ON THE BRINK

- ISSUES OF SUSTAINABLE RESPONSIBILITY

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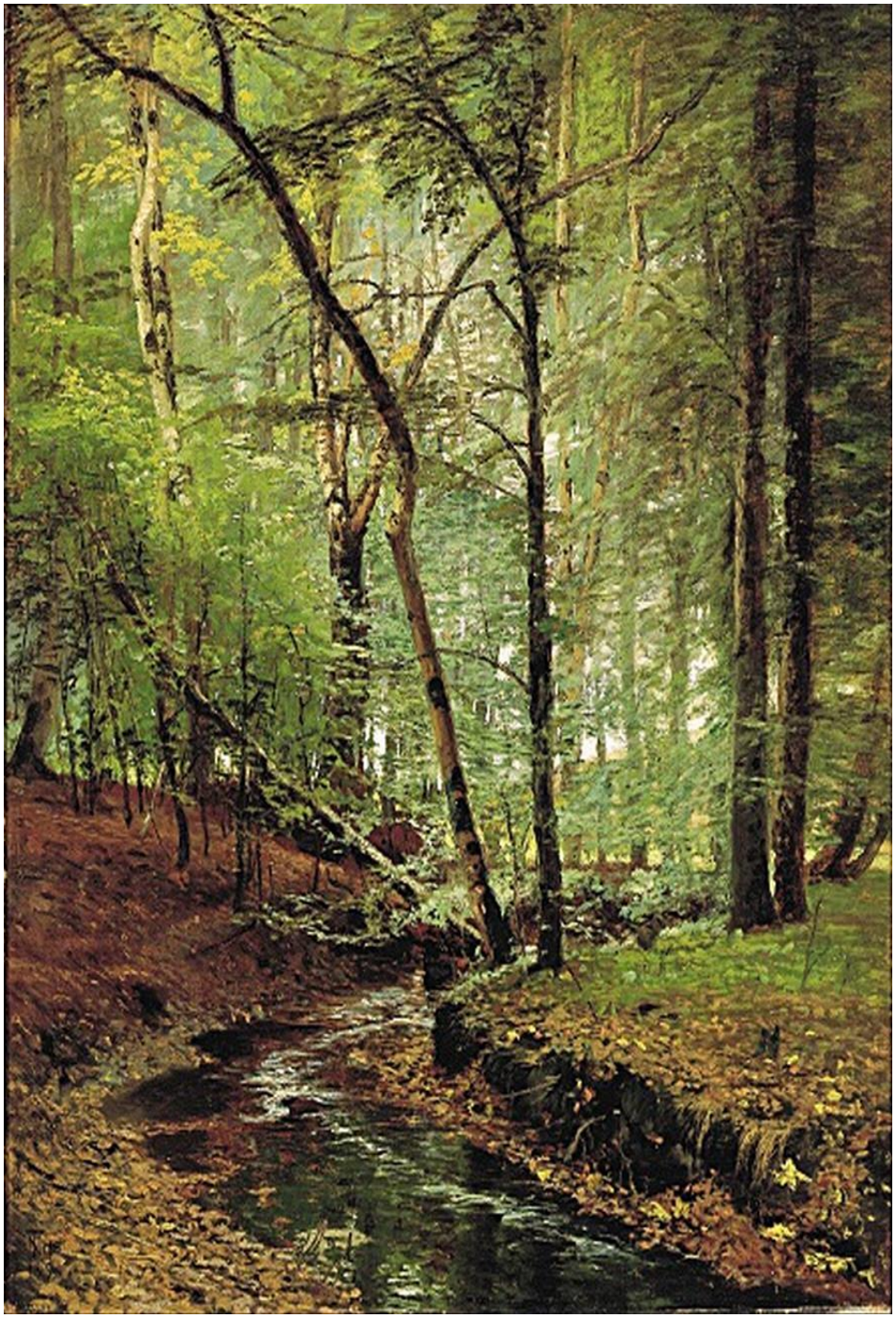

CONTENTS

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CHAPTER 2
NATURAL SCIENCE

In chapter 2 we will introduce the basic concepts and workings of nature. This will be split into the atmosphere, the hydrosphere, the lithosphere and the biosphere the four being defined as the geosphere. We will look at the very fundamental forces of nature and the problems that has occurred due to man's invention into the natural world.

Nature teaches more than she preaches.
There are no sermons in stones.
It is easier to get a spark out of a stone
than a moral

John Burroughs

Natural science has for long been recognized as an area which has been developing crucial answers and solutions to a long range of fundamental questions dealing with genetics, space, medicine, physics etc. Thus, natural science has given us a range of tools, methodologies, concepts, prescriptions etc. that has made life much easier for human beings. It has provided us with a number of essential medicines. It has allowed us to send a man to the moon. It has constructed buildings, bridges and roads that have changed the face of the earth. It has stressed facts instead of fiction. So let us have a look at some basic assumptions or relationships of natural science: We can observe that:

- nature and society affect each other mutually
- the earth constitutes a dynamic system
- resources are limited
- nature exhibits a high degree of biodiversity
- all life has developed through evolution
- organisms consist of cells – the genes of these can be hereditary or changeable
- everything in the universe is buildup of small particles
- basic physical forces work all over the universe
- the energy in the universe is constant but can change from one form to another
- the solar system is a tiny fraction of billions of galaxies in the universe
- human beings are the only species who exhibits an articulated purpose

These assumptions take the character of being facts given our present knowledge of the world. These assumptions are observable, and constitute scientific evidence. We can anyhow say that though being facts they do not necessarily contain a universal truth. Some resources are abundant; in some place's nature does not exhibit a high degree of biodiversity. On the other hand, it would be hard to argue that organisms do not consist of cells or that all life has developed through evolution. So, let us try to systematize it a bit.

2.1 WHAT IS NATURE?

Not so long ago the former Danish Minister of the Environment stated that in his opinion a wheat field formed part of nature and a couple of years ago I was commissioned before the Danish Parliaments Environmental Committee where the Chairman asked me what I meant when talking about "sustainability". Now at best these two instances could be a result of ignorance at worst a deliberate attempt of a politically motivated change of the conceptual meanings of normally well-understood concepts. These initial observations just stated to make sure that no matter at what level we find ourselves, even the concept of nature can be given different conceptual meanings and that even household names like that of nature and sustainability might not be what they normally are expected to be.

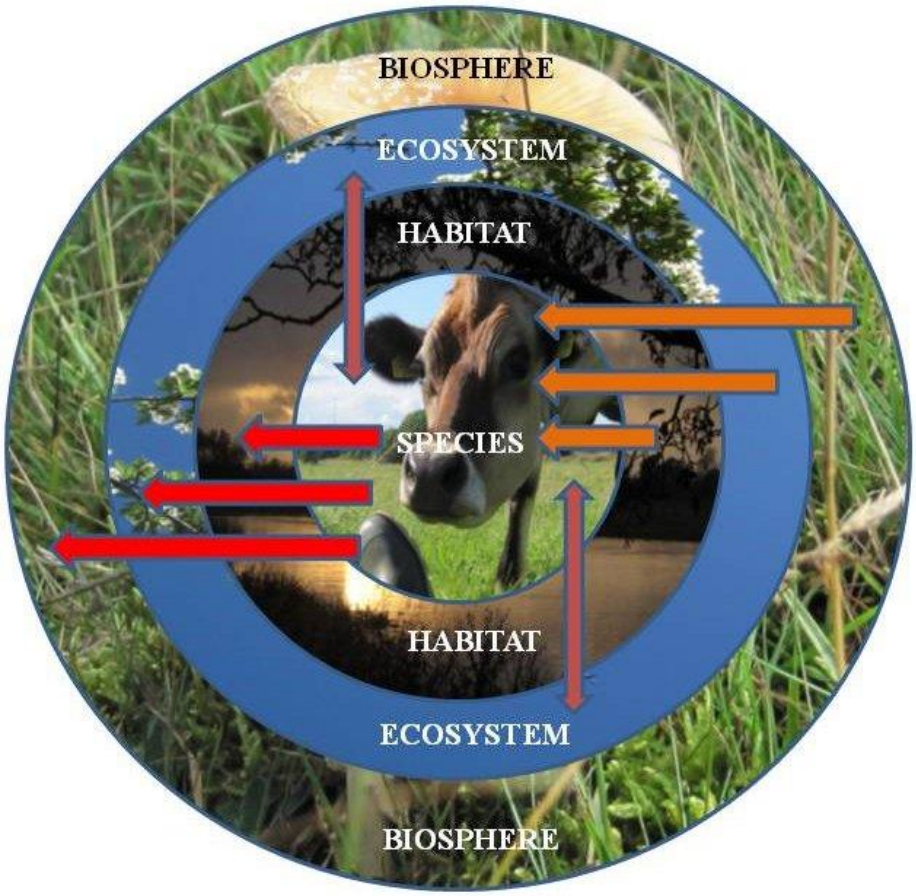


Exhibit 2.1. The way nature's elements are classified in this book

Our understanding of *nature* consists of a part of the world in which *abiotic* and *biotic* elements are and live which acts as a fundamental and vital element in order

for such elements to survive and thrive or expire. Negatively we will define nature more specifically as different from: *a) areas of urban settlements, b) areas where human interference has made this an artificial playground for human's desires and c) areas of private or public industrial and agricultural activities.* Of course, we will find wild-life and flora here. London is actually more populated by foxes than the forests encircling it. However, we will distinguish these areas from nature because there is a big difference in our handling of nature and areas where humans have interfered with the natural processes and those that are left for such natural processes to develop by themselves. This non-natural environment we will instead define as a part of the concept of *culture.* Gardens, parks, fields, plantations, harbors, fish farms etc. are all manifestations of human *culture* as opposed to *nature*. Nature does not manifest itself by purpose; it just *is.*

The core of nature consists of its biotic *species* that is wildlife, bugs, plants, bees and so on as well as their sounds, traces etc. Species occupy a *habitat* where they unfold their natural instincts - that is at savannas, in forests, mountains, cubes, beehives etc. A natural habitat satisfies the requirements a species is demanding for existence, breeding and competing. Collectively such habitats form the total make up what we will call the *ecosystem*. Such ecosystems can exist within the atmosphere, the hydrosphere and the lithosphere and in short, we will name the collected ecosystems *the biosphere* where an ecosystem formally comprises a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.

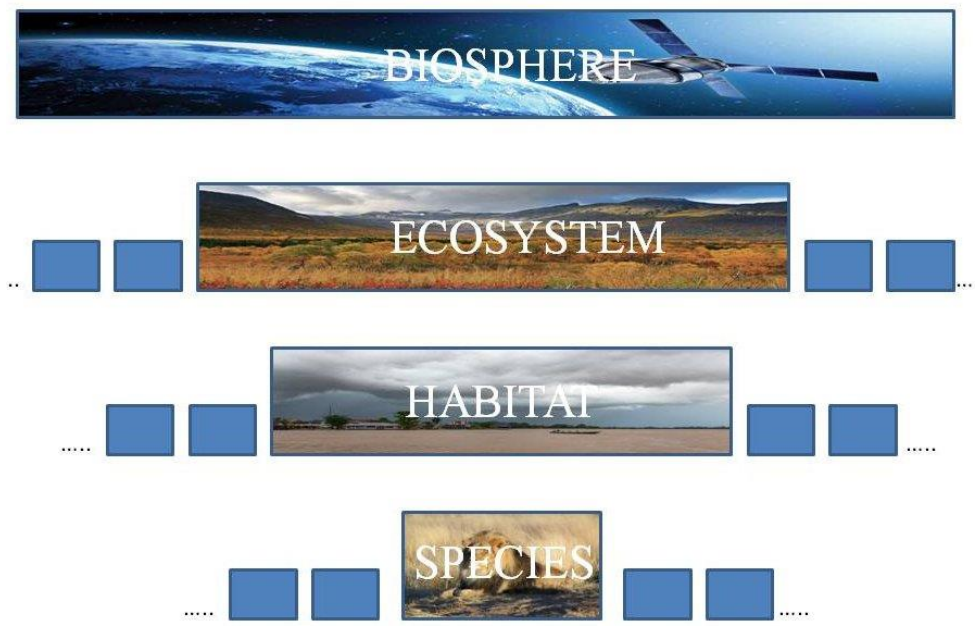


Exhibit 2.2 Nature as a hierarchical concept

The arrows in Exhibit 2.1 mark the interrelated exchanges of matter and energy and the interactions of various kinds between the 4 conceptual elements. A lion – a *species* - will find its territory – its *habitat* – in different places (savannas, swamps, mountains etc.) and will use this habitat for catching prey, mating and giving birth to new lion cups. It will fight – compete – for its habitat in order to secure its own existence and that of future generations of lions. Species like the lion will also affect the surrounding habitat and ecosystem. When the wildebeests migrate, they will enter the lion's habitat and the lion will kill some of the wildebeests thereby affecting not only its habitat but the ecosystem as well.

However, human beings are the only species who are able to change the biosphere. We've seen this unfold by our emissions of excessive amounts of CO_2 thereby altering the weather system and the workings of many ecosystems in the lithosphere and the hydrosphere as well. These interactions are portrayed by the red arrows in Exhibit 2.1.

So, lions and people affect their habitats etc, but they are also affected by the same habitat, ecosystem and biosphere. During increasingly dry periods lions will thirst and some of them will die due to this. So, changes in the biosphere will alter the living conditions of the species. The wildebeest may have changed their pattern of migration and may not enter the habitat – ecosystem changes then affect the lion's food sources within their habitat. Furthermore, the habitat might change when e.g., rainfalls alter the area, when trees are destroyed by wildfires etc. Such interactions are marked by the orange arrows in Exhibit 2.1.

Likewise, we will also see interactions taking place among the 4 elements marked by the 2 two pointed arrows of *pink color* in Exhibit 2.1. Elephants for example might destroy the vegetation in their habitat and then find a new place where to feed. Salmon migration might be affected (habitat) if a hydroelectric power plant is being built (ecosystem). People can affect the biosphere by emitting excessive amounts of CO_2 and thereby affect the climate that then will drizzle down the 3 other elements.

This way of classifying nature gives us a way to be more specific of what we're talking about. It hopefully will give us a better understanding of the actions and interactions taking place in various system elements and among these. Such interactions are a mix of cause-effects linkages, and they can span over short periods of time as well as very long periods. It can cover the smallest one-celled species as well as human beings. It is for sure a coarse dividing of the natural world, but it anyhow will allow us to be a bit more specific of what we're dealing with.

We will also distinguish between the: a) *man-made environment* or *managed environment* (the anthroposphere) and b) the *natural environment* or *unmanaged environment* because nature works in different ways in these two systems. We will maintain that human beings are almost entirely active in the man-made environment and *not* a part of what we understand as *nature*. Of course, we are defined as a mammal because we breathe with our lungs, but it is also pertinently clear that man is now dominating what's happening in both the managed and the unmanaged environment. We do *not* follow the rules of nature but has formed our own rules specific to us. We are *not* complying with survival of the fittest. Developments or evolution in our own species takes a whole lot of *different paths* than that of nature. We have found ways to feed ourselves, clothe ourselves, keep warm, migrate, understand and transform the ecosphere so that it suits our needs. The idea of human beings as a part of nature is a romantic, delusional, and dangerous way to consider our own role. We have been retracted from the natural environment and we have to painfully accept that human beings are in a class all of its own. We are now the managers of the man-made as well as the natural environment. It's our decisions that count as to how both the managed and the unmanaged environment will develop in *all* of the next centuries to come. It's we that hold the destiny of *our* planet in our hands. The success - or failure - of the human species is really a one-off story in our planetary system.

Exhibit 2.3 This is what we mean when talking about an unmanaged environment

Basically, the laws of nature are fundamentally different from the human world in that it is based on e.g., physics, biology and chemistry and researched through processes designed to understand and measure what *is* instead of what *ought* to be (ethics). We will furthermore *not* in essence distinguish between *laws of nature* and *scientific laws*. We've discovered a number of laws that pertain to nature – gravity, division of cells, genes, atoms etc. and we'll dig a bit deeper in the following sections, especially in section 2.4 Earths spheres.

2.2 ENVIRONMENTAL DEGRADATION

There is an old saying that any substance is toxic if exceeding certain thresholds. In order to measure what is *environmentally damaging* we must, however, dig a bit deeper and ask what *kinds of effects* constitutes environmental damage? Furthermore, we must also be able to establish *an indicator* that reflects environmental damage and be able to *measure* this indicator. We must also ask the question of environmental damage to *whom* or *what* and we must ask about the *time frame* as well? This involves questions that has to do with both ethics and scientific standards. Nature itself just adapts to changes.

It is also important to notice that nature is a *dynamic* system. It evolves and changes with time. Nature itself is a scene for dramatic changes that happens all the time - when volcanoes erupt, plains get flooded, wildfires emerge, wildlife deteriorates due to predation, rain falls washing out nutrients running into rivers and lakes and so on. These are natural phenomena that sometimes can be prevented but most often happens without any possibility for humans to alter such processes deliberately. This must be contrasted to human induced changes to nature that we deliberately or unconsciously cause to happen. When micro plastic is found in organisms in Antarctica this is not a natural phenomenon but due to human activity. Some people hope for a technological fix of such problems, some don't really care but most often it's human nature that gets in the way of furthering sustainable solutions. This also means that environmental damage has *everything* to do with culture, human preferences, economics and societal developments.

Please note that when we here talk about environmental degradation this includes pollution, deforestation, climate changes, smog, loss of biodiversity etc. or in short; the effects that are unwanted when trying to protect, preserve and restore our natural ecosystems. Following Exhibit 2.4 below we will claim that environmental degradation is dependent on the environmental regulations that are in place, the social acceptance of such regulations, the extent to which environmental regulations are enforced and the behavior exhibited by the corporations and persons submitted to these environmental regulations. There will furthermore be links between each of these four elements.

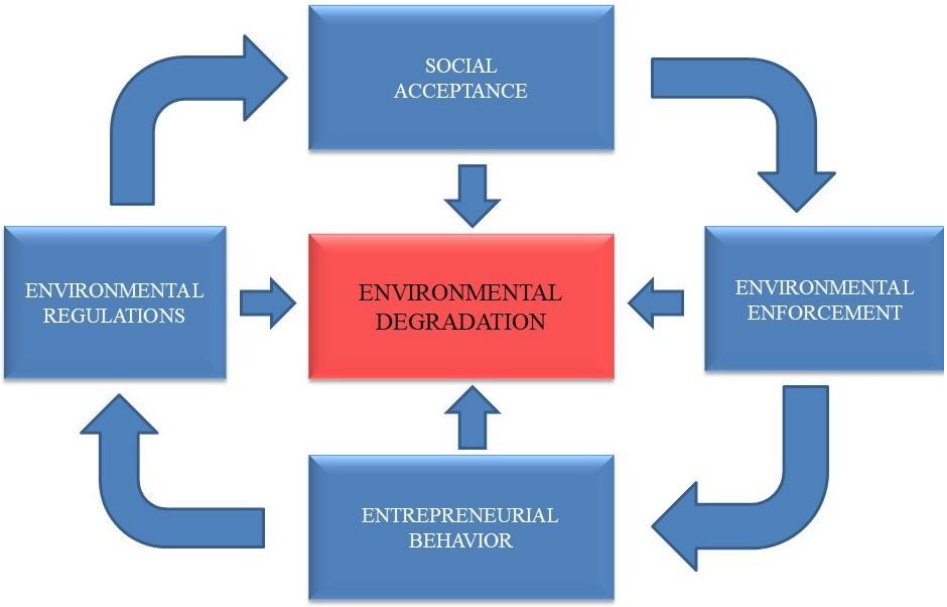


Exhibit 2.4 Environmental damage – factors affecting it

Environmental regulations

Environmental laws are necessary means for regulating human behavior. If no quotas existed for fishing cods in the North Sea the stock would have been depleted decades ago. If no regulations banned the use of CFC gases, they would still be part of the cooling systems of refrigerators and if no environmental laws existed concerning dumping chemical wastes into the sea this would still be a part of ongoing industrial operations. Laws prohibit such acts to take place in pursuance of the common good. Instruments are many – market mechanisms, bans, fines, permits etc. making certain activities illegal that prohibits environmental protection. The adequacy of environmental laws is determined by the level of measures needed to accomplish the objectives formed in a given society.

Besides national laws levels of environmental protection are regulated via international laws, conventions and treaties drawn up by international organizations such as CITES, WWF, UN etc., They are of utmost importance and reflect an international willingness to mitigate environmental degradation. Such international instruments are aimed at transboundary environmental problems. If elephant tusk weren't sold in Chinese markets and if an endangered wood species like Brazilian rosewood were not transported around the globe national measures would suffice. This is not the case, and we therefore need strong international instruments to combat such transboundary issues.

Social acceptance of environmental regulation

It's important that society at large supports the objectives and methods used within the environmental regulatory framework. Sometimes you will find that this is the cause of conflicting interests between agriculture, industry and service providers on the one hand and the public and environmental authorities on the other hand. This does not necessarily have to be so. Industrial organizations in Denmark have actually seen environmental regulations as a means for improving entrepreneurship and increasing efficiency and effectiveness within industrial operations. So, the conflict might not be as severe as some tend to suggest. The growing environmental awareness that the climate crisis has spurred during the last decade is another issue that will increase social acceptance of environmental measures taken by the government. Though social acceptance might be present it will nevertheless not deter some people from behaving contrary to environmental objectives if environmental regulations are not enforced.

Enforcement of environmental regulations

If environmental regulation is not enforced, it just becomes a piece of paper and hence something that some will bypass. If this is accepted by society environmental degradation is bound to occur. If society demand that laws are enforced this will mitigate environmental degradation. We've seen countries with excellent environmental objectives and measures to implement these nevertheless being exposed to this "environmental fraud" by not enforcing such objectives and measures. It then just becomes a bureaucratic waste basket. So, if the environmental regulatory framework is to have a chance it must be followed up by enforcements measures that are strict and meaningful. Otherwise, human nature will overrule such regulations and pursue economic profits and jumping fences to the detriments of the environment.

Entrepreneurial behavior

In a recent case involving aquaculture in the inner straits of Denmark an owner of a facility situated near Hjarnoe in the fjord of Horsens – or rather his wife who is the formal owner - had an environmental license to discharge 145 tons of nitrogen and 16,5 tons of phosphorous into the sea during 2013 - 2018. In fact, he discharged more than 500 tons of nitrogen and almost 50 tons of phosphorous into the inner straits. In order to lessen the environmental impact, the owner was furthermore required to establish a "mussel farm" (smart farm) that was intended to filtrate seawater according to the environmental permit obtained. This did not happen. According to a report submitted to the environmental authorities he claimed to have submerged 70.030 kg fish into the nets. However, it was documented that he actually put 418.435 kg fish into these nets. Furthermore, he bred tons of silver salmon (coho) that he hadn't any permits for. He is now charged and faces 6 years in prison and a confiscation of 191.574.671 DKK (more than 25,5 million Euros) considered to be his economic profit by this criminal behavior.

The example above demonstrates that if regulations are just regarded as a means for occupying people in public offices, if environmental enforcement is lacking and nobody cares you will find people who are willing to go to extreme lengths to circumvent the system in order to create economic profit for themselves. So entrepreneurial behavior becomes an important part of environmental issues and degrading the environment can become an option they will exploit.

However, the way corporations normally confront the environmental agenda is to do so by *lobbying*. That's why the German car industry will be a key player when forming environmental protection measures in EU/Germany. That is why the American oil and gas industry will impact US environmental regulations. That is why the Danish agroindustry will be vital in discussions when drafting environmental regulations in Denmark. Millions upon millions are spend performing lobbying activities throughout the world. The unfortunate way of doing this is when such lobby organizations decide to sponsor political leaders. Some politicians will find it hard to reject substantial economic endorsements unfortunately. Money is power. To say otherwise would be naïve.

Measuring environmental degradation - examples

In order to for us to secure that measurement of environmental degradation takes place we must have standardized and accepted measurement methods. The US EPA develops such methods that are to be used when analyzing samples e.g. *"Method 546: Determination of Total Microcystins and Nodularins in Drinking Water and Ambient Water by Adda Enzyme-Linked Immunosorbent Assay. EPA August 2016"*. This standard includes concepts, methods, procedures etc. in order to investigate the number of certain microbes contained in drinking water and ambient water. It's just an example of the accepted way of institutionalizing measurement methods and the idea of having world-wide accepted standards and concepts in the area of environmental degradation are crucial to implement credible measures.
In order to conclude about such tests, we must also know about the *level* of damage. Which levels are considered non-harmful, and which are not? This can create a debate in the scientific community but within the EU there is one principle attached to such assessments – *the precautionary principle*. This principle is important because it requires that if there is any risk of contamination the threshold level should be fixed so conservatively that any human health risks are avoided. It goes without saying that this will most often involve political interference or lobbyism.

This standardization is also crucial when we perform life cycle assessments of products and services. The following Exhibit 2.5 can illustrate some of the main issues associated with environmental degradation. The causes are to be found in activities human beings undertake. *Causes* indicated in Exhibit 2.5 are a mixture of processes and elements that can harm the environment. When e.g., SO_2 is emitted into the atmosphere this can cause a reaction here that later will find its way to lakes and streams by rainfalls (*damage categories*). This can cause a lake to

become acidic killing all aquatic life (*ecosystem quality*) etc. Some damage categories will affect one or more objects in the ecosystem, human beings included. Human health e.g., can be affected by a number of environmental damages of which only the most basic are indicated in Exhibit 2.5.

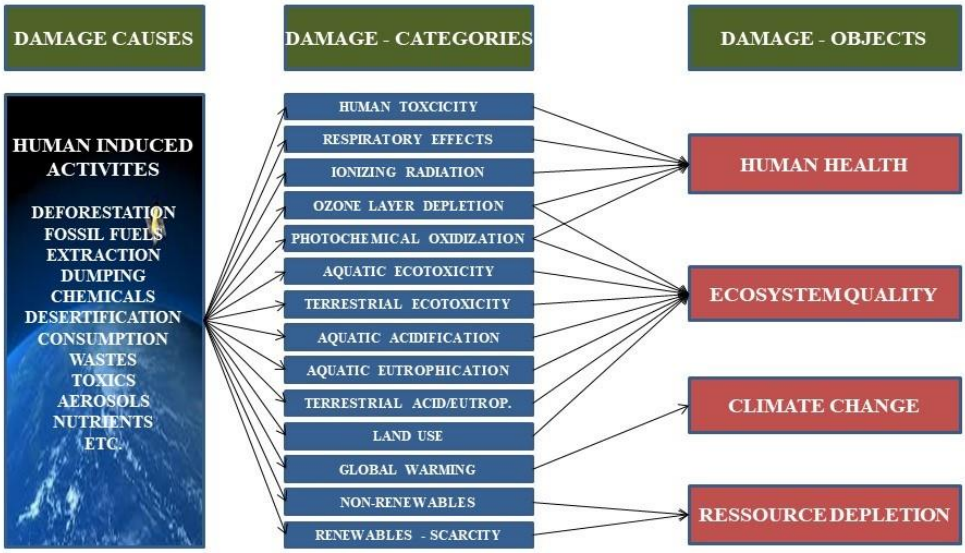


Exhibit 2.5 Causes, categories and objects – environmental degradation

Measuring environmental degradation or damage can also be viewed as a problem concerned with measuring a decline in the beauty of a landscape, a site or a view. If looking at a painting, is it then possible to objectively assess the quality of such a painting? The same question could be asked if we were to assess the beauty of a landscape, scenery or a natural wonder. Is it possible to attach any objective attributes to a landscape? Some will say that money – either market prices or costs – are true determinants of the quality of such a landscape. Others would say no. A paintings worth – or a natural wonder - is only possible to assess in the eyes of the beholder some would argue. Others might not agree with that.

When Henry Hudson in 1609 looked on Manhattan or Mannahatta as the Indians called it ("the island of many hills") his eyes would have caught a landscape full of trees, small lakes, a rich wild-life, salt marches etc. Nowadays, instead we see the squirrels in Central Park – both are ecosystems but very different from one another. The original landscape was *natural (unmanaged)* the present is *man-made (managed).*

This tells us that it's we – human beings – that are the main drivers for environmental degradation. Animals, however, can also act as drivers of changes to

the ecosystem but we don't describe such changes as "environmental degradation", so environmental degradation is strictly tied to human beings' objectives and actions.

In order for us to describe and measure what environmental degradation is about we have developed sets of concepts, tools and procedures that will let us know about this. Such methodologies have been developed within all areas of the ecosystem – water, soil, biodiversity etc. in order to measure harmful contents, noise, poisons, changes in the landscape and so on.

We will define environmental degradation as occurring when the natural environment is altered by way of human interaction with the purpose of meeting social - including economic - objectives. Please note that this says nothing about good or bad, right or wrong but just that an alteration has taken place due to human interference. More formally the UN has defined environmental degradation in the following way: [1]

"the reduction of the capacity of the environment
to meet social and ecological objectives, and needs"

We will look at a couple of examples below in order to show how environmental degradation is defined and measured to give an idea of what we're talking about. Degradation involves the perceived quality of a natural site, habitat or an ecosystem, species reduction or extinction, polluting waterways, emitting harmful substances into the air etc. So, the following will contain examples of how we measure environmental damage when we talk about ozone depletion, acidification, eutrophication etc.

It's clear that such measurements are anthropogenic. They are formed according to scientific evidence of levels of harmful influence on human beings. This is done according to mortalities by exposure, safety issues and other and such measurements constitutes a change that is unwanted by us. Limiting the amount of nitrogen and phosphorous is bad news for the bacteria thriving on these substances and good news for people who want a clear water lake to bathe in. However, the key issue here is *change*. Nature doesn't evaluate change it just adapts. Human beings are the ones that put an assessment to change thereby qualifying it.

[1] *"ISDR : Terminology". The International Strategy for Disaster Reduction. 2004-03-31*

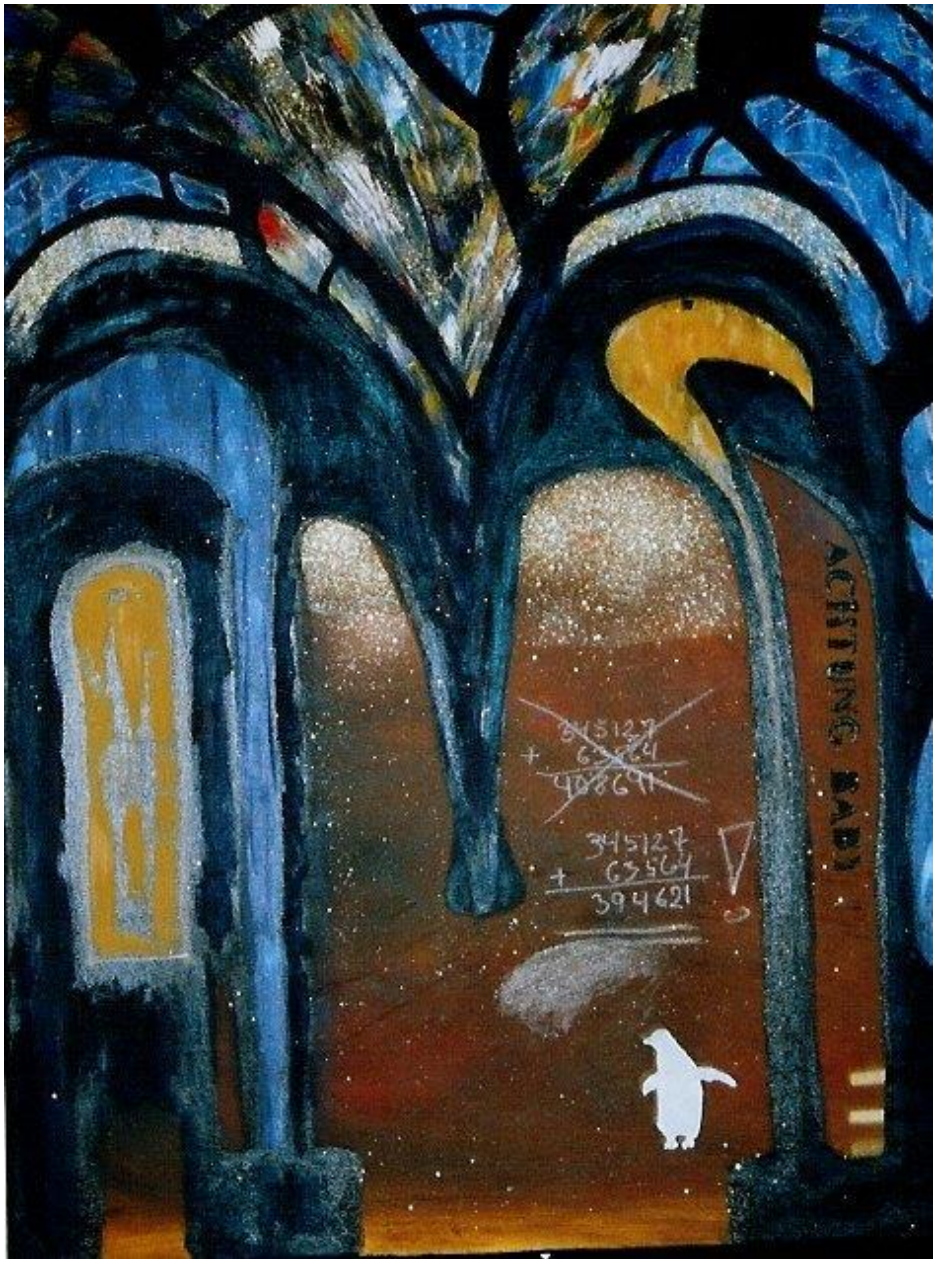


Exhibit 2.6 Is it possible objectively to assess the quality of a painting?

