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FROM ECOSYSTEM TO ECODEVICE

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Science on the whole is always in search of components of the universe, which, somehow, show the extrinsic property of 'usefulness', 'suitability' or 'value'. In pure science the component involved at least has to be suitable for research purposes as such. In applied science usefulness plays a leading role again, but this time in the well-known, more technical sense: can we use it or not for this or that technical purpose.

Parts of the universe, which prove to be suitable as a topic for scientific work, are generally looked upon as 'systems', while the conceptual systems, derived from these efforts, are named 'theories'. Such theories, of cause, have to be suitable for scientific purposes too.

On the other hand, those systems or parts of systems, which are endowed with usefulness for our technical aims, are presented here together under the collective noun of 'devices'. All possible kinds of natural or artificial resources (both in the sense of 'sources' and 'sinks'), should be regarded ad devices, as for example: the sun, the air, water, rocks, soils, slopes, coal layers, mineral veins,nutrients, medicines, preservatives, plants, animals and human beings, physical organs, tools, machines, furniture, statues, weapons, books,libraries, roads, bridges, airplanes, rivers, dikes, buildings, fields, meadows, hedges, parks, forests, cemeteries, nature reserves, factories, dumps, communities, social organizations, laws, and so on ad infinitum.

After all, technical suitability merely forms a type of biological or, more in particular, ecological usefulness: no organism can live within an environment which is not useful or suitable for it. Therefore we suggest to speak of 'ecodevices' whenever attention is paid to those parts of their environment, which, no matter how, show suitability for living creatures, plants, animals and humans, be it on an energetical, material or informational base.

'Usefulness', shown by a device, also and even better can be described as its 'protective power', Now, we have to realize that this power is always related functionally to the protective power shown by some other device, which, in turn, must be related functionally to a next one and so on.

When we say that 'device A is using device B', this means the same as 'device B is serving or protecting device A, or as 'device A enjoys protection from device B'. The outcome of this protection, afforded by device B, may be one out of three sorts:

1. It keeps the protective power shown by device A on its original level. We call this 'protection sensu stricto'.
2. It brings the protective power originally shown by device A back to its former level, after a lowering. We call this 'recovery, restoration or repair'.
3. It raises the protective power originally shown by device A to an even higher level than before. We call this 'improvement or amelioration'.

On the contrary, the use of device B by device A, will lower the protective power shown by device B, which lowering here is called 'damage' ('harm', 'deterioration') or 'worsening', as the opposite of 'improvement'. Now this very decrease of the protective power as originally shown by a device represents what in the first place has to be counteracted by using the protective power of another device.

Since in this way no protection sensu lato, so including recovery and improvement, is possible for any device without bringing about more or less damage for some other device, we will be faced with the 'law of preservation of misery' and its tricky games everywhere in ecology, including the phenomenon known as 'human technique'. In the last case the so-called 'harmful side-effects', which, in some way, always result from taking measures, only form one out of its many expressions.

Speaking about functional relations, how can it be made clear what they really are? Well, within the source-sink relations between a system and its environment we distinguish 'input relations' when the system acts a sink, next to 'output relations' when the system acts as a source.

These two types of relations, now are brought into combination with the idea that every system, conceived as a steady-state, is ruled by two limits of tolerance, namely one of minimally required (at least necessary in order to keep up the given steady-state) next to one of maximally tolerated (at most allowed in order to keep it up). This combination then produces four and no more than four possible types of 'disturbance', or, speaking of devices, four types of 'damage'. These four basic types are:

1. Underfeeding. The device as an actual sink receives too little input. It cannot get enough energy, matter or information from its environment in order to keep its protective power on the given level.
2. Stoppage (constipation, blocking). The device as an actual source gives too little output. It cannot transfer enough of something into its environment.
3. Overfeeding (pollution, poisoning, etc.). The device as a potential sink receives too much input. It gets too much energy, matter or information from its environment in order to keep its protective power on the given level.
4. Loss (deprivation, bereavement). The device as a potential source gives too much output. It delivers too much of something to its environment.

The four possible types of damage taken together are known under several names, such as 'disease', 'evil', 'complaint', 'suffering', 'misery', and in the worst case as 'destruction' or 'total loss'. Separately considered, the number of terms, dealing with special cases, seem to be almost countless.

Against these four types of damage, four types of protective power or, what represents the same, four types of 'service' or 'function' can be distinguished. These four, and no more than four, basic types are:

1. Supply (feeding, adding). The function directed against underfeeding.
2. Disposal (removal, discharge, elimination). The function directed against stoppage.
3. Resistance (keeping outside). The function directed against overfeeding.
4. Retention (memory, keeping inside). The function directed against loss.

