1. Ecological Stability

1.1 Introduction

The aim of all ecological studies is to give a scientific answer to the question: just what are the normal conditions of human existence and how may these be secured for both the present and future generations? Man exists in his environment. Therefore ecological studies should first of all provide for conservation of an environment fit for man's existence.

If the result shows that changes in the environment are mainly controlled by erroneous management of business, the ecological problem would turn into a problem of finding out possible ways of organizing these activities such that they do not alter the environment (Schneider, 1989a). The problems of protecting the wilderness areas and of preserving wild species in both the fauna and flora would then only be secondary, related mainly to catering to the aesthetic tastes of man. Preserving the unique gene pools of the wild species in their natural conditions, as well as in reserves, zoos, and gene banks would then become a purely applied interest, having nothing to do with the ecological task of protecting the environment. Reserves, negligibly small in their areal extent, would serve merely as wild nature memorials, fit only for studies by some narrow circle of dedicated experts. It is apparent that many wild species can only survive if at least 30% of habitable land surface is withdrawn from industrial use (Wilson, 1989). However, mankind will certainly never go to those extremes if all the above is true, and the respective species would be doomed to die out without causing any great concern in the general public.

If, on the other hand, it appears that the communities of natural biospheric species completely control and support the existing state of the environment in which man himself exists, then protection of the wilderness areas, preservation of the natural communities of all the wild species and estimating the threshold of admissible perturbations in the natural biota become the central problem and task of ecology. The restructuring of industry towards a lower level of environmental pollution is then reduced to a local task of second priority which is, strictly speaking, not related to ecology itself.

The task of the present study is to demonstrate that it is impossible to preserve a stable environment fit for man's existence within the prevailing tendencies in restructuring the natural biota and the biosphere.

1.2 Biological Regulation of the Environment

Now, what exactly are the environment, the biota, and the biosphere? All the fundamental notions used by natural science are characterized by their measurable properties. Since the knowledge of these properties is enriched as science develops, the definitions of these fundamental notions change too with time. For example, such fundamental definitions as those of mass and energy have passed through some impressive changes during the last hundred years or so (Sect. 2.6). The term *biota* was initially introduced to combine the two notions of fauna and flora. The environment includes substances and bodies from the biota with which the given living organism interacts. Following Vernadsky (1945) the biosphere is understood to be the global biota plus its environment. The biosphere also includes the external environment (such as the upper atmospheric layers, for example), in which one can find no living beings, but which is intimately connected with the immediate environment of the biota. However, all such definitions only indicate the study target. As our knowledge accumulates, these concepts are filled with new content.

The environment is first of all characterized by certain concentrations of chemical substances consumed by living beings. For those organisms busy destroying organic matter (such as bacteria, fungi, and animals) the important concentrations are those of such organic matter and of oxygen in soil, water, and air, while for plants, which synthesize such organic matter, they are the concentrations of inorganic substances: carbon dioxide, certain chemical compounds including nitrogen, phosphorus, and many other elements used in the bodies of living organisms. The question arises then, whether the concentrations of all those compounds (often called nutrients, biogenes, or biogenic elements, Kendeigh, 1974; Ivanoff, 1972, 1975) in the environment are random from the point of view of the biota, or whether the concentrations are established by the biota itself, and maintained by it at an optimal level for life?

In the first case, the biota should function continuously, adapting to the changing environment. However, concentrations of inorganic nutrients may change by about 100 % within time periods of the order of a hundred thousand years due to geochemical processes alone (Budyko et al., 1987; Barnola et al., 1991). Thus, during the lifespan of life in general, which already covers several billions of years, the concentration of practically every nutrient should have changed by several orders of magnitude, reaching values at which no life can exist at all. The Earth's environment should have reached a state similar to that found on the other planets within the solar system (cf. Sect. 2.7).

Naturally, the biota is incapable of altering such natural parameters as the extraterrestrial flux of solar radiation, the rate of Earth's rotation, the magnitude of tides, the terrestrial relief, or the level of volcanic activity. However, adverse changes and random fluctuations in these characteristics may be compensated for by the biota via directional change of concentrations of nutrients in the environment, which it controls, so that the overall reaction is similar to the action of the Le Chatelier principle in physical and chemical stable states (Lotka, 1925; Redfield, 1958; Lovelock, 1972, 1982).

At a prescribed flux of solar radiation the Earth's surface temperature is controlled by the rate of evaporation of moisture from the surface, by the concentrations of certain atmospheric gases producing the greenhouse effect, mainly water vapor and carbon dioxide, and by the albedo – that is, the coefficient of reflectance of solar radiation by the atmosphere and the Earth's surface (Sect. 2.7). The present day average surface temperature is 15 °C (Allen, 1955). A change of that value by 100 °C in either direction would also have resulted in all life perishing. A practically unequivocal conclusion follows: namely that living beings should not use any substances whose concentrations are not subject to biological regulation. Hence, these substances should not be included in the concept of the environment. Moreover, biologically regulated processes and concentrations of substances should define the values of characteristics of the environment such as temperature, the spectral composition of solar radiation reaching the Earth's surface, the regime of evaporation and water precipitation on land.

The measurable natural parameters affecting the biota, supported by the biota at a certain quantitative levels, and liable to directional change by the biota in response to external forces, may be found step by step. In what is to follow we are going to include in the concept of the biosphere only those characteristics that are controlled by the biota. The components of nature bearing traces of former life activity in the geological past (the traces of late biospheres, Vernadsky, 1945), not subject to contemporary biospheric forcing, will be excluded from such concepts. We shall further call "nutrients" only those substances (biospheric components) whose concentrations are controlled by the biota (Redfield, 1958). If we stick to such definitions, no preliminary hypothesising is necessary concerning components of nature with which the biota interacts, and which might be controlled by life (Redfield, 1958; Lovelock, 1972). The presence or the absence of such control can be directly or indirectly found by empirical means.

1.3 Means of Biological Regulation of the Environment

The effect of biota upon the environment can be reduced to the synthesis of organic matter from inorganic components, and to the decomposition of that matter into its inorganic components, and, hence, to a changing ratio between the stores of organic and inorganic substances in the biosphere. The rate of synthesis of the organic matter defines production of, and that of decomposition, destruction of, that matter. Since the organic substances entering living organisms bear a constant ratio to the chemical elements forming them, production and destruction are usually measured by the mass of organic carbon synthesized or destroyed per unit time. On average, synthesizing 1 g of organic carbon in the biota requires the absorption (or release in case of destruction) of 42 kJ of energy (Kendeigh, 1974; Odum, 1983). Production or destruction of 1 tonne (t) of organic carbon per year (1 tC/year) corresponds to energy absorption or release at a power of 1.3 kW. The power of biota should be understood as its production, measured in energy units.

The biota is capable of producing local concentrations of nutrients in the environment differing by 100% or more from the concentrations in the external environment (where no living beings function), when the fluxes of synthesis and destruction of organic matter per unit surface area (called productivity and destructivity) exceed the physical fluxes of nutrient transport. Such a situation is found in soil, where the physical flux of nutrient diffusion is significantly lower than biological productivity. That is why soil is enriched by organic matter and by the inorganic substances necessary for plant life, as compared to lower ground layers where there are no living organisms. Hence, local concentrations of nutrients in soil are biologically regulated.