Environmental degradation – BOD

Looking at the *hydrosphere* an indicator of environmental health would be to calculate the *BOD (Biological/biochemical Oxygen Demand).* The BOD is defined as:

$$BOD = \frac{IDO - FDO}{VS/VB}$$

with

BOD = Biochemical Oxygen Demand (mg/liter)
IDO = Initial D.O. (Dissolved Oxygen) of diluted sample (mg/liter)
FDO = Final D.O. of diluted sample (mg/liter)
VS = Volume of sample (ml)
VB = Volume of bottle (ml)

SAMPLE NAME	BOTTLE #	SAMPLE VOLUME (ml)	INITIAL DO (mg/l)	FINAL DO (mg/l)	DIL. %	0_2 DEPL. (mg/l)	BOD (mg/l)	FINAL BOD (mg/l)
Influent	10	6,00	8,60	5,20	2,00	3,40	170,00	147,17
	11	8,00	8,70	4,90	2,67	3,80	142,50	
	12	10.00	8,80	4,50	3,33	4,30	129,00	

Exhibit 2.7 Calculating BOD
Source: HAC WIMS, http://www.opssys.com

The BOD is a measure of the load of microorganisms' or rather organic matter in wastewater, rivers, lakes etc. and measures this load by looking at have much such organic matter will use of the oxygen contained in a water sample when it's left for the microorganisms to incubate during a 5-day period. After that most of the organic matter will have been degraded. That's why it's often referred to as BOD_5. The sample is then analyzed before and after the incubation period by 20^0 Celsius in order to determine BOD. The higher the BOD the more it demands of oxygen to perform the bacterial processes. Several ways exist for testing for BOD of which we will refrain from going any deeper.

Besides the BOD several other tests are used to determine water quality; suspended particles, acidity, algae, toxins etc.

Toxicity

Toxicity refers to a dose of a substance that will affect an organism or an ecosystem in a harmful way. Toxicity is normally divided into *chemical substances* e.g. heavy metals, radioactive materials etc. that can cause genetic problems, birth defects etc., *pathogens (*microorganism and parasites) that can cause toxic reactions by inflicting various diseases like destroying cells metabolism, suffocate fish life etc. and *physical toxicants* e.g. coal dust, exhaust particles that can cause for example respiratory problems and cancer. One measure often used is that of LD_{50} (LD = Lethal Dose). LD_{50} can be inflicted by e.g., swallowing (*inhalation LD*), by injections (*dermal LD*) or by penetrating airways (*oral LD*). In an LD_{50} experiment you will test the toxic contents by observing when 50% of a sample's species have died after having been exposed to the toxic one time. The lower the amount the deadlier it is. Other uses of this principle can also be found e.g., the EC_{50} that can measure the potency of a drug with EC_{50} being the point on the curve where an effect will be experienced. Take for instance alcohol. This will normally be measured in o/oo. If the alcohol content in your blood is above 4 o/oo things look pretty grim.

- 0,2 – 0,5 o/oo: You feel slightly aroused
- 0,5 – 0,7 o/oo: Dampens anxiety. You become more uncritically and risk taking
- 0,8 – 1,4 o/oo: Loss of inhibitions, tiredness and dullness.
- 1,5 – 2,9 o/oo: Big problems controlling balance and movement
- 3.0 – 3,9 o/oo: Approaching unconsciousness, coma
- 4,00 o/oo : Deadly dose (risk of dying = 50%)

Sometimes you will also employ testing of *cumulative* toxic effects. Here you will inflict animals with smaller doses several times and observe when 50% of the animals have died. The measure can be determined as LD_{50n}/LD_{50} with n = the total amount of doses given before 50% of the animals have died. When testing toxicity on humans the LD_{50} this is of course not a feasible solution. Instead, *placebo tests* are often undertaken. Here you administer the drugs to be tested so that 50% of a human sample population gets the drug while the other 50% gets a harmless substance usually lime tablets. You can then see if there are any significant differences in responding to the drug in question between the two groups.

Contamination

Closely related to toxicity is that of *contamination* of resources. This may take place in the *atmosphere* (radiation, gases, particles etc.), the *lithosphere* (agrochemicals, GMO's, viruses etc.) or the *hydrosphere* (heavy metals, nutrients, oil products etc.). One important issue concerning contamination is that of exposure to radioactive materials. Radiation is measured by its *Becquerel* or *Bq*. It measures the activity of quantity of a radioactive material decaying by 1 nucleus per second or:

$$Bq = S^{-1}$$

with:

S^{-1} = number of disintegrations per second

When calculating the amount of radioactivity measured in Bq the following formula is applicable (see Wikimedia for this example):

$$A_{Bq} = n \times N_A \frac{\ln 2}{t_{1/2}}$$

with:

A_{Bq} = radioactivity measured in Bq
$N_A = 6{,}022 \times 10^{23}\ mol^{-1}$ (Avogadro constant)
n = number of moles
$t_{1/2}$ = half-life of a resource in S
ln 2= the natural logarithm of 2 (= 0,693)

So, if e.g., 1 gram of potassium contains 0,000117 gram of a radioactive isotope with an atomic mass of 39,964 g/mol and a $t_{1/2}$ of $4{,}030 \times 10^6$ s then you can calculate radioactivity by: [2]

$$30\ Bq = 0{,}000117 \times 39{,}964 \times 6{,}022 \times 10^{23} \times \frac{0{,}693}{4{,}030 \times 10^{16} s}$$

When measuring the concentration of a potentially harmful substance several ways are used to classify a pollutant's harmful concentration level:

- *No effect concentration* (NEC),
- *No observed effect concentration* (NOEC),
- *No-observed-adverse-effect level* (NOAEL)
- *Lowest-observed-adverse-effect level* (LOAEL)
- *Acceptable operator exposure Level* (AOEL)
- *ECx (in percent)*

[2] See Wikimedia for this

Radioactivity can also be measured by e.g., *rad* (*r*adiation *a*bsorbed *d*ose) and the standard for this is measured in Gray (Gy) with 1 Gy = 100 rad. It can also be measured in Sieverts or millisieverts (mSv) that is a measure of health risks associated with radiation. On average a person is exposed to 2 – 4 mSv/year or approx. 0,002 – 0,0045 mSv/hour. If radiation goes beyond 1 mSv it is considered dangerous. A measure called *rem* (*r*oentgen *e*quivalent *m*an) are also employed instead of Sieverts with rem = rad x Q where Q is a measure of the radioactive potency of a substance.

Loss of biodiversity

When measuring biodiversity this often involve collecting samples from which you then infer about total biodiversity. If being in a forest and looking at insects that live at the bottom of the forest you could e.g., mark a spot of 100 x 100 meters (10000 m^2) and count the types and number of insects. If looking at the birds in a specific area you could count the birds flying over, feeding or nesting in that area. If looking at a marine environment, you might count the fishes caught in a specific area. One of the problems is that animals often are migratory so a precondition for such measurements is that you understand the lifecycle, interactions and habitats of such animals.

A loss of a species in a specific habitat could be permanent or temporary. So, in order to establish that a loss in biodiversity has in fact taken place you must be able to have a time frame often involving several years, decades or even centuries. You can then make a list of the species and estimate the number of *endangered, threatened, vulnerable* etc. by defining these groups most often by their numbers now and before. This is what the so-called CITES list do. The loss can also be calculated as the mass measured in kg, tons, mega-tons etc. e.g., if estimating the loss of insects during a specific period. Genetic variability can also constitute a loss of biodiversity. As an example, due to rising temperatures the number of females versus male sea turtles has risen since gender is dependent on temperatures when eggs are being hatched. This constitutes a serious threat to the survival of that species.

A "*biodiversity intactness index"* has also been suggested. It works like this. "*It draws on expert knowledge about how human activities increase or decrease the total populations of groups of ecologically similar species — such as insect-eating birds or large herbivorous mammals. Using a simple equation, the index gives a measure of how close populations of each of these 'functional groups' are to those in pre-industrial times. The researchers tested their index by looking at seven countries in southern Africa. They asked experts on plants, mammals, birds, reptiles and amphibians about how different degrees of human impact, including agriculture and urbanization, affected groups of similar species in six types of habitats. The researchers used existing data sources to assess how much of the study area each of these habitats occupies and the patterns of land use in each.*

Overall, their index suggests that by 2000, populations of the plants and animals assessed had declined, on average, to 84 per cent of their pre-industrial levels." [3]

Exhibit 2.8 Biodiversity threats
Source: FAO

[3] See https://www.scidev.net/global/biodiversity/news/measuring-loss-of-biodiversity-the-expert-way.html or *Nature* 434, 45 (2004)

Degrading the climate - climate change

Often climate change is considered synonymous with the atmospheric contents of CO_2. However, in order to recognize the different potencies of various substances for causing global warming we will have to turn these into a common denominator. We call this *CO_2 equivalents* or *$CO_{2\text{-}e}$.* We use CO_2 being the reference value by which we arrange other harmful global warming potential sources in order to be able to get a better picture of what's happening in the atmosphere. We list such substances by their *Global Warming Potential (GWP*). Methane as an example has a GWP of 34 meaning that if 1 tons of methane is emitted into the atmosphere this corresponds to emitting 34 tons of CO_2.

Radiative forcing

Another way of determining global warming mechanisms is done by looking at the *radiative forcing*. Radiative forcing is the difference between insolation (sunlight) absorbed by the Earth and the energy radiated back into space. The five most widespread greenhouse gases (CO_2, CH_4, N_2O, CFC-12, CFC-11) account for approx. 96% of this radiative forcing. IPCC defines radiative forcing as:

… a measure of the influence a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system and is an index of the importance of the factor as a potential climate change mechanism. In this report radiative forcing values are for changes relative to preindustrial conditions defined at 1750 and are expressed in Watts per square meter (W/m^2)."

When heat (radiation) is trapped in the earth's atmosphere and less heat is radiated back into space temperatures will rise and global warming occurs. The reason why heat is trapped is due to more heat being absorbed by the earth e.g., by the melting of glaziers since these radiate more light back into space (so-called Albedo factor) and because the composition of the atmosphere where greenhouse gases are increased makes it more difficult for heat to be reflected back into space. Greenhouse gas molecules simply trap the heat that otherwise would be reflected. Other molecules in the air like nitrogen and oxygen do not have that heat trapping mechanism attached. In that way such greenhouse gases function like the glasses of a greenhouse.

In Exhibit 2.9 below is an indication of the proportions attributed to the mechanism described above. Due to the chemical composition of the atmosphere 29% of incoming solar light will be reflected back into space when hitting the atmosphere while 23% will be absorbed. The majority of incoming solar light will be absorbed by the earth's surface – mountains, trees, plants etc. The amount absorbed is critically dependent on the attributes of the surface. Ice, snow and glaziers will be much better to reflect sunlight than oceans lakes and rivers.

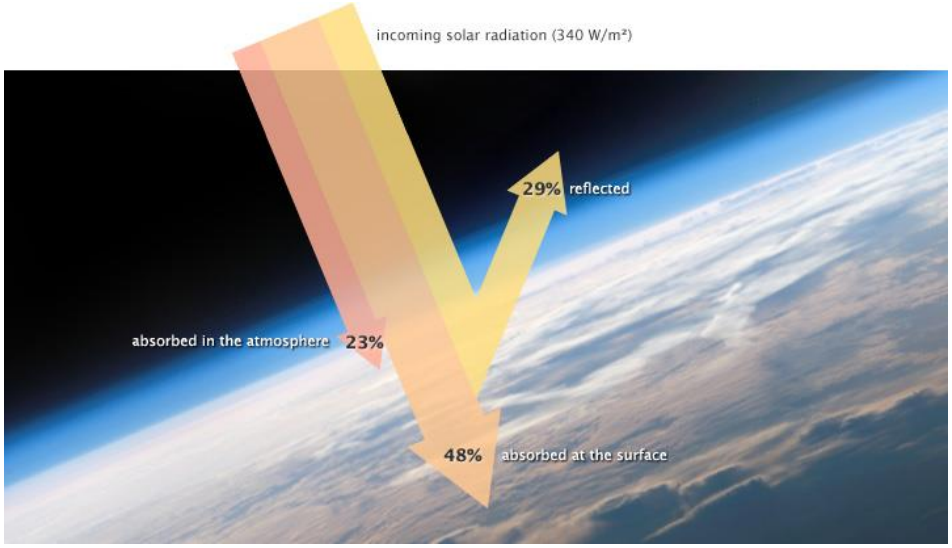


Exhibit 2.9 Incoming solar radiation
Source: NASA

For pure CO_2 the radiative forcing is determined by:

$$RF = \alpha \ln(C/C_0)$$

with

RF = radiative forcing
ln = natural logarithm
$\alpha = 5{,}35$ (constant)
C_0 = preindustrial concentration by 1730 of CO_2 in parts per million (= 280 ppm)
C = present concentration of CO_2 in the atmosphere measured in ppm.

In order to show an example of radiative forcing the IPCC has provided for this. In IPCC's 5th report total anthropogenic RF is documented by the following table shown in Exhibit 2.10. It shows the emissions of various gases (well-mixed greenhouse gases and short-lived gases and aerosols) into the atmosphere and the resulting drivers of radiative forcing. These drivers of climate change can result in the earth getting warmer (positive indication) or the earth getting cooler (negative indication). As can be seen from the last part of this Exhibit 1950, 1980 and 2011 have seen the earth warming up relative to its base year 1750. These measurements are qualified by medium (1950) to high (1980, 2011) levels of confidence.

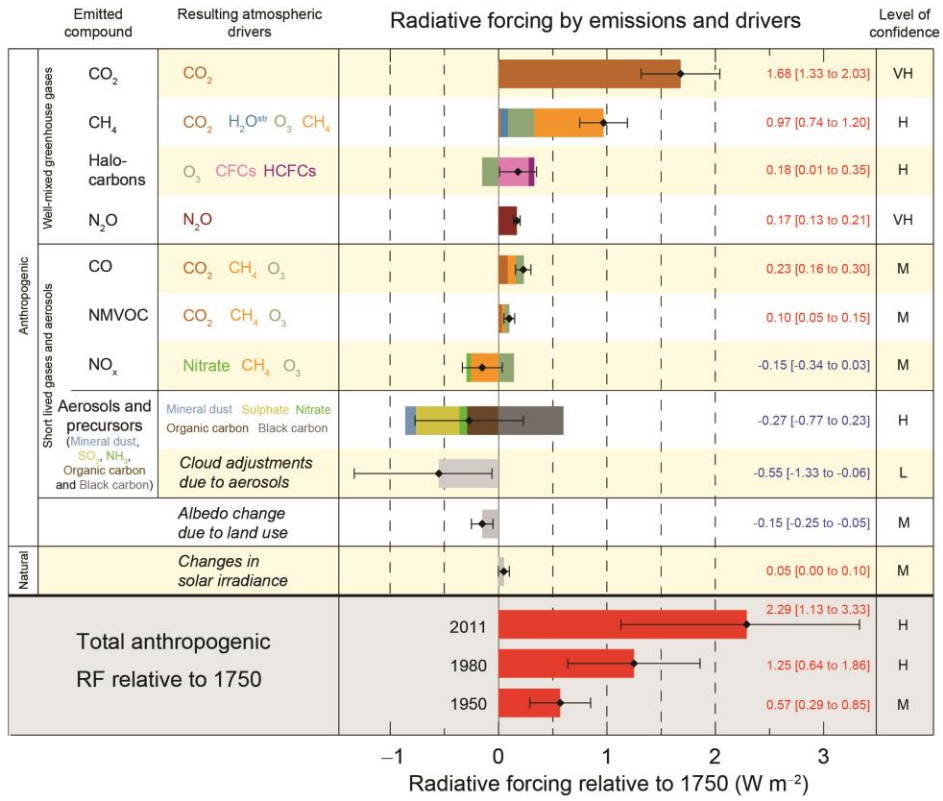


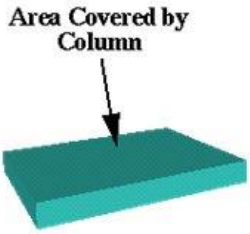
Exhibit 2.10 Radiative forcing relative to 1750 measured in W/m²
Source: IPCC, by Femke Nijssen and Eric Fisk

Ozone depletion

Discussions about depleting the ozone layer that protect the earth from harmful radiation from space were particularly intense a decade ago. Scientists had discovered large areas of the ozone layer that was more or less split wide open allowing more radiation to occur. This gave rise to concerns. Now the issue seems to have stabilized somewhat. The use of CFC and HCFC gases were thought to have caused the problem. The basic unit for characterizing ozone depletion is the so-called *Dobson Unit (DU)*. A Dobson Unit of 1 corresponds to 2,69 x 10^{20} ozone molecules per square meter. The unit for calculating the *effects* of substances affecting the ozone layer is measured in *ODP* or *Ozone Depleting Potential* with ODP defined as:

$$ODP = \frac{Calculated\ global\ O3\ depletion\ by\ gas(i)}{Calculated\ global\ O3\ depletion\ by\ CFC11}$$

Taking CFC-11 as a base it has an ODP of 1. Halon 1211, however, has an ODP of 7,9 and Halon 1301 one of 15,9 making them more damaging to the ozone layer than CFC-11. This way of indexing we can make up for e.g., the differences in the time by which the substances will remain in the atmosphere. CFC-11 takes 45 years to disappear while e.g., CFC-13 will stay in the atmosphere for 1.020 years. So, if the chemical components etc. were the same CFC-13 would be almost 23 times as bad as the CFC-11.



All the Ozone over a certain area is compressed to 0^o and 1 atm pressure.

The slab seen above is e.g., 3 mm thick corresponding to 300 Dobson Units (DU)

Exhibit 2.11 Dobson Unit (DU)

In its most basic form, the chain reaction going on when e.g. HFC gases or other are reaching the stratosphere are shown in Exhibit 2.12 below. Incoming ultraviolet light will impact the HCF molecule, and a chlorine atom will be separated. This chlorine in turn will affect the atmospheric content of ozone by splitting the ozone molecule into two components – oxygen and chloride monoxide. Free atomic oxygen will then separate the chloride monoxide molecule into oxygen and chloride and the process can start all over again with chloride splitting new ozone molecules and thinning the layer of ozone.

Protection of thinning the ozone layer is of importance if we want to avoid harmful effects on plants and human beings. If the ozone layer is too thin it will not protect biotic life against the incoming solar light and it can cause cancer and altered genetic composition of crops and other plants.

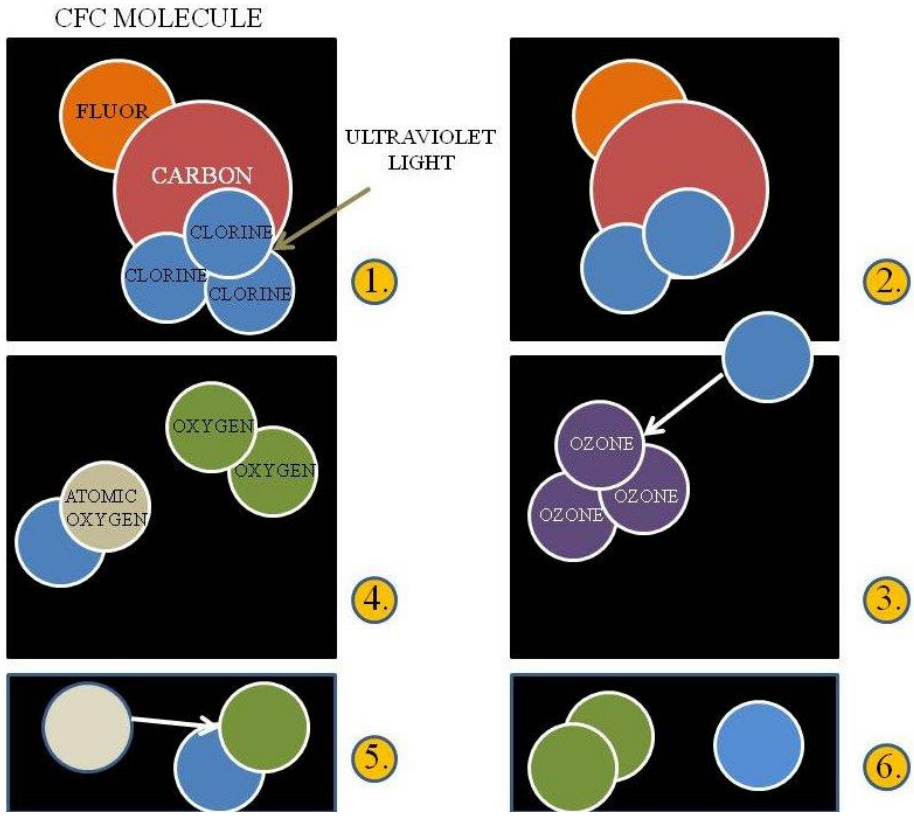


Exhibit 2.12 The ozone depleting process…

Noise

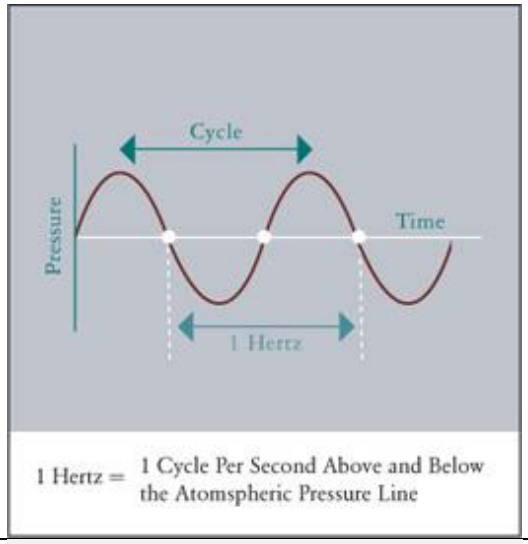
Sound is measured by *Herz (Hz)* where 1 Hz marks the *frequency* of a cycle per second – see Exhibit 2.15 below while *decibel* is a measurement of the strength of the frequencies that we can *hear*. But when does sound become a noise? Well from a purely physical viewpoint sound and noise are equivalent. It's only when the ear picks up sound that it might turn into noise – an unpleasant, loud or disruptive frequency that make our brain react in a negative way. So, the way forward in defining noise is given by the number of decibels. Noise can be a big problem e.g., with windmills since the turning of the wings will cause a noticeable sound to be heard. It can pose problems when working in a noisy environment e.g., in an airport or being exposed to traffic noise etc. That is why authorities will issue guidelines and ensure that sound levels are within certain limits before issuing environmental permits to a corporation. In order to determine sound levels these will be measured at several time intervals. Often there will be differences in the noise level permitted when speaking of the time period involved. Is it noise experienced in daytime or at night? What is the distance between the sound source and those exposed to the noise? Are noise levels constant or changed during the day? Is it temporary or

permanent? As an example, sound levels – thresholds - listed below are currently in effect in Denmark:

Area	Noise levels (Db)
Industrial areas	70 Db
Public places	40-35 Db
Windmills	44 – 39 Db
Airports	55 – 60 Db

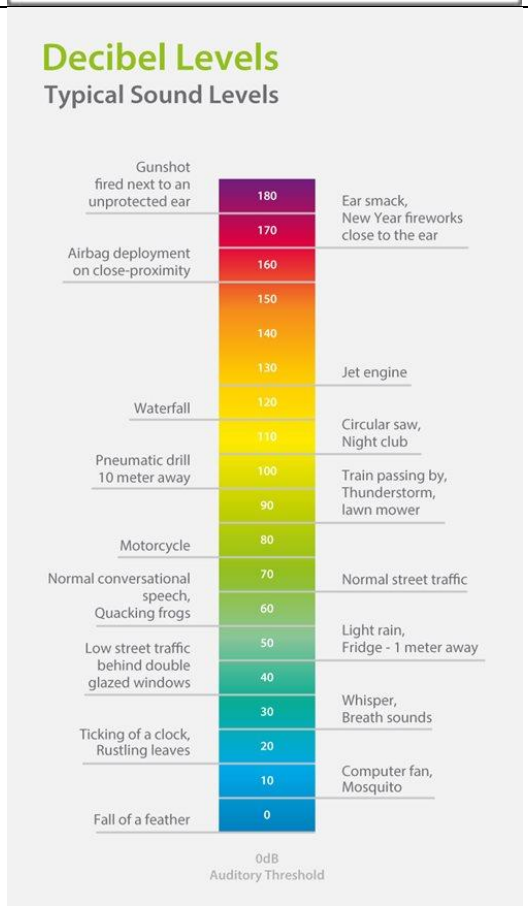
Exhibit 2.13 Noise levels permitted in Denmark

Exhibit 2.14 Whales communicate by sound



HERTZ

Herz is a very useful concept when making music, when measuring noise levels, when a warning signal is to be issued etc. Sound is also vital for animals to communicate by varying the loudness of their voices and screams and by communicating about prey in our oceans like our whales do.



DECIBEL (dB)

The name “deci-bel” actually were conceptualized in honor of the inventor of the telephone Alexander Graham Bell. *Deci* stands for 10 and *bel* for the surname Bell – decibel. It was accepted as a standard in 1928.

It’s a relative indication of the level of sound of 50 db being higher than that of 40 db.

Exhibit 2.15 Hertz and decibel

Degrading resources - resource depletion

The earth is principally and practically a place with limited resources. We define some of these limited resources as *non-renewable* (oil, gas, minerals etc.) and some as *renewable* (forests, crops, water etc.). However, the amount of both resources can be hard to determine. New deposits are found, vast areas of land are thawing due to climate change that will open up new areas for exploitation, new technology makes previously inaccessible resources viable, scientific research makes it possible to substitute materials etc. Furthermore, this distinction will often have a local orientation so though crops in principle are renewable desertification can mean that it in principle as well as for all practical purposes are gone locally.

No matter what, the earth's resources are almost all finites. Some of these can be exploited – re-harvested - within short time frames and others will ultimately run dry within 100, 200 or 300 hundred years from now. Environmental damage in most cases concerning resource depletion must be considered an *intergenerational problem*. What we do now will affect our children and grandchildren's possibilities for creating their own future. The non-renewable resources we extract today will not be available to them in the future. This requires us to take a *long-term perspective* of the decisions we make today. Typically, this long-term perspective is measured in decades mostly two or three. However, this time frame must be regarded as a very narrow reference to the time span necessary to consider. So instead, we must regard 100 - 500 years as the short term, 500 – 1.000 year as medium term and above as the long-term perspective. This idea is not unknown to people working in forestry.

Obviously handling this time frame cannot be backed by data. It therefore becomes much more essential to operate with visions and values in order to form directions that pertain to this kind of time frame. If doing that it becomes clear that the only solution for creating the amount of future energy supplies needed, will be that of renewable sources. Existing and potential non-renewable sources will be depleted long before that and even a time frame of 1.000 years will just be a blink of the eye in human history.

One key indicator of resource depletion would be to have the worlds known reserves of a specific resource acting as the denominator and actual consumption of it as the numerator multiplied by hundred to get a percentage. According to the U.S EIA (US Energy Information Administration) the world's oil reserves amounted to 1.779.685 million barrels by the beginning of 2017. OPEC valued the oil reserves at 1.535.773 million barrels by the end of 2017. In 2016 the worlds annual production of oil amounted to 29.427 million barrels per year corresponding to 1,6% of known oil reserves. Venezuela's oil reserves could possibly last 360 years from now with known reserves and production and the UK's oil reserves are about to run dry within the next 10 years.

Despite new methods of extracting, new deposits found, changes in product features etc. we're still left with a resource with a finite life that will run dry in about 60-100 years from now. So, a measure of a non-renewable resource would be to consider:

1) $$\frac{\text{Yearly avg. consumption}}{\text{Known reserves}} \times 100 = \text{consumption in \%}$$

and

2) $$\frac{\text{Known reserves}}{\text{Yearly avg. consumption}} = \text{years before exhaustion}$$

The first equation will give you the yearly consumption of a non-renewable resource in percent (static) while the other equation measures years left to use this resource.

One key problem of resource depletion is that of human induced depletion or *"planned obsolescence*". It might have had a potential for creating jobs during the great depression in the 1930s, but it has increasingly revealed serious drawbacks when talking about environmental issues.

As an example, some printers have contained a pre-programmed failure date if using 3rd party ink cartridges. This is the mild version of resource depletion. It originates due to the fact that a company does not make money on its printers but of its ink cartridges. The durability issue is also a part of this planned obsolescence. When e.g., the Japanese entered the American market with more durable cars the American motor industry had to respond. Instead of furthering the idea of changing your car with short intervals they were forced to adapt to the durability issue. This goes on to the idea of "fashion" where literally billions upon billions of kg of clothes, shoes, watches, hats - you name it - goes into the drain to accommodate trends within the fashion industry and its subscribers due to cultural traits. If you consider that is takes 10 times the water consumption to make a black T-shirt instead of a white T-shirt you will have an indication of the problem.

The reasons these issues emerge are all due to the fact that clashes between profits and the environment becomes insolvable. The fashion industry dictates environmental depletion on a big scale. *Product development* and *design* are at the center of attention when dealing with planned obsolescence. The sustainable customer's response to this has been to go 2nd hand shopping instead of buying new stuff. This trend is still on the rise and will be more so in the future.

2.3 THE EARTH

The Earth is a unique planet as far as we know. It's part of our galaxy called *"The Milky Way"*. Billions of other galaxies are out there with billions of stars included in these galaxies. The Milky Way was formed around 4,5 billion years ago after the *"Big Bang"* occurring some 9,2 billion years before. Just after – actually just 10^{-32} after the "bang" – the universe started to expand and it's expanding ever faster. Eventually big skies of gas and matter began to collect, and our solar system emerged being comprised of 4 solid planets (Mercury, Venus, Earth and Mars) and 4 gas planets (Jupiter, Saturn, Uranus and Neptune) with a belt of asteroids between the two systems all circling around the sun being hold together by gravitational forces. So, the age of our universe is about 13,7 billion years old. Before the "bang", it is suggested that the world just consisted of energy containing no matter. Matter then emerged in the core of stars after the bang had occurred. At one time – approx. 5 billion years from now - the sun will run out of fuel and end up as red giant but long before that, conditions of life will have been eroded due to excessive heat and possibly due to merging with another galaxy – the Andromeda. However, long before that all traces of the universe probably will be gone due to power of expansion – the stars of the night sky will disappear. We're just here for a while.

A lot of speculations have been fostered about both the beginning, composure and end of things – black holes, multi-verses, dark matter etc., - but we will leave at that and just point to two opposite positions. "Well, what the heck if it's going down why bother about Mother Earth?" and "If the Earth is going down, we have to take care of it as long as it lasts." You will probably find out that we subscribe to the latter.

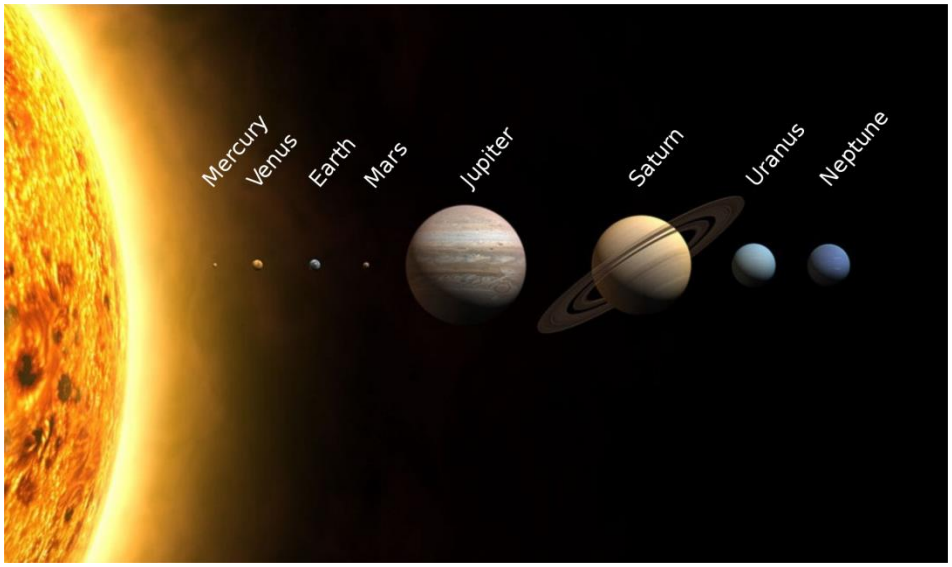


Exhibit 2.16 Planets in our solar system – distances not scaled

There are, however, some initial points we would like to make that relates to the formation of the Earth that impacts the natural environment.

