steadily augmented step by step since, using the water supply and treatment at steadily increasing costs for water and wastewater as an object for privatizing Berlin's water facilities. Today, barges are still transporting even dangerous freight on this river. The sandy shores of the rivers, along with their littoral vegetation, have been eroded away by the action of the infiltration wells, to such a degree that the wells after a while were directly in the rivers. Breakthroughs of phosphorus have occurred in the filtrate and the old wells had to be renewed and moved back behind the shoreline. The landscape is still degrading: by the deepening acidification of soils, the lowering of groundwater levels in the surrounding landscape, and the decreasing cation exchange capacity of the whole landscape.

(f) *The challenge to overcome the inefficiency in today's societies*

Short-sighted segmented planning, optimizing each step according to an economic framework based on political arguments, often leads to highly inefficient structures and irreversible damage to landscapes—increasing the ageing process and preventing sustainable development. Despite rising investments for drinking water production and sewage treatment, environmental protection and various control activities, the irreversible material flows, the degradation of water cycles and the spread of overheated landscape areas still continues. And as production and economy are not growing anymore, they shrink. The inefficient structures erode away if energy prices increase and subsistence functions can no longer be provided to all.

Europe is already an old-aged continent carrying overaged societies. The ageing process during the short phase of industrialism, based on non-renewable energy, had been intensified and left deep scars. Water and matter

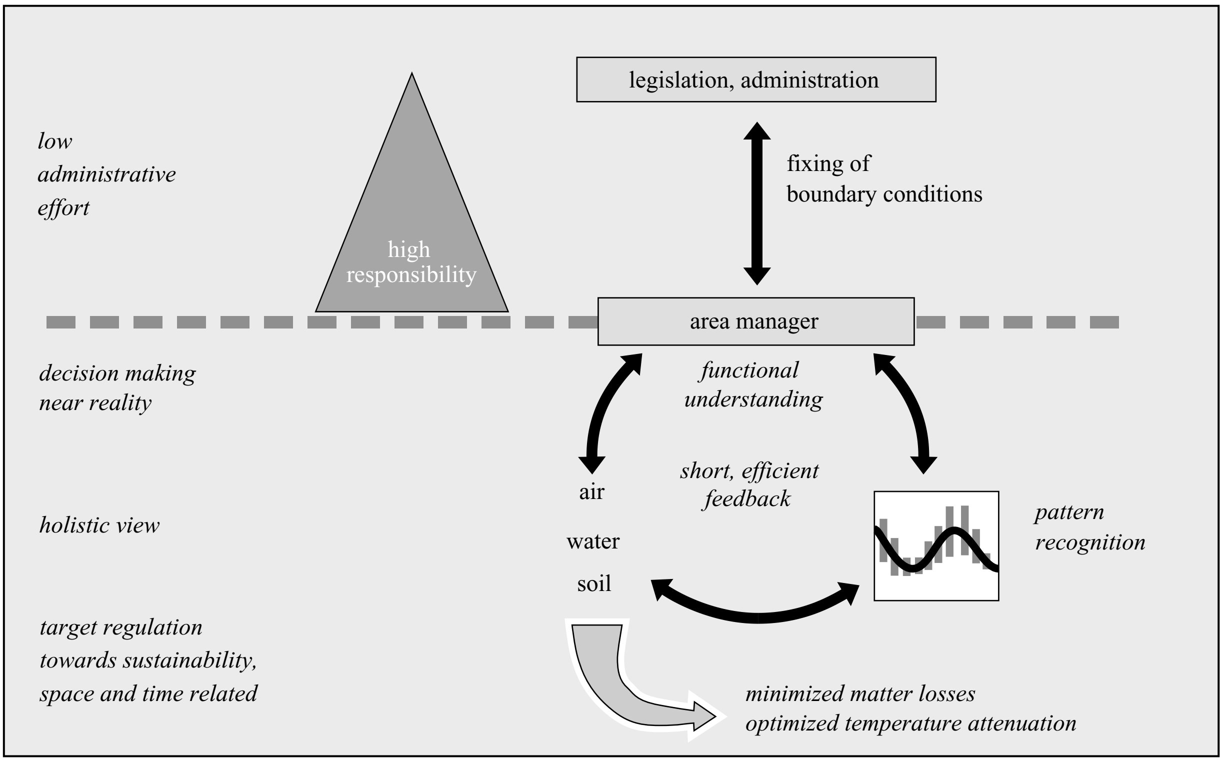

Figure 6. Future target-related regulation (holistic approach; W. Ripl and K. D. Wolter, unpublished data).

cycles have been degraded in unprecedented fashion. However, it should still be possible to turn and gain a future—by determining the properties of dynamic systems, by changing the target functions of societies away from ever-increasing production and productivity towards efficiency. An efficiency that we can measure as the ratio between total matter turnover minus irreversible matter losses divided by total matter turnover, both expressed in proton-equivalents or charges. European societies have to decide now if they want to contribute to and to survive in a sustainable world. A world with a hierarchical adaptive process order given by the energy-dissipative properties of water, controlled and improved by humans. Or if they will be flushed away soon by more efficient societies and people with increased resource efficiencies—people able to live more on much less.

We should now be able to imagine how water, with all its many properties, could turn into the most crucial criterion deciding the life and death of landscapes and societies—as, of course, it always has been, if we refer to the many ancient and recent cultures that chose to interfere with the bloodstream 'water'. Either we take the chance to listen and act in a feedback mode to our adapted bloodstream as a result of evolution—and change our view upon the life-giving element water—or we might suddenly surrender.

This paper is the result of a discussion process within our working group at the Technical University Berlin consisting of K. D. Wolter, C. Hildmann, I. Gerlach and the author, and discussions with the working group in Trebon consisting of J. Pokorný, M. Eiseltová and S. Ridgill. S. Ridgill and M. Eiseltová revised the English text. The final revision was done by C. Folke at the SIWI Institute Stockholm. Their contributions and work are acknowledged by the author.

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GLOSSARY

DEU: dissipative ecological unit