Concentrations of dissolved carbon dioxide (CO_2) in the depths of oceans are several times larger than at the surface. At the same time the surface concentration of CO_2 is at equilibrium with that in the atmosphere. If life ceased in the ocean, all the concentrations at depths and at the surface would even out. The concentration of CO_2 at the surface and in the atmosphere would then increase severalfold! That could result in catastrophic changes in the scope of the greenhouse effect and in the planetary climate within decades. Hence, the oceanic biota determines the atmospheric concentration of CO_2 and thus regulates the greenhouse effect, keeping the surface temperature at a level acceptable for life in general (Sect. 4.9).

The $N/P/O_2$ concentration ratios in oceanic waters coincide with the ratios of these elements absorbed during synthesis (released during destruction) of the organic matter of living bodies in the ocean. That consideration points to biotic control of these components in the ocean as well (Redfield, 1958).

If the physical fluxes of nutrient transport exceed biological productivity by a factor of several hundred, the concentrations of those nutrients in the environment may only differ from their concentrations in the external environment by several tenths of one per cent due to activities of living beings. However, if the biota acquires any appreciable advantage that way (in other words, if such changes fall within the margin of biotic resolution), these differences will be supported by the biota in that direction. The resulting difference in concentrations will trigger physical fluxes of nutrients from the external environment to internal and back again. Such fluxes will keep on flowing until the concentrations in the external and internal environments even out, that is the concentration of nutrients in both media reaches an optimal value for the biota. Thus biota is also capable of regulating the global concentrations of nutrients in the external environment, so the latter should also be included in the definition of the biosphere.

For example, excessive carbon dioxide in the external environment may be transformed into comparatively inactive or dead organic forms by the biota. Conversely, lack of carbon dioxide in the external environment may be compensated for by the biota by decomposing such organic stores. These stores of organic matter are contained in soil humus, in peat, in the wood of living and dead trees, and in the dissolved organic matter in the ocean (the oceanic humus). More than 95% of all the organic matter of the biosphere is stored in these media. Apparently, the constant concentrations of not only carbon dioxide but also oxygen in both the atmosphere and the ocean are supported by the biota using those stores. So far, neither the value nor the direction of change of stores of organic matter in the biosphere are measurable with the required accuracy on a global scale. They are only known to an order of magnitude. However, these changes may be assessed from other data (Sect. 4.11).

1.4 The Action of the Le Chatelier Principle in the Biosphere

Stores of organic and inorganic carbon in the biosphere coincide in their order of magnitude, see Fig. 1.1. The ratio of these stores to the productivity of global biota yields the time period of biological turnover of the biogenic store in the biosphere, which is of the order of tens of years (Fig. 1.1). Hence, were synthesis of organic matter to take place with no decomposition to accompany it, all the inorganic carbon in the biosphere would be used up and transformed into organic substances in a few decades. Similarly, were only decomposition to take place, all the organic carbon in the biosphere would vanish in decades.

It is found, from measurements of the concentration of carbon dioxide in air bubbles entrapped in ice cores of different ages from Antarctica and Greenland, that the concentration of carbon dioxide in the atmosphere remained constant to within measurement error over the last several thousand years (Oeschger and Stauffer, 1986). It remained within the same order of magnitude over time periods of several hundred thousand years that is for time periods exceeding the turnover time by the factor of 10^4 (Barnola et al., 1991). It follows quite unequivocally from these data that the global annual average fluxes of biological synthesis and destruction of organic matter coincide with each other, to an accuracy of four digits, that is compensate each other to the relative accuracy of 10^{-4} (Fig. 1.1).

Inorganic carbon is released into the atmosphere in the process of degasing (including volcanic activity, filtration from the mantle, etc.) and is stored in sedimentary rocks, leaving the biosphere in the processes of weathering. The biota has no effect on the carbon emission from the Earth's core. The land biota can slightly change the rate of weathering (Schwartzman and Volk, 1989). The difference between emissions and sedimentation yields the net flux of inorganic carbon into the atmosphere. It appears that this flux is positive and is of the same order of magnitude as emissions and depositions. Thus emissions and depositions of inorganic carbon do not compensate each other. The ratio of the present-day store of inorganic carbon in the biosphere to its net geophysical flux corresponds to a timescale of around one hundred thousand years. In other words, that store should have increased about ten thousand fold during a time span of about a billion years. However, that never actually happened. Hence, some compensating process must function, and that process is the storage of organic carbon in sedimentary rocks. Direct studies have demonstrated that the stores of organic carbon, accumulated over approximately one billion years and dispersed through the sedimentary layer about one kilometer thick, exceed the stores of both the organic and inorganic

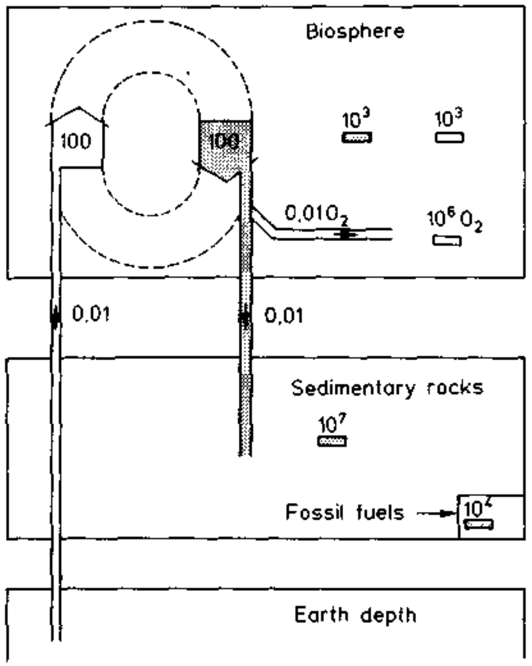

Fig. 1.1. Annual fluxes and stores of carbon in the biosphere. Stores of carbon are given by underlined figures in Gt C. Fluxes of carbon are given by figures at arrows in Gt C/year. Fluxes of carbon going into store as organic matter are shaded and underlined by thick shaded lines, respectively. Clear arrows give the fluxes of inorganic carbon. The stores of inorganic carbon and oxygen (in Gt O_2) in the biosphere are underlined by thick blank lines. The flux of organic carbon going to deposits in sedimented rocks is equal to the difference between its synthesis and destruction in the biosphere. That flux coincides with the net flux of inorganic flux entering the biosphere, to a relative accuracy of about 10^{-4}. Fluxes of synthesis and destruction coincide with each other to about the same level of accuracy. That situation works to hold constant the stores of carbon in its organic and inorganic form in the biosphere during the whole of *Phanerozoi* (6×10^8 years).

carbon used by life in the biosphere by about four orders of magnitude; Fig. 1.1 (Budyko et al., 1987).

It also definitely follows from the above that the net geophysical flux of inorganic carbon into the biosphere and the flux of organic carbon buried into sedimentary rocks (which is equal to the difference between production and destruction) have, on average, coincided to an accuracy of four digits, that is to a relative accuracy of 10^{-4}.

Thus the first four digits in the values of production and destruction coincide over a time period of about ten thousand years. The four digits left in the difference between production and destruction coincide with those giving the net geophysical flux of carbon over hundreds of millions of years. Hence, during geological time periods biota has been controlling up to eight digits in the values of production and

destruction, that is, the resolution of biota is extremely high, because the random coincidence of different values to so high an accuracy is extremely improbable (for details see Sect. 4.3).