1) The core of the earth is comprised of solid iron. This fact was first suggested in an article from 1936 by Danish seismologist Inge Lehmann and magnetic fields are placed into space where it will form magnetic fields around the earth.

2) All matter originally stems from the "big bang" billions of years ago – iron, copper, diamonds, gold, salt etc.

3) The Earth only holds finite resources and is itself a finite system

The Earths systems can be seen as a well-balanced total system, a chaotic system or a black-box system. No matter how you look upon it you will most often be stunned when thinking about the complex systems that comprise it and the variety it exhibits. Such systems interact and dependencies are a huge part of how such systems work. So let us try to look at the major elements that comprise the earth's spheres and some of the building blocks that make it work.

IMPORTANT BUILDING BLOCKS OF THE EARTH'S SPHERES

There are some fundamentals processes and elements that constitute what nature *is* – its *biotic* and *abiotic* elements split into a man-made environment and a natural environment. *Biotic* life constitutes human beings, animals and plants that are being comprised of living or dead cell material. *Abiotic* matter consists of non-living matter e.g., chemicals, rocks, minerals etc. that forms part of the environment and relates to the biotic elements in complex patterns. "Life" is considered to have begun approx. 3,8 billion years ago when the first one-celled organisms – bacteria also known as *prokaryote anaerobic microorganisms* - emerged in a watery environment when it is estimated that the atmosphere had no, or only small amounts of oxygen present possibly around so-called underground vents (from so-called *stromatolites*). Our earliest fossil evidence date back to that time, but "life" might have been around before that.

Biotic and abiotic elements will work throughout the system of the atmosphere, the lithosphere and the hydrosphere. They are interconnected and form a complex system of interchanges of energy and matter. Some basic elements that pertain to all spheres like weight, temperature, humidity etc. will not be treated here specifically but rather be directly integrated into the issues represented. So let us have a look at some of the most basic elements of these building blocks that span all 3 (4) spheres keeping in mind that they can be mutually interdependent, give rise to various exchanges and relationships and in general are fundamental to life on earth. Exhibit 2.17 displays some of these important building blocks of the spheres. These issues will pertain to all elements of the Earths spheres – the *atmosphere, the hydrosphere*

the lithosphere and the *biosphere* and they will work in association with biotic as well as abiotic elements. We find molecules in the air, in the soil and in our water.

Thermodynamics and biogeochemical cycles will be at play in all spheres as well. A fish will eat insects and be caught by a fishing eagle (foodchain - biosphere). So, in essence they form first level elements – or building blocks - in a display, change and exchange of environmental cause and effects. So let us have look at the most basic elements of the Earths spheres – please refer to Exhibit 2.17 below.

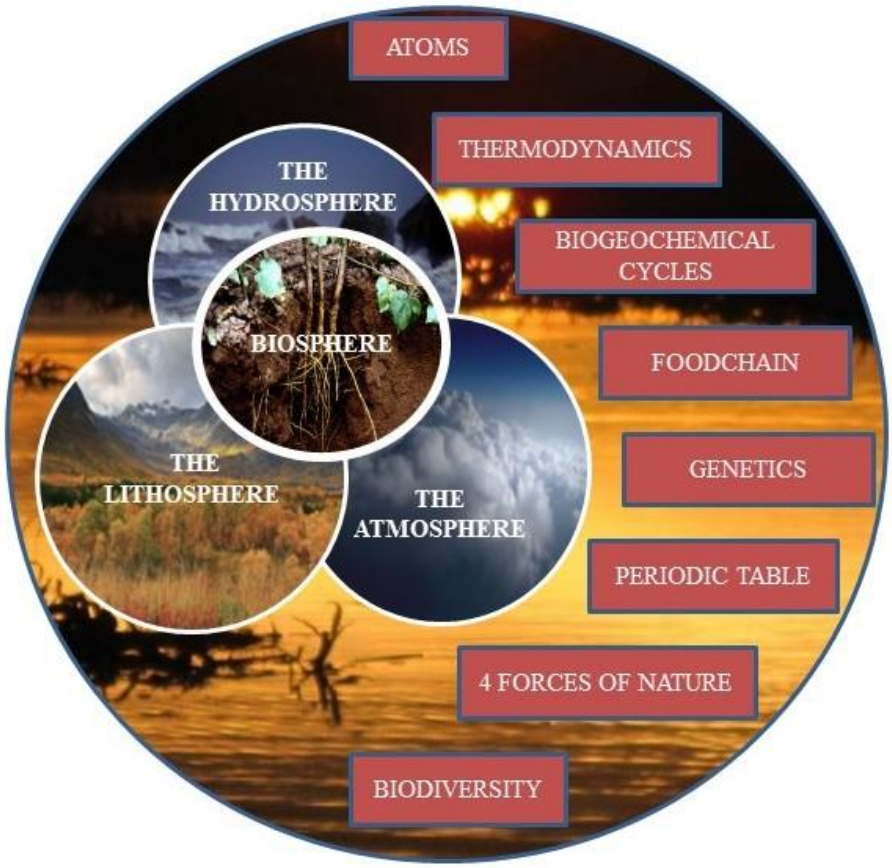


Exhibit 2.17 Important building blocks of the Earths spheres

BASIC BUILDING BLOCKS – ATOMS, MOLECULES AND MOLES

All matter on earth is built up by small pieces - atoms. The word atom in Greek means *indivisible*. It consists of a *core* or *nucleus* and *shells of negatively charged electrons.* The core consists of two elements: positively charged *protons* and neutral *neutrons.* If the number of electrons and protons are equal the atom is said to be

neutral. If an atom consists of fewer or more electrons than protons it is called a *ion*. *Molecules* are comprised of different atoms.

KEYPOINTS – THE ATOM

When describing the atom X two more set of information will be available:
A is the number of nucleons, being the atoms number of protons and neutrons and
Z indicating the number of protons in the nucleus.

Exhibit 2.18 The conventional way of describing the atom

It is furthermore true that:

$$A \text{ (nucleons)} = Z \text{ (protons)} + N \text{ (neutrons)}$$

where N is the number of neutrons in the nucleus.

Inside the atoms core of protons and neutrons an even smaller element is thought to exist –that of *gluons* and inside these gluons strings of energy is at the – currently thought – bottom of it all called *super strings.*

Atoms have a lot of different characteristics one of these being their ability to act as *magnets*. It is the electrons circling the atom core that influences how magnetic a substance is.

Atoms also have a weight called an *atomic weight*. Relative atomic weight is measured as *molar mass* and constitutes the relative atomic masses of all isotopes of a chemical element weighted by their respective abundance on Earth. If looking at copper, we have an isotope ^{63}Cu that counts for 69% of the earth's copper resources (relative atomic weight is 62,929) and another isotope ^{65}Cu that accounts for the remaining 31% of the earth's copper resources (relative atomic weight is 64,927). The dimensionless standard atomic weight of copper then is equal to:

$$0{,}69 \times 62{,}929 + 0{,}31 \times 64{,}927 = 63{,}55$$

An *atomic mass* is the mass of a unified atom. It corresponds to 1/12 of a single carbon-12 atom and an atoms atomic mass is almost entirely due to its protons and neutrons in the nucleus.

Molecules

A molecule is a very small particle structure that consists of two or more atoms with various chemical bonds attached between them. They vary in size and properties. Our DNA is an example of a complex molecule basically consisting of four molecules with specific chemical bonds – *adenine, guanine, thymine* and *cytosine*. Water is another example consisting of a molecule having two hydrogen atoms and one oxygen atom attached. When only one atom exists - like atmospheric oxygen O - we call it *atomic oxygen* to stress its deviation from a molecule like that of oxygen (O_2).

Moles

In explaining what atoms and molecules are, we would also introduce what a *mole* – abbreviated *mol* – actually is. It was first suggested in 1811 by an Italian scientist called Amedeo Avogadro and he defined a mol as a unity that measures:

> *"The amount of substance of a system that contains as many elementary entities (atoms electrons, protons, molecules etc.) as there are atoms in 12 g of carbon-12 having 6 protons and 6 neutrons"*

This led to defining a mol more precisely as:

$6{,}022 \times 10^{23}$ expressed as $6{,}022 \times 10^{23}\ mol^{-1}$ and abbreviated N_A

expressing the number of molecules in a substance also known as *Avogadros number*. If we look at the mass of one mol of a substance it equals that substance's molecular weight. If water's molecular weight is 18,015 amu (atomic mass units) the corresponding mass of one mol of water would be 18,015 grams or:

1 amu = 1 gram.

This means that if we put $6{,}022 \times 10^{23}$ carbon-12 atoms on a scale (equals 602.000.000.000.000.000.000.000 carbon atoms) we would find that they weighed exactly 12 grams. By eliminating carbon-12 and 12 grams we will find

that 1 amu equals 602.000.000.000.000.000.000.000 carbon atoms. This way we have found a common denominator or conversion factor from which to depart. So, if we want to find the mol of water (H_2O) mentioned above we get:

H_2 = 2 x 1,008 g/mol (= 2,016 g/mol) +
O = 1 x 15,999 g/mol →

2 H_2 = 2 x 2,016 g/mol (= 4,032 g/mol)
2 O = 2 x 15,999 g/mol (= 31,998 g/mol) →

2 H_2O = 36,03 g/mol →

1 H_2O = 18,015 g/mol

The mol is a crucial measure in chemistry because it makes it more feasible to relate substances and to compare them or "*how many there are of substance 1 and substance 2?"* By knowing the mass of substance 1 and 2 and their atomic weights we are able to find out how many atoms there are of each substance. These atomic weights can be found in the periodic table.

BASIC BUILDING BLOCKS – GENETICS

When Gregor Mendel – an Austrian friar - found out about the hereditary laws by experimenting with more than 28.000 pea plants in the mid-1800th Century e.g., either wrinkled or round peas he assumed a position as one of the giants of science. He published his findings and presented them to the Natural History Society in Brno in February and March 1865. However, it was only at the beginning of the 1900th century his ideas actually began to catch hold of the scientific community some 20 years after his death.

Mendel found out that you will find *dominant* genes and *recessive* genes in the hereditary structure. This fact will create patterns that will be determinants of how plants will look like down the line of heredity - the attributes or characteristics of the genes. These hereditary genes stem from the genes (chromosomes) of a female and a male each having alternate forms called *alleles* (e.g., a brown eyed and a blue-eyed gene) with one allele being dominant (e.g., brown eyes) and the other allele being recessive. Alleles are inherited – one gene from the female (e.g., brown eyes gene) and one from the male (e.g., blue eyes gene). When the pea seed plant and pollen meet each bring one allele with them and when *fertilizing* happens these alleles are united in pairs into so-called *gametes.*

A *genotype* is the term used for the complete set of inherited genes while a *phenotype* expresses the forms or attributes actually expressed in an offspring e.g.,

hair color, height, eye color etc. The noun *gene* was articulated by the Danish biologist Wilhelm Johannsen in 1909.

Mendel's discoveries formed the basics of what we now call *genetics* and he formed 3 laws:

Mendel's 1. law (Law of segregation) says that each attribute of an organism (color, physics, eyes etc,) contains two alleles for each attribute. During fertilization these will separate into gametes that only contain one allele from each parent.

Mendel's 2. Law (The law of independent assortment) states that alleles for attributes of an organism are passed on independently from parents to their offspring. So, the alleles for e.g. eye color has no relationships to that of other attributes like skin color, fur, head shape etc.

Mendels 3. Law (The law of dominance) states that recessive genes will always be "overruled" by dominant genes.

The master plan for all living organisms is its *DNA (DeoxyriboNucleicAcid).* The DNA takes care of hair, color, looks, gender, teeth and everything else in constructing and upholding living organisms. DNA was discovered by Friedrich Miescher – a Swiss researcher – in 1869 and later refined by Maurice Wilkins and finally identified by James Watson and Francis Crick who both got a Nobel Prize in 1962 for their groundbreaking research with the double helix structure of the DNA molecule – together with Maurice Wilkins.

The genome is built by strings of 4 bases – adenine, guanine, thymine and cytosine. The order of these is what determines the genetic outcome. These bases are arranged in pairs marked by the two colors of the horizontal "ladders" in the Exhibit 2.20 below. However, while genetics is a mechanism that normally is thought to adapt life to present conditions it has also been suggested that the genome has a sort of in-built "memory" that so to say are "sleeping cells" that can be awoken if things change.

When temperatures e.g., changed by 6-8^{o} during the last ice age this didn't mean that species went extinct – they survived - but how they genetically did that is still a hot topic within scientific circles. This couldn't have happened by a so-called evolutionary process. The time span was simply too short to accommodate such processes before temperatures changed.

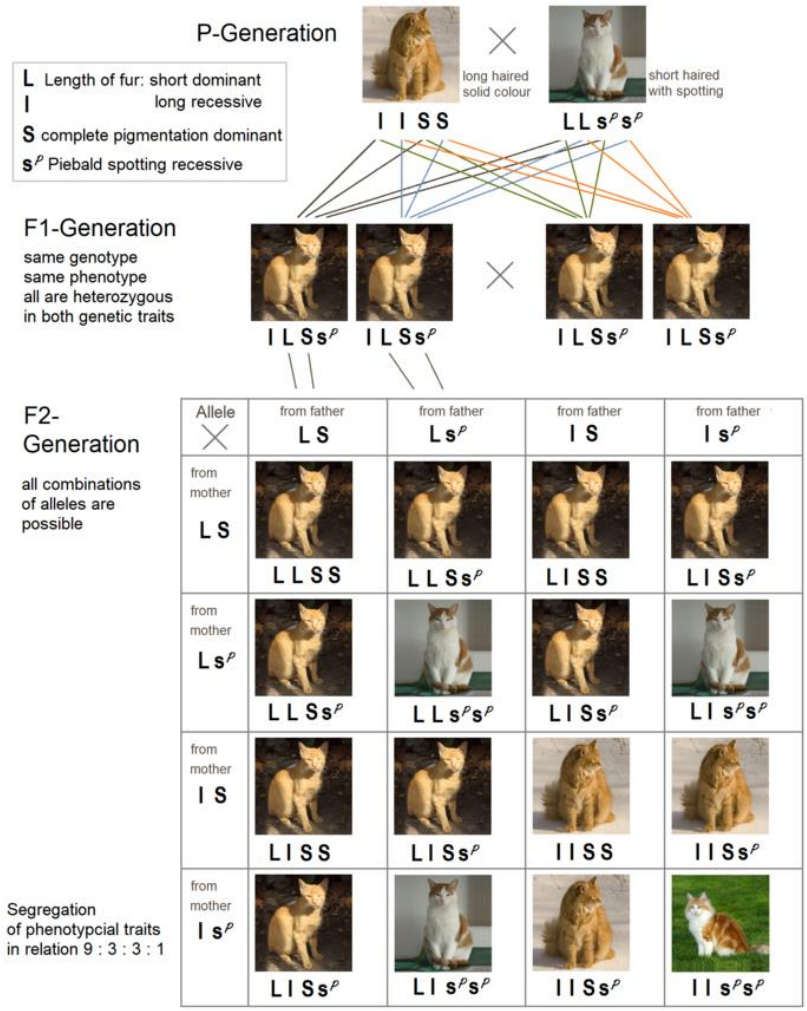


Exhibit 2.19 The hereditary structure of cats by applying Mendel's laws

In 2003 the human genome was determined, and research has furthermore shown that the typical difference between two human beings' genomes typically is approx. 0,1% no matter what race, phenotype etc. you belong to and 99% of a chimpanzee's genome corresponds with the human genome as well though being a relatively distant cousin of homo sapiens. The bonobo monkey is another one of our distant cousins. Due to evolution we at one time separated from these and through other evolutionary processes end up what we are today – the most cruel and wonderful species on earth. But basically, we're all pretty much alike from a genetic standpoint.

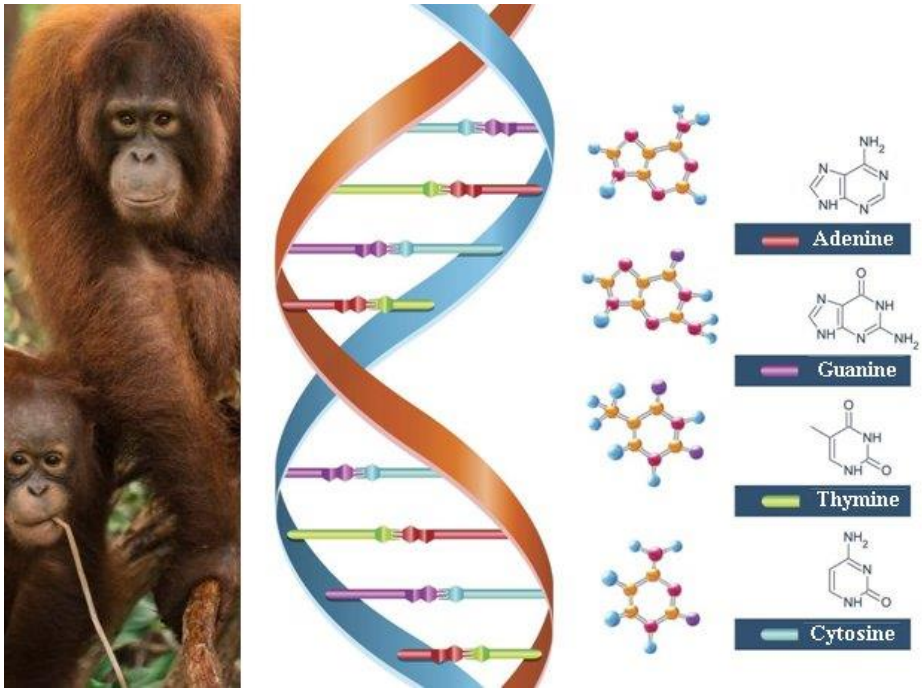


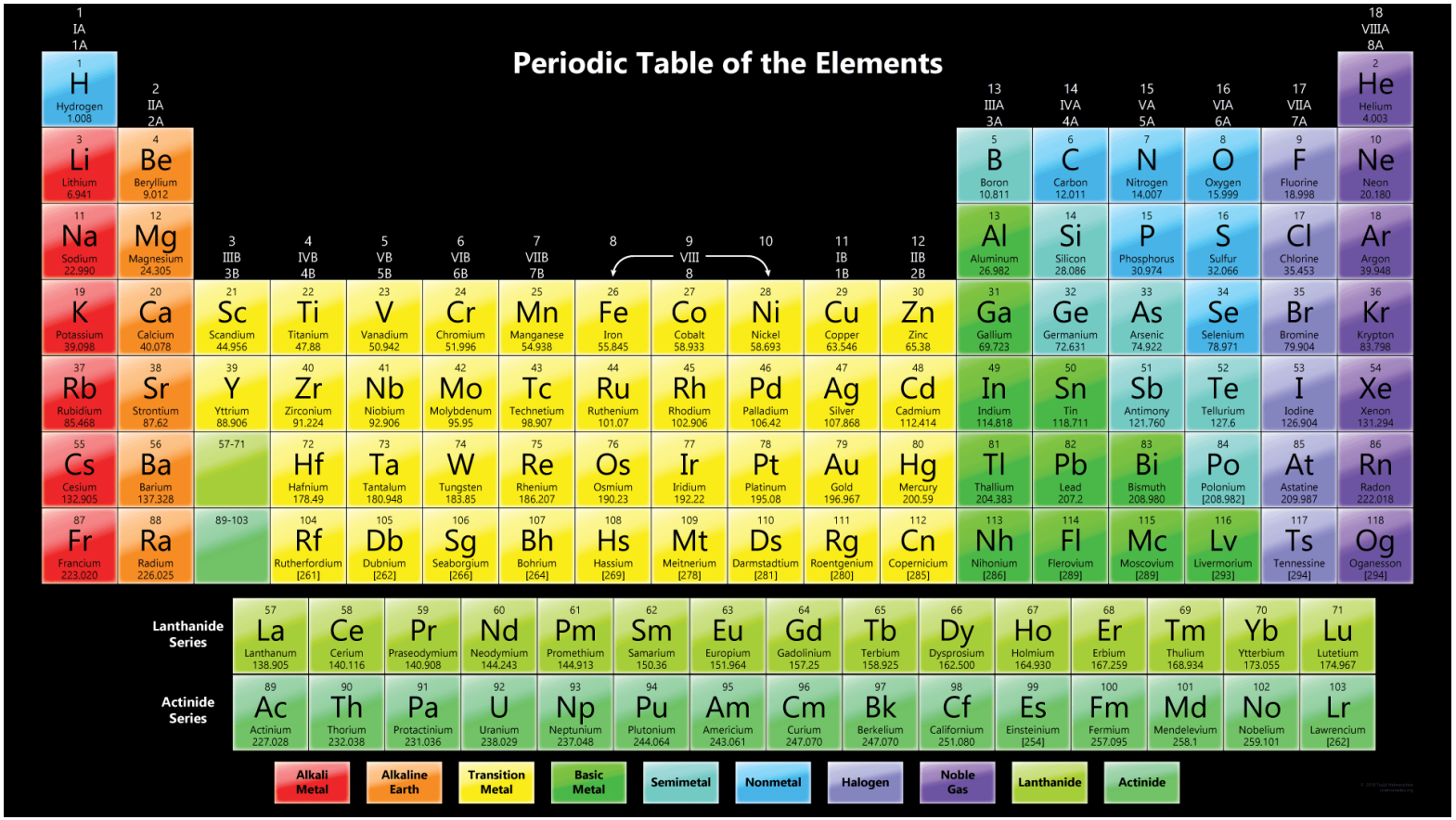
Exhibit 2.20 The double helix structure of DNA

BASIC BUILDING BLOCKS – MATTER (THE PERIODIC TABLE)

All the elements of the Earths sphere's substances or chemicals have been collected in the *Periodic Table*. It shows the name, the atomic number (how many protons in an atom), its electron configuration (its distribution of electrons in an atom), its form (liquid, solid or gaseous) and other characteristics arranged in *seven periods* (the rows in the periodic table) and eighteen columns called *groups*. Colors are used to differentiate the characteristics of the elements.

Many of these elements can form bonds e.g., sulfur (S) can mix with oxygen (O_2) and then becomes sulfur dioxide (SO_2) etc.

Chemicals in disproportionate amounts are an important part of the environmental problems we experience be it in the atmosphere (e.g., S, C, Cl etc.), in the hydrosphere (e.g., Cu, N, Zn etc.) and in the lithosphere (e.g., R, Pb, K etc.). We will not go into any deeper description of the periodic table, it's just meant for providing an overview of the chemical elements that are inherent parts of the earth's basic spheres – the atmosphere, the lithosphere and the hydrosphere.



Exihibit 2.21 The Periodic Table

BASIC BUILDING BLOCKS – THE FOUR FORCES OF NATURE

According to physics four forces are in play when we describe what goes on around us in the material world. These are *gravity, strong and weak nuclear forces* and *electromagnetism*. Two of these we experience every day – that of gravity and that of electromagnetism. So let us have a brief look at each of these four forces.

Gravity

Normally we don't think about gravity – it's just there. If you drop a plate, it will ultimately fall to the ground, but in space we will discover that dropping a plate does not necessarily have the same consequences – conventional gravity is not the same. So, what is gravity?

Originally it was *Isaac Newton* who described the *theory of gravity*. Beginnings were made when Danish astronomer Tycho Brahe observed how planets move in space. Up until that point it was thought that the earth was the epicenter of things – Tycho Brahe observed that this was wrong. Later, Johannes Kepler expanded on Brahe's thoughts and Galileo Galilei formed the ideas of *inertia*. Using these ideas Newton was able to derive the law of gravity. Afterwards his theory was modified by *Albert Einstein* when he came up with his famous theories of *general and special relativity*. Einstein's formula $E = mc^2$ is probably one of the best-known equations in the world. E stands for *energy*, and *m* is the mass of an object while c^2 is the squared root of the speed of light. Einstein's ideas are for all everyday practical purposes equivalent to that of classic physics as defined by Isaac Newton, however, when we move to the subatomic level things change. Here you will find the genuinely strange idea of the *twin paradox* e.g., that an object at the subatomic level can be at two places at the same time. Things also change when we look at the concept of time. Einstein defined the concept of *space-time* where time is actually *curved*.

Gravity is a force that exists due to mass and its relationships with other objects. Planets circle each other due to gravitational pull. You are standing on the earth due to the earth's gravitational pull and because the earth's mass is so much bigger than your own mass it will pull you to the ground and not vice versa. The gravitational pull from the moon circling the earth is also very visible – we know it from the flows of tidal water and gravity is felt when we take a tour in a carrousel.

Gravity is measured as the acceleration it gives to a free-falling object. If near the earth's surface the acceleration will be 9,8 meter/second. If being on the surface of the moon, the acceleration would be 1,6 meter/second. This is in fact also the speed of light. Newton's gravitational law – or the law of motion - says that:

$$F = G \times m_1 \times m_2 / r^2$$

with

F = gravitational force measured in Newton (N)
G = very small universal gravitation constant ($G = 6{,}67428 \times 10^{-11} N \times m^2/kg^2$)
m_1 = mass of object 1
m_2 = mass of object 2
r^2 = distance between the center of masses m_1 and m_2 squared

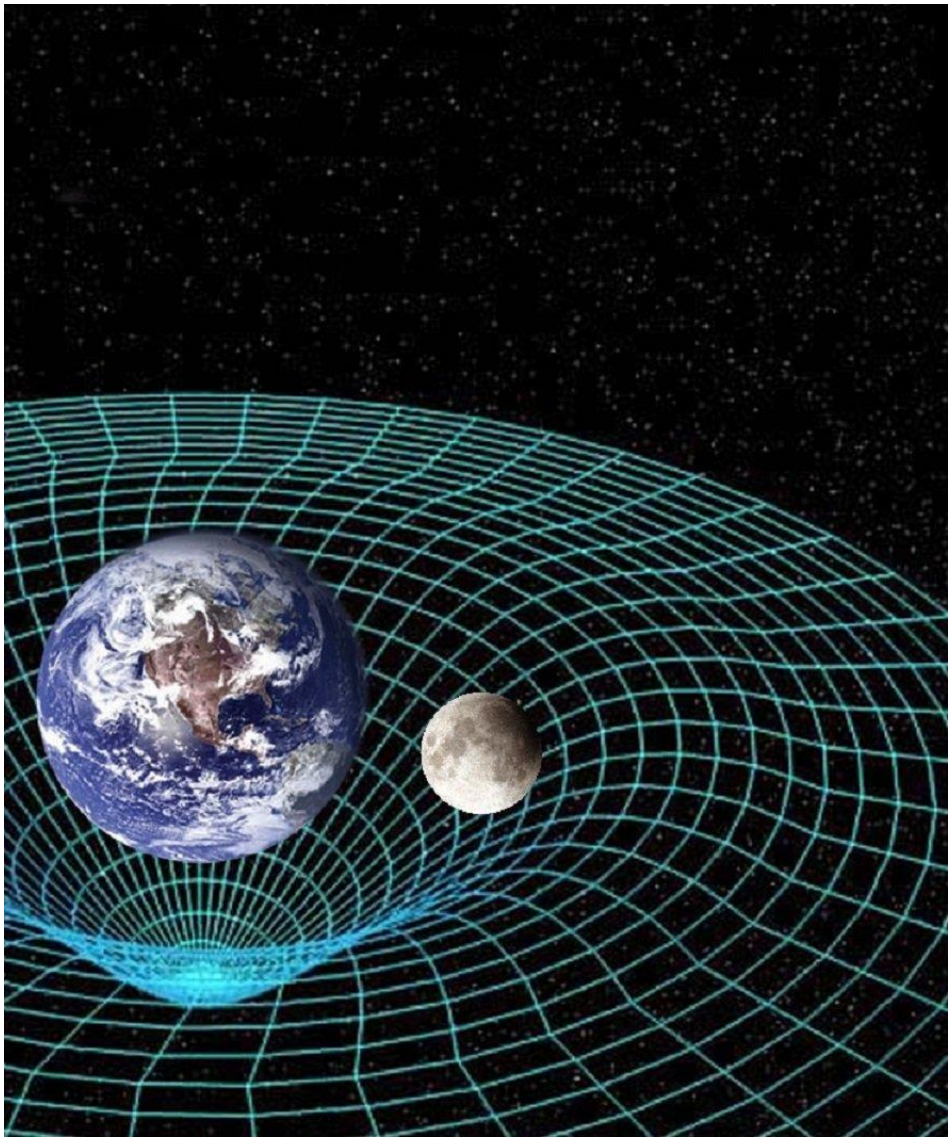


Exhibit 2.22 Gravitational pull

Strong nuclear force

The strong nuclear force constitutes a "vehicle" for holding atoms together. We don't feel this force since it's positioned deep inside the atoms. The strong nuclear force emits so-called *gluons.* These are particles that act as super strong springs that bind *quarks* extremely tight together in neutrons and protons.

Weak nuclear force

The weak nuclear force is a particular force in particle physics inside atoms that emits W and Z particles, so-called *bosons*. While a W boson is electrical charged (W^+ and W^-) the Z boson is neutrally charged. It is 10^{13} times weaker than the strong nuclear force and acts at very short distances. It affects the *neutrinos, leptons* and *quarks* exchanging energy, mass and charge.

While the other three elements of the four forces of nature holds things together the weak force pertains to elements falling apart or decaying. It's called *beta* decaying and happens when there are too many protons or neutrons in the atom's nucleus.

Electromagnetism

Besides gravity and nuclear forces electromagnetism is an important feature of nature. It was actually a Danish scientist who discovered electromagnetism in 1820 when *Hans Christian Oersted* saw that the needle of a nearby compass react – deflected away from the magnetic north - when an electric current in a wire from a battery was turned on. His curiosity about this phenomenon brought about the basic foundations of electromagnetism later to be coined by 4 differential equations suggested by J. C. Maxwell. The basic idea is the understanding of a substance as being comprised of particles loaded with a *charge*. *An electric field* is created by an atom with negative loaded electrons in rest while if atoms are moving an *electromagnetic field* will be created. Charges and flows of electricity then are the two basic ingredients for understanding electromagnetism. Maxwell's 4 equations connect the two. We will leave the issue of electromagnetism with that. In practical workings the concept of electromagnetism is of less importance to sustainable corporate responsibility.

BASIC BUILDING BLOCKS – THERMODYNAMICS

Energy on a global scale is an *open system*. The input into that open system is that of incoming solar radiation. All other elements must be recycled in order for them to enter the cycles of nature. Energy is the very root of life itself – without energy, no life can exist. The human body is a prime example of an energy system; however, energy is also needed to perform all other processes on earth be it the atmosphere, the lithosphere or the hydrosphere.

When talking about energy human beings have been very inventive when it comes to exploiting the earth's resources. It all began when the first commercially successful steam engine was invented in 1712 by Thomas Newcomen and later improved by James Watt. It laid the foundation for the industrial revolution beginning in England. Before that energy was mainly exploited through water mills, the wind and by burning wood. During the industrial revolution, however, a range of new opportunities opened up and we saw the use of nuclear energy, thermal and geothermal energy, hydroelectric power, biomass, energy from gas and hydrogen sources and windmills replacing especially non-renewable sources like oil and gas. When electricity was put into use by people such as *Thomas Edison* and *Alexander Graham Bell* in the beginning of 1900 it quickly changed the world and the amount of energy needed and supplied.

Different forms of energy can be found – a) *kinetic* energy and b) *potential* energy. A dam is basically using the waters kinetic energy in order to produce electricity (potential energy).

Exhibit 2.23 The Three Gorges Dam in China

However, some rules apply when working with energy – the laws of *thermodynamics*. Thermodynamics is concerned with understanding large scale effects on a system by employing heat, work and energy.

The laws of thermodynamics were discovered in the 19th century by a number of scientists from Germany, The Netherlands etc. and constitute an important scientific element. So let us briefly look at the basic ideas of thermodynamics.

Thermodynamic laws

The *first law of thermodynamics* says that energy can neither be created nor destroyed but can only be transformed from one form to another. In this process both heat and energy or "work" is produced. The first law is also called *The Law of Conservation of Energy.* It implies that it is not possible to have nothing for nothing and hence the idea of a *perpetuum mobile* will be out of the question. The idea can be illustrated by Exhibit 2.24.

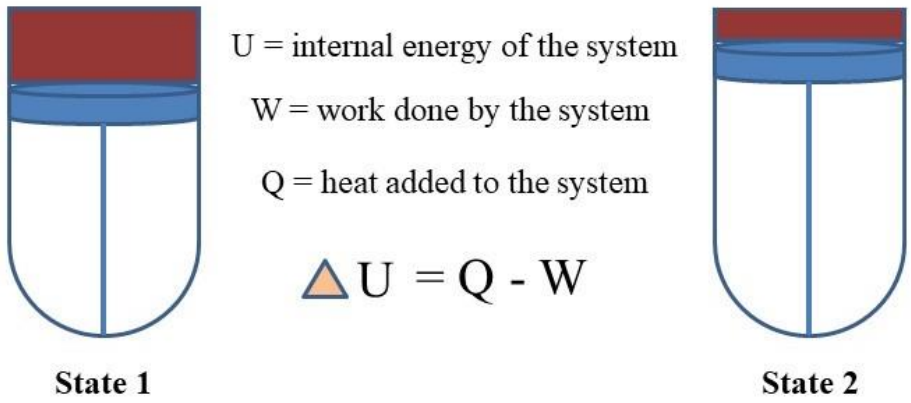


Exhibit 2.24 First Law of Thermodynamics

State 1 (S1) is a thermodynamic system in a steady or equilibrium state. Assume that we have cylinder with a piston that we warm up. At the top of the cylinder, we have a gas contained that by the heating is pulled upwards so that the gas gets concentrated. In other words, we reach a new state (S2). So, through this process we will experience a heat transfer (Q) that is the air is warmed up from S1 to S2 and "work" (W) is done by moving the piston upwards. If U is the internal (potential) energy of the system, then:

$$\Delta U = Q - W$$

That is the change of the energy of the two steady states S1 and S2 will be equal to the transfer of heat *into* the system and the work done *by* the system. This can also be seen as Q (heat) being "responsible" for doing work (W) as well as raising the temperature of the system and thereby compressing the gas.

