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Resume

The argument of the paper is that environmental problems are a direct consequence of a certain Weltanschauung Christianism brought into Western societies.

Fairly simple solutions exist for the large ecological problems generated by the intrusion of humanity in the ecosphere, including at the limit an almost complete *withdrawal*.

Because cultural changes have long time constants, there is no hope of short-term application of the solutions. Ecologists have to learn thinking long term and recognize that perseverance is more important than argument.

ENVIRONMENTAL PROBLEMS AND TECHNOLOGICAL OPPORTUNITIES

When man first emerged as a talking monkey, his way of living was well embedded into the ecosystem. Men were very few, and, like any other animal species they just carved a thin slice in the big flux of negentropy: from sun light, through plants, to the dust bin.

The first breakthrough came with fire. Because fire, breaking down physical and chemical defenses, made available as food a large spectrum of vegetable products. A large food base means large populations, and a more noticeable *intrusion*. Furthermore, fire was used for hunting or cleaning wooded areas, so giving leverage to the force of man.

As an intruder ,however, man got his long trousers when he started interfering with ecological equilibria by favoring certain plants against others. I think agriculture is still today the number one rapist, in spite of all the fuss about car emissions and industrial smokes.

Man and nature, however, did live together reasonably well for the half million years or so after the invention of fire, and the ten thousand after that of agriculture. We must look for the mechanisms in the way man did behave in the past, in order to reach that effective compromise. If we define a culture as a formula for survival, we should look there to find the appropriate cultural pattern.

Such cultural attitudes being of necessity long term, they must have been embedded deep, i.e. into religion. Just to stay specific, in our greco-roman antiquity, the most important element of the recipe is probably animism. Every tree, every spring, every stream, every hill had its *genius loci*, its guardian spirit. Before one cut a tree, mined a mountain, or dammed a brook, it was important to placate the spirit in charge and to keep it placated. That provided the proper

ritual to keep the problem of the intrusion in sight and work out appropriate compromises.

By destroying pagan animism, Christianity made it possible to exploit nature in a mood of indifference to the feelings of natural objects. For nearly two millennia Christian missionaries have been chopping down sacred grooves which are idolatrous because they assume spirit in nature. The only countervoice was St. Francis of Assisi. He talked to brother wolf and persuaded him of the error of his ways. The wolf repented, died in odor of sanctity and was buried in consecrated ground.

The real miracle is that St. Francis did not end at the stake, but his message was certainly buried away. The *Christian arrogance* toward nature is now more vital than ever, although in the last twenty years a *thin vein of doubt* seems to be creeping in. Curiously, both in science *and* in technology. That is why we are here in Venice by the way, pondering the issue.

My point is that *the ecological problem is before all cultural, and because it lays deep, religious*. It feeds on our basic attitudes toward the world. These are very slow to change, and that is why the problem will be difficult to solve.

Coming to brass tacks, the fruits of Christian arrogance, Western science and technology, are making man's intrusion into the ecosystem *start* look quite dangerous. In spite of the alarm signals we are not yet as big as we think. The metabolism of the world forests is a good order of magnitude above all energy we consume, and the amount of materials they mine from the ground, is a good match to our mining industry. The danger is more in the potential. When ten billion people will behave as we "the Western" do, the wolf will already be in the house.

On the other side every selfreproducing system keeps multiplying till the niche is full. Although man surreptitiously took the soul away from other living creatures, and endowed himself with rational wisdom, if we look quantitatively at his behavior in the last ten thousand years, he kept the niche duly filled up like

any other living creature. This means he will use the great powers that science and technology confer to him, to keep numbers growing. Let us look how we may face the situation.

The greatest breakthrough of humanity after the discovery of fire in my opinion is the discovery of nuclear energy. This is because up to now our only primary source of energy was the sun, mediated by plants, or directly, or via geological storages in form of coal and hydrocarbons. In a way or another this plugs us into the ecosystem.

But if we zoom into the mechanisms, we see the privileged position of plants in the system, and consequently of agriculture, stems from their capacity to split water into oxygen and hydrogen with their chlorophyll. All the rest, including the reduction of CO_2 with hydrogen, can be done by all sort of organisms.

This means if we split water by another mean, e.g., through nuclear energy and electrolysis, and we feed it to appropriate processors, e.g., to *Hydrogenomonas*, *we can brew our food and write off agriculture*. This is not a gleam in the eye. There are pilot plants in the universities of Graz and Göttingen producing proteins and other things that way. Selection and genetic engineering can expand the menu.

For the food conscious, I can tell that taste and eating habits belong again to cultural patterns and can be relearned. On the other side, two classes of food I think the most sophisticated in terms of subtlety and variety, come from the blandest and insignificant raw materials one can imagine, grape juice and milk. On top of that we can certainly "brew" vegetable cells for special effects, as it is done already to produce special chemicals.