The amount of oxygen in the atmosphere exceeds that necessary to decompose all the organic carbon in the biosphere by three orders of magnitude. That is so because the oxygen released during synthesis of the organic carbon deposited in sedimentary rocks did not stay in those sedimentary rocks but instead entered the atmosphere in its free form. The process of burial of the organic carbon in sedimentary rocks, going on even now with its flux being equal to only one ten thousandth of biological production by the biosphere, provides for the constancy of concentrations of oxygen and of carbon dioxide in the biosphere.

The organic carbon buried in sedimentary rocks leaves the biological cycle and should thus be excluded from the definition of the biosphere. These stores remain intact for all of the natural biota. Man has started to use fossil fuel, found in the form of concentrated deposits of coal, oil, natural gas, which together contain about one thousandth of the total organic carbon contained in sedimentary rocks (Meadows et al., 1974, 1992; Skinner, 1986).

Thus Fig. 1.1 testifies in favor of the biological regulation of concentrations of various substances in the biosphere. The natural Earth biota is organized so as to be capable of supporting, to the highest level of accuracy, a state of environment fit for life. The question arises, why does the biota develop that enormous power of biological production? Indeed, it seems that it would have been sufficient to have had power four orders of magnitude lower. However, geophysical processes are not constant in their nature. They are subject to large fluctuations such as catastrophic volcanic eruptions, falls of large meteorites, etc. If the biota were slow to reestablish the normal state of environment, many species would be forced to exist in abnormal conditions for quite long periods of time. Such a situation could have resulted in a quick extinction of species and in a loss of capability to compensate for perturbations of the environment by the biota. The enormous power reached by the biota makes it possible for it to repair all the natural perturbations of the environment in the shortest time possible, shorter than a few decades. Such short-lived perturbations of the environment are safe for any living species.

1.5 Violations of the Le Chatelier Principle in the Contemporary Biosphere

The enormous power that the Earth biota develops, however, conceals a potential danger of quick destruction of the environment. If the correlated interaction between the species in the natural communities was disrupted, the environment could be completely perturbed (changed by about 100%) in just a few decades. If all of the biota was exterminated, the environment would change to the same degree by geophysical factors alone in hundreds of thousand of years. Therefore, breaking up the natural structure of the biota through the transformation of nature by man presents a threat to nature exceeding that of complete extermination of the biota (complete desertification) by a factor of ten thousand.

It is well known by now that global changes of the environment do take place at the present time: the atmospheric concentration of CO_2 is quickly increasing; see Fig. 1.2. That effect strengthens the greenhouse effect and may yet lead to increase in the surface temperature of the planet. For a long time that build-up of carbon dioxide in the atmosphere has been related to combustion of fossil fuel alone (coal, oil, natural gas). It would be reasonable to expect that the biota both on land and in the sea reacts to that increase in accordance with the Le Chatelier principle, absorbing the excess carbon dioxide from the atmosphere.

However, the global analysis of land use practices (Houghton et al., 1983, 1987; Houghton, 1989) indicates that organic carbon is decreasing instead of increasing over large areas of the continental biosphere, the rate of emission of carbon from the continental biota and organic stores in soil into the atmosphere coinciding in its order of magnitude with the rate of emission of fossil carbon during combustion of coal, oil, and natural gas (Watts, 1982; Rotty, 1983). Hence, the biota violates the Le Chatelier principle in lands subject to direct industrial and agricultural use.

The Le Chatelier principle, characterizing the degree of stability of the system, is manifested in that the net rate of absorption of carbon by the biota (at low relative perturbations of the environment) is proportional to the increase in carbon concentration in the environment with respect to the non-perturbed preindustrial state. When the Le Chatelier principle is satisfied the proportionality coefficient in that relation should be positive. The analysis of rate of emission of fossil carbon and of accumulation of carbon in the atmosphere makes it possible to determine the validity of that coefficient with time for continental biota as a whole; see Sect. 4.12. Prior to the beginning of the last century, land biota had been following the Le Chatelier principle, that is it remained weakly perturbed by man. During that time the Earth biota was compensating every impact of man upon the biosphere, and no problem of environmental pollution arose.

From the beginning of the last century land biota ceased absorbing excess carbon from the atmosphere, increasing the environmental pollution precipitated by industrial enterprises from then on, instead of decreasing it. That means that the structure of the global biota appeared to be perturbed on a global scale. Taking into account that all of man's activities transform the biosphere, one may estimate the threshold anthropogenic forcing, at which the Le Chatelier principle ceases to function in the biota, i.e., the threshold beyond which the biota and its environment lose their stability. The area of cultivated land amounted to less than 5% of total land area during the preindustrial era, and man was using no more than 20% of the net primary production from those areas. As a result the overall anthropogenic share of consumption of biospheric net primary production did not exceed 1%. The present day share of anthropogenic consumption of the biospheric net primary production is almost an order of magnitude higher than that value. One may find a detailed account of that estimate below, based on different approaches and on various empirical data (see Sect. 4.12 and Chap. 5).

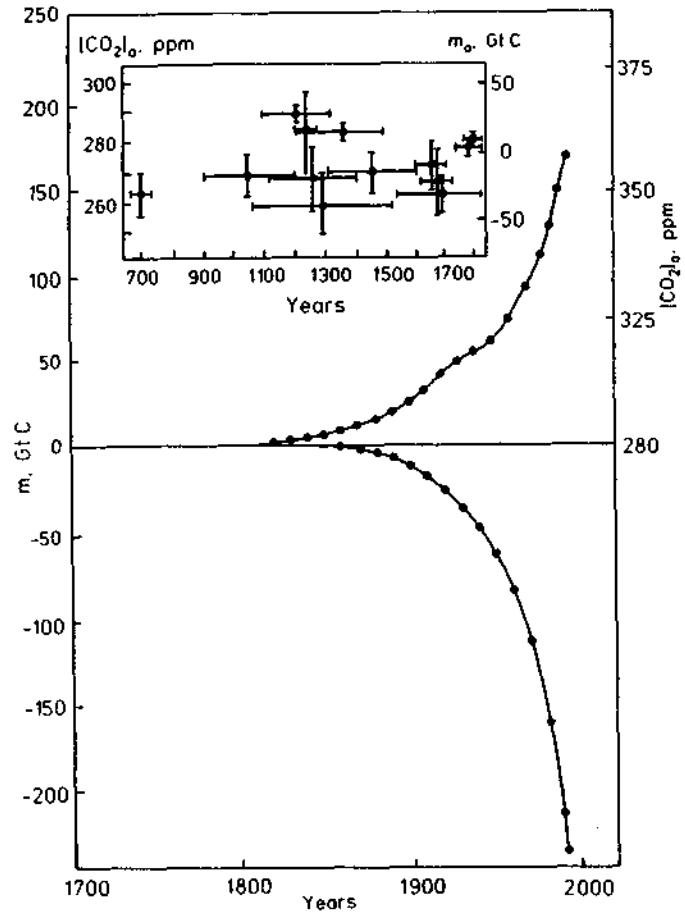

Fig. 1.2. The observed global changes of carbon stores. m_a is the increase of the mass of atmospheric carbon according to measurement data on CO_2 concentration in the atmosphere, $[CO_2]_a$, (after 1958: (Watts, 1982; Gammon et al., 1986; Trivett, 1989)) and in ice cores (prior to 1958: (Friedli et al., 1986; Oeschger and Stauffer, 1986; Leuenberger et al., 1992)); m_f is the depletion of fossil carbon due to combustion of coal, oil, and natural gas (Starke, 1987, 1990; Reviere and Marton-Lefevre, 1992). According to ice-core data the global build up of the atmospheric carbon store had started before combustion of fossil fuel was initiated. That means that global changes in the environment are related to changes of carbon stored in the global biota, and hence to perturbation of the stability of the latter.