The *second law of thermodynamics* says that the *entropy (disorder*) of a closed system will always increase. You can fire up a pile of wood but once it's burned down you cannot possibly assemble the ashes once again. Before the fire is lit the wood pile might seem pretty organized but once it's turned into ashes this will be

blown around by the wind, washed out by a tidal wave etc. – that is entropy is increasing. We can also illustrate this point by Exhibit 2.25.

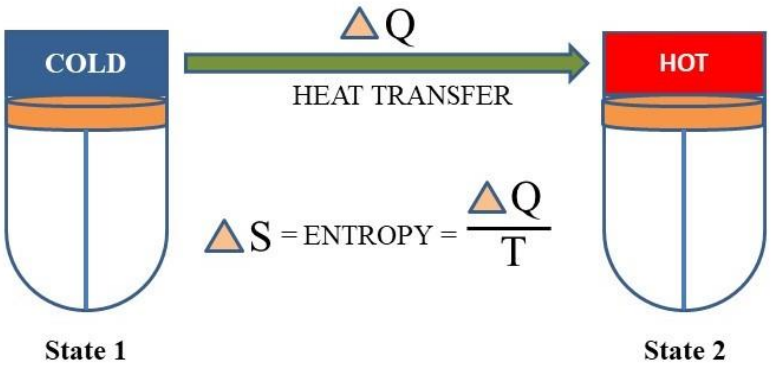


Exhibit 2.25 Second Law of Thermodynamics

If heat of a state e.g., consisting of warm water is transferred to another state 2 in an irreversible process then the variable *entropy (or disorder)* will be increased. If hot water comes into contact with another colder reservoir of water the temperature of the hot part will decrease and the temperature of the colder part will increase. Entropy will be increased (Δ S) by the heat transferred (Δ Q) divided by the temperature (T) or:

$$\Delta S = \frac{\Delta Q}{T}$$

This process is irreversible since when the two parts merge and if trying to separate them again they will still hold the same temperature. We cannot possibly get back to the isolated states of warm and cold water in an irreversible process.

The *third law of thermodynamics* says that the entropy of a system will approach a constant value when temperatures approach absolute zero (-273^{o} Celsius). This constant value of entropy will typically be zero.

Finally, it should be mentioned that we also see the so-called *zeroth law* of thermodynamics that defines equilibrium states of systems in the sense that when two systems are in a thermodynamic equilibrium with a third system, they will be in equilibrium with each other. It's the very basic law of thermodynamics and therefore named the "zeroth" law.

While thermodynamic laws might have applications within physics and engineering, we will use them as a way of thinking about certain kinds of systems involving energy, heat and work in a more superficial way of studying systems.

BASIC BUILDING BLOCKS - THE FOOD CHAIN (METABOLISM)

In principle species competition for the earth's biomass – its stored energy - is the driver behind the *food chain* - sometimes called the food web. This competition can be viewed as a competition for carbon by the various biotic elements in nature. This battle is mainly dominated by plants and bacteria - please refer to Exhibit 2.26 below.

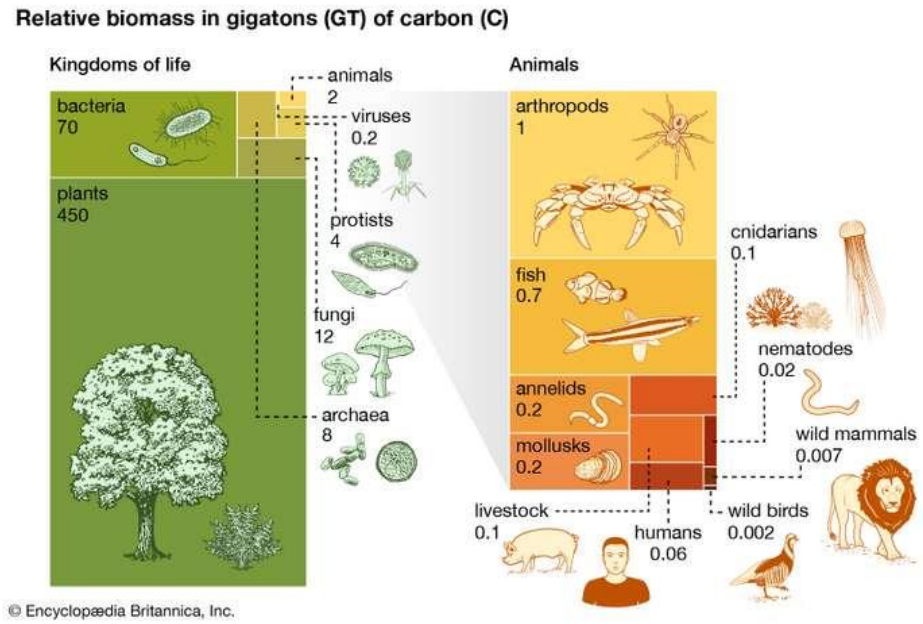


Exhibit 2.26 Relative biomass on earth measured in Gigatons of carbon
Source: Encyclopedia Britannica Inc.

If we divide "the kingdom of life" into seven basic chunks – *bacteria, plants, animals, viruses, protists* [4] *(any eukaryotic organism that is not an animal, plant, or fungus), fungi and archaea (domain of single celled prokaryotic organisms)* – we

[4] A *protist* is an organism whose cells contain a cell nucleus also called a *eukaryotic* organism. *Prokaryotic* organisms lack a specific nucleus

can attribute a number of Gigatons of biomass (carbon) that each of these seven groups demands. The remarkable thing is that of these 546,02 GT of carbon human beings only accounts for 0,06 of about 2 GT of animal carbon.

A very fundamental way to look upon nature is to realize that everything is connected to each other. We often call this interconnectedness of different kinds for *symbiosis* when looking at how organisms benefit from living close to each other. One example would be the symbiosis of the clown fish and the sea anemone. The clown fish protects the sea anemone from those fish that eats it and in return the anemone will protect the clown fish with its stinging tentacles with the clown fish seeking shelter among these.

Exhibit 2.27 The clown fish living in symbiosis with the sea anemone

Likewise human beings benefit from the oxygen emitted by trees, flowers and other plants, while these in turn benefit from the carbon dioxide we emit. This interrelatedness is also true when looking at the *food chain*. Some are considered *basic producers* e.g., plants and insects. These are eaten by birds, deer and other animals called *primary consumers*. At the next level these are eaten by predators like rabbits, skunks and badgers - *secondary consumers*. At the top of the food chain indicated in Exhibit 2.28 below we will find animals like bobcats, bears, mountain lions etc. or *tertiary consumers*.

If we take it to the top – not shown – human beings will be the ones who are the most important predator of all in the food chain. It is so because human beings are capable of preying on all other species, because human beings fundamentally are able to impact the entire food chain and because we have a free will.

If elements of the food chain for some reason are taken out it can affect the elements of the entire food chain – it's an interconnected and dynamic system. The more specialized elements are, the greater the risk for serious consequences to emerge. As an example, one can think of the panda. If the bamboos of which they're living for some reason would vanish from the area the pandas would ultimately die. On the other hand, e.g., other bears use a variety of food sources and are therefore not that vulnerable to changes in their ecosystem because of the variety of their diet and their ability to adapt to changed circumstances.

Let us give an example. At one time it was found that the number of caribous in Yellowstone National Park, USA was rapidly dwindling. Nobody knew why. A research project was undertaken, and they discovered the reason. Normally the bears of Yellowstone would prey on the cutthroat trout that each year went spawning in the rivers coming to and from the Yellowstone Lake. At one point some anglers decided to release another trout species in the lake (lake trout) and this trout competed with the cutthroat and preyed on it to the point where spawning runs came to a halt. The bears reacted to that by beginning to prey on caribou calves instead and the number of caribous of course went down. Since the bears of Yellowstone have a very diverse menu when it comes to feeding, they adapted to the changed circumstances of developments in the food chain.

It's important to note that this basic food chain pertains to the smallest creatures like bacteria to the largest mammals like the blue whale – it's interconnected - and disturbances in the food chain will impact up and down the chain – sometimes in unforeseen ways. Major disturbances e.g., the drop of insects or the loss of habitats will impact the food chain throughout the entire network – it's interconnected. Disturbances in the food chain functions like the "butterfly effect" that James Gleick described in his book about *chaos theory*.

Some of the participants in the food chain are *carnivores* (plant eating animals) other *herbivores* (meat eating animals) and still others feed on both plants and meat called *omnivores (*e.g., bears). Another important distinction in the food chain is that of *predators* that will eat other animals and *prey* that constitutes animals being eaten. The relationship between predators and prey are numerous and often very complex and pertains to all species, mammals, insects, microbes etc.

Another important issue that pertains to the food chain is *biodiversity.* This feature is important because the food chain is built upon the notion of biodiversity. In an environment where we find a rich biodiversity species will thrive on each other. The richer we see biodiversity unfolding, the more opportunities we will find for diversification, genetic variation, feeding, mating and competing within the food chain. This will at the same time further *metabolism* that is the chemical reactions with a life-sustaining effect by eating, drinking and getting rid of waste products.

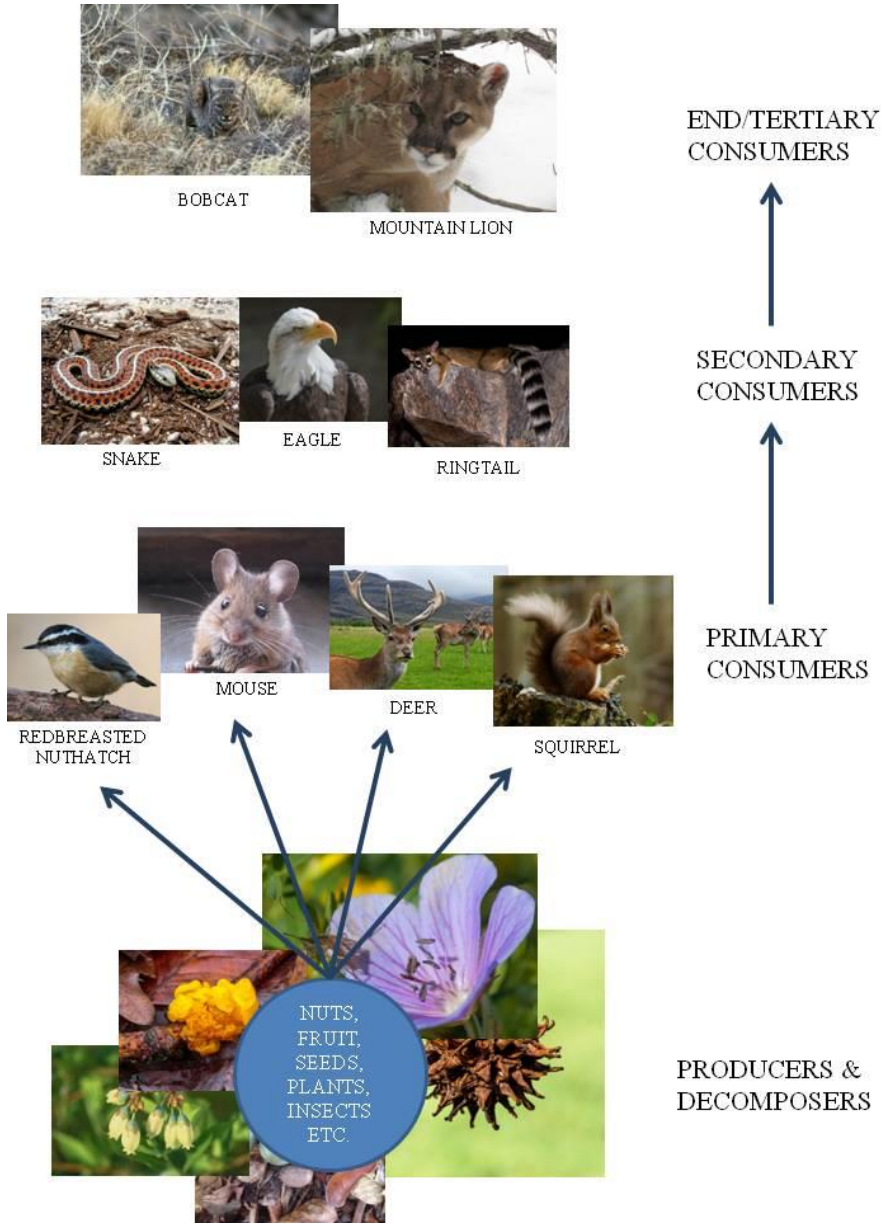


Exhibit 2.28 The Food Chain – producers, decomposers and consumers

Natural selection, survival of the fittest

When Charles Darwin after having visited the Galapagos Islands wrote his book *"On the Origin of Species*" first issued in 1859 he coined one of the most important discoveries of nature – how species develops in an evolutionary way. They basically do so due to a closed environment and from simplicity to complexity.

Before issuing this book, he had been on a travel with HMS Beagle to many exotic places on Earth and when he arrived at the Galapagos Islands, he discovered certain differences between finches and the variations of shells of turtles living on the islands and he began to wonder why. Before beginning on his treatise, he said:

"In October 1838, that is, fifteen months after I had begun my systematic enquiry, I happened to read for amusement Malthus on Population, and being well prepared to appreciate the struggle for existence which everywhere goes on from long-continued observation of the habits of animals and plants, it at once struck me that under these circumstances favourable variations would tend to be preserved, and unfavourable ones to be destroyed. The result of this would be the formation of new species. Here, then, I had at last got a theory by which to work.

Exhibit 2.29 "The Origin…" – theories began with studying beaks of finches

Darwin had found his mission and the answers are described in his book that said that *evolution* basically happens through *natural selection.* This selection was confined to the species best fitted to adapt to their natural environment often coined as *survival of the fittest.* The difference between the finches then was not due to being specific species but to adaptation according to Darwin. He later related his findings to that of the breeding of domesticated animals and saw some of the same traits being revealed supporting his ideas.

Darwin expanded on his ideas by working further with the descent of man and in 1871 he wrote "*The Decent of Man and Selection in Relation to Sex*". Evolution, according to Darwin, has a common origin most notably related to human beings whom Darwin claimed originated from chimpanzees and bonobos. This of course gave rise to an outcry from the theological community.

The ideas and theories of Charles Darwin have few parallels in the history of science. He has fundamentally affected peoples view about the world. He has carried out science in its most beautiful edition and he has left a decisive scientific mark on our understanding of nature.

BASIC BUILDING BLOCKS – BIODIVERSITY

65 million years ago a meteorite hit the Yucatan peninsula in Mexico with devastating effects for all life on earth. 65% of all life vanished and almost 100% of all dinosaurs with it. Nowadays it's not natural forces that come into play when biodiversity is lost but human beings that have the same effects on biodiversity as the meteorite that hit the Yucatan 65 million years ago. In other words, it's we as a species that are about to eliminate most other species on earth. Some scientists call it the 6th mass extinction currently happening.

Both the number of species as well as the numbers within species is increasingly vanishing from earth. Human impacts on nature and wildlife have had serious consequences for the entire ecosystems. Nature needs space and habitats, and wildlife are dwindling rapidly. Some scientists now compare the current state of biodiversity on earth with the currently unfolding climate crisis. Biodiversity is suffering. More officially UNEP defines biodiversity - or natural variation - from both a genetic, species and ecosystem level.

A couple of examples of what climate change means. In Sweden the Arctic fox is threatened by climate change. Due to higher temperatures its cousin the Red fox will begin to move into its territories and being bigger and stronger it will kill the Arctic fox and take over its dens and territories. In Thailand the Sea turtle is also threatened by rising temperatures. When the turtle lays its eggs along the shores of the Indian Ocean the distribution of females and males are dependent on temperatures. With rising temperatures, the share of female Sea turtles will increase and thereby push the balance between genders and disturb the reproductive cycle of this species. Thousands upon thousands of other species currently experience the effects of the dominance of human beings.

Taking it to a more general level it is assumed that there are five drivers concerning loss of biodiversity: [5]

1) loss of habitats
2) invasive species
3) overexploitation
4) pollution and
5) climate change

[5] See Encyclopedia Britannica

BASIC BUILDING BLOCKS - BIOGEOCHEMICAL CYCLES

Biogeochemical cycles are processes whereby substances like phosphorous, oxygen, nitrogen etc. are transported or transformed in *biotic* (living or dead cellular organisms) or *abiotic* (non-living non-cellular) systems. It's simply how the earth works in terms of processing atoms and molecules. Such cycles are always the result of the collected workings of the atmosphere, the hydrosphere and the lithosphere e.g., carbon atoms are found in the air, in the soil and in water. These cycles are basically *closed systems*. In the following we will briefly look at the fundamental processes that occur in the carbon cycle, the nitrogen cycle, the oxygen cycle, the phosphorus cycle and the sulfur cycle.

a) The carbon cycle

The carbon atom (C) is vital for all life to exist. It easily forms bonds with other chemicals – actually 10 million different compounds containing carbon are known - and if it weren't for the carbon molecule the amino acids that are the very basic fabric of the human DNA would not be possible to form. Carbon can be found in the atmosphere, the lithosphere and the hydrosphere and in organic structures (e.g. DNA, cells) and inorganic structures (e.g. diamonds and graphite). The fossil fuels found all around the world are in fact stemming from organisms that decayed millions of years ago and through geochemical processes were transformed to crude oil containing massive amounts of carbon. However, for our purpose the carbon cycle begins as a gas – CO_2 – in the atmosphere.

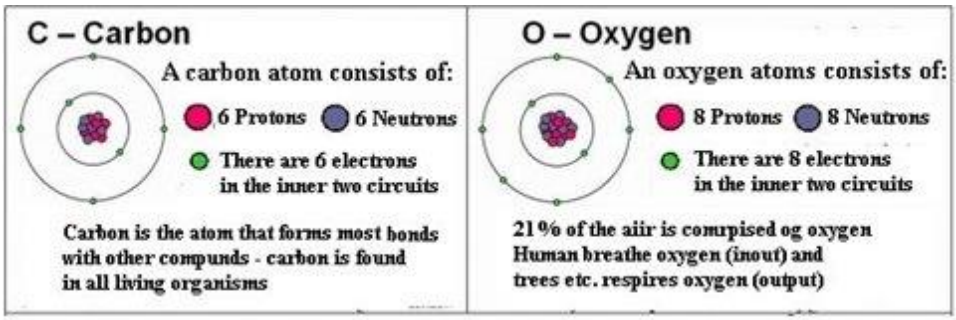


Exhibit 2.30 Elements of the carbon atom and carbon dioxide

Through photosynthesis plants are able to absorb this gas through their leaves and inject this into their processes where they form proteins, sugar, lipids etc. During night plants respires and emits oxygen (O_2) back into the atmosphere. Animals later eat these plants and the organic carbon and sugar, lipids and proteins are then transformed in their bodies in order to release the energy it contains. Through this process the carbon is broken down into various compounds and some of it is released back into the atmosphere through respiration as well as a significant amount of methane (CH_4). When animals die, they will be decomposed by bacteria

and some of these will also emit CO_2 back into the atmosphere. Some of the carbon, however, will be stored in the soil while other parts will be taken up by the ocean – the largest single absorber of CO_2 – as well as by our rivers and lakes etc. It will react with water by forming *carbonic acid* (H_2CO_3) and the oceans acidity will be increased (lower pH).

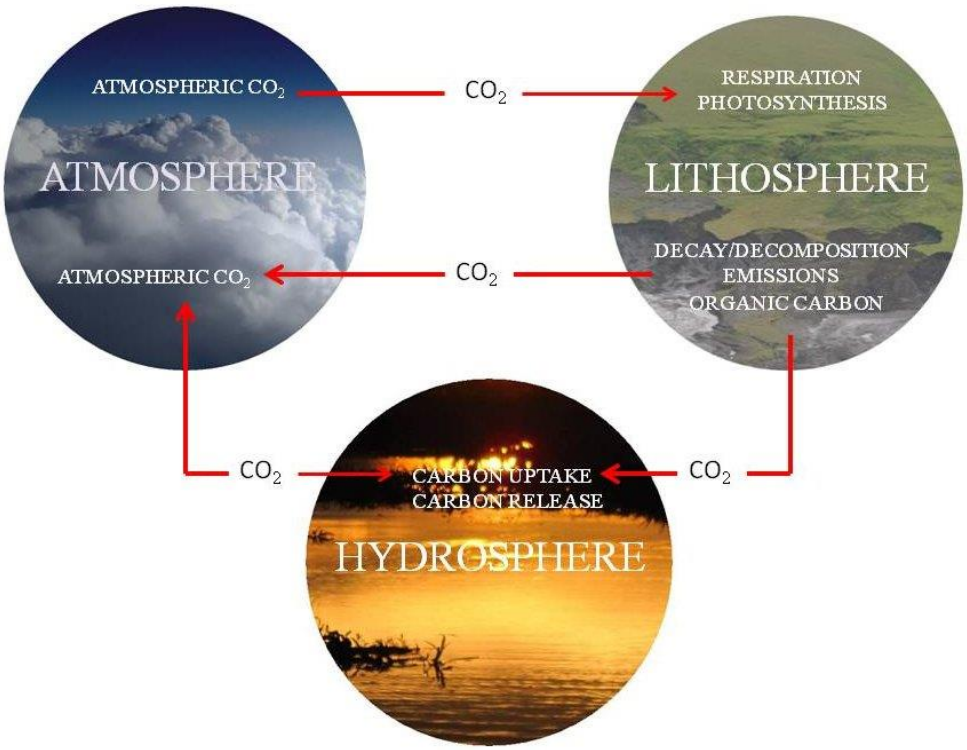


Exhibit 2.31 Basic carbon Cycle

The fossil fuels we use will contribute to the greenhouse effect emitting additional CO_2 back into the atmosphere. However, most of this is "old" carbon stored millions of years ago that are now being brought back into the cycle. In an equilibrium state such processes would continue forever just being disturbed once in a while when volcanoes erupt etc. However, when humans interfere through the infusion of old carbon into the natural cycle things can go out of hand and the carbon cycle is temporarily set out of its normal mode. Nature will respond by the consequences we now see – the climate crisis and its rippling effects. The severity of this should not be overlooked. During the so-called Permian extinction 299 – 251 million years ago 95% of all life on earth were wiped out. It is thought that excessive greenhouse gases in the atmosphere like carbon dioxide led to this extinction, due to maybe volcanic activity, an asteroid or massive fires. Mineral

carbon is another form of carbon deposits found in coal, diamonds, calcite, graphite etc. Like its liquid form it contains carbon that we can use e.g. for heating, energy, jewelry, writing etc.

b) The basic nitrogen cycle

Nitrogen (N) is an important substance in the biological cycle. In fact, 78% of the air that surrounds us is made up of nitrogen. Through nitrogen other important processes occurs including *fixation, ammonification, nitrification* and *denitrification.* This cycle is shown in Exhibit 2.32 below. Nitrogen is furthermore essential to living organisms because e.g., amino acids found in the DNA uses nitrogen compounds and farmers utilizes nitrogen as a fertilizer and organic material thrives on nitrogen,

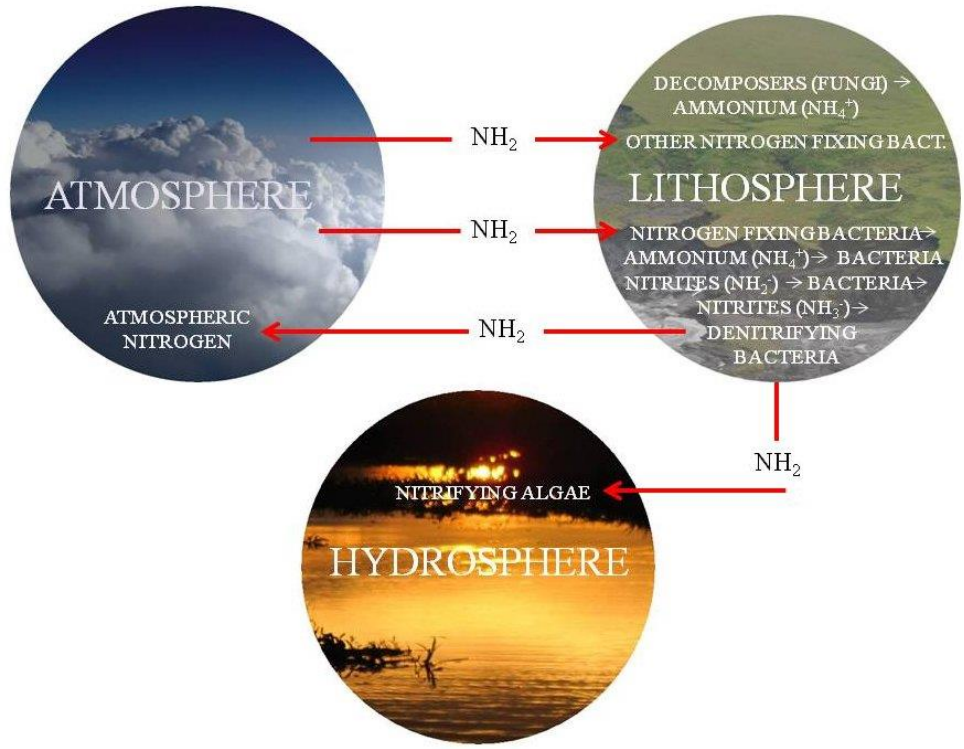


Exhibit 2.32 Basic nitrogen Cycle

Nitrogen *fixation* occurs when atmospheric nitrogen – a gas (N_2) - reacts with substances (enzymes in bacteria) in the soil. Biological fixation occurs when aerial nitrogen is converted into ammonium (NH_3) by the help of soil bacteria (nitrogen fixing bacteria) or by bacteria found in the roots of legume plants e.g., peas, alfalfa,

soybeans or locust trees (other nitrogen fixing bacteria). The ammonium is then turned into nitrites (NO_2^-) called *nitrification* once again with the help of bacteria and further processed into nitrates (NO_3^-) by other bacteria. This is called *denitrification*. Through this process the nitrogen partly becomes available to plants, called *assimilation* and partly turned into atmospheric nitrogen once again by the help of bacteria (denitrifying bacteria). When plants or animals die, urinate etc. the nitrogen is fused back into the ammonium cycle by decomposers such as fungi. Nitrogen ends up in our waterways by run-offs or leaching when plants and animals are not able to absorb the amount of nitrogen contained in the soil. In a lake, river or in the ocean nitrifying algae such as the blue-green algae will feed on this nitrogen. In cases this can lead to eutrophication – a common problem due to fertilization.

c) The basic oxygen cycle

Atmospheric oxygen (O_2) is a necessary component for all living things. Human beings and animals breathe oxygen when *respiring* and *decaying* as well as *combustion* processes also need oxygen to work.

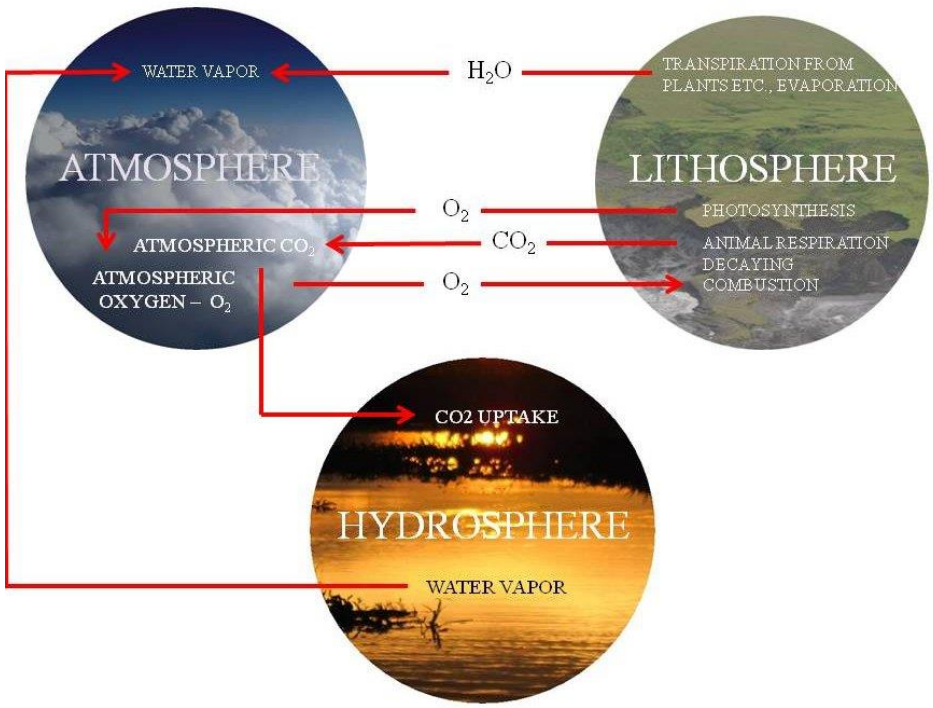


Exhibit 2.33 The Oxygen Cycle

People and animals breathe oxygen while plants *transpire* oxygen via photosynthesis that becomes part of the *atmospheric oxygen*. Through *evaporation* - or *transpiration* from plants and soil - oxygen and hydrogen – or water that is H_2O – is condensed and will form clouds that later will reach the lithosphere as *precipitation* - rain, drizzle, moist etc. It's a molecule that reacts with many other molecules among this carbon that can form e.g., carbon dioxide or CO_2 or hydrogen and then form water (H_2O). Atmospheric CO_2 is formed when plants and animals decays, when animals and human beings breathe and when fossil fuels and others are combusted.

d) The basic sulfur cycle

Sulfur (SO_2) is a substance that like hydrogen can move between and among biotic and abiotic systems. It's a part of many proteins and used e.g., in respiration by microbes. Sulfur enters the atmosphere by the burning of fossil fuels and by chemical reactions taking place in the lithosphere (sulfides) which is then emitted into the atmosphere (abiotic systems). From the atmosphere it can be deposited in a *wet* or *dry* form. If content of sulfur in the atmosphere is high, we will see *acid rain* being deposited (wet form) and by coming in contact with the soil or by decomposition it can then be deposited in the soil layers (dry form). It can be absorbed by the oceans, lakes and rivers by run-offs, acid rain or sedimentation.

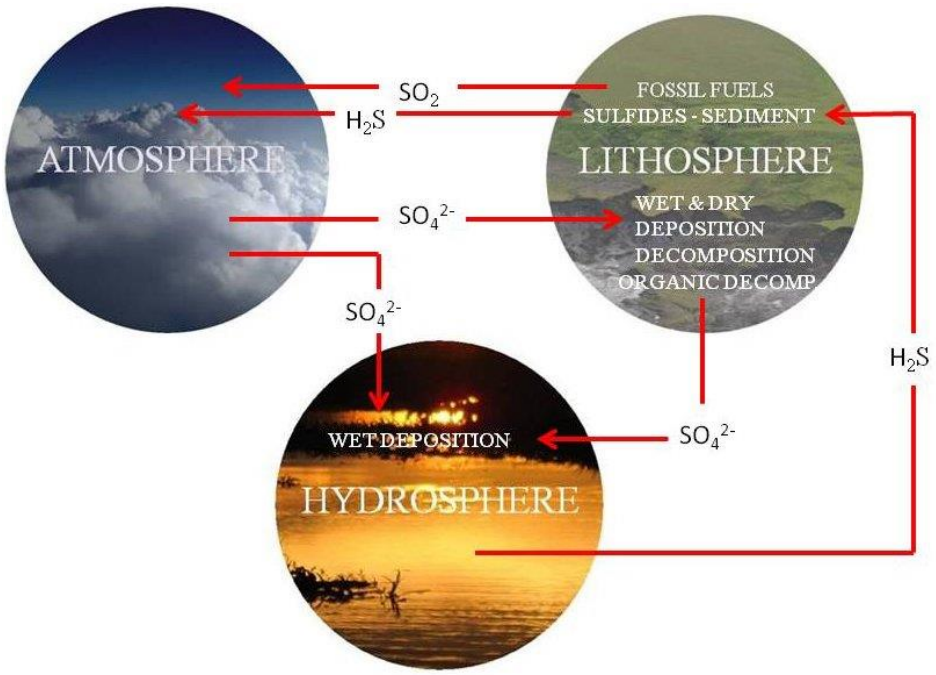


Exhibit 2.34 The basic sulfur cycle

Problems with too much sulfur in the environment include its ability to acidify water reservoirs killing both fish and plants. Besides that, sulfur will also react with buildings and other human constructs where they will turn the facade grayish black and deteriorate bricks and other. In its aerial form it can affect human health especially in cities with heavy traffic, smog due to industrial operations etc.

e) The basic phosphorous cycle

Phosphorous (P) is an important substance for a variety of biological processes. Many living organisms use phosphorous for forming bones and teeth's (calcium phosphate), as nutrients for plants and microorganisms, as fertilizer etc. In fact, it is a condition for all living organisms since phosphates also impacts our DNA.