The functions 3 and 4, named resistance and retention, are able to protect the suitability of a device against transgression of its limit of maximum tolerance. Taken together they here are called the two 'defence functions', dealing with protection sensu stricto (the first type of protection mentioned before). These two functions prove to be defensive in relation to the environment of a device. They both serve the device involved as a screen against impediment or inconvenience and represent, in terms of selection and regulation, what is called 'prohibitive or veto-regulation' (it is not allowed). As a matter of fact, resistance and retention are defending the potential protective power which the device concerned contains for its environment by prevention from the actual use of this power. In such cases we often speak of preventing 'improper or undesired use'.

The functions 1 and 2, supply and disposal, are both able to protect the suitability of a device against transgression of its limit of minimally required. We call them together the recovery functions. These two prove to be offensive regarding the environment of a device. They both serve the device involved by fulfilling its desires and represent, in terms of selection and regulation, what is called 'prescriptive regulation'('it must be done').

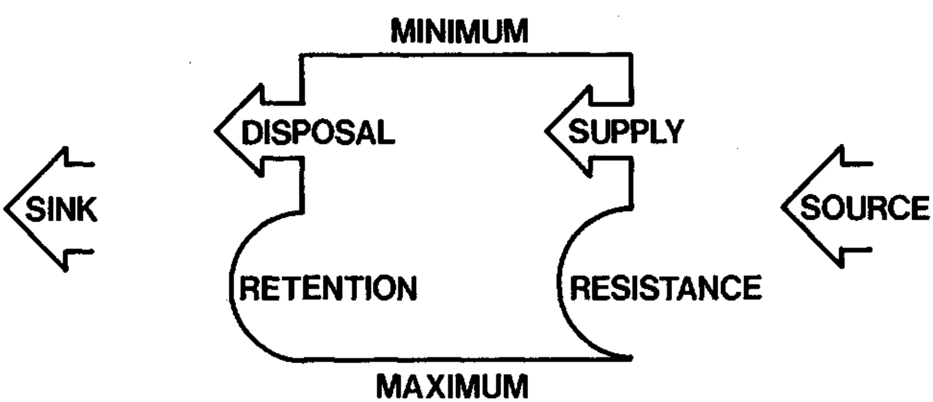
The recovery functions prove to be necessary in three different cases:

1. When resistance or retention are failing to prevent improper use from the outside.
2. When the level of protective power of the device involved has been lowered by proper use from the inside.
3. When former recovery has been carried out by means of wrong devices.

The same functions, supply and disposal, are also indispensable when 'improvement' has to be obtained. In this special case of protection both offensive functions together are called the 'building functions'. In terms of functional in- and output relations every act of construction or making is carried out by supply and/or by disposal.

What has to be constructed, of course, represents some new or better device endowed with protective power of some kind. When, for example, a bird builds a nest, it improves its environmental ecodevice by adding a special subdevice, which was lacking until then. This special subdevice, which in the first place has to serve by providing resistance and retention for its eggs and chickens, furthermore will be built either by supply or disposal, or both together.

My colleague, Mr. van Wirdum, has designed a very clearcut and instructive model showing the four functions in their mutual relations, thus representing together a complete ecodevice:



Now, by means of this model, we are able to show, for example, how internal problems, raised by the four types of damage, at least partially can be solved by crossing over from the failing function to its -diametrically opposed-counterpart, then called the 'saver'.

So, when the supply function is failing, the threat of underfeeding may be compensated to some degree by switching over to the retention function: energy becoming scarce and expensive we try to compensate this by a better insulation of our houses in order to lower the loss of heat.

In the same manner failing disposal may be compensated by its opposite, the resistance function, failing retention by supply and failing resistance by disposal: when a ship starts a leak, it may be saved by pumping out the water coming in.

The Van Wirdum model is also useful when we wish to show how the external functional relations between two or more devices are working. So, for example, when a given device called B succeeds in using another one, called A, as a source in order to fulfill its supply function, then device A can only afford this service to device B if it itself gets damaged by bereavement, its retention function being broken through.

When, on the other hand, device A by its retention function succeeds in keeping inside what device B is hungry for, the last one will get damaged by underfeeding.

Of course we also know the special cases in which two devices are protecting each other, or, what is the same, are using each other. An example of this type of co-operation delivers the functional relation between a device A which has something to dispose, whereas a second device B wants this disposal as a supply.

Next I would draw your attention to an important difference in the way the two defence functions, concerning resistance and retention, are fulfilled when we compare the so-called robust ecodevices with those known as fragile ones. For by introducing this difference we enter the vast and complex field of modern land-ecology, where the functional relations between robust and fragile biotic communities, represent a topic in which many of us are specially interested nowadays.

In the case of robust communities, such as, for example, found in tundras, taigas, steppes and deserts, the concerning ecodevice to a certain degree can act as a sink, without being seriously damaged itself when it has to cope with the danger of getting overfeeded by its environment. In other words it then shows a great absorbing capacity. In the same way such a device is able to provide itself with a sufficient additional source when deprivation threatens. Thus, what has to go lost is supplied with redundancy, or, what is the same, compensated by suppletion.