It follows quite unequivocally from the data on changes in the global cycle of carbon that, on the one hand the threshold of admissible forcing of the biosphere is much lower than the present-day consumption by man, that is below about 10%. On the other hand, the biosphere is apparently capable of compensating for any perturbations initiated by mankind provided the share of consumption by mankind does not exceed 1% of the net primary production by the biosphere. It is then irrelevant whether mankind occupies one per cent of the whole land area where he completely perturbs the natural biota, or inhabits 10% of the land area where the perturbation of natural biota does not exceed 10%. The biosphere could support a mankind completely ignorant of environmental protection for thousands of years, while that mankind overran all of Europe and most of Asia.

We now have arrived at a position from which we can update the notions of the biota and the biosphere. Biota should be understood as such natural communities of individuals, both fauna and flora, which are capable of following the Le Chatelier principle and compensating for all the perturbations of the environment. (Domesticated animals and cultivated plants raised by man, as well as domestic patches of land, gardens and parks, which do not have inner stability, should not be included in the concept of the natural biota.) The biosphere should be understood as a stable state of the biota, of the external environment surrounding it and interacting with it, in which the level of external perturbations remains below the action threshold for the Le Chatelier principle.

There may be no doubt whatsoever that with the present-day tendencies of transgressing nature the natural biota will be completely exterminated and the biosphere destroyed.

There are then two most important questions to be answered: (1) Has the biosphere irreversibly left its stable state by now or may it yet return to it after contemporary anthropogenic forcing is significantly reduced? (2) Is there some other stable state of the biosphere to which it may proceed with anthropogenic forcing continuing to increase? The most likely answers to those questions may be obtained by studying the structure of the present-day biosphere as carried out in this monograph. These answers are as follows: (1) The contemporary state of the biosphere is reversible, and the biosphere should return to its former stable state if its anthropogenic forcing is reduced by an order of magnitude; (2) There is no other stable state of the biosphere, and with the anthropogenic forcing remaining at its present level the stability of the environment will be irreversibly ruined.

1.6 Biosphere as a "Free Market"

How does the natural biota function, and how is such a high degree of control over the levels of synthesis and destruction of organic matters in the biosphere maintained? The governing principle determining the functioning of life at any level is competitive interaction between autonomous, mutually uncorrelated individuals. The same principle constitutes the foundation of a free market. It is well known that the accuracy to which prices are determined in a free market is very high. No simulations employing modern mathematical models and computer software can reach this level, so as to be substituted for the action of the market itself. Rejection of the free market approach leads to a loss of such accuracy and to growing non-productive expenditure. The market was not been invented by man. It can prevail because at its foundation lie the actions of living people – the members of the human population. Modern markets are but an adjustment of the basic principles

of life to existing human culture and civilization. So what does the free market look like in the biosphere?

Any living being combines extremely complex correlations at molecular, cellular, individual and social levels. The principal feature of life is the fact that, due to this extreme complexity of correlational ties, any given type of correlation in the biota is unstable and decays with time. For a separate individual such a decay means death. The existing types of correlation between living individuals may be maintained only within the population of such individuals. In the course of time the successive offspring of a single individual inevitably accumulate decay changes (deleterious substitutions) in their hereditary program (see Sects. 3.4–6). The relative number of "decay individuals" in the offspring of a normal individual is a quantitative characteristic of a species. The decay individuals are mostly capable of breeding no less actively than the normal ones. To maintain the level of organization in the population all the decay individuals must be either prevented from breeding or eliminated from the population. These functions may be the responsibility of the normal individuals, which, in conditions natural for the given species, have the highest competition capacity. This feature of the normal individuals is most important. The program of elimination of the decay individuals from the population might itself be subject to decay. Identification of decay individuals and their elimination from the population is realized in the process of competitive interaction between all the individuals (Chap. 3).

When the environmental conditions deviate from natural, i.e. the population leaves its ecological niche, the competition capabilities of the normal and decay individuals even out. The criteria by which the normal individuals are distinguished from the decay ones become void. The process of decay is constantly going on, so during such periods the relative number of decay individuals in the population (i.e. the genetic diversity of the population) grows exponentially. The proportion of normal individuals diminishes and they can completely vanish from small populations. However, following a return to normal environmental conditions the maximum competitive capacity of the normal individuals is restored and they expel the decay individuals from the population (Sect. 3.9).

Were the normal individuals to vanish completely from any such population, they would be restored upon return to natural conditions (but not to conditions deviating from the natural). Such would be the end result of inverse mutations and genetic recombination in the course of mating between the decay individuals (see Sects. 3.10,11).

Note also that decay individuals are always present in the population in its stationary state due to the permanent character of decay processes; however under natural conditions their frequency of occurrence is low.

Only the population as a whole, but not the isolated sequential offspring of one individual may enjoy stability. If competitive interaction is neutralized ("switched-off") a decay individual cannot be distinguished from a normal one at all. In this case the population degenerates into several isolated progeny sequences from various individuals. Due to the ongoing process of decay such individuals keep accumulating decay traits and finally the species dies out.

Complex intercorrelated interaction of various individuals in the social structures is maintained via competitive interaction of such structures. For social insects, such as ants, this would be competitive interaction between different anthills in the population of such anthills. In exactly the same way the correlated interaction of individuals from different species in the community may be maintained by way of competitive interaction of different communities (however, they should be identical in their speciation). The simplest type of such a community is lichen, consisting of mutually correlated species of algae and fungus. Such a correlation is maintained through competitive interaction between various individual lichens in the population of lichen of the given species. The correlated formation of social structures like anthills or the communities of different species may be envisaged as the hyperindividual. The internal correlations in hyperindividuals should be maintained by way of their competitive interaction and stabilization selection in the respective hyperpopulation (Chap. 3).

Evidently, stabilization of the existing type of internal correlation of the living individuals based on their competitive interaction and selection in the population is possible only in cases where all the individuals within this population are completely mutually independent and non-correlated with each other. In the opposite case, expulsion of a decay individual from the population becomes impossible in exactly the same way a defective organ cannot be expelled from the body. It also follows from this reasoning that maintaining an inner correlation between the individuals in any population by way of centralized government of that population as a whole is impossible in principle. In other words neither the population nor the hyperpopulation should be considered as superorganisms.

1.7 Biospheric Communities

The most complex type of correlation among living formations, i.e. more complex hyperindividuals, is the correlation between the individuals of different species in the communities. It is particularly this type of correlation which makes possible the operation of the Le Chatelier principle in biota with respect to external perturbations of the environment. Complexity of organization of various individuals in the community and high diversification of the community species composition serves to maintain environmental stability.

To do this, every species executes some strictly prescribed function in stabilizing the environment, operating in a correlated interaction with other species in the community. In conditions where nutrients are artificially fed into and wastes evacuated from the environment, communities fall apart. For instance, urban sparrows have kept their species stability for thousands of years even though they are now out of the natural communities they had once been part of. The introduction of pigeons to those sparrows does not result in the appearance of any new community. The same applies to any and every species of domesticated animal and cultivated plant.