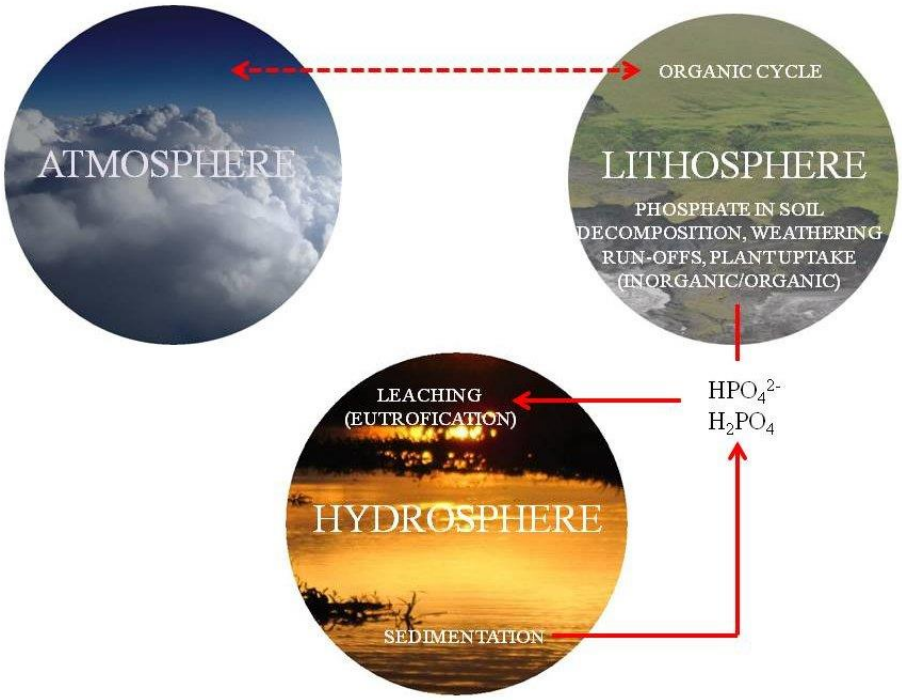


Exhibit 2.35 The basic phosphorous Cycle

Phosphorous stems from rocks exposed to weathering conditions where it is washed out and ends up in our soil or water systems. Here it acts as building blocks for plants, animals, and microorganisms like algae and when these die the phosphorous is then returned to the environment through decomposition. Phosphorous can be deposited in the sediments in our rivers, oceans and lakes. It acts as a nutrient for years to come even though harsh regulations may have been implemented. So the phosphorous cycle can be slow to unfold. When phosphorous is deposited in our oceans it will be a part of the sediment and in millions of years form rocks from

which it once again though weathering returns to the oceans etc. The atmosphere does not play a part in the cycle. In the Exhibit above there is a dotted line. This just indicates that when birds e.g., feed on anchovies that eats plankton this plankton will have absorbed phosphorous from the water. The excrements of the birds then deposit this phosphorous in the form of guano and the cycle start again.

One of the biggest problems with phosphorous is its use as a fertilizer in agriculture. Since plants are not able to absorb all of the phosphorous it will eventually end up in our rivers and lakes by run-offs or by being washed out of the soil. An excessive amount of phosphorous will spur e.g., algae to grow faster and when this happens the environment can suffer through massive eutrophication which in its extremes can result in the extinction of fish populations and pose a threat to people through toxins that goes with the blue-green algae.

Exhibit 2.36 Phosphorous is a driver of eutrophication

Exhibit 2.37 "Mother Earth" – painting by Frank Baldus

2.4 BASIC ENVIRONMENTAL PROBLEMS

The lesson of the industrial revolution has been pertinently clear; there is a cost to everything. Costs of the industrial revolution are borne by the Earths spheres. During the first half of the 21st century it has become increasingly clear that the climate, biodiversity and resources cannot cope with the changes induced by the industrial revolution. The second half of the 21st century must become the "green" revolution if we want to honor the responsibilities entrusted to us by future generations. It has taken us just a nick of time to fundamentally change the ecosystems, eradicate a number of species and consume vast amounts of resources. The benefits achieved by human endeavors has been correspondingly enormous when measured as economic development, technological breakthroughs, living conditions, art, health, culture etc. The costs on the other hand for achieving these benefits have likewise been astronomical when seen through the lenses of nature, our landscapes, our waterways and the previous richness of species.

a) Basic environmental problems – climate change

The earth has undergone many different periods during the past 500 million years with rising or falling temperatures, different levels of carbon dioxide in the atmosphere, ice covering most of the earth and periods with less ice coverage.

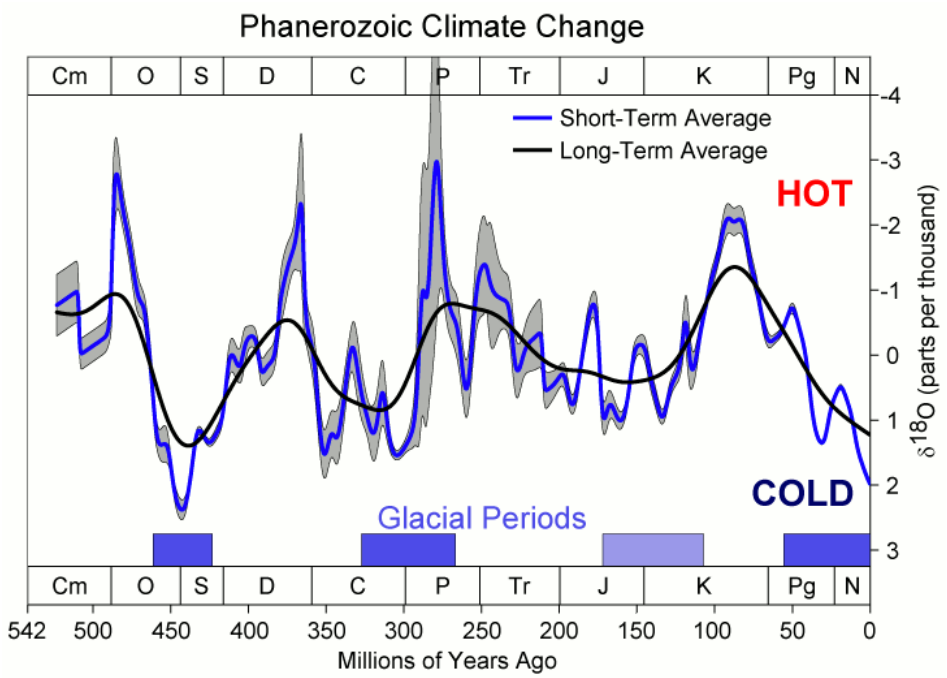


Exhibit 2.38 Phanerozoic Climate change

The *Phanerozoic eon* is the term for the current geological period beginning with the *Cambrium Period* 542 million years ago lasting up until now. This period is characterized by the development of the animals and plants we know off today. During this period, we have seen four peaks in long term average temperatures and four corresponding lows consisting of colder glacial periods of which we're in the middle of the last of these. This have made scientists as well as others ask whether the current rise in temperatures might be a sign of whether we're about to leave this cold glacial period and move into a natural upward slope of the curve *or* if this natural cycle is about to be changed by human induced climate changes? The scientific community is in no doubt. Human induced climate change is about to alter the natural cycle. A recent study from Cornell University of 88.125 peer-reviewed scientific articles dealing with climate change showed that 99,9% of the scientists agreed on this issue.

Most environmental problems are interconnected, and the issue of climate change is one of these. Climate change affects and is affected by air temperatures, rainfalls, melting of the ice sheet, warming of the ocean, changed ocean currents and so on. It impacts the atmosphere, the lithosphere and the hydrosphere. Changes to the climate have been an ongoing issue for the past decades. Average temperatures in July 2019 were in fact the warmest ever measured on earth and in June 2020 temperatures in Siberia, Russia exceed 38° Celsius north of the Arctic Circle and there is an overwhelming consensus that changes in climatic conditions in large part

are due to human activities. The IPCC has for long warned politicians and other decision makers about the impacts this could possibly have, and certain policy choices have been made to combat excessive climate changes – but far from enough and too diverse in the worlds perception of these issues and hence its practical measures for combating the climate crisis. This interconnectedness is also visible when looking at forests in Germany. Especially spruce forests are now dying due to climate change. An example. When temperatures are rising, and it gets drier a certain species of beetles will attack spruce trees by penetrating the outer layer. Normally the trees will combat these beetles by emitting resin from the holes the beetles have dug that will trap the beetles. When the weather is hot and dry spruce trees are not able to produce enough of this resin and the beetles will have a ball. The consequences can be devastating for the spruce forests as is now evident in certain parts of Germany. However, climate change has been an issue that seemingly has opened the eyes of many people. At no time in previous human history has the challenges facing the earth and human population been so clearly exposed and the response has correspondingly been unparalleled in many parts of the world. This is probably mainly due to the fact that the real consequences of climate change have been painfully obvious. More frequent hurricanes, flooding and storms, rising water levels, the ice melting around the globe, warmer weather etc. has been a wake-up call to many. But the rising CO_2 contents in the atmosphere will also likely affect the ecosystems as well. As CO_2 rises in the atmosphere plants photosynthesis will change as well. Some plants will grow faster. This will cause plants to shed their leaves more often and this in turn will mean that more flammable material will be available for wildfires to occur and the ecosystem near bushes and trees will be altered as well. So, climate change will exhibit some very real consequences that will unfold in the decades to come.

What are the causes of climate change – direct and systemic issues?

The content of CO_2-equivalents in the atmosphere have risen compared to a pre-industrial level as can be seem from Exhibit 2.39 below. Before 1950 the level of CO_2 in the atmosphere had never been above 300 ppm in human history. We can say so with a high degree of accuracy since these data have been extracted from ice cores precluding any misconceptions. Today, we're not confined to analyzing ice cores, when stating facts about CO_2 contents; we are actually able to measure it directly in the atmospheric contents. When CO_2, methane, HCFC's and other substances are emitted into the atmosphere in abnormal amounts the composition of the atmosphere will change as well. The atmosphere like most other systems is a well-balanced organism. In order for it to be in equilibrium what goes in must come out. Today this is not so. What goes out (into space) is less than what goes into the system, and it will respond by increases in CO_2 levels in the atmosphere – in other words we see a *"greenhouse effect"* occurring. This is an important – and natural – mechanism in our atmosphere. The question is no longer whether we're about to interrupt this natural cycle. When ice is melting the oceans coverage of the earth's surface will be expanded and we will see land freed of its former ice sheet. Since the ocean's surface only reflects approx. 6% of solar radiation and the ice reflects about 50-70% we will be seeing an increase in the greenhouse effect in the future

due to less ice coverage. This rise is above average when looking at both land and ocean temperatures. Between 1850 and 2015 the temperature over land has risen by 1,53% and the period 2015 - 2020 has been the warmest ever measured since measurements began in 1850. This has given rise to more frequent, intense and prolonged heat waves around the globe, thereby creating more droughts and ultimately desertification, increasing the frequency of hurricanes, proving for heavier rain falls in some parts, less snow in winters, melting glaciers etc. In short, our weather system is changing at this very moment due to human impacts on the variables that create the world's climate.

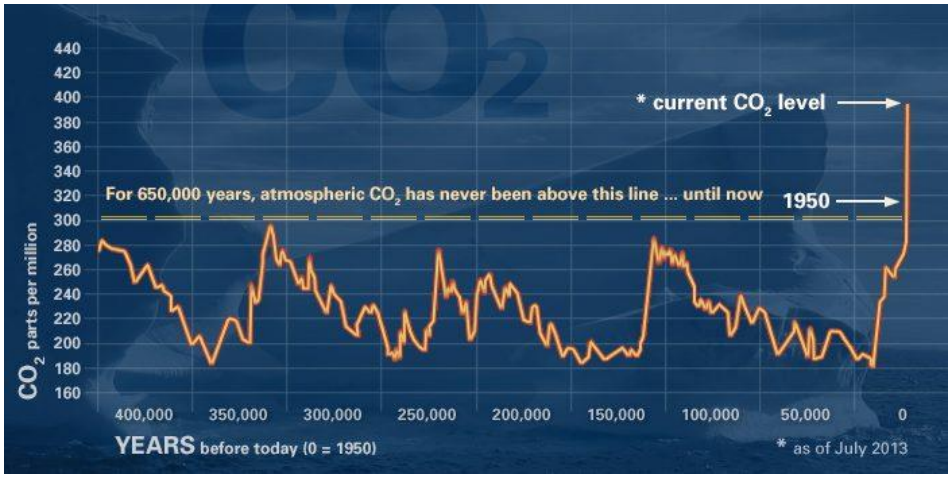


Exhibit 2.39 Atmospheric content of CO_2 - from 800.000 years B.C. up to now
Source: NASA, climate.nasa.gov

In 2017 UN's WMO (World Meteorological Organization) documented a record level of average global CO_2 concentrations in the atmosphere amounting to 405,5 ppm. In 2018 this had risen to 407,8 ppm and in September 2022 it stood at 420 ppm. This is 50% higher than it was before the industrial revolution began and such high concentrations have not been recorded for at least 2 million years. NOx as well as methane have also risen making scientists warn about the serious potential effects this could have on future human welfare. This corresponds well with UN's documented release of the world's CO_2 emissions in 2017 (53,5 Gt) and 2018 (55,3 Gt). According to UNEP we're now on our way to see an average global temperature increase of 3,2° in 2100. A level of 400 ppm was last seen 3 million years ago when the earth was considerably warmer and oceans levels a whole lot higher. [6] According to the *Paris agreement* from 2015 signed by 196 countries emissions of CO_2 by 2030 must be reduced by 40% from base year 1990 in order for temperatures not to exceed 2,0°. Plans have been formed and adopted by several countries. The G20 countries submit 78% of global CO_2 but only 5 have adopted

[6] See *Climate Science Special Report. 4th National Climate Assessment (NCA 4), Volume* I, US Global Climate Change Program 2017

zero-emission goals. But that's not the only systemic issue. According to the *Energy Charter Treaty (ECT)* corporations can sue countries if they put strict limitations or taxes on their oil drilling operations, gas pipelines and other fossil fuel operations. This Treaty have been used by e.g., Swedish Vattenfall which was relieved of environmental taxes concerning one of its coal operations in Germany by suing the German state for €1,4 billion. [7] Another example is that of German coal and gas producer Uniper Gmbh who currently have sued the Netherlands according to a so-called ISDS claim (Investor-State-Dispute-Settlement). Originally the ECT was set up to protect Western European investments in Eastern European countries.

However, nowadays the ECT is used for intra-EU measures to protect "dirty" fossil-based businesses from going green. The consequences of the rising contents of CO_2 in our atmosphere are materializing rapidly. The exhibit below documents that both air and sea temperatures are rising and have been so for a number of decades by using a smoothed average temperature measure.

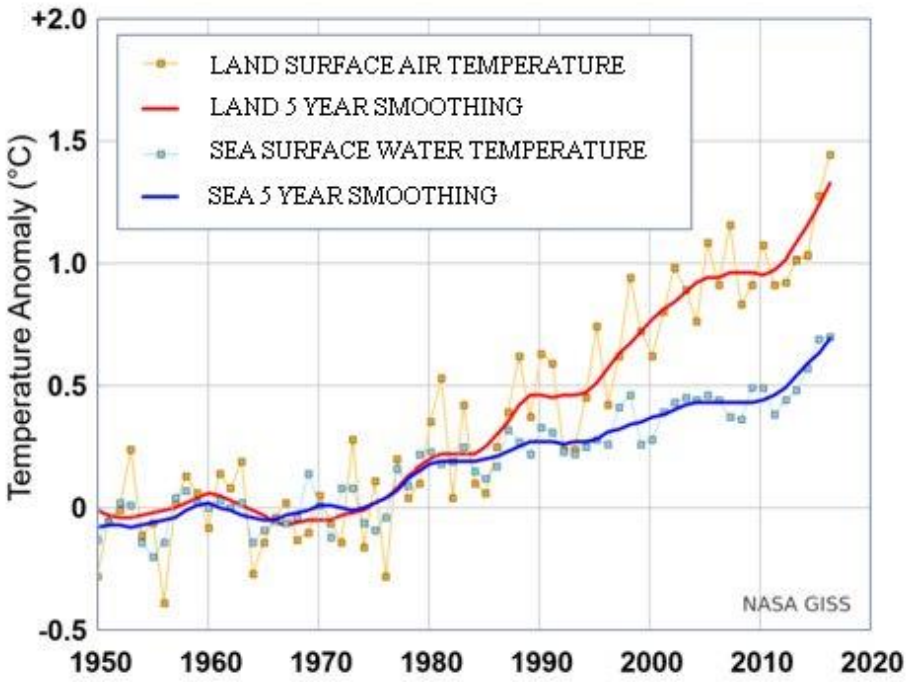


Exhibit 2.40 Short term annual mean land and sea temperatures 1950 – 2017
Source: NASA. 2017

[7] Sum Of US, by David Norton, nov. 2019

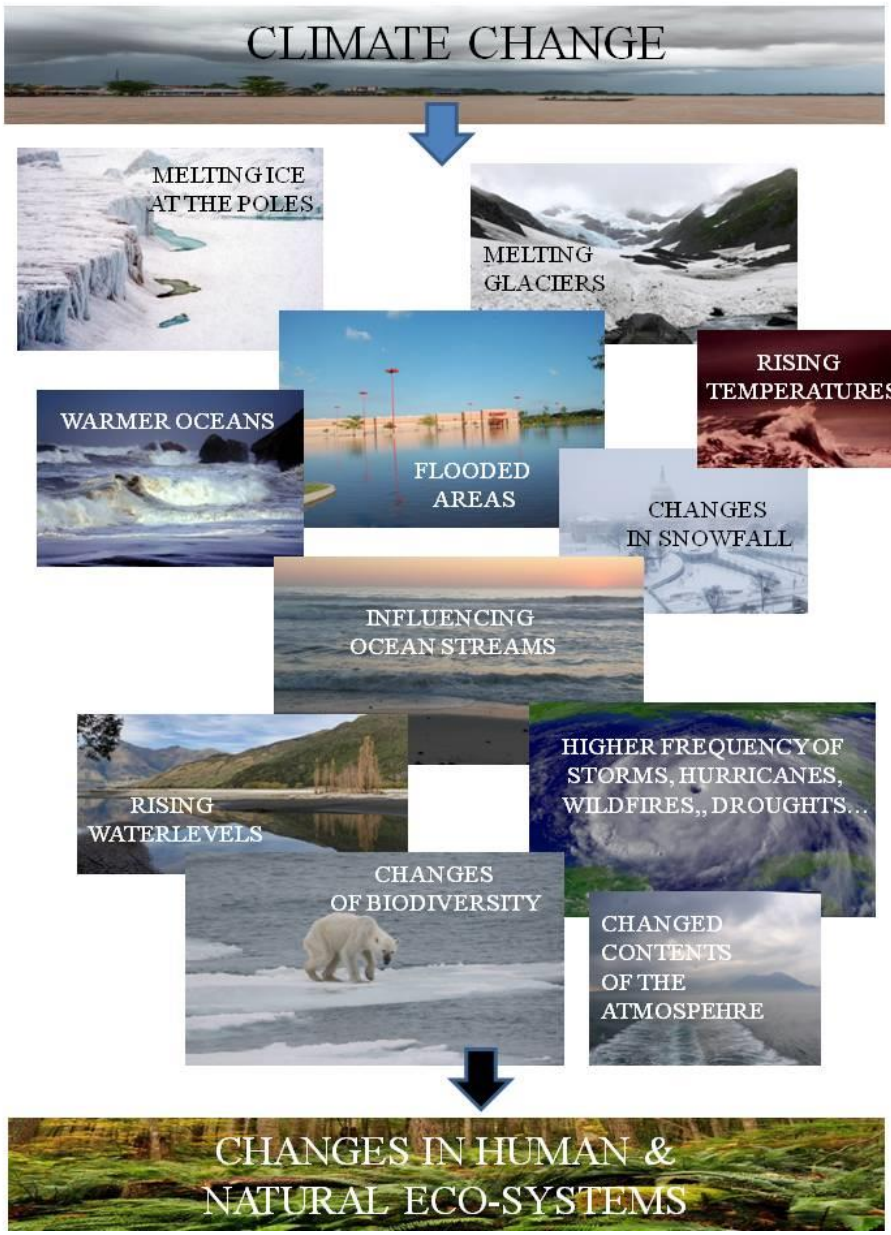


Exhibit 2.41 Direct issues involved in changes to the climate

Consequences of climate change

Consequences can be serious to mankind if we experience a full-blown change in climate. We know that the ice is increasingly melting most places on earth. Temperatures in Greenland are at its highest in years and the ice melting as a consequence runs into billions of m^3. We know that most glaciers are retreating due

to warmer weather and that cold winters with heavy snowfalls are about to vanish in some places. Permafrost areas are about to thaw in Siberia and northern Canada thereby releasing unparalleled tons of methane and other gases into the atmosphere advancing the greenhouse effect. According to the IPCC and others if CO_2 contents rise further, we can expect a rise in sea levels up to 7 meters in 2300. Even with the most conservative assessment we can expect sea level rises of between 3 – 4 meters, acidification of our oceans and sharply decreases in the cryosphere.

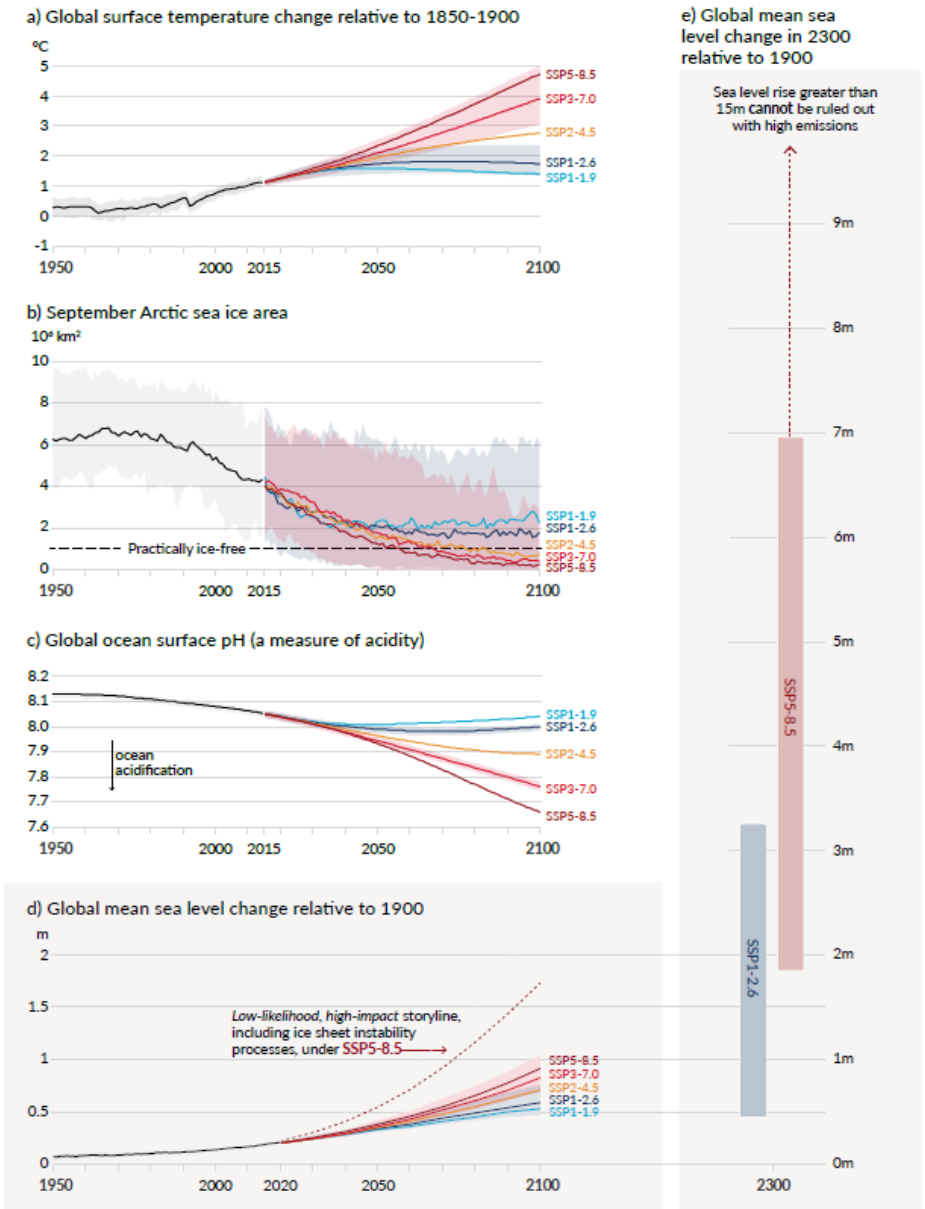


Exhibit 2.42 IPCC scenarios from the AR6 report August 2021
Source: IPCC AR 6

We've already experienced some of the consequences. The Maldives and other areas are threatened due to their physical characteristics. When temperature increases the air can hold more water and this will cause more clouds to form and boost extreme weather events with hurricanes, heavy rain falls and flooding. So rising water levels is already occurring and might develop exponentially during the years to come. This will mean that low lying coastal areas will be flooded, cities and farming areas will be abandoned, and people will move accordingly. Since approx. 40% of the world's population live in coastal cities future problems will be massive. For wildlife dangers are also lurking. When water temperatures change fish migration in the oceans will also change and this has already had serious effects of bird populations along the coastline that feeds their offspring from this vital food source. Things are connected. Besides rising sea levels, we will also see higher temperatures in many places around the globe. Summers will be prolonged, and we will experience recurring heat waves. Precipitation will increase and flooding and hurricanes will be more frequent. The ocean will warm up and become more acidic. So, consequences of climate change in the biosphere are huge, severe and possibly threatening to the conventional life we and our environment have been accustomed to. These effects will force people to move. 2017 saw 18 million climate refugees and this might only be the beginning.

b) Basic environmental problems – biodiversity

If driving a car on hot summer's day you might have noticed that your windscreen does not need washing anymore. It's evidence that something is wrong. Our insects are not there anymore. In 2020 a report in *Science* revealed that 25% of the world's insects have been eliminated during the past 30 years. Since the 1700th century over 700 animals have become extinct as well as more than 80 plants and more than 17.000 species are now threatened and placed on the IUCN Red-list. This number is abnormal. The background rate of species lost to extinction is less than 1 in 1.000 years. To that should be added the loss of habitats all around the globe. More than 32.000 species are threatened on a world-wide scale, and this only count for the 10% of species that has been assessed according to the "red-list" system. Up until now 1,8 million species have been documented but a huge number of species have not yet received this documentation and a number of these might disappear even before this will happen. These are alarming facts, and the alarm bell has kept on ringing for many years unfortunately with only few real measures taken to stop this decline. A recent report from WWF from autumn 2020 collecting evidence from 134 experts all around the world concluded that wildlife has vanished by 68% from 1970 to 2016. [8] In 2018 this number was estimated at 60%. This study concerned 20.811 populations of 4.392 vertebrate's species around the globe. Nature is currently collapsing in front of our very eyes and especially Latin America and the Caribbean are hit hard. In this respect Sir David Attenborough noted that in order to combat this massive decrease it will require a: [9]

[8] *Living Planet Report 2020*, WWF
[9] *The Guardian*, 10. September 2020

"…systemic shifts in how we produce food, create energy, manage our oceans and use materials. But above all it will require a change in perspective,"

I think he's right. We've lost perspective and we've done that for decades. We're actually right now destroying our own global geosphere and we've been doing this knowingly. Not because we want this to happen, but just because it takes second place in our system of values – our perspective!

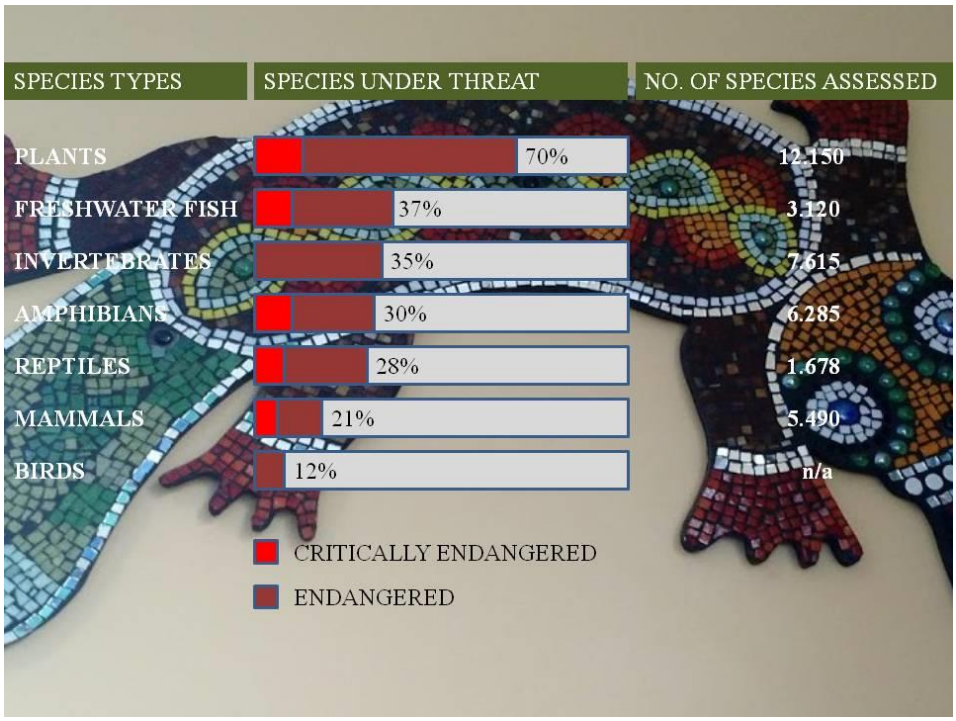


Exhibit 2.43 Species under threat globally
Source: Data - IUCN

The overview given in the Exhibit below indicates that we could very well be on the brink of seeing massive destructions of life taking place around us in the future. An overview of the decline in wild-life population is given in Exhibit 2.44 below. These numbers must give rise to grave concern. In the future they will have profound and devastating effects on our ecosystems. In prehistoric times natural catastrophes were the main cause of mass extinctions. We've now claimed that role for ourselves. This is a symptom of a much larger crisis. We are in fact in the process of killing life around us – and among us. We call this the *biodiversity crisis.* And not only have we killed insects and other species we are also destroying the habitats where they're living so this is a mutually dependent crisis. In 2016 WWF reported that wildlife population had declined 76% (freshwater species), 39% (terrestrial species) and 39% (marine species) and an overall decline by 52%

between 1970 and 2010. With the increase in the biodiversity crisis things look problematic as the latest IPCC report from March 2023 also underlines. Especially around equator serious issues are emerging if temperatures get near +3º - 4º C.

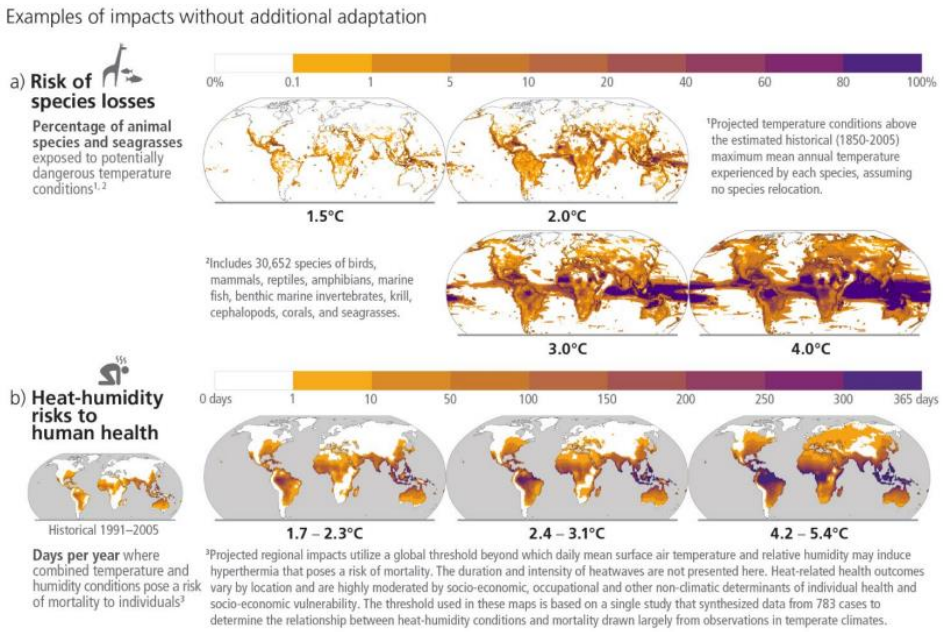


Exhibit 2.44 IPCC projections 2023 – increasing the biodiversity crisis at 3º-4º C
Source: IPCC, March 2023

It matters to us and moreover it matters to the organisms we're killing. If vital elements and dynamics of the biosphere are disturbed or disrupted, we will see changes in our environment that may be even more severe than the climate crisis. Reasons or the decline can be traced back to human activities – invasive species, consumption, poaching, agriculture etc. are all contributing factors that fuels the decline in biodiversity. The chilling factor is the rate of decline we're witnessing. Biodiversity is important because loss of it means depriving future generations of important possibilities for discovering and developing new medicines, experience a natural richness and unfolding human potentials. Furthermore, we can potentially destroy the delicate balance of ecosystems with serious consequences that cannot be predicted due to complexity. However, this is of course an anthropocentric point of view but it's the only one we've got.