Reversing the agricultural intrusion, and that linked to the use of fossil fuels, does go orders of magnitude beyond the wild dreams of the ecologists today, but I would add another step to the logic, saying that man has the basic technologies to

retreat into his "walled cities" and symbolically *switch the sun off*. i.e. decouple completely from the ecosystem. Apart for the few percent of the earth surface necessary for the city, and actual deserts would do it, all the rest could be left wild, for the children to see the lions in proper context.

Some years ago, to tease my friends in the Club of Rome ligue, I wrote a short essay, sketching how more or less current technology could be used for the purpose. Just to stay ferocious I took as carrying capacity of the earth 10^{12}, one trillion people. And I did show they can live a materially abundant life, at least for a thousand years, without depleting any resource.

Just to give an example of the solutions, the effect of the 10^{13} KW they use can be easily canceled by painting white all human artifacts, to increase the albedo of the earth. It would be just enough.

For the dowry of materials this intense humanity should dismantle a couple of mountain chains and recover the elements. Just as rarity led the bronze age into the iron age, aluminum, magnesium and organics would be the work horses.

The sinister conclusion is that if I am right, humanity will in due time reach the 10^{12} level. No niche in the earth's history was ever left half empty. The suggestion that man will behave "rationally" although not to be rejected in principle, is certainly against the grain of ten thousand years of history.

An interesting example is given by development of agriculture, seen from the point of view of its energetics. Curiously, the ratio between edible energy output, and energy input in the agricultural system has been always constant (before the use of the fossil fuels) and equal to 40-50. It was like that in neolitic agriculture as in the Chinese agriculture of today. The only thing that changed was the spatial density of production. The neolitic hunter-farmer needed approximately a square kilometer of land per person supported. A Chinese farmer one hundred meters square. The densification is by a factor of ten thousand! The rationale is that the

maximization of numbers was privileged against any other possible objective. E.g., reduction of labor through the improved technologies.

These considerations loom long. But we can zoom into the next future with the same logic. Much of man's intrusion is linked to the massive use of fuels. We started at IIASA a conceptual scheme, later developed at the Kernforschungsanlage Jülich (KFA), and of MIT, we christened "zero emissions". Here again the use of fossil fuels is "decoupled" from the atmosphere, with little or negative economic penalty. But the problem of implementation will be above all cultural, and in any case it will take long. The typical constant for the acceptance of an innovation of this kind will be in the range of about fifty years.

This is the core of my message: *the core of the problem is cultural*, and the appropriate modifiers have to be applied there. The intrusion of man is still puny if we compare it, e.g. with the intrusion of plants and the megacatastrophe caused by the introduction of oxygen in a reducing context. On the other side a whole panoply of "decoupling" measures are technically possible, including the total switch off. Like Longino's lance, our Christian arrogance carries inside the compensatory mechanisms.

Concerning the willingness of the system to do that, I am quite optimistic. The fact that a bunch of expensive people meet in an expensive place like Venice, to discuss problems that may become acute a century from now, is certainly a good omen. But I will say something beyond this point observation. The analysis of hundred of cases on the dynamics of social and economic structures shows that the system behaves like an organism, with feelers, reactions, wisdom, occasional folly, and above all, rock solid selfconsistency.

The Leviatan revisited? Well, I will give only two examples out of the hundreds I worked out. The number of fatalities due to motor car circulation did increase in the US together with the number of cars. It was 25 per hundred thousand

population in 1928. At that time there where in the US about 20 million cars. In 1985 the cars are about 140 million and the death toll is still 25 per hundred thousand, oscillating plus or minus one. For the benefits of using automobiles, the system is ready to pay its pound of flesh, but not more. What strikes me is the precision of the feedback regulation, and in particular the precision of the measurement. How the "system" may feel the difference between 25 and 26 is jet-black mistery to me. On top of that car traffic death rate in most Western countries is just 25 per hundred thousand.

The second example is of different character and shows the cohordination, or better syncronization of the system at world level. All railway *nets* were started around the world during a period of about 50 years (again!) in the centerpoint of the last century. The cumulative numbers of "starters" (the inauguration dates of the first line of each net) fit perfectly a logistic curve. This means the whole operation was *cohordinated* presumably through information links. And the system is so selfconsistent that by taking the first half of the inaugurations, one would have predicted each one in the second half with a precision of months. (Although not where. I have not yet developed a model for spatial cohordination!)

So our real task is to clarify, quantify, discover, invent, prepare the context for the "system", which is all of us informationally linked, to wisely act. *L'intendance suivra.*