As with separate individuals, each given community has a finite size, occupies a definite space region and decays with time. This decay takes the form of a loss of capacity the community formerly had of maintaining stable local environmental conditions with a high degree of accuracy. This change in the capabilities of the community eventually leads to its expulsion from the environment by the new communities constantly forming. The only organization remaining stable may be the population of communities, i.e. the hyperpopulation.

The size of a separate community is determined by the area in which the synthesis and destruction fluxes of organic matter may, under normal conditions, be balanced by this community to the highest possible accuracy, and where the biotic regulation of the deviations from this balance, forced, as they were, by perturbations of the environment, is at its maximum. Indirect estimates demonstrate that the linear size of any internally correlated community existing in the biosphere does not exceed a few dozen meters (Chap. 5). Quick expulsion of the decayed communities leads to an apparent homogeneity of the hyperpopulation of the communities, occupying a vast surface of the Earth, which is usually called the ecosystem (Odum, 1983).

The correlation of the species in a community may be quite rigid. For example, lichen consists only of the strictly determined species of the algae and the fungus. Certain insect species are capable of feeding off only one single plant species. It is exactly this correlation which provides a wide range of reactions of the community to any possible fluctuations of external conditions. When such correlation breaks, the range of possible reactions narrows in exactly the same way that the range of possible reactions of the separate organs of the body is narrower than the range of such reactions for the body as a whole. The term "adaptation" can characterize neither the interaction between separate organs within the body, nor that between the male and female in bisexual populations, nor the relations between the various casts in the social structures of the insects. All such interactions are but correlations in the sense described above. Similarly, the term adaptation cannot be substituted for the notion of intercorrelation between individuals of different species in a community.

The term adaptation may characterize the interaction of individuals with components of the environment that cannot be regulated by the biota.

The normal genome of an individual contains the information on adaptation to all its natural habitats in which the individuals from that species may find themselves, including possible adaptive morphological changes in the offspring of an individual dependent on the environment. The adaptation to natural environment (the adaptation program) is a necessary but subsidiary part of the information in the normal genome. The principal part is the information concerning action on the environment by the individual (feeding, general behavior, population density, etc.). It is part of an individual belonging to the given species within a given community, and it serves to stabilize the optimal natural environment. It is a stabilization program. Functioning of the whole community is optimized that way, i.e. it is a program for stabilization (but not adaptation) of each separate species. All the normal individuals should produce an optimal, instead of maximum, offspring, which would provide for the best regime of functioning of the whole community.

Numerous species may exist which are unnatural for a given community, but which are well adapted to the given environment, sometimes even better than the species natural to that community, their normal genome being, however, free of a stabilization program. Such "gangster" species destroy the internal correlation in the community, as well as the environment. As a result the community containing such species is supplanted by communities free of such gangster species. Thus selection of the species with necessary stabilization programs is carried out in the biota.

Large animals are present in practically every community of the biosphere. Consequently, communities including such animals are the ones of the highest competitive capacity. The feeding territories of large animals include many separate communities, and a population of a species of large animal sometimes occupies a territory in which all the population of communities, i.e. hyperpopulation dwells. However, the destructive capacity of all large animals (the rate at which they destroy the organic matter) constitutes less than 1 % of the total destructive capacity of the community (see Fig. 1.3 and Chap. 5). Hence, under natural conditions the mammals are a "superfine tuning" of the community. The largest animals have never been the masters of the biosphere as is usually claimed. Violation of this rule always leads to distortion of the communities and to extinction of the large animals. The disappearance of dinosaurs did not perturb the biota to any great extent. It did not affect the capability of the biota to compensate for unfavorable external fluctuations of the environment. Communities keep the destructive capacity of large animals low in the same way as they control the other global characteristics of the environment which equally affect the whole hyperpopulation of the communities. The communities of plants and single-cell beings completely control the number of large animals exactly as they do the concentrations of various substances in the external environment. It may be said that the large locomotive animals jointly present a certain component of the external environment, which, together with concentrations of the biochemically active substances, are kept at certain levels by the hyperpopulation of the communities consisting of plants and microorganisms; see Fig. 1.3.

Extermination of an entire hyperpopulation of communities is irreversible, as is the case with any biological species. (The known examples of such irreversible exterminations of natural communities are the rape of the steppes and the tropical forests.) Following a heavy perturbation of a considerable number of communities comprising a hyperpopulation, the natural communities maintaining closed cycles of matter and a stable environment are restored. Quantitatively, the degree to which the matter cycle is closed may be characterized by the value of its breach, which is equal to the difference between the synthesis and destruction fluxes, divided by the synthesis flux. In the cultivated, constantly perturbed agricultural

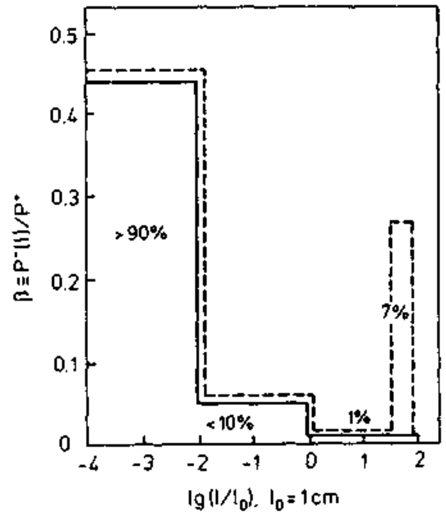

Fig. 1.3. Distribution of the rate of destruction of organic matter with body size of individuals destroying the organic matter (bacteria, fungi, animals) on land. $\beta = P^-(l)/P^+$, $P^-(l)$ is the spectral density of destruction, produced by individuals of body size l, P^+ is the production of land vegetation (net primary production), see Chap. 5. The solid line gives the universal distribution found in all the non-perturbed ecosystems (Sect. 5.6). The area enveloped by the solid curve is equal to unity. Numbers in per cent give the relative input from various parts of the histogram. The dashed line describes the present-day distribution on land, accounting for the anthropogenic perturbation. The area under the anthropogenic peak (7 %) corresponds to man's food, plus cattle fodder, plus consumption of wood (Sect. 6.5). The difference between the areas under the dashed and the solid lines characterizes the breach of the biochemical cycle. It is obtained from the measurement data on the global carbon cycle, and is close to the area of the anthropogenic peak (Sect. 4.12).

areas this value is always at a level of several tens per cent. Meanwhile, the moment a perturbation terminates (e.g., after complete wood cutting, fires, or natural disasters) the level of breach quickly lowers, reaching 1 % in just a few decades. However, the relaxation to the background breach of hundredths of a per cent takes hundreds of years, following multiple changes of speciation in the plant cover and restoration of the natural age distribution of the vegetation. If a considerable part of the hyperpopulation of the communities is destroyed more often than once in every few hundred years, the background breach is never reached, and the environment begins to disintegrate.

1.8 Evolution Rates

The described mode of stabilization of the biota and the environment also makes possible the evolution of the biological species and of their communities. Only those species which do not decrease the overall competitive capacity of the community can take a firm hold in the biosphere, e.g. they do not lower the average level of closedness of the matter cycles and capacity to maintain the environmental stability by the community. Paleodata prove the evolutionary process to be extremely slow. Noticeable changes in the speciation of the biosphere take several million years. On the scale of hundreds and thousands of years no development can occur in the biosphere (see Chap. 3). Only processes of relaxation to the stable state typical of the given geological period may take place following natural external forcings or processes of disintegration of the biosphere following such perturbations which exceed its stability limits. The extremely long duration of the existence of the biosphere and of life demonstrates that such catastrophic perturbations have never occurred during the whole of the history of life on Earth.