If we destroy biodiversity other important links will be missing, and conventional evolutionary processes could be brought to a hold. We would furthermore be missing important opportunities for utilizing nature's unique capabilities.

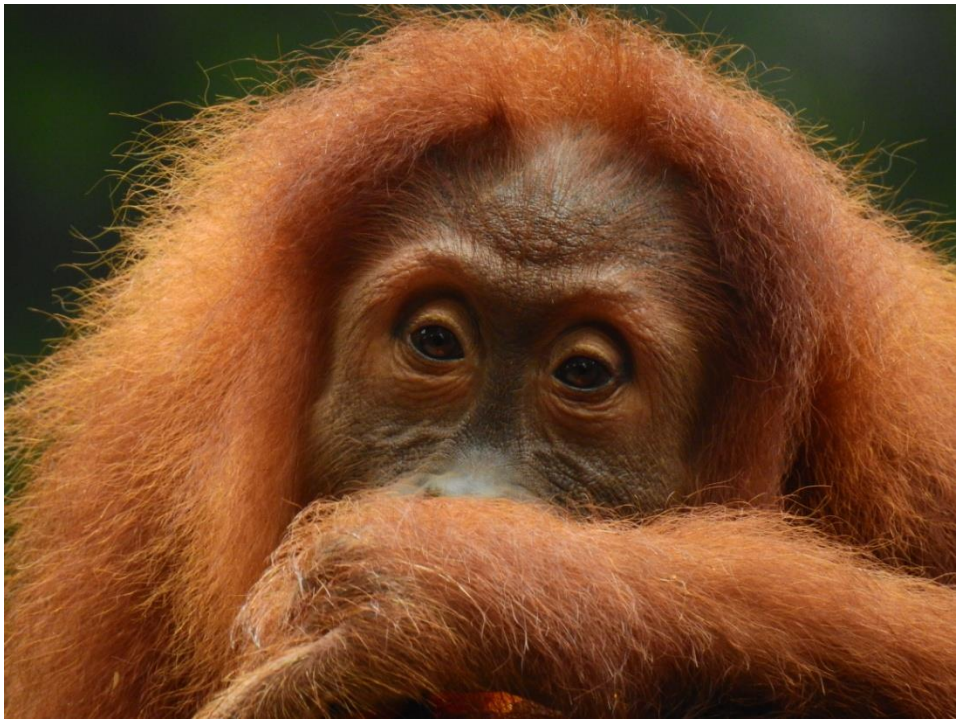


Exhibit 2.45 Orangutan – wondering what human beings are doing?

Let us give an example. At one time a researcher had followed a specific orangutan in the forest of Borneo. He discovered it had problems with carrying its baby orangutan around and seemed to have problems with its left arm. Now, some of the leaves they eat are poisonous and the orangutan knows about 500 different leaves in the Borneo jungle taught to it by its parent orangutan. The researcher then observed that it took a specific leave and put it in its mouth and chewed on it until greenish foam emerged. It then took this paste and rubbed it against its left arm. The researcher quickly made the connection - the orangutan suffered from arthritis. Based on his findings a medical company found a new remedy for treating humans suffering from arthritis.

During the past 4 decades over 60% of the orangutan habitats in Borneo and Sumatra have been destroyed to give way for palm oil production and recent estimates from IUCN suggests that we lose between 3.000 – 5.000 orangutans each year. The example demonstrates what we lose if such trends continue. This is of course not confined to the orangutan but pertains to most species. In Kenya as an example, we currently find the only two living species of the Northern white rhino and in India there are 3 eggs from this species that has been frozen. If fertilization goes wrong, we're about to lose yet another magnificent species and if we lose this, we lose something invaluable - to us and to the world.

A recent study from March 2020 by Trisos, Merow and Pigot publicized in *Nature* [10] suggests that decline in biodiversity will be abrupt and swift. In their high emissions scenario involving a temperature increase of 4º Celsius it is estimated that in 15% of ecosystems 20% of key species would hit their temperature threshold in the same decade. This abrupt change is due to the temperature tolerances of many species that will fall within the same range creating serious implications for wildlife. IPCC estimates that by a temperature change of 3º C we will see 39% of land and forest species experiencing a high risk of extinction and at just 2º C increase 99% of our coral reefs might be gone.

The change can possibly occur before 2030 in tropical oceans and by 2050 for Northern forests. As climate warms up species will be able to cope with a gradual increase and keeping temperature changes below 2º Celsius could allow species better adapt. However, when we pass the threshold for species ability to adapt to this warming up e.g., above 4º Celsius we will reach a point where biodiversity will be in peril. They will look into an abyss that will hit different areas at different times. The researchers looked at different grids around the world (100 km x 100 km) and identified over 30.000 species and combined this with climate models from 1850 – 2006 in order to know when species would exceed their historic temperature range in a 5-year span. Findings suggested that 73% of species would cross the line of their temperature threshold at the same time making biodiversity decline abrupt and swift when looking at the high temperature scenario.

Another research project from 2018 looked at the loss of species (insects, vertebrates and plants) if temperatures could be kept at 1,5º Celsius instead of 2º Celsius by 2100. [11] The metrics used consisted of two: a) "the proportion of species losing >50% of their current climatically determined range, providing a broad-brush indicator of biodiversity range loss comparable with previous studies; and b) the total integrated range loss, providing a complementary indicator of biodiversity range loss that allows the full range of outcomes within taxa to be examined. It has a maximum value of 1, which corresponds to 100% range loss in all species and gives the magnitude of range loss across all species in a taxon".

Results in Exhibit 2.46 below showed that if keeping warming at 1,5º Celsius 50% of all species exposed to a temperature range loss of > 50% would be better off.

[10] See Christopher H. Trisos, Cory Merow & Alex L. Pigot, *The Projected Timing of Abrupt Ecological Disruption from Change,* Nature, No. 580, June 2020.
[11] See R. Warren et al., *The projected effect on insects, vertebrates, and plants of limiting global warming to 1.5°C rather than 2°C, Science*, 18. May 2018

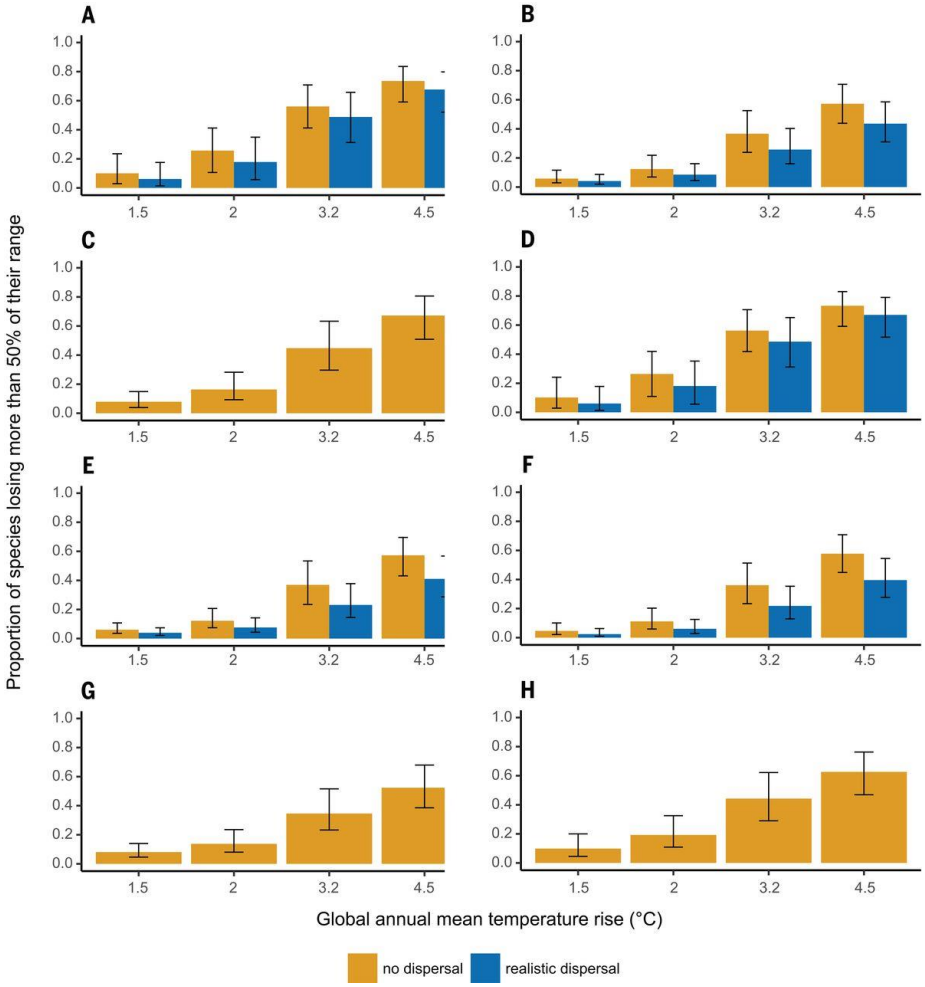


Exhibit 2.46 The proportion of modeled species losing more than half their climatically determined range by 2100 at specific levels of global warming.
Source: The projected effect on insects, vertebrates, and plants of limiting global warming to 1.5°C rather than 2°C, Science, 18. May 2018
Note: (**A**) Invertebrates (*n* = 34,104), (**B**) Chordata (*n* = 12,640), (**C**) Plantae (*n* = 73,224), (**D**) Insecta (*n* = 31,536), (**E**) Mammalia (*n* = 1769), (**F**) Aves (*n* = 7966), (**G**) Reptilia (*n* = 1850), and (**H**) Amphibia (*n* = 1055). Colors: Including (blue) and excluding (orange) realistic dispersal. Data are presented as the mean projection across 21 alternative climate model patterns with error bars indicating the 10 to 90% range.

The projected range loss (temperature range) for all species is shown in the following Exhibit 2.47 for various levels of global warming marked by the different colored lines.

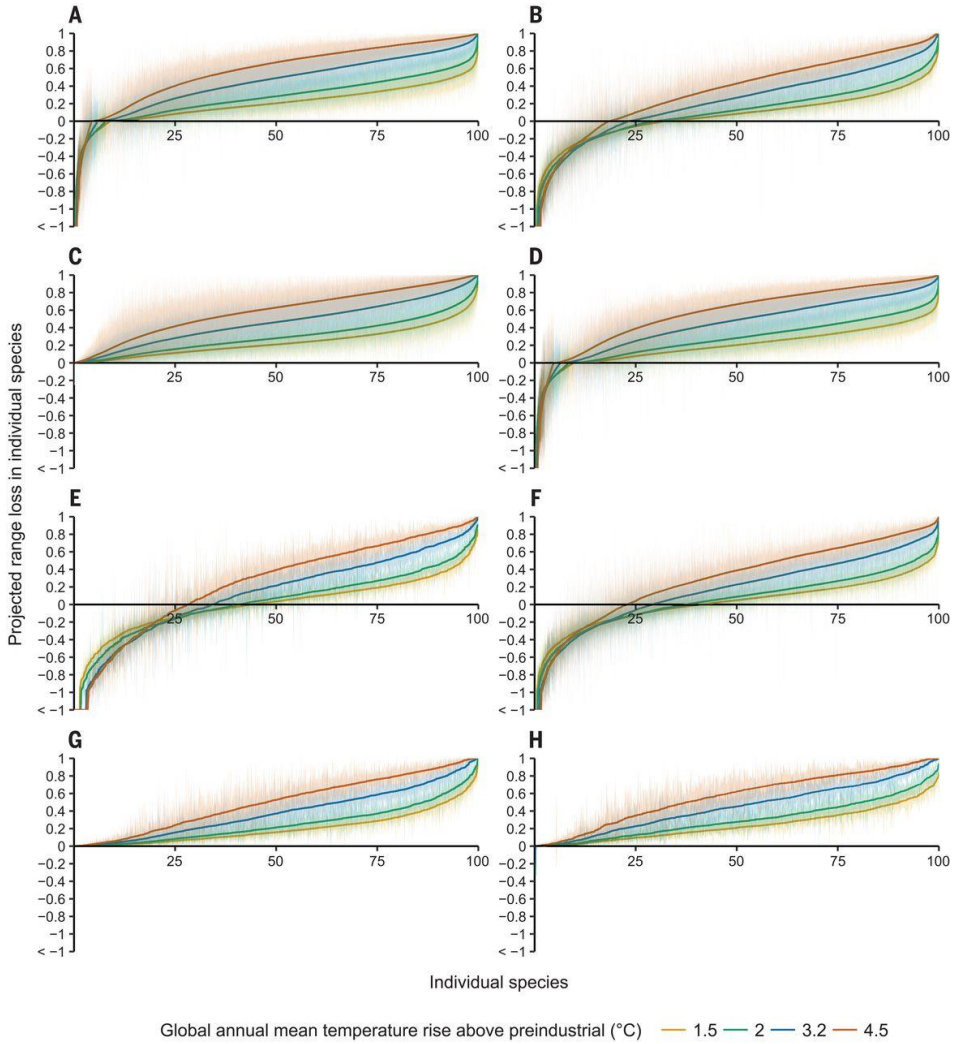


Exhibit 2.47 Projected climatically determined range loss by 2100 for all species at specific levels of global warming.
Source: The projected effect on insects, vertebrates, and plants of limiting global warming to 1.5°C rather than 2°C, Science, 18. May 2018
Note: (**A**) Invertebrates (*n* = 34,104), (**B**) Chordata (*n* = 12,640), (**C**) Plantae (*n* = 73,224), (**D**) Insecta (*n* = 31,536), (**E**) Mammalia (*n* = 1769), (**F**) Aves (*n* = 7966), (**G**) Reptilia (*n* = 1850), and (**H**) Amphibia (*n* = 1055). The proportion ranges from +1 (100% loss) to −1 (100% gain); values <−1 indicate more than 100% gain. *X* axes represent the 0th to 100th percentile of species arranged in order of increasing range loss, normalized by the number modeled in the taxon. Losses for each species are shown as mean and 10 to 90% range across regional climate model patterns as in Exhibit 2.47.

There can be no doubt that biodiversity loss and the climate crisis are indeed related to each other and that there will be far ranging effects whether or not we're able to keep temperature increases below 1,5° Celsius. This conclusion pertains to all species. Current estimates suggests that we are *not* keeping it below 1,5°.

What are the causes of the biodiversity crisis?

We've briefly touched upon this before. Man occupies approx. 50% of the earth's landmass making less room for wildlife. Especially agriculture and horticulture have been among the main forces that have driven developments and animals are deprived of their habitats. Pollution, commercial fishing and hunting, land development and deforestation are other elements. Invasive species is yet another element that can lessen biodiversity. This happens when invasive species are better suited for competing for food and other resources and habitats than their native opponents. This can totally change the elements and processes of an original ecosystem. The best example of this is in fact human beings. The enormous success of the evolution of human beings is beyond comparison. We've eliminated habitats and species, we've changed the basic mechanism of the earth, we've exploited natural resources in a way no other mammals have ever done, and we might now even be on the path of destroying ourselves. So, the finger points towards us when we talk about *the* major cause of biodiversity loss. It is assumed that approx. 70 species in Denmark can be categorized as invasive species. If we look at the Pacific Oyster as an example it was introduced by people from the aquaculture industry because of their growth potential. It was assumed that the Pacific Oyster could not reproduce in the colder waters surrounding Denmark. This was a huge mistake. This Oyster actually thrives and reproduces excellent here and the enormous growth potential of this species means that common mussels and stocks of the original oysters are being more or less wiped out. This will affect bird life too since formerly many seabirds fed from the original stock of common mussels. Since the Pacific oyster has a very thick shell this is not a viable food source for these seabirds anymore and they will vanish together with the decline in the stock of the common mussel. Another example would be that of the Saragossa weed that have meant that the original weed species and sea grasses in the Danish Fjords are about to being heavily reduced. It is thought that ballast water from ships is the main driver behind this invasive species; this point to globalization as a basic force for inducing invasive species and loss of biodiversity.

Consequences of the biodiversity crisis

The overwhelming evidence that biodiversity is at a peril will have serious consequences for life on earth. Our chances of experiencing wildlife will be diminished being left to parks, zoos and enclosures. Our possibilities for finding new medical treatments will be less. Interactions among ecosystems and hence evolutionary developments will be impaired. In other words, we're about to make our planet becoming a biodiversity desert.

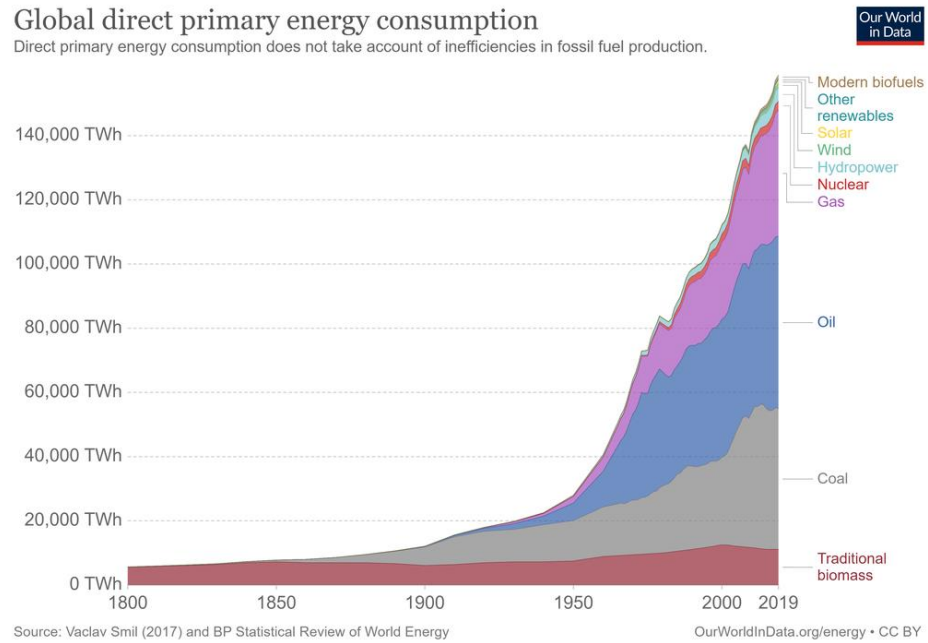
BASIC ENVIRONMENTAL PROBLEMS – RESOURCE SCARCITY

Besides the climate crisis and biodiversity problems we will rate resource scarcity among the most fundamental environmental problems facing future generations. This counts for biotic as well as abiotic resources. This issue was especially promoted during the 1970s when the book "*Limits to Growth*" emerged.

In British Columbia, USA the salmon populations have had a wide-ranging impact on economics, culture, tourism etc. Alarming signals have now for a long time been sounding. The pacific salmon is about to vanish or have been seriously decimated. In 2019 it was expected that 4.795.000 sockeye salmon would enter the Frazier River to spawn, however only 629.000 actually came back. Similar results have been seen all along the West and East coast of USA. The state of the stock of sockeye salmon is now so dire that the authorities warn about an *"imminent threat of extinction"* for some populations of sockeye salmon. Other salmon species like the Chinook are also endangered and some of these populations can be wiped out within the next 10-20 years if nothing is done. However, many issues seem to pertain to the decline of the pacific salmons and variability as to catches and runs are great and still undergoing investigation. There is, however, no doubt that the commercial fish farms in the nearby coastal waters are a serious threat due to the sea lice problem these fish are infected with. When the young salmons – the smolts - enter the sea, they will also be infected when passing the commercial nets in the fjords and that takes a great toll on the stock of wild salmon. The example above dealt with a resource that in fact can be considered as renewable. The problem of resource scarcity also pertains to non-renewable resources like oil, gas, metals and other. These resources are becoming increasingly scarce and there is only one way for these in the future; they will be gone. Nickel for instance is important for manufacturing batteries and supply problems are now beginning to emerge making mining companies interested in mining the deep ocean for nickel. The real problem is the speed by which such metals are vanishing. It has taken us only a fraction of a second to utilize these resources but even 5.000 or 10.000 years from now will only constitute a fraction of human beings' existence. What do we leave for the coming generations in order to fulfill their aspirations? We've so far put our trust in technological developments and more intelligent and considerate use of resources but that might not be any way near enough to accommodate coming generations in the far future. Technology will not be able to replace non-renewables.

What are the causes of resource scarcity?

The answer to this question centers itself around one key issue; human consumption. We simply consume too much to regenerate the earth's reproductive capacity. We live on an earth with finite resources and there only seems to be one way in the future – consumption trends are pointing upwards and resource availability trends are pointing downwards. Let us have a look at the world's energy consumption to get an understanding of how such consumption patterns developed from 1800 to 2019 as demonstrated by Exhibit 2.48 on the next page.



Exhibi 2.48 The Worlds energy consumption 1800 – 2019 in TWh
Source: Our World in Data

This picture very clearly tells us that we are consuming enormous amounts of energy and that this must be seen as an exponential increase spawned by the industrial revolution. Drivers of this change have been the increased population size, technological developments, consumption patterns and economic growth. The picture furthermore tells us that coal (27%), natural gas (24%) and oil (34%) still are primary sources when it comes to the worlds demand for energy accounting for approx. 85% of the world's energy consumption. It also shows us that renewable energy sources slowly have caught on during the last couple of decades. We also know for sure that oil and gas will be gone within the next 200-300 years and that renewable sources with our present knowledge will be the only option available to us. 85% of our present energy sources will be gone by then.

The problem is symptomatic – our resources are in limited supply. The salmon is a resource that in principle is renewable. Many other resources are not. The sources of fossil fuels might run dry in the lifetime of our grandchildren and some crucial metals are now running scarce as well. The answers to the problem have been slow and piecemeal and it seems that politician's time frame is very limited and might even be confined to the next election period. This must be related to the outcry that can be heard from people living 5.000 years from now. Resource scarcity also has another interpretation when we look at resources from a different angle. The Australian koala is an iconic creature and the population in New South Wales has inhabited the state for thousands of years. However, they can be gone before 2050

if nothing is done to help the population. The koala lives of eucalyptus leaves. It's the only food source they are able to eat. These leaves have provided the koala with food and water contained in the leaves. Now it seems that the koala population is about to vanish completely. Since summers in New South Wales have been increasingly hotter and droughts more severe and prolonged there are indications that the eucalyptus leaves are also changing. They do not contain as much moisture as before and this affects the koala. They are now about to die due to thirst. The eucalyptus trees are changing due to climate change and this in turns affects the koala chances of survival. So, water resources when talking about the eucalyptus tree is about to run dry and this will affect both the eucalyptus tree and the koala population as well. Things are interconnected.

Consequences of resource scarcity

Consequences can be dire if basic resources are vanishing and if technology can't cope with such changes – resulting in severe hunger, production shortages, and eventually a real threat to human existence on earth. We must recognize that we're looking into the next million years of human existence on earth and the real problem is what we leave for these thousands of future generations? If we're the "big spenders" those generations will be at a disadvantage, however, this in fact must be the real time span to look at when talking about resource availability in the future. Only a generation of "don't cares" will be able to cope with that aspect – we're about to become victims of our own success. Those non-renewable resources exploited by us will not be available for future R&D, new medicines, technological innovation or future consumption.

Exhibit 2.49 Iconic animal of Australia – the koala

2.5 THE EARTHS SPHERES – WHAT MAKES THE WORLD GO 'ROUND?

When looking at the elements, processes and interactions in natural ecosystem we will describe them as parts of *Earth spheres.* We will see this as comprised of four elements: a) *the atmosphere,* b) *the hydrosphere,* c) *the lithosphere* and d) *the biosphere*. The Earths spheres are defined as the systems, where exchanges of energy and matter take place in and among the four subsystems. *The biosphere* is a label that concerns itself with all living organisms on earth – in other words the inhabitants of the atmosphere, the hydrosphere and the lithosphere. Biotic (living/organic matter) as well as abiotic elements (inorganic matter) will be parts in the overall system.

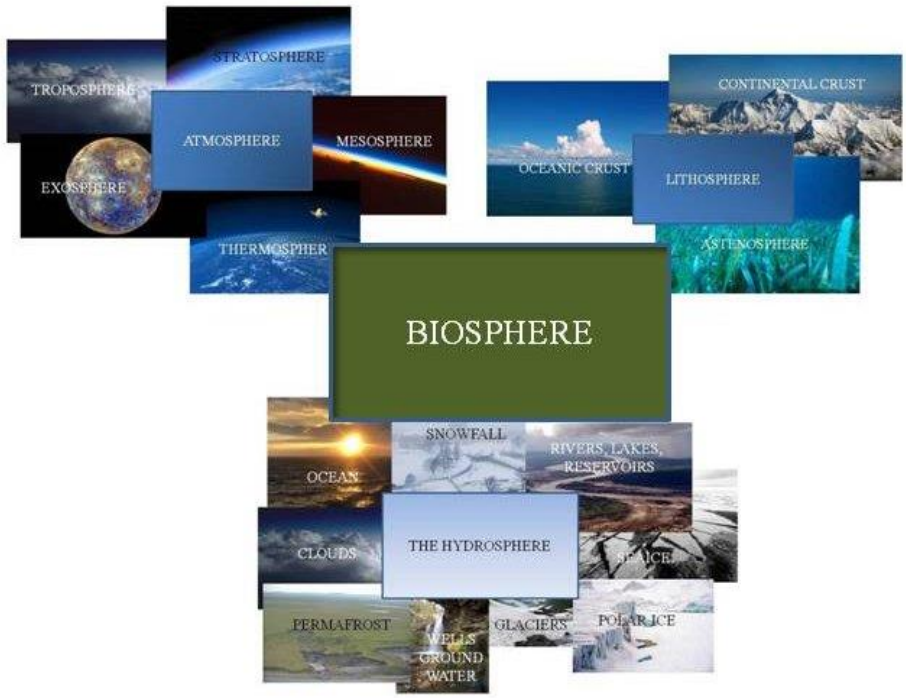


Exhibit 2.50 Earths spheres – atmosphere, hydrosphere, lithosphere & biosphere

A great many changes occur as natural phenomena in Earths spheres – volcanoes erupt, flooding occurs, tectonic plates move, natural fires take its toll on the African savanna and drought can lay the land idle where it former had been a thriving and biodiverse place. Such things occur as parts of a natural cycle. However, a great many changes also occur due to human interventions, and these can have profound effects on nature being outside of – and altering - the natural cycle – cultivating

land, using finite resources, affecting the climate, erecting dams, building cities and highways, emitting harmful substances and so on. We will deliberately separate these two phenomena into *manmade changes* and *natural changes*. We've long surpassed nature as the primary ingredient for changes within our natural ecosystems.

2.5.1 THE ATMOSPHERE

Only astronauts have really experienced the thin blue line that covers our earth. This is the outer layer of the atmosphere that marks the difference between the earth and the cold, hostile outer space that surrounds us. It's hold in place by gravity and comprised of various gases. The atmosphere consists of various layers that differ concerning the amount of *pressure*, *temperatures* and *composition* of its elements or gaseous contents – we have named these layers *the troposphere, the stratosphere, the mesosphere, the thermosphere* and *the exosphere*.

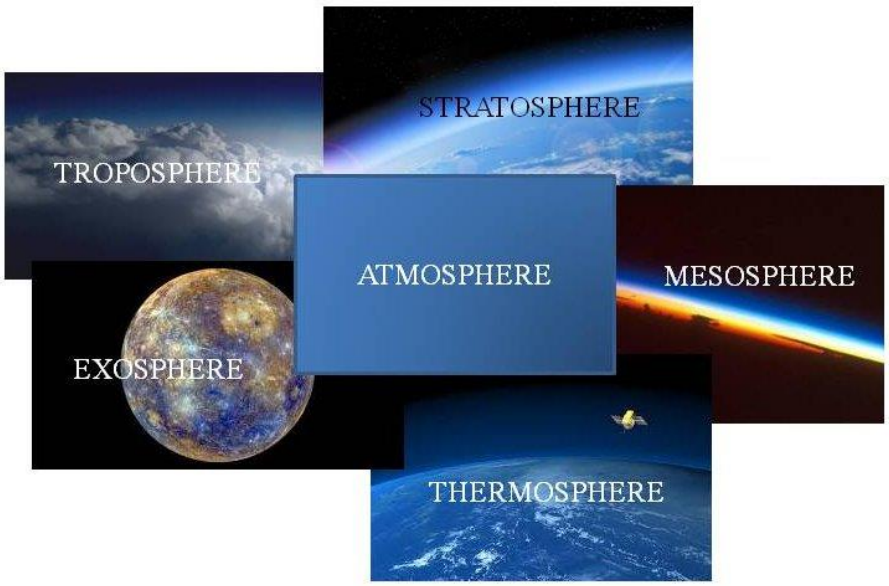
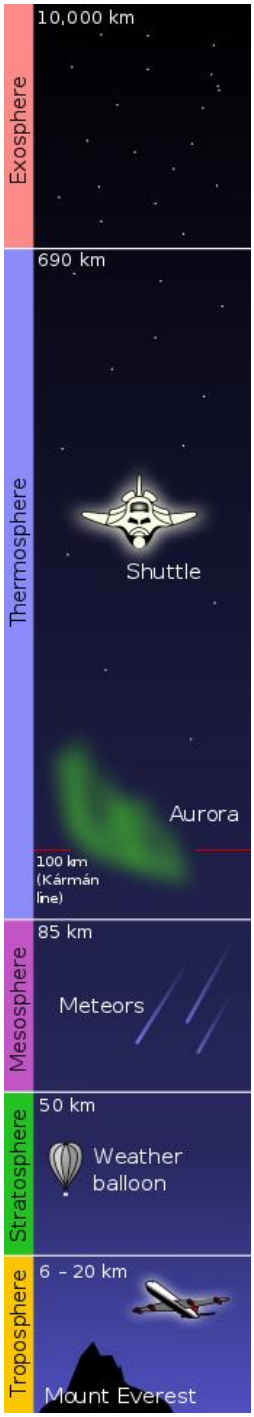


Exhibit 2.51 Elements of the atmosphere

The air covering the earth contains 78,084% nitrogen (N_2), 20,946% oxygen (O_2), 0,934% argon (Ar), 0,041% carbon dioxide (CO_2), and very small amounts of neon (Ne), helium (He), methane (CH_4) and krypton (Kr). To this should be added water vapor that only exists in the lower parts of the atmosphere. This relationship is fairly constant up until 10.000 meters above the earth's surface and as can be seen the overwhelming part of the atmosphere consists of nitrogen and oxygen accounting for approx. 99% of atmospheric contents.



The *exosphere* is the outermost part of our atmosphere. It's comprised of atomic oxygen (O), hydrogen (H), helium (He) and carbon dioxide (CO_2). The exosphere is about 10.000 km thick and when it ends outer space begins. Here at the edge between the earth's gravitational pull and the suns radiation we find the *exopause.* Some have figured out that the end of the exosphere then is about 190.000 km (about half-way to the moon). Temperatures in the exosphere can range between 0º – 1.700º.

The dividing line between the *thermosphere* and the exosphere is called to *thermopause*. Many consider the thermosphere as part of outer space and the Space shuttle, satellites as well as the International Space Station (ISS) all orbits in the thermosphere. Air density is very low in the thermosphere and unlike the lower parts of the atmosphere the thermosphere can get extremely hot. Temperatures in the upper part of the thermosphere can range between +500º to +2000º depending on whether it is night or day and variations in solar activity. The components of the thermosphere are made up of atomic oxygen (O), atomic nitrogen (N) and helium (He). In the thermosphere much of the sun's radiation is absorbed.

In the *mesosphere* temperatures will drop with increasing altitude and can reach -90º within the so-called *mesopause* - the upper part of the mesosphere. This is the coldest part of the earth's atmosphere. The mesosphere is dry, however clouds can form – so-called *noctilucent clouds*. In the mesosphere incoming meteors mostly evaporates.

The *stratosphere* is characterized as being less volatile than the troposphere and temperature rises when moving up through the stratosphere and does not contain water vapor like the troposphere. It's dry and the air is thin. Ozone (O_3) is an important part. The upper part is the so-called *stratopause.*

The air in the *troposphere* is the primary ingredient in shaping the earth's weather and pressure and temperatures fall until they reach -56º when they become fairly constant. This is the outer layer of the troposphere called the *tropopause.* Heavy winds and the so-called Jetstream are at play in the troposphere.