So, in general, robust ecodevices are able to do their own job when dealing with the two defence functions, by crossing over from resistance to disposal and from retention to supply. This ability of shifting from the two defensive functions to their offensive counterparts within the total ecodevice, means that ecodevices of this kind are mainly working by their recovery functions in order to protect themselves against overfeeding or deprivation from the outside. Working by the recovery functions in the way just mentioned now appears to be characteristic of primitive and more or less simple communities bound to high degrees of environmental dynamics.

These types of communities, in the absence of defensive barriers being continually engaged with, so to say, keeping heads above water, are unable to develop sophisticated internal regulation mechanisms and therefore are marked by poorness in species, together with richness in individuals. Here we meet those communities, which, according to C.S. Holling, show 'resilience' as the main strategy for staying alive.

Moreover, their robustness as such gives them the ability to serve other ecodevices with regard to all of the four thinkable functions, without the chance that they soon will collapse. This is mainly valid in the energetical and material sense.

On the contrary fragile communities, such as tropical rainforests, coral reefs and several other ones, showing a relatively high degree of species diversity, as well as a large quantity of internal regulation mechanisms, are marked by a striking variety in specialization among their organisms, next to the importance of information considering the functional relations between them and also by the recycling of nutrients and materials within the community.

In this case we are dealing with ecodevices which enjoy the service of external protection barriers keeping outside whatever is not allowed to enter and keeping inside whatever is not allowed to leave them, a service which provides the base for their internal development of spatial complexity. The supply and disposal functions being of less importance, the accent now lies on the resistance and retention functions. Here we recognize those communities, which, in the sense of Holling are using the strategy of 'resistance'.

But where do these external protective barriers come from? Well, answering this question is rather simple when we realize that the total ecodevice necessary for such fragile communities has to contain robust subdevices somewhere outside the locality where they are living, which subdevices can serve as their furnishers of resistance and retention. These robust subdevices may be composed from parts belonging to the cosmosphere, the atmosphere, the hydrosphere, the lithosphere and the biosphere, and in the case of nature reserves, from components of the technosphere too.

So for a first small scale example we can look at the two slopes of a dunehill, one on the luffside exposed to the seawind and the other on the opposite leeside, the last one protected against the wind by the sandbody of the hill. Comparing the difference between the relatively fragile community on the landward slope and the relatively robust one on the seaside, we have to consider that the ecodevice serving the fragile community, spatially seen, not only consists of the slope on the leeside, where the community in question is located, but that it also includes the other, on the luffside. We could say that the last one, with its robust community, has to bear all the troubles coming from the seaside, and therefore represents an indispensable part of the ecodevice serving the fragile community on the landward slope.

Looking at a sandy dune area between the beach and the hinterland as a whole, the robust outer dunes in the same way form an indispensable component of the ecodevice protecting the fragile communities of the inner dunes against overfeeding and deprivation.

An example on a much larger scale we find in the functional relations between the two opposite coasts of an ocean around the equator. There the main direction followed by the circular ocean current near the surface, runs from east to west, while, along the bottom it goes from west to east, upwelling near the eastcoast and descending on the westside. The seawater rather heavily loaded with nutrients, on the way taken up from the ocean bottom and carried on to the eastcoast, there provides the base for robust biotic communities, which are marked by large masses of plankton, fish, seabirds, seals and whales. These communities, on account of their robustness, can also serve man as a feeding device, be it, of course, to a certain degree.

But the very same robustness gives it a protective power in the sense of resistance when considered as in functional relation to the coral reefs on the other side of the ocean, marked by utmost fragile communities, which, being bound to seawater poor in nutrients, could develop their astonishing world of recycling mechanisms, combined with the ample use of information flows.

On a still larger scale, it seems likely to us that the tropical rain forests are functionally related to those parts of the earth carrying tundras, taigas, steppes and deserts, all of which are located within the total ecodevice necessary to make and keep the rainforests what they are. Instead of being indispensable for the rest of the world by their protective power in a energetical or material way the rainforests themselves completely depend on that rest.

In fact the only help these fragile and, with regard to their total area, rather small communities, are able to offer their far more extensive environment, lies in the field of information: man can learn a lot of them, assumed that, as often has been said already, he does not use this library by burning its books, in order to keep his feet warm.

Man now emerging into our scenery, I would like to end my theoretical contribution to this congress by posing a thesis with regard to the functional relations between our modern, in a technical sense so highly developed western civilization, and the earth as its environment. For I suppose that this civilization, because of its striking fragility in many respects, to-day cannot subsist without the use of a very large area serving as its robust ecodevice and consisting of, what are called, man-made steppes and deserts. The question whether this necessity has to be ascribed to the explosive growth of human population moreover, however probable, will be left unanswered for this moment.