The direction of evolution is always determined by the appearance of more competitive forms and the expulsion of their predecessors. Increase of competitive capacity may not always be caused by higher organization (complexity of correlation) of the living beings. Evolution can also go in the direction of increasing aggressive competitiveness at the expense of life capacity, destroying the already achieved level of organization, i.e. by way of extermination of the more organized but less aggressive individuals by those more aggressive but less organized ones. Such a process could, in principle, lead to complete disorganization, and, finally, to extinction of life. In particular, this might happen if both the separate living beings and the social structures and communities were to physically grow in size without any restriction; such a growth is accompanied by an increase in their respective competitive capacities. The growth in physical size would lead to fewer individuals in the population, and, finally, complete correlation between all parts of the population, thus stopping the competitive interaction and natural selection. Besides, the reduction of the number of independently functioning living beings would block the operation of the well-known statistical law of large numbers – the only means of damping fluctuations known to nature. Thus such a development would lead to an unlimited increase of fluctuations in the processes of synthesis and destruction of organic matter in a community, and to further inability of the community to keep them intercorrelated (Chaps. 4 and 5).

The overall duration of life and the available paleodata show that there existed in nature some acting agents, which stopped (at least prior to the anthropogenic perturbation of the biosphere) the tendency of evolution in the direction of disrupting the foundation of life. Among such agents is the lack of abundance of nutrients in the environment. Abundance corresponds to a situation where the store of nutrients in the environment is much larger than their expenditure (production) in the course of evolution (or progress), that is where the time of evolution is much less than the time of biological cycling of the nutrients, i.e. the residence or turnover time (Chap. 4).

The timescale of the biospheric evolution is determined by the rate of change in speciation of the biosphere, i.e. by the average lifespan of a species. As noted above, this lifespan, according to paleodata, is of the order of a million years. The timescale of the biological cycling of nutrients in the environment is equal to the ratio of the nutrient store and the productivity of the biota, and is of the order of

10 years; Fig. 1.1. Thus it is 10^5 times shorter than the timescale of evolution. As a result, the evolution of natural biota takes place under conditions of strictly limited natural resources, extremely far from those of abundance. Any evolutionary change disrupting the correlation between the synthesis and destruction of the organic matter in a community appears impossible, since a complete local distortion of the environment (due to the extremely high power of the biota to synthesize and destroy organic matter) occurs much faster than such a change. This distortion, should it take place, would lead to an immediate loss in competitive capacity of such a community and to its expulsion.

1.9 Progress

However, following a transition from genetic evolution to scientific-technological progress in free market conditions, the changes speed up. The timescale of the technology overhaul shrinks to several years and becomes considerably less than the timescale of deterioration of the biospheric resources (i.e. the timescale of their imaginary anthropogenic cycling). In such a situation mankind faces a seeming abundance of natural resources. Deterioration of natural resources occurs too slowly and cannot affect technology. Resource-spending technologies appear to be competitively stronger and quickly expel all the resource-conserving technologies, including the natural communities of the biosphere.

The economic progress attains its maximum rate and efficiency of exploitation of natural resources when the maximum number of competing technical units ("technological communities") takes part in solving a given problem. The minimal size of such a technological unit is determined by the correlation radius within a plant (factory) needed to solve this particular task. In the conditions of a seeming abundance of natural resources the market economy inevitably leads to a maximum possible rate of expenditure of such resources and to their deterioration.

Renunciation of competitive interaction and market economy through a transition to its centralized control on a global scale might help to regulate progress and reduce the rate of deterioration of the environment. However, when there remains competitive interaction with the "external environment", which develops on the basis of market economy, the centrally controlled system will lose its competitive capacity and eventually be expelled. Due to lower efficiency in the use of natural resources the centrally controlled system might under those conditions develop local rates of deterioration of these resources that would exceed the overall maximum reached by the market economy. The existence of the centrally governed system might only be possible under conditions of complete isolation when competitive interaction with the external world is stopped. This is equivalent to either the absence or annihilation of the latter.

Parallel to global deterioration of the environment by the progressing market economy there may exist certain localities in which the environment remains in a stationary state or is even apparently improved on the basis of the open cycle of matter. That would mean constant introduction of new amounts of matter needed for consumption into, and removing the wastes from, such a location. This principle is also employed by nature to maintain the life of a separate individual. It is employed by man to keep stationary the state of his personal dwelling, lot, park, or any other cultural complex. However the breach of the local cycle means that the existence of such an artificially stable area is paid for by ever deepening deterioration of the environment for the rest of the biosphere. The garden in bloom, an artificially clean lake or river, kept in such a state on the basis of an open matter cycle, is much more dangerous for the biosphere as a whole than wasted, desertified land.

For resource-spending technologies operating in free market conditions to lose their competitive capacity against the most resource-conserving ones, the cycling time for the environmental resources involved in the technological processes must be considerably less than the timescale of the technology overhaul. Taking the current value of the latter at about 10 years, we conclude that the timescale for complete cycling of all the resources involved should not be more than 1 year. However, for most of the non-renewable resources of energy and materials the timescale of their deterioration is of the order of a hundred years. To reduce the cycling timescale for technological resources it is necessary to either increase the rate of their consumption several hundredfold, or reduce respectively the amount of resources consumed. In other words, either quickly spend all the non-renewable resources or refuse to spend them at all. Only after satisfying these conditions will the economy actually become "ecological". In the opposite case the economic progress related to spontaneous increase in competitive capacity must inevitably lead to complete deterioration of all the resources and to destruction of the environment fit for life.

Note that the natural biota does not use non-renewable resources. Starting to use them is only dangerous if there is evolution or progress. Only if the latter two processes take place is there a possibility of development in the direction of disrupting the environment. In a conservative state, when evolution and progress are absent (when the timescales of these processes are infinitely long) the initially closed matter cycles cannot be disorganized by the existing communities, even if they randomly turn to using the non-renewable resources; in such a case these resources will be automatically restored. Free market mechanisms described in Sects. 1.6 and 1.7 are used by biota only to stabilize an individual's or a hyper-individual's internal organization. A direct free market mechanism could never be used by the biota in the evolution of species (Sects. 3.15, 3.16 and 4.14).

Let us look at the two possibilities mentioned for attaining resource-conserving technologies, while operating in conditions of progress in a free market economy. The first of them – connected with accelerating the rate of consumption of resources many hundredfold (the current civilization is still attuned to this possibility) – is not a real possibility. It could only bring positive results in the case where such an acceleration could happen instantly, i.e. during a time interval short enough for the ongoing progress not to have been able to disrupt the biosphere noticeably, without spoiling the environment and decimating the biota. In reality such an acceleration and a respective increase in consumption must inevitably take too long. During such an inevitable period of the rate of consumption gradually picking-up, the ongoing resource-consuming progress would surely bring the biosphere into a state unfit for life.