Exhibit 2.52 The atmospheric layers of the earth
Source: Wikimedia

In the *troposphere* there is an average drop in temperatures by approx. 6,5° per kilometer called the *environmental lapse rate*. Near the stratosphere – in the tropopause – temperatures sink to above -50°. In the *stratosphere* the rising temperatures are due to the absorption of the sun's ultraviolet radiation by the ozone layer. These temperatures range between averages of -51° near the troposphere to – 15° near the mesosphere.

SOLAR RADIATION

The atmospheres composition is important when it comes to solar radiation. If it weren't for its chemical composition all life on earth would be impossible. The so-called ozone layer protects us from solar radiation. The sun emits energy being powered by its continuous nuclear fusions going on. It travels through space and hits the earth with a mixture of wavelengths. Some of this is visible short-wave light the other part is near the infra-red spectrum being invisible to our eyes – please refer to Exhibit 2.53 below.

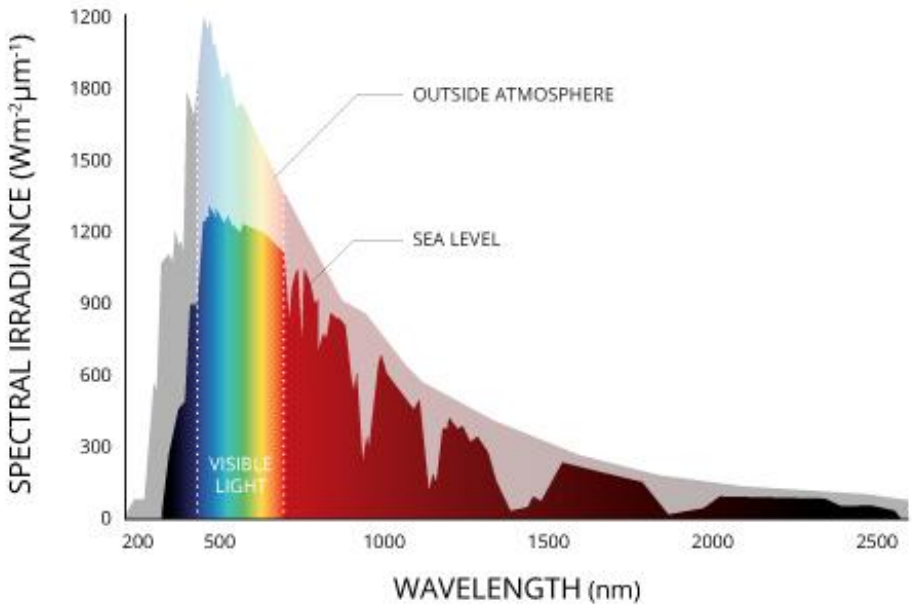


Exhibit 2.53 Solar radiation
Source: www.fondriest.com

It is in fact just a part of the radiation we actually can see in form of colors. Others are outside of our ability for recognizing these wavelengths. This counts for gamma rays, x-rays, ultraviolet and infrared light. Basically, the earth is hit by short-wave radiation and will then emit long-wave radiation back into space. This equilibrium has constituted a general rule. Now this equilibrium is affected by increasing amounts of greenhouse gasses.

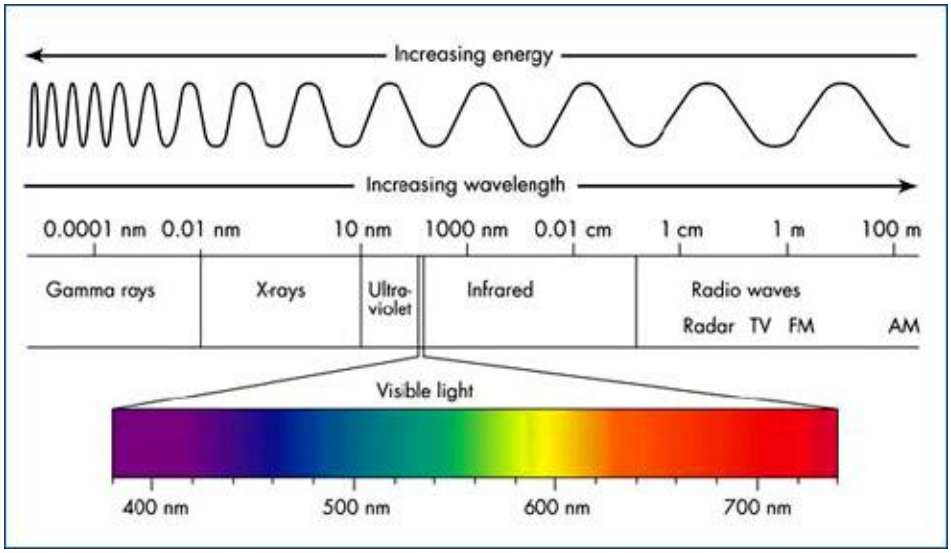


Exhibit 2.54 Wavelengths

Being exposed to radiation with short wavelengths can be detrimental to an organism while other radiation e.g., infrared and radio waves do not harm an organism. We can see the effects of e.g., ultraviolet radiation when sunbathing. If being exposed a certain amount of time the skin can be affected to the point where it begins leaving wounds caused by the ultraviolet radiation received.

The earth's *magnetic field* is another element that protects us from solar radiation. We can actually visualize this magnetic field when we experience the Northern Light phenomenon. When the sun ejects its solar whirlwinds from its 1-10 million Celsius heated plasma surface (*the Corona*) it emits loaded particles (neutrons and electrons) that is deflected by the earth's magnetic field. If this magnetic field weren't present these particles would inflect devastating effects on the ozone layer and life would not have been possible. When the loaded particles hit, they will boost formation of nitrogen oxides that are particularly harmful to the earth's ozone molecules (O_3).

It is thought that - like the protective layer around the earth - such a protective layer was also found on Mars maybe 3,5-4,0 million years ago when Mars experienced similar conditions we experience on earth today – a protective atmosphere, approx. 25º C, water covering large parts of Mars etc. However, this protective layer was less effective and an important gas – CO_2 - seeped out and left Mars as the lifeless sandy and rocky planet we know of today. So, the protective layer around the earth is of paramount importance to life and the earth's magnetic field is a part of this protective layer.

Exhibit 2.55 Northern Light flashing over the church in Vik, Iceland

JETSTREAMS IN THE ATMOSPHERE

The airspace also contains currents like our oceans do and one of these important currents is called the *Jetstream*. Near the tropopause we will find heavy winds blowing divided into *polar jets* and *subtropical jets* with both jets found in the Northern as well as the Southern hemisphere. The polar jets can reach speeds up to 400 km/h. Jets also exists in lower levels of the atmosphere. They occur because air masses with different temperatures collides giving rise to winds speeding up. In areas at high altitudes where air friction is lower winds can build up more freely.

The flow, speed, cycles and direction of these Jetstreams have important implications for how the weather unfolds in different parts of the globe. It affects low and high pressures, precipitation and temperatures distributed over large areas of the globe. Furthermore, it seems that the Polarjet sometime is splitting into two creating a sort of heat trap that can possibly account for the excessive heat over Europe. This also means that *if* the Jetstream is changed the world's weather system will change as well. The ten-dollar question is then if changes in our weather systems could possibly change the speed and direction of the Jetstream? During 2012 – 2018 Greenland saw periods of cold weather and the Jetstream was a contributing factor to that. In the future one might possibly expect that the Jetstream will behave differently than today thereby eventually causing weather to change as well and if that happens, we're in for an increase in the melting of the ice in Greenland, prolonged periods of heatwaves and changes in precipitation.

ENVIRONMENTAL PROBLEMS - THE ATMOSPHERE

Environmental problems in the atmosphere are serious since they will affect other systems – things are interconnected. So, while we may term them atmospheric problems, they will have large scale impacts on other systems as well. So let us look at some of the issues that materialize as environmental problems in the atmosphere based on scientific evidence collected so far.

Air temperatures rising

The meteorological authorities in Denmark noted a record temperature when Copenhagen on 15th January 2020 witnessed a temperature of 11,9º C. This is not a singular event. It's part of a broader picture around the globe. Europe for example has never recorded higher temperatures during winter than was recorded in 2021 and on a global scale temperature has seen record breaking average temperatures during the last 7 years (2015-2021). For the past 10.000 years changes in temperatures never were above 1º C. Today we are at 1,1º C and rising. So, air temperatures increase in the global weather system and will impact ocean temperatures as well. These consequences will ultimately impact the whole weather system giving way to more severe storms, heavier rain falls, longer periods of drought, rising water levels and so on ultimately impacting all ecosystems and their way of working. The reason for air temperatures rising is above all caused by the greenhouse effect that traps heat in earths systems. The IPCC has tried to assess future temperature increases according to various scenarios. Results are alarming.

SCENARIOS	Near-term 2021-2040 Very likely range	Mid-term 2041-2060 Very likely range	Long-term 2081-2100 Very likely range
SSP1-1.9	1,2-1,7 C	1,2-2,0 C	1,0-1,8 C
SSP1-2.6	1,2-1,8 C	1,3-2,2 C	1,3-2,4 C
SSP2-4.5	1,2-1,8 C	1,6-2,5 C	2,1-3,5 C
SSP3-7.0	1,2-1,8 C	1,7-2,6 C	2,8-4,6 C
SSP5-8.5	1,3-1,9 C	1,9-3,0 C	3,3-5,7 C

Exhibit 2.56 The IPCC's scenario predictions of temperature rises 2021-2100
Source: IPCC 6th Assessment Report

The base period is 1850-1900 and changes ranges from 1,2º – 5,7º C depending on the scenario in question. These hotter temperatures will spur extreme heat waves and a 10-year event as well as a 50-year event has been indicated by the IPCC below giving the intensity as well as the frequency. It will be 5,1º C hotter (global warming level is increased by 4,0º C) we will see heat waves 9,4 times more often – up to 55º C. If we once again reckon that the global warming amounts to an increase of 4,0º C we will see a 30,2% wetter environment occurring 2,7 times more often in a 10-year perspective (Exhibit 2.57 below). So, temperature rises do not happen in isolation but will provoke a number of other events to happen.

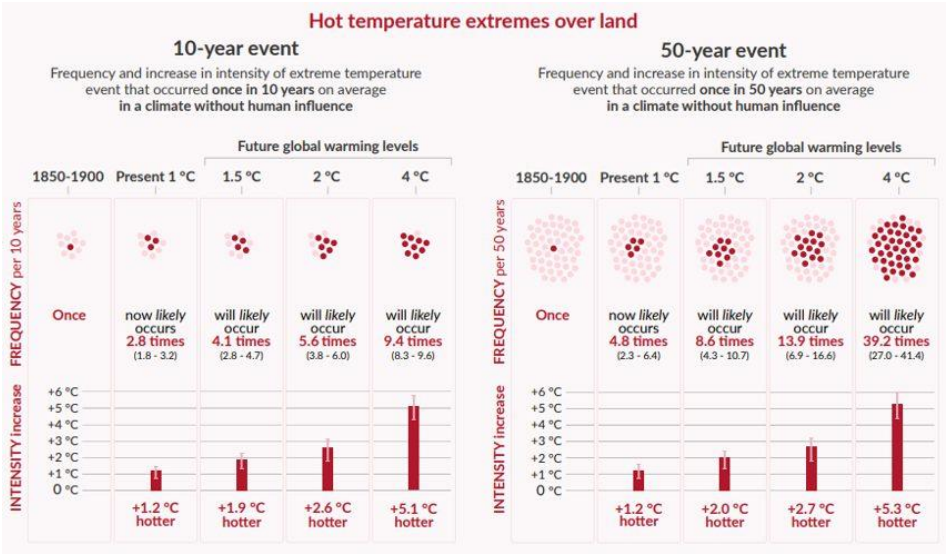


Exhibit 2.57 10 year and 50 year extreme events for various scenarios – heat waves
Source: IPCC 6th Assessment Report

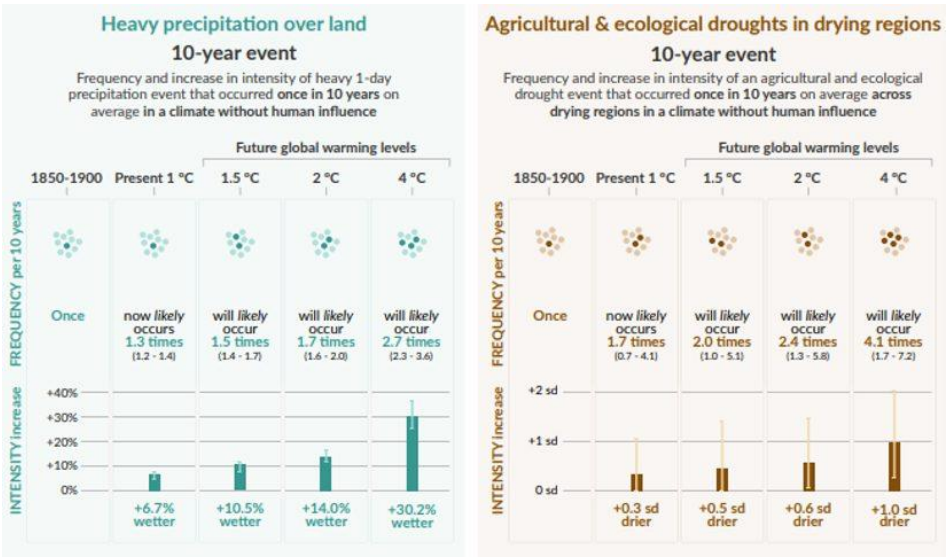


Exhibit 2.58 10 year and 50-year extreme events for various scenarios – precipitation/droughts
Source: IPCC 6th Assessment Report

Ozone depletion

The stratospheric ozone layer protects us from incoming shortwave radiation from the sun and is a vital element in the atmosphere. Near the earth ozone on the other hand can cause respiratory problems for humans and damage other elements of the ecosystem. So, there is a god and a bad side to the ozone issue. The ozone layer is of vital importance to the earth's climate. Ozone is formed when shortwave ultraviolet light (UV-B rays) from the sun hits the oxygen molecules in the air. These will be split in two forming two atomic oxygen atoms (O) that will react with other oxygen molecules (O_2) to form ozone molecules (O_3). When propellants, refrigerants and solvents such as CFC, HCFC's gases and others reach the stratosphere it can weaken the ozone layer by splitting these ozone molecules (O_3) into oxygen (O_2) and atomic oxygen (O) by reacting with chlorine (Cl) and bromine (Br) thereby letting more solar radiation reach the earth. This can cause increased number of skin cancer incidents and genetic damage thereby affecting ecosystems. So, protecting the stratospheric ozone layer is of utmost importance. The "ozone hole" started a big controversy back in the mid-1980s. Alarming signals went out and reactions to the "ozone hole" were global. This now, however, fortunately seems to have stabilized and is expected to reach its pre-1980s ozone level in 2075. So doing something about environmental problems on a worldwide scale can definitely help combat such problems.

Aerial borne pollution

Several gases and other elements are a part of the earth's atmosphere. They partly stem from natural sources, partly from human sources. Gases such as CO, CO_2, CH_4, NOx, VOC (Volatile Organic Compounds) and others can cause the greenhouse effect. Fires from potentially deadly sources such as chemical plants, fertilizer plants and others can have serious effects locally while erupting volcanoes can spread their exhausts over hundreds – even thousands - of kilometers. The wind can carry infections and diseases as well as micro plastics around, sandstorms can rise and spread over large areas. The same is true for particles emitted by vehicles. In the old days the plague, bacteria, viruses etc. took the lives of millions of people. These days are fortunately gone but we still find outbreak of deceases like SARS, MERS and Covid-19 that we initially find difficult to treat. No vaccine can cure SARS. In recent years we've seen spreading of viruses through the air by coughing forming pandemic outbursts of illnesses. The SARS *(Severe Acute Respiratory Syndrome)* and the MERS (*Middle East Respiratory Syndrome*) have been examples and in 2020 the Corona virus (Covid-19) spread from China to a number of other countries that craved the lives of nearly 7 million people world-wide. This has nothing to do with systemic environmental issues but will nevertheless be an important issue in future developments. However, the day a mutated resistant virus or bacteria spreads we might be in for the next pandemic catastrophe and this resistance has everything to do with environmental issues because resistance can be formed by mutations that stem from exposure to chemicals, pesticides and other substances. During the Spanish Flu in 1918-20 – the worst example of a pandemic virus - some 50-100 million people died. Formerly lead was one of the additives of

gasoline and when exhausts were formed huge contents of lead spread via air later to be deposited in our lakes, rivers and soil. So, winds in the atmosphere are a source of a great variety of causes for environmental damage, sicknesses and natural phenomena to occur. However, the "aerial pollution" also embraces unpleasant smells as well as noises. Neighbors are sometimes exposed to these when farmers spread manure and when manufacturing facilities emits various exhausts from its plants. The same is true when we talk about noise. Windmills for example emit noise from the spinning of its wings and this sometimes inflicts problems for neighboring settlements and exposure to high frequencies can cause various physical and psychological problems for those exposed, wildlife included.

Massive decrease in number of birds and insects

In September 2019 scientists reported that 29% or approx. 3 billion birds had vanished from USA and Canada since 1970. More than 50% had vanished from e.g., the grasslands according to this study. It's by far the most comprehensive study of avian animals that has ever taken place in the US and results once again are alarming. Some biologists call this: *"a full-blown crisis"* other say: "*we were just stunned by the result – it's just staggering*". In Europe populations have dropped similarly with over 50% birds being lost during the same period.

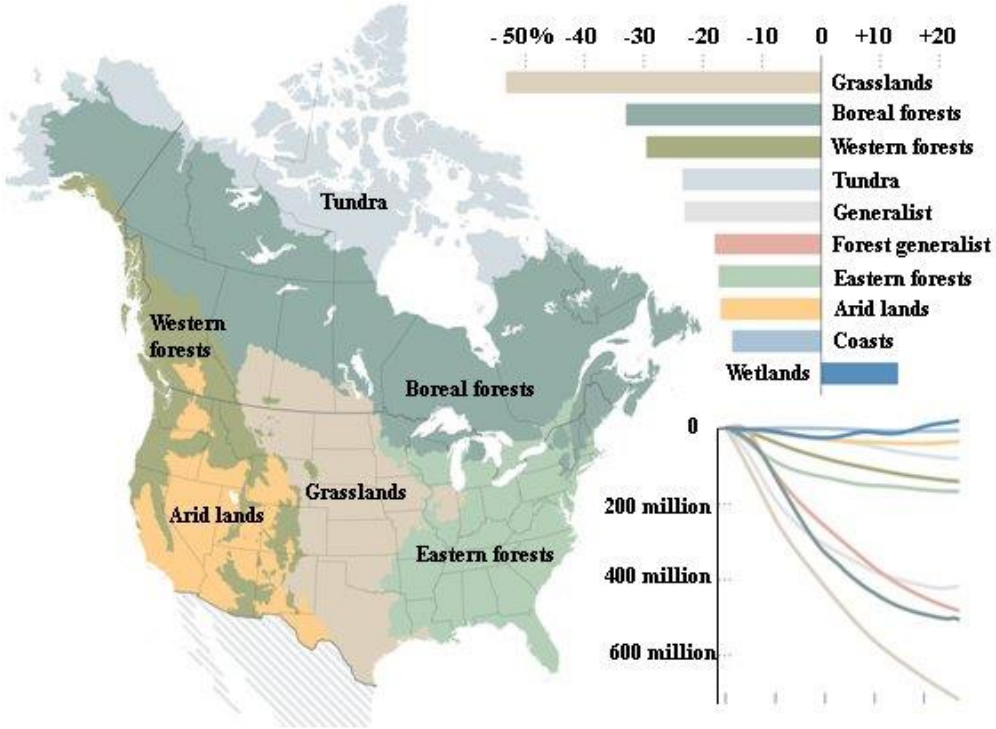


Exhibit 2.59 Bird population change since 1970 by breeding habitat
Source: Adapted from Science, September 2019

More than 500 species were examined by use of bird counters and weather radar, and it was found that e.g., warblers had declined by 617 million species; blackbirds had dropped by 440 million. So, it seems that "silent spring" is now returning to America. Loss of habitats, modern agriculture, drainage and extensive use of pesticides are among the most likely causes of this drop in bird populations.
The same tendency can be observed in Europe and elsewhere on a comparable scale. Insects are an important part of bird's diets and an important element in the food-chain. A world-wide study from April 2019 indicated that Europe has lost 80% of its insects measured as biomass during the last three decades. Some 400 million birds have vanished with them. A recent study of the German populations of arthropods revealed the same tendencies.[12] Some researchers now claim that we are close to a mass extinction comparable to the extinction of the dinosaurs 65 million years ago or the extinction during the Permian period some 250 million years ago. Once again, the use of pesticides in commercial agriculture was seen as a main driver of the decline as well as deforestation, urbanization, loss of habitats and conversion to farmlands. The numbers are once again alarming since insects are a vital part of the food chain. They act as important pollinators and drivers for ecosystem diversity and might constitute the next important food source for human beings being rich of unsaturated fats and proteins.

When the bird and insect population are being decimated in numbers it will also have a considerable effect on behavior. In Australia for example only 400 birds of the Regent Honeyeater (*Anthochaera phrygia)* exist, and each bird will have about 70.000 km^2 at its disposal. This vast territory means that the young male birds have lost their ability to sing. This ability has normally been adopted by listening to older male's song repertoire. When gone the young males are left in the dark and this will have serious impacts on the behavioral patterns of these birds.

Acid rain forming

Acid rain occurs when precipitation becomes richer in hydrogen ions which then are spread to the lithosphere and hydrosphere. Sulfur dioxide (SO_2) stemming partly from phosphorous as well as volatile organic compounds (VOC), NO_x and chlorine (Cl) all do theirs to pollute the atmosphere. Acid rain is - as the name implies - acidic (low pH) and when the rain falls into our lakes and reservoirs it will alter their chemical composition. The lakes itself will turn acidic and when this happens all life in the lake can eventually die. The reason for the formation of acid rain is most of all due to the existence of SO_2 in the atmosphere. This sulfur dioxide will react with the water molecules in the atmosphere and form acid rain with cloud formation. Precipitation will then deposit SO_2 in our water systems and on land as well. The anthropogenic sulfur contents are emitted from cars, smokestacks, power plants and other industrial and private facilities.

[12] *Arthropod decline in grasslands and forests is associated with landscape-level drivers,* Nature 30. Oct. 2019, by Sebastian Seibold et. al.

Sulfur oxides and photochemical smog

Due to emissions of many kinds of gaseous contents (aerosols) and their chemical reactions in the atmosphere but especially exhausts – sooth - from vehicles (primary aerosols) the air we breathe in our cities are filled with different harmful substances. Basically, some air masses are containing sulfur oxides; some are containing particles matters, nitrogen oxides and hydrocarbon called *photochemical smog*. In London from 5th December to 9th of December 1952 more than 4.000 people died as a direct consequence of the smog and each year these exhausts, particles, oxides etc. causes the death of thousands upon thousands of people all over the world. We usually call it *smog* – an acronym for smoke and fog. It has gotten so bad that at times big cities around the globe will be covered in a haze of smog and vehicles might be banned from entering the city. As an example, it has been estimated that approx. 1.700 people die each year in the greater Copenhagen area as a consequence of air pollution and a study indicates that up to 30% of all deaths in China are caused by air pollution. On a world-wide scale approx. 7,2 million people each year die of smog related problems the EU accounting for 309.000 of these.

Exhibit 2.60 Shanghai, China covered in a layer of smog

Photochemical reactions also pave the way for low level ozone (O_3) that potentially can cause health problems if meeting or exceeding 70 ppb for more than 8 hours. Especially a city like Beijing is hit hard by excessive amounts of smog due to massive emissions and climatic conditions. Big cities all over the world are suffering from such consequences. The side-effects of the Covid-19 suddenly made such cities experience a period of being able to breathe clean air once again. However, unlike deaths caused by e.g., terror, smog is a silent killer. During the

past *five* years from 2014 – 2018 altogether 364 people have been killed as a result of terrorist attacks in Europe - one fifth of what has been killed in the city of Copenhagen in just *one year* related to air pollution. This shows something about the disproportionate reactions in the political environment if human lives were the ultimate point of concern and not mass psychosis. Besides emissions from vehicles grilling, fireplaces at home and VOC from paints etc. also causes smog problems to emerge (secondary aerosols creating photochemical smog).

Altering the Jetstream

Jetstreams can impact the weather system by affecting cyclones to form, by impacting storms and hurricanes, by transporting matter over vast areas, by affecting precipitation and temperatures. Jetstreams thus become an important part of weather predictions and will have a huge impact e.g., on airline companies' costs when it comes to flying against or with the Jetstream. Likewise, it can give us cold winters or warm winters because it separates low- and high-pressure weather fronts. How global warming will affect the jet stream is not fully understood but some scientists have claimed that it will weaken the speed of the Jetstream by reducing the temperature differences in air masses that drives the Jetstream. This could potentially have large scale effects on our weather system.

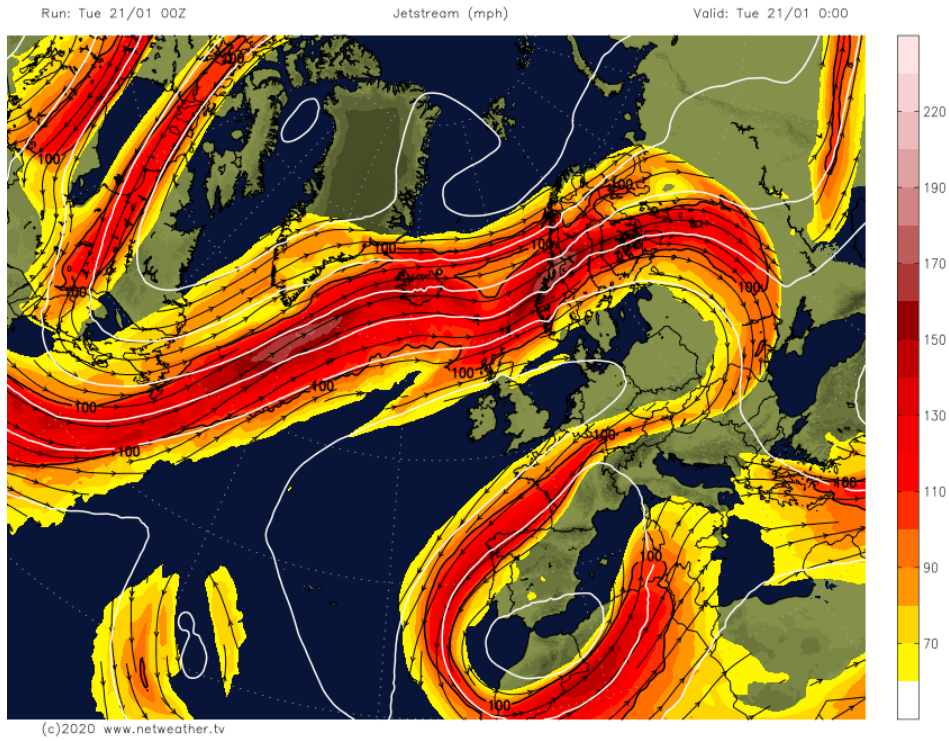


Exhibit 2.61 Forecast of the jetstream over Western Europe, Greenland etc. in 2020
Source: Netweather.tv

Increase in disruptive weather phenomena – storms and rainfalls

According to the World Meteorological Organization (WMO) we've seen a five-fold increase in extreme weather conditions during the past 50 years. Rainfalls are becoming more intense and concentrated; storms and hurricanes have increased in numbers as well as in their intensity. In short, we'll have to adjust to another type of weather in the decades to come. In July 2021 Germany experienced unprecedented flooding in Rhineland-Westphalia with more than 200 casualties and property damages worth billions of Euros. In 2006 hurricane Katrina hit the southeastern USA claiming more than 1.800 lives. Costs of Katrina amounted to 125 billion dollars. The same phenomena have been seen all over the globe and will increase.

2.5.2 THE HYDROSPHERE

The *hydrosphere* consists of water in all its forms - below, on and off the earth's surface - and water is a primary ingredient for sustaining life on earth, so it is no wonder that our planet is called "The Blue Planet" - water covers approx. 71% of the earth's surface. Of this saltwater is the most common part of the hydrosphere – it accounts for 97,5% while freshwater accounts for the remaining 2,5%. Of these *ice* accounts for approx. 69%, *glaciers* 30% and our *lakes, rivers* and *reservoirs* constitute a minor 0,3% of the hydrosphere's freshwater contents. This also means that changes in the amount of ice contained at the poles, permafrost areas and glaciers will have a large effect on eco-systems when a warmer climate unfolds.

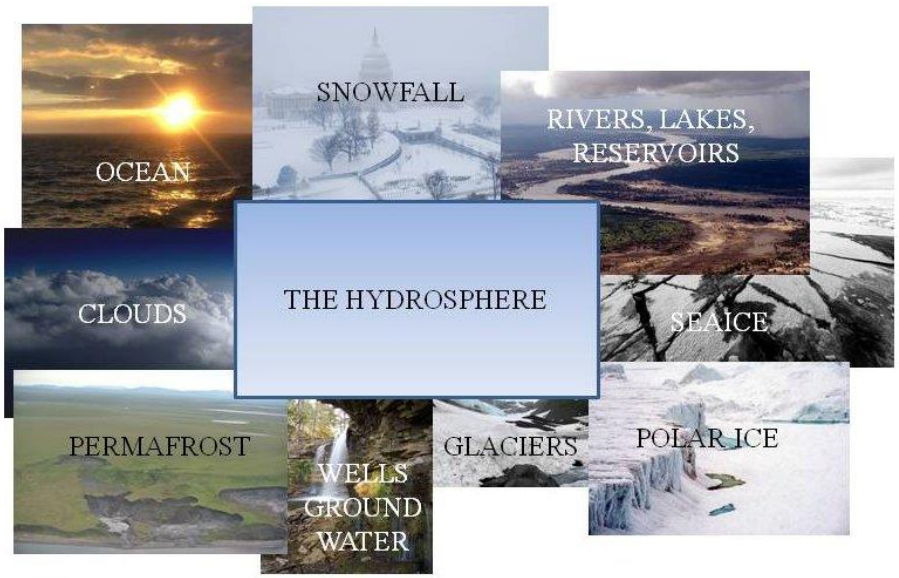


Exhibit 2.62 Elements of the hydrosphere

The frozen parts of the earth's hydrosphere is called the *cryosphere.* Approx. 10% of the land surface of the earth is covered by ice sheets and glaciers. There are some specific qualities that apply to the hydrosphere among these the pH factor and salinity.

BUILDING BLOCKS OF THE HYDROSPHERE - WATER

The basic formula for water is the familiar molecule H_2O that is two hydrogen atoms and one oxygen atom. Water is a basic ingredient for the formation and survival of life. Water also comes in a form of semi-heavy water and heavy water increasing the mass compared to H_2O. How water ended up on this planet is still not known and cosmologists are very interested in discovering possible water resources on other planets – without water, no life. Water comes in the form of a *liquid, a vapor* or as *solid* - ice. Besides hydrogen and oxygen atoms water also contains different salts and minerals.

A distinction is often made between *surface water* and *groundwater*. While surface water is caused directly by precipitation or wellsprings, groundwater can take decades to form. During its journey towards the groundwater reservoir, it can be purified by bacteria found in the soil or it can be contaminated by e.g., pesticides used for agricultural and industrial purposes. We also make a distinction between *freshwater* and *seawater*. The basic difference between these two is the contents of salt contained in the water. In e.g., lake Retba in Senegal, Africa you will find a content of 400g/kg salt while the Baltic Sea in Northern Europe just contains 10g/kg. This puts a demand on the wildlife living here to adapt to these circumstances.

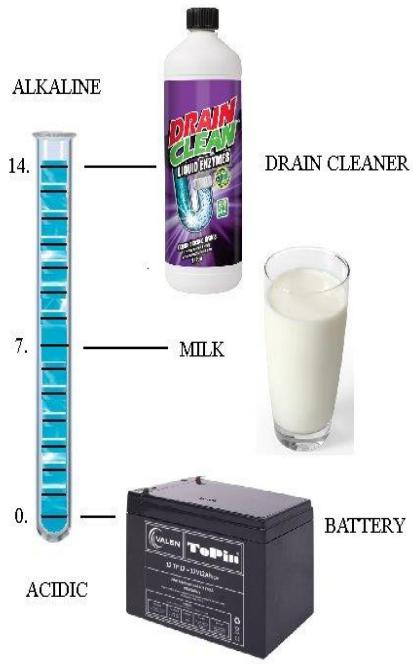
This leads us to yet another distinction, that of *potable* or *drinking water* and *wastewater*. According to the WHO (World Health Organization) safe drinking water *"does not represent any significant risk to health over a lifetime of consumption, including different sensitivities that may occur between life stages".* In some countries we get tap water that will meet the regulatory standards set forth by the authorities. In other countries water might have to be boiled or otherwise treated before being used for drinking purposes or preparing foods. Wastewater stems from industrial operations, toilets and other household applications, livestock etc. One of the main problems is if water quality standards are not met requiring you have to use bottled water. This adds a strain on resources for tapping, transporting and retailing this resource.