1.10 Conservation of the Biosphere

The second possibility connected with a refusal altogether to further spend the non-renewable resources is quite realistic. The present-day consumption of energy by civilization is 90% based on non-renewable resources. Renunciation of the latter would lead to a tenfold reduction in energy consumption. The human population should then be reduced by the same factor. This would in turn reduce the anthropogenic perturbation of the continental biota by the same factor of ten, which would let the latter return to within the margin of the Le Chatelier principle. Let us stress that consuming energy at its present level even after a transition to the so-called ecologically clean energy resources would still mean destructively perturbing the natural biota and the biosphere (Fig. 1.4). The whole process of reduction should be prolonged so as to let the technological progress in free market conditions restructure itself to the resource-conserving technologies. This could feasibly happen in a few decades to a hundred years, in which the biosphere would not be rendered completely unfit for life: its anthropogenic perturbation would gradually diminish. During such a period a global transition to one-child families (this rate corresponds to a 2% annual reduction of the population) will reduce the population during the next century exactly by the needed factor of ten.

It should be stressed that the transition from the current population growth (of about 2% a year) to its reduction at the same rate would not produce any economic problems. The demographic stress the society now suffers raising children would then turn into respective stress from the elders. The level of stress is then determined as the number of children under 15 and elders over 60 years per one person in the 15–60 age bracket. The lowest demographic stress is suffered by the stationary population (neither growing nor shrinking). However, in the contemporary technologically developed society, all children must pass through a costly period of learning and training. On the other hand, the present-day elders maintain their health and working capacity for a long time and can practically always earn their own living. This fact leads to a situation in which the economic stress from a child heavily exceeds that from an elder. In the end the transition from a growing population to its reduction at the same rate would decrease the economic stress upon society severalfold and it could even appear to be less than in the stationary state. In such a situation the economic stress would have to be determined as a ratio of the number of non-working people to the number of those working. Traditionally the fear of depopulation is associated with the loss (inevitable in the past) of competitive capacity by a nation reducing its population as compared to one increasing it. This danger would be eliminated if all nations started to reduce their populations proportionately.

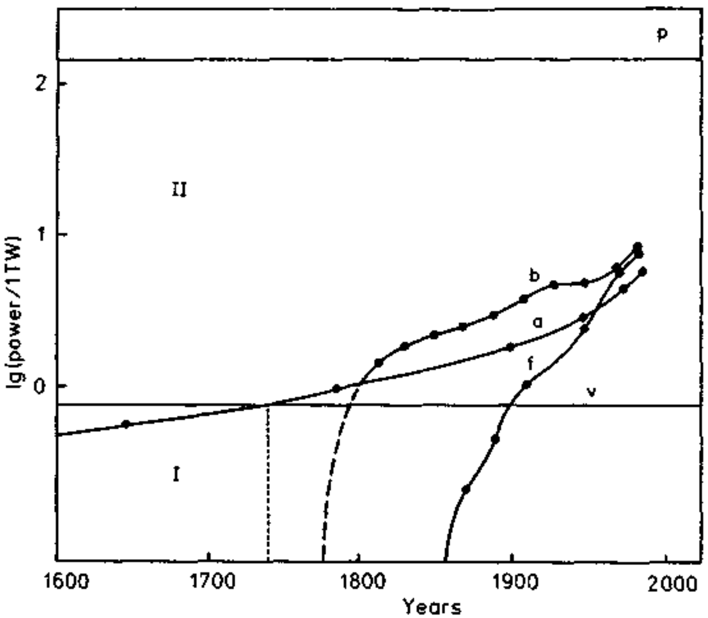

Fig. 1.4. Energy consumption and environmental stability. Horizontal lines are as follows: p is the global power of gross primary production by the whole biosphere; v is the global consumption by all the natural herbivore vertebrates (see Fig. 1.3 and Sect. 5.6). The v-line coincides with the threshold of the ecologically admissible anthropogenic consumption of biospheric production (Sect. 4.12). Curvilinear lines are as follows: f is the power of fossil fuel combusted; a is anthropogenic consumption of biospheric production (man's food, animal fodder, wood consumption; see Sect. 6.5); b is the reduction of organic stores on land. Ranges: I – the ecologically permitted value of anthropogenic consumption. All the anthropogenic perturbations of the biota and the environment are compensated by the natural biota; II – the global consumption of primary production by small invertebrates of the natural biota, who perform the principal work of stabilizing the environment; see Chaps. 3–5. Anthropogenic consumption in that range is ecologically prohibited, since it results in forcing the natural communities out and in violating stability of the biota and the environment.

The program of reducing anthropogenic perturbation and of returning to the margin of the Le Chatelier principle might be successful on one condition: the economic expansion to cultivation and development of new parts of the biosphere, yet unspoiled by civilization, must be stopped totally and immediately on a global scale. Then these parts may become the active sources of restoration of the biosphere. Such a demand calls for the minute inventory of the still intact parts of the biosphere; it should be undertaken without any delay, using all available technological capabilities.

The most productive continental communities are forests and bogs. The highest productivity is demonstrated by the tropical communities. Their productivity

exceeds that of the respective communities in temperate zones by a factor of four, see Chap. 5. In accordance with the Le Chatelier principle, when seeking to compensate for the perturbation of the environment, a unit range occupied by virginal tropical forests and bogs would be equivalent to four such ranges of virginal forests and bogs in mid-latitudes. Non-perturbed virginal forests and bogs do not affect their environment. In particular, forests are neither releasers nor absorbers of oxygen. The fact that a forest is a closed system with respect to oxygen means that all the oxygen produced by plants is immediately utilized by other individuals of the forest community. The forest starts to alter its environment only when the latter is perturbed, and its reaction is to compensate for the perturbation.

The secondary forest growing in the wood-cut areas possesses approximately a thousand times worse capacity for compensating environmental perturbations as compared to its virginal predecessor, see Chaps. 4 and 5. In billions of years of evolution nature has mastered the most effective means for reactivating the Le Chatelier principle in the shortest possible time. The damaged forest areas are inhabited by repair species which organize the repair community and quickly reduce the degree of breach of the natural cycles. Then successive substitution (succession) of repair species takes place, during which the degree of breach keeps reducing. Apparently in about 300–500 years this process is finished and the forest returns to its initial unperturbed state (it may only happen if the damaged part is surrounded by non-perturbed areas, i.e. the hyperpopulation of the natural communities still exists), see Chap. 4. If man interferes with the succession process, pursuing his economic profit and tries to grow the most valuable tree species too speedily (e.g., processes the cut areas by herbicides, weeds out the non-valuable species) the process of repairing the cycles slows down.

Periodic felling of mature, economically profitable wood (every 50 years or so) interrupts the restoration of the virginal forests of the closed matter cycles, capable of compensating for environmental perturbations. To return to the natural biosphere it would be necessary to extend the time between such wood-cuts to 300–500 years, i.e. globally reduce the cutting by a factor of six to ten. Since at present more wood is cut everywhere than grows naturally, so that the forested areas globally shrink, the reduction factor should at least reach ten. The same figure was obtained above for the scale of population reduction.

It follows from Fig. 1.4 that large vertebrates may envisage the biosphere as an energy processing engine which stabilizes the environment and provides them with the energy necessary for their existence; however this engine operates at an efficiency level of about 1%. The remaining 99% of the power of the biosphere is consumed by small invertebrates and is spent on stabilizing the environment.

As demonstrated in Sect. 1.5, the action of the Le Chatelier principle in continental biota appeared to be disrupted as soon as the share of biotic production consumed by man throughout the continents exceeded 1%.

The development of civilization, based on and boosted by the free market, under conditions of unlimited energy resources, may be compared to the effect of doping in a sportsman's body. Such a development opens the way to reach good results within a short time period, with the standard of living of all the people becoming very high, but only at the price of destroying the natural biota. Using various waste cleaning and disposal techniques produces an illusion of ecological well-being. However, extermination of the natural biota results in irreversible global changes of the environment.

The so-called highly developed regions (or countries) have only been able to reach their level of prosperity without completely destroying their natural environment because the nature of the developing regions, not yet spoiled by civilization, keep compensating for the devastation wrought upon nature on the global scale. The virgin nature of the developing regions took it upon itself to stabilize the global environment. Without all that biota, 99 % of the gross product of the developed regions would have had to be spent on conserving the environment. In that case there could have been no development of the economy of those regions. The development of the "developed" regions is borrowed.

To stop further destruction of the biosphere, all the developed regions should pay an international tax to those still having some natural biota, not spoiled by civilization, and that tax should exceed the possible income from using the resources of that biota. It is completely inadmissible to use the economic potential of the developed regions to speed up the extraction of resources from the virgin nature of the developing ones.

Trying to raise the standard of living of people in the developing regions to that enjoyed in the regions already developed via the free market economy by extracting the highest economic profit from the exploited natural resources will inevitably result in a global ecological catastrophe. Provided the population of the planet remains at its present level or even grows, the modern standard of living available in the developed regions can only be given to every man on Earth at the cost of the complete destruction of the environment fit for life. Supporting a stable level with the natural biota and environment remaining intact is only possible for a human population that is an order of magnitude smaller than the present one.

If some unused natural resources are still available, the rate of economic growth and the standard of living of the whole population may be increased if a working part of the population (labor force) is imported. That is how North America was conquered. This also explains the present-day demographic policy of the developing countries, particularly in Latin America. However, such a policy results in a quick destruction of natural communities in the biosphere. At the start of the industrial revolution such a development only resulted in local perturbations of the biosphere. But with modern levels of technology such a policy inevitably leads to irreversible global perturbations of the environment, thus significantly lowering the probability of following generations surviving.

The policy pursued in developing the natural resources of Russia also produces significant doubts. In Siberia and the extreme North of Russia the largest areas on the planet still conserved exist, featuring the natural biota only slightly affected by industrial activities. That biota is of enormous value for the whole of mankind, not just for Russia. It is the duty of the developed countries to help Russia preserve

that biota, which would be in the best interests of both Russia itself and all the countries of the world. The remaining natural communities of Russia should not be destroyed. That is why the West should help Russia overcome its present-day economic difficulties, to prevent the otherwise inevitable economic development and destruction of a piece of natural biota unique in its scale.

1.11 A Transition to the Noosphere?

An alternative for the further development of civilization is to liquidate competition between groups of people, including countries, and proceed to a globally correlated civilization based on centralized government, i.e. to start constructing the noosphere. In this case any species of untamed living organisms outside their natural communities would present an enormous global danger to the environment: breaking from under control and breeding in natural proportions without any restraint, such species would be capable of destroying the environment much quicker than man does now; remember the enormous power of synthesis and destruction of organic matter that the biota is capable of developing on the scale of the whole biosphere. Note that examples of the destruction of the environment following the introduction of new species into it are numerous and well-known. Therefore, all the remnants of the perturbed continental biota, including wild species unfit for taming must be destroyed. The only biota kept by man would then be represented by a small number of cultivated species. However an incredible multitude of both living organisms and technological objects would then have to be governed and controlled on a global scale within the noosphere under conditions to prevent the recovery of large numbers that would inevitably precipitate growing fluctuations in the processes of synthesis and destruction of biological and technological products. These could finally destroy the environment and bring civilization to its downfall.

With the destruction of natural biota biological regulation of the environment will be lost. The flux of information, extracted from solar energy by the natural biota exceeds the maximum possible information fluxes in the computers of the whole of civilization by 15 orders of magnitude (Sect. 2.8). Thus it appears unrealistic to expect to be able to construct a noospheric system for regulating the environment which would be as efficient as the biotic one. Therefore, even if some completely waste-free technological cycles are organized in place of the natural biota, running on ecologically clean energy sources which do not alter the state of the environment, the latter will be subject to biotically uncontrolled natural fluctuations, which might destroy the environment fit for man in just a short time (Sects. 2.7, 4.12).

Hence the noosphere in the form described above is Utopia. Noosphere is only possible as a stable ecological niche for the existence of civilized man, and with technological progress taking place that niche is only possible if the natural biota is preserved over most of the planet, while the overall energy consumption by the planetary human population is brought down to an ecologically permissible level (Fig. 1.4).

Moreover, even with the construction of a noosphere commanding stable global environment and possessing an efficiency equal to that of the biosphere, no less than 99 % of all the energy and manpower (labor) of such a civilization would have to be spent maintaining the stability of the global environment. Since the limit of energy consumption by mankind compatible with climate stability coincides with the power of the biosphere itself (Fig. 1.4 and Sect. 6.6), man in the noosphere would have less power available to satisfy the needs of civilization than he would command in a stationary biosphere, where he would not have to bother stabilizing the global environment.

These are strong grounds for believing that the biosphere (which consists of natural biota developed in the course of evolution, interacting with the environment) presents the only system capable of stabilizing the environment under any external perturbations. Consequently, preservation of the natural communities and the existing species in numbers capable of satisfying the Le Chatelier principle with respect to the global perturbations of the environment must be envisaged as the main condition for further life on this planet. To do that, virginal nature has to be preserved on the larger part of the Earth's surface instead of in tiny reservations, zoos, parks and gene banks.

2. Solar Energy and Ordered Processes in Inanimate Nature

2.1 Decay of Ordered States

We may constantly observe ordered macroscopic processes in nature: wind, generation of clouds, precipitation, the flow of rivers, etc. The ordered motion of molecules of a substance is always envisaged as the opposite of their chaotic (non-correlated) thermal motion. The ordered character of such motion means that a single molecule or a group of molecules appears to be related (correlated) in its motion to that of another such molecule or group of molecules. For example, all the molecules of water in a river have a downstream velocity component. During turbulent flow in whirlpools macroscopic groups of molecules feature identical angular velocities. The phenomenon of wind means that all the molecules of air have a common velocity component.

Molecules taking part in macroscopic motion interact with other molecules of the medium in which such motion occurs. An enormous number of finite states may result from that interaction: during elastic collision a molecule may change the direction in which it moves, while during nonelastic collision it may transmit its energy to a molecule of the medium. All the final states of the two interacting molecules are apparently equally probable. In other words, only an infinitely small fraction of molecules interacting with the medium will retain their velocity component from the initial ordered motion after the interaction, and almost always that component will be transformed and transmitted to molecules of the medium. Hence an ordered correlated motion will decay into disordered chaotic movement of molecules. The energy of that ordered motion dissipates and is transformed into thermal energy. Note that such decay only takes places if a transition is possible from the initial into a large number of final states. A set of objects initially organized into one and the same initial state, will then be transformed into another set with differing final states. Such a transition is envisaged as a transition from order to chaos. The existing order must always be initially organized via some preparatory act.

Since decay and dissipation of energy go on permanently, any ordered process may only be supported if there exists an influx of energy to it from another ordered process. Clouds may only form because water vapor condenses. The latent heat of evaporation released during condensation generates macroscopic motions of the molecules of air, so that cyclones, tornadoes, etc. may form, accompanied, as it were, by strong winds. The energy of wind also gradually dissipates, transforming