Since water is a necessary commodity it can be in short supply at times and the way to manage this resource will be different in various parts of the world. In the USA water rights are question of private property that owners can sell. In Denmark water supply mainly is undertaken by companies that for the most part don't hold private property rights. The price of your water consumption is determined by the costs

associated with pumping the water from groundwater reservoirs and distributing it. Such costs are controlled by the authorities and considered a common good that nobody can profit from. Since access to water is crucial it is no wonder that conflicts previously have been seen and, in the future, also will be a part of the conflict zone especially in areas where water supply is limited or being exhausted.

BUILDING BLOCKS OF THE HYDROSPHERE – THE pH FACTOR

One of the attributes of e.g., water is its level of acidity or alkalinity. Everyone knows that a lemon has a certain bitter taste – it's *acidic.* Likewise, everyone knows the taste of soap when it gets into your mouth or gets into your eyes – it's *alkaline.* A measure of such differences has been invented – the so-called pH factor ("*p*ower of *H*ydrogen"). It measures the pH value on a scale of 0 – 14. The pH factor is an important measure for the environmental conditions that exists in the sea, in our rivers and lakes and how it develops. Earlier on the pH e.g., in a lake like the Danish Tange lake approached a pH of 10 - the lake was actually in jeopardy. The pH will reveal this. Likewise, when more and more CO_2 is absorbed in the ocean the pH will reveal the consequences when acidity increases (the pH drops). This is important information since it constitutes an indicator of an environmental system not functioning appropriately.



KEYPOINTS pH

The measure of pH was first suggested by a Danish chemist Søren Peder Lauritz Sørensen when working at Carlsberg in 1909

pH measures whether a substance is *acidic* (pH between 0-6), *neutral* (pH = 7) or *alkaline* (pH between 8-14).

The key to measuring pH is the number of hydrogen ions (H^+) in a solution. This is important since e.g. growth and multiplication of e.g. algae is dependent on this ion concentration.

The pH number 0 - 14 indicates the amounts of hydrogen ions concentrations in a specific solution expressed as mol per liter

Exhibit 2.63 The pH measurement scale (acidity/alkalinity)

Oceans absorb CO_2 from the atmosphere. In fact, it's by far the largest single factor when it comes to absorbing aerial CO_2. When water and carbon dioxide is mixed it will result in positive *hydrogen ions* and *bicarbonate*. This will induce a chemical reaction to form *carbonic acid* also known as a *carbonation reaction*.

$$H_2O + CO_2 \rightarrow H^+ + HCO^-_3 \rightarrow H_2CO_3$$

However, there is a catch to that since the pH level of our oceans will also be affected by the CO_2 absorbed. The pH level of the ocean will be reduced – *acidity* increases - and this can have harmful effects on marine ecosystems in the future. The opposite can be true if we look at our freshwater lakes or rivers. Especially during eutrophication, the pH level will respond. It will rise – in other words a lake or a slow running river might become more *alkaline*. This phenomenon is a recurring issue in many of our water systems today.

BUILDING BLOCKS OF THE HYDROSPHERE – SALINITY

Water contains *salt* (NaCl or natriumchloride) and it's this fact that separates our different kind of water resources. Salinity is measured as *gram/kilo* water or *ppt* (parts per thousand). The level of salinity has a great effect on aquatic life, and this is why most fish and plants are dependent on either fresh or salt water. Some species, however, are able to switch between the two including the bull shark, the salmon and the seatrout.

It was Danish physicist Jens Christian Skou who in 1957 discovered the way which fish adopts to these changed circumstances when switching from fresh water to salt water when he discovered the so-called *"sodium-potassium pump*". In 1997 he got the Nobel Prize for his discovery. Due to the salt contents seawater is not suitable as drinking water. This has made some countries without sufficient drinking water resources invest in so-called *desalination plants*. Such investments are huge and consume energy, so these plants are normally reserved for rich states to construct. With the increasing scarcity of fresh water such plants are constructed increasingly in many parts of the world. As can be seen from the exhibit on the next page salinity differs widely between seas as well as between sea and fresh water. The Red Sea for example has a salinity of 200 gram of salt per kg water.

The level of salinity in seawater will affect the ocean currents since this circulation for a part is dependent on the level of salinity. With the increased amount of freshwater running into our oceans due to climate changes the ocean currents will likely be affected. It will also impact the oceans' ability to absorb CO_2 since more saline water is unable to take up as much CO_2 as less saline water. Increased levels of freshwater will stimulate the oceans absorbing capacity.

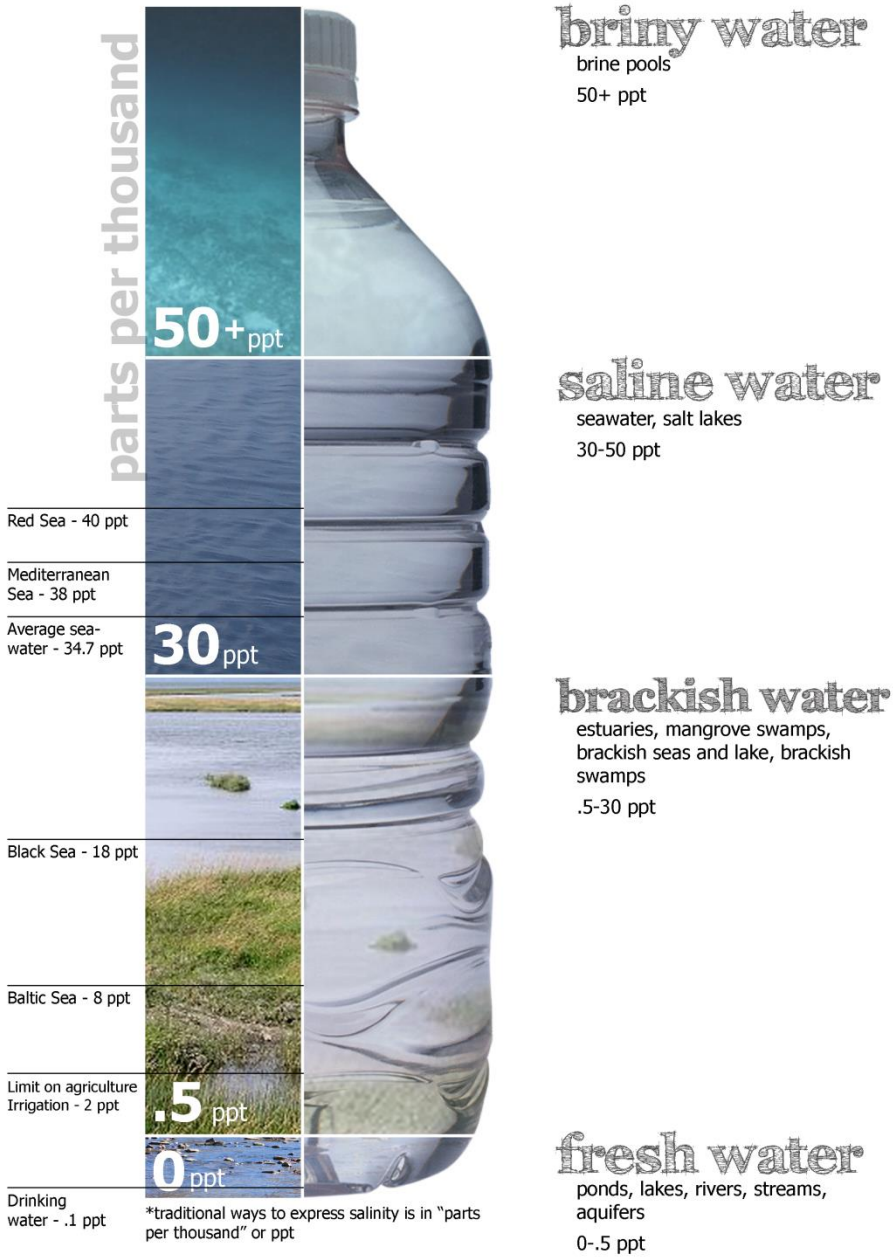


Exhibit 2.64 Different levels of salinity

ENVIRONMENTAL PROBLEMS IN THE HYDROSPHERE

Not surprisingly the hydrosphere has been plagued with various environmental problems due to human activity. This has been going on for centuries, but the last 200 years has been the most devastating centuries in human history when it comes to human induced problems in the hydrosphere.

One of the basic problems in the hydrosphere is rising temperatures. This causes the polar and arctic snow caps to melt, it causes glaziers to withdraw, and it lessens sea ice and snowfalls.

Ice is melting in the cryosphere

We know beyond reasonable doubt that ice is melting in Antarctica and in Greenland and several other places. The largest mass of ice is in Antarctica which accounts for about 8,3% of the earth's total land area with 12,3 million km^2 of ice covering the Pole holding 60% of the world's freshwater resources. Satellites have since 2002 recorded an increasing amount of ice melting in the Antarctic region – corresponding to approx. 100 km^3 of ice vanishing each year. The IPCC in 2019 estimated that Antarctica on average lost 155 Gt of ice between 2006 and 2015. It has been estimated that if the ice were to vanish altogether in Antarctica it would mean rises in sea levels by more than 50 meters – and this ice cover seems to melt faster and faster. In 2020 temperatures reached a record level in Antarctica - measured at 18,3^o C. The previous record came in 2015 and measured 17,5^o C and The World Meteorological Organization (WMO) has documented those average temperatures have risen by 3% during the last 50 years. If rising temperatures begins to manifest themselves in Antarctica at this level, we're in for big long-term changes globally. Just to cut to the point February 2023 saw the lowest level of sea ice coverage ever measured in Antarctica – 34% below average level of February. Greenland in the Arctic is the second largest ice-covered piece of land on earth with its 1,8 million km^2 covering 83% of Greenland's total land mass. However, the ice coverage on the North Pole is for the 10th year in a row shrinking by 3% in winter and 12% in summer. By 2040 the ocean in the region could be ice free during summer if manmade greenhouse gas emissions continue. During 2003-2011 the ice mass saw an annual average loss of 234 km^3. To this should be added that the IPCC in 2019 estimated the average loss of ice in Greenland between 2006 and 2015 to be approx. 278 Gt. In the winters of 2016 and 2018 the temperatures were +6^o above the average temperatures measured during 1981-2010. If the total mass of ice in the Arctic were to melt it is estimated that sea levels would rise by approx. 7 meters. This also mean that Greenland's land mass is actually rising – by some 4 cm per year when freed of its ice coverage. Besides ice melting it also gets darker. Dark ice is a biological phenomenon since the dark matter is comprised of microorganisms - algae's - in the ice. As the Arctic is warming up the algae's environment improve. This darker ice will affect the radiation reflected – this reflection will get weaker - its Albedo getting lower - and will thereby increase global warming.

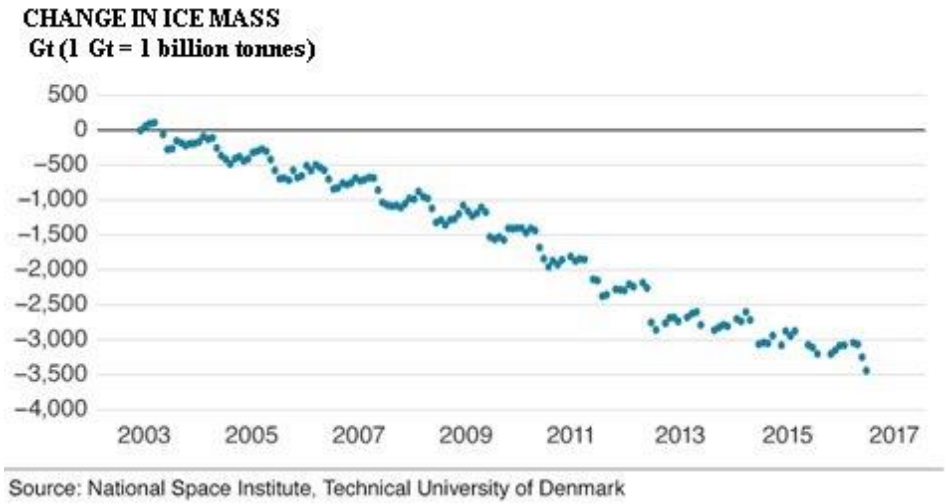


Exhibit 2.65 The ice mass in Greenland - a loss of more than 3.500 Gt. in 15 years

Ohio State University in September 2020 claimed that the Greenland ice sheet has entered into a state of irreversibly sustained ice mass loss. The melting, calving and retraction of Greenland's glaziers are simply too massive to get compensated by snowfalls that accumulates on the ice sheet. Even if temperatures might fall this wouldn't stir up the conclusion. We might have passed the point of no return concerning Greenland's ice sheet or to paraphrase the authors: [13]

"As a result of the new, semi-static rate of ice sheet-wide decline that is >60 Gt higher than in 1985, annual surface mass balance greater than two standard deviations above the 19-year (2000–2018) mean is required for the ice sheet to gain mass and is thus likely in a long-term state of persistent loss."

Or put more bluntly – the ice mass is likely and irreversibly vanishing in Greenland over the long-term opening up opening up new sea routes and vast amounts of new land with a population inhabiting it being the size of an average Danish city.

According to the IPCC *glaciers* outside of Antarctica and the Arctic are estimated to have seen loss of ice of 220 Gt between 2006 and 2015. In Africa a report from WMO issued in October 2021 estimates that the 3 glaciers present here can be gone by the 2040s. The retreat of the African glaciers is higher than the global mean and they now constitutes just 20% of their former early twentieth century extent. If such

[13] King, M.D., Howat, I.M., Candela, S.G. et al. *Dynamic ice loss from the Greenland Ice Sheet driven by sustained glacier retreat.* Commun Earth Environ 1, 1 (2020).

vast amounts of ice-covered land begin to thaw the effect on the world's ecosystems will be colossal with changes in our weather system, wildlife, ocean currents, habitable areas etc. Though changes are gradual we nevertheless seem to experience unprecedented changes in the ice masses covering the earth's surface. We've known for some years that glaciers around the world have been retracting. That means the ice sheets are melting and for the most part will end up in our oceans. This in particular is due to global warming.

Exhibit 2.66 White Chuck Glacier in 1973 and 2006 (right)

The *White Chuck Glacier* in Washington, USA might serve as an example of a retreating glacier. It retreated some 1,9 km in 30 years – from 1973 to 2006. The same phenomenon has been recorded in many other places around the globe – *the Pine Island glacier* in West Antarctica, *the Muir glacier* in Alaska, *the Holgate glacier* in Colorado – in short, the glaciers are melting, and they are melting faster and faster. Our glaciers are right now in the process of being lost. The World Glacier Monitoring Service (WGMS) has established that the glaciers monitored during 1980 – 2001 on average had become 6 meter thinner. It has been estimated by the IPCC that if all glaciers in the world were to disappear sea water level would rise by approx. 0,4 meter. Further problems exist since people in e.g. Lima, Peru and La Paz in Bolivia are dependent on glaciers for their supply of drinking water, wildlife is affected and the living conditions in these areas will change profoundly when these glaziers are gone. The climate change effect on glaziers, however, does not only concern water run-offs or drinking water supply but is also able to change the ecosystem. In Yukon, Canada the glacial Slims River normally flowed out into the Bering Sea. In 2016 this was changed when the Slims River actually dried out and instead convened with the Kaskawulsh river through a change of the channels that normally fed the Slims River with glacial water. The change was caused by the warming of the weather altering the channel system. The Slims River case was dubbed "river piracy". In the future we might see similar cases occurring.

In Siberia in Russia some areas have been covered by a permanent layer of *permafrost*. This layer is now beginning to thaw due to global warming. In e.g.,

Yakutsk average temperatures have risen from -10° to -7,5° during the last decades and the summer of 2020 has been the warmest ever recorded in Siberia. Similar effects have been recorded in Alaska. This affects the landscape, the wildlife and how the ecosystem behaves – more flooding's is occurring, wildlife is changing, summers are extended and the people living here will have to adapt to such circumstances. Thawing might mean a 0,1 – 0,2° C rise in global temperatures

When the ground is thawing large quantities of methane and CO_2 will be released into the atmosphere and the absorption of incoming solar light will be increased. The ice is good for reflecting such solar light, while rocks, soil, vegetation etc. are not. Such increases in solar absorption are measured according to the *Albedo factor*. A totally white surface will have an Albedo factor of 1 while a totally black surface will experience a value of 0. The Albedo factor thus measures the intensity of solar light reflected from an object. There is a huge difference how such solar light is reflected. The surface of the sea has an Albedo of 3,5%, sand has an Albedo effect of 25-30% while the surface of Antarctica has an Albedo factor of 81%. This will add to the greenhouse effect since incoming solar light is absorbed not deflected.

Exhibit 2.67 Oil leakage - river Ambarnaya, Russia a result of the thawing process

However, the thawing process also gives rise to unexpected catastrophes. Recently a major environmental disaster happened when an oil tank containing diesel fuel in May 2020 broke down and leaked its content to the nearby Ambarnaya river in Siberia, Russia north of the Arctic Circle. The Norilsk Nickel Corporation, working with extraction of nickel resources in the area and the world's biggest producer of

this metal, was responsible for this catastrophe that ranges only second when it comes to environmental spills in Russia. The reason for this leakage was due to the fact that the site where the oil tank was situated up until that point in time had been frozen solid as a part of permafrost in the area. This is now beginning to thaw, and the consequences now being felt in a very real manner, when the oil tank foundation began to slip away, and the spill occurred. We've furthermore recently seen large craters form due to thawing permafrost and buildings in the area are now also beginning to feel the effects of this process.

The thickness and coverage of *sea ice* is yet another player in the game. According to IPCC sea ice in the Arctic has declined 13% each decade during the period 1973-2018 according to satellite data and over 2 million m^3 of sea ice has vanished since the end of the last century. [14] The old, thick layer of sea ice which has prevented other ice to melt is now vanishing and it is estimated that only 10% of the sea ice is more than 5 years old.

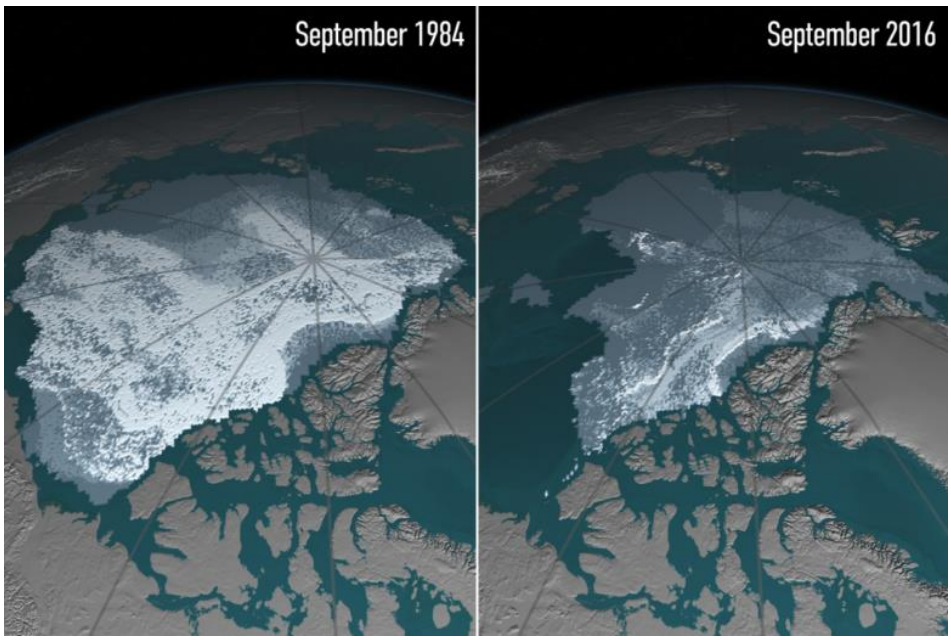


Exhibit 2.68 Visual depiction of sea-ice decline September 1984 – September 2016
Source: Ecobriteservices.com

This has had devastating effects to wildlife in the area. Sea-ice algae and sub-ice phytoplankton which accounts for 57% of primary annual production in the Arctic Ocean have suffered an enormous loss of habitat. This trickles down through the entire Arctic food chain. Polar bears normally hunting seals on sea ice have to find

[14] See Eric Post et. al., *Ecological Consequences of Sea-Ice Decline*, Science 341, 2013

other sources when traditional hunting grounds are being devastated, the feeding grounds of the Elephant seal is disturbed, the Arctic fox is losing its habitats and so on. As more sea-ice vanishes we will furthermore experience that the warming of our oceans increases - it's beginning to resemble a process that only goes in one direction and consequences can be dire.

Exhibit 2.69 This might very well be a picture of the past in parts of the world

Snow coverage in the mountains has also declined in extent, duration and depth. Like with sea ice snow coverage also declined some 13% each decade during 1968-2018 in the Arctic region. The IPCC expects a decreased snow cover in low elevation mountain areas of 10% - 40% in 2031 – 2050 compared to that experienced during 1986-2005. Some regions in the world where snowfalls have

been common will now experience a new reality without snow covered streets and landscapes. It will be a history of the past. The European Environment Agency has documented a severe lack of snowfalls during the last 90 years over the Northern Hemisphere and especially since 1980 this lack of snow has been increasing. Simulations have shown that this reduction will continue throughout the 21st Century. It goes without saying that this will have huge impacts on wild-life, habitats as well as living conditions of human beings. [15]

Exhibit 2.70 Sea ice

The IPCC has assessed the developments – historically and in the future – in two scenarios shown below. It shows among other things that sea levels will rise, the pH (acidity) will be lowered, ocean oxygen levels will likely be affected, and that the temperature of our oceans will rise as well. These likely consequences are partly due to the loss of the ice sheet in Greenland and Antarctica as well as the decreasing mass of our glaciers and dynamic effects within the system. These effects are unfolding right now. We see compelling evidence that major changes are underway in the hydrosphere. In the spring of 2021 research conducted by the University of Leeds, UK involving satellite data from 215.000 glaziers, the ice sheets in Greenland and Antarctica as well as sea ice for the first time concluded that the worst projections might be turning into facts. The loss of ice has increased from 0,8 trillion tons in the 1990s to 1,3 trillion tons by 2017.

[15] See European Environment Agency
- https://www.eea.europa.eu/data-and-maps/indicators/snow-cover-3/assessment

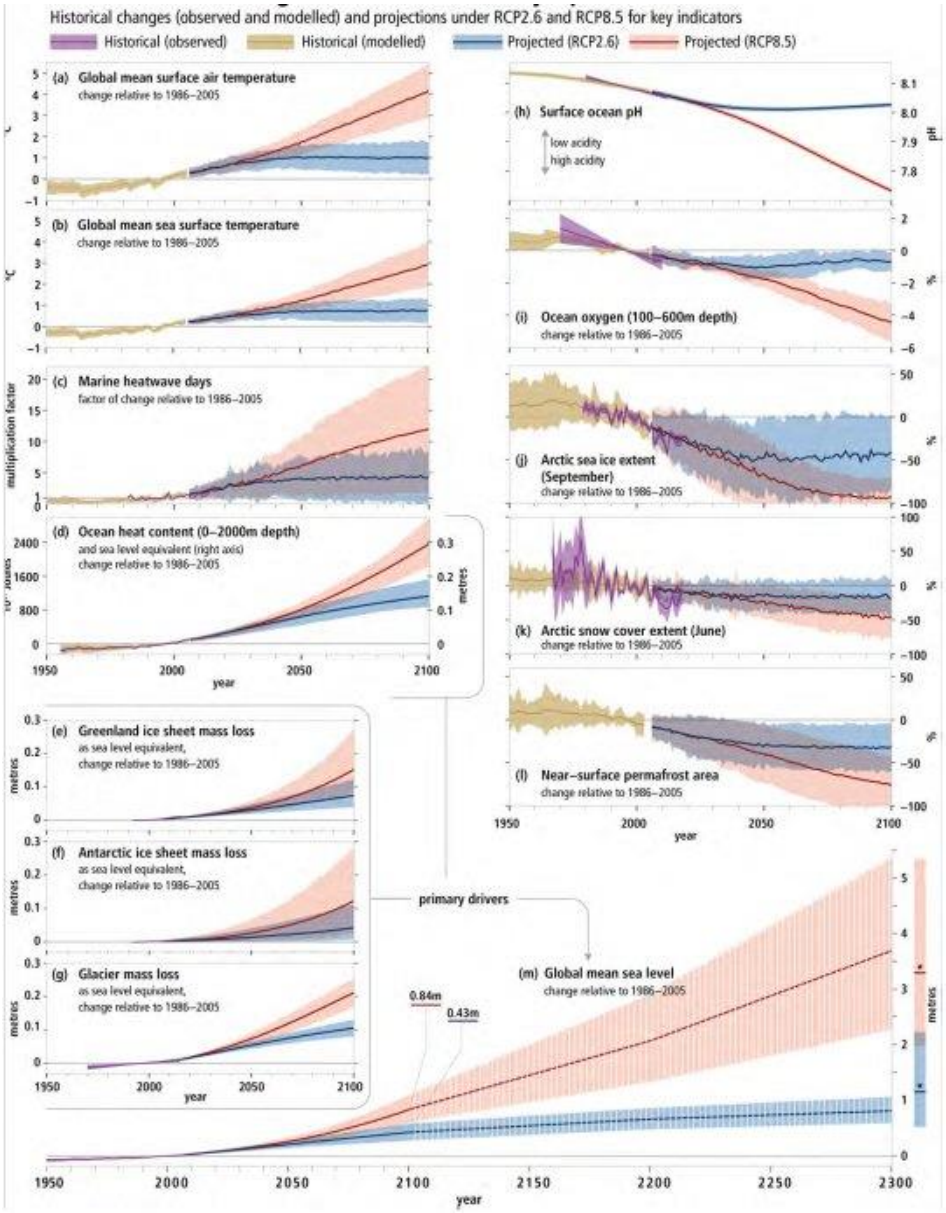


Exhibit 2.71 Two scenarios of the hydrosphere/cryosphere 1950 – 2300
Source: The Ocean and Cryosphere in a Changing Climate, IPCC, 2019

One of the major issues is that the Arctic is warming 4 times faster than the global average (called *arctic amplification*). Analyzes of data from 1979-2021 has revealed that especially the Barents Sea is exposed to this phenomenon temperatures climbing by 2,7º C each decade for the past 20 to 40 years. The fact that oceans by far is the biggest heat absorber adds to the problem.

ENVIRONMENTAL PROBLEMS – INLAND AQUATIC SYSTEMS

Not surprisingly human activities have had a huge effect on our inland aquatic systems. February 2020 was the wettest month ever recorded in history in Denmark due to heavier rainfalls creating massive problems all over the country partly due to the greenhouse effect. This impact has been severe, swift and probably enduring. Another example would be that of the Colorado river in USA.

Exhibit 2.72 The once mighty Colorado river, Horseshoe Bend

The river comes from the Rocky Mountains and flows through several states. Huge dams have been built by the river, 70% of its water is used for irrigation and drinking water supply and now climate change is about to severely impact the river – the Colorado river is about to run dry. White bands around the artificial lakes reveal that water levels have dropped considerably during the last decades. Tributaries have already run dry and nowadays the Colorado River does not regularly reach the sea. If the Colorado River itself really runs dry it will have large scale effects on the future lives of millions of people. The *WHO (World Health Organization)* has estimated that around 1 billion people around the globe likewise now live in regions that are water-stressed. This number is expected to double by 2050. We see the same effect pertaining to e.g., Lake Mead the largest reservoir in the USA which has dropped over 42 meters since 2000. In the summer of 2022, the river Rhine saw its water levels plummeting affecting the transportation of goods down the river. Sinking water levels will affect agriculture, water intake for a number of uses, transportation and other industries dependent on the constant flow of our rivers.

But let us look at some of the further problems we've created for ourselves within a fraction of a millisecond due to our existence here on earth concerning the inland aquatic systems. Our rivers, wetlands and lakes have been exposed to human activity for thousands of years but it's only during the industrial era we've seen huge adverse effects created. Rivers have been used as waste dumps for chemicals, heavy metals, polluting substances, discharges, and garbage. They have been used as a resource to the point of and above fishing capacity and as a means for supplying potable water, as an essential element of running heavily polluting fish farms and as instruments of draining etc. They have been used at highways for penetrating deeper into the forests and jungles and they have been exposed to dams and hydroelectric facilities. Some of these activities have been good for developing societies, some have not. Short term as well as long term effects to the environment and wildlife has largely been ignored. Costs now begin to mount as consequences begin to unfold.

In order to elaborate a little on what goes on in inland aquatic water systems we can use Exhibit 2.73 to show some of the main issues.

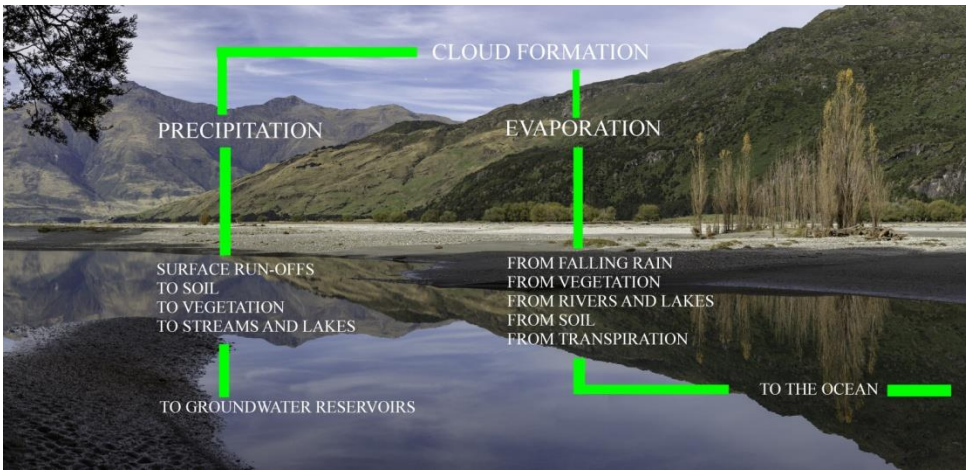


Exhibit 2.73 Simplified inland aquatic systems circulation

Rain falls will often function as run-offs that eventually find its way into other systems – drainage, brooks, sewers etc. The soil will absorb some of the rain fall and enrich the soil and change its composure. The plants will use the rain as a food source through its root system. It acts as a necessary resource for all living matters. Trees, plants, flowers etc. uses *photosynthesis* during the day and *respires* through the night. It's simply how such organisms breathe. In the night it uses the oxygen it has stored in its cells as well as glucoses and emits CO_2 as well as water to the atmosphere. In the day it absorbs CO_2 as well as water through its root system. Other parts of the rain fall will wind up in our rivers and lakes. Eventually some of it will seep through the ground layers, being cleansed or contaminated during the

process and will end up in a ground water reservoir. Such river systems are named *effluent streams* while river systems not connected to groundwater resources (e.g. rivers fed by glaciers) are called *influent streams*.

Due to differences in temperatures some parts of a rain fall will evaporate up into the air already when falling down but most will end up in our rivers and lakes. Once again evaporation will take place once in the rivers and lakes and the higher the temperature the more the evaporation will be. The same evaporation will occur from the soil and respiring plants. With increasing evaporation clouds will form more frequently. Eventually the rain falls that's deposited in our rivers and lakes will be led through the water system connected with the ocean until it ends up here to be mixed with its salt water.

Acid rain affecting water systems

Some years ago, many lakes in Scandinavia experienced a period of a lifeless environment. It was later found out that *acid rain* had caused this problem. Acid rain is defined as precipitation with a pH lower than 5,2. During rainfalls these substances were mixed with the rain and eventually deposited in many Scandinavian lake systems. This caused the fish to die and plants to vanish. The EU reacted to this and put strict limits on SO_2, NO_x and other emissions. The situation now seems to be remedied somewhat. Acidic lakes are much more uncommon now than before. The reductions in SO_2 amounts submitted to the atmosphere reacting with various gases in the atmosphere are thought to be the main cause of this development. The pH value is heavily correlated with nitrate and sulfates in the rain falling down - the lower the pH the higher the concentrations of nitrate and sulfate.

Flooding

At the end of 2019 Venice, Italy experienced the worst flooding in 50 years with water levels rising to 1,87 meter above normal. The Marcus square became impassable. In Denmark November 2019 was the wettest month ever recorded in history. These are but a couple of examples of recent phenomena occurring in all parts of the world. The increased greenhouse effect has seen changes to the weather systems. When waters are warmed up more clouds will form, and we've experienced an increased number of hurricanes, storms, and heavier rain falls in some parts around the globe. This has caused flooding incidents like the one in Venice to increase as well. In august 2005 hurricane Katrina reminded us of what devastating effects such hurricanes can mean when it made havoc in Louisiana and Florida and flooded New Orleans in the US. 1.833 people lost their lives in that event. It was a so-called category 5 hurricane. In September 2019 hurricane Dorian meant that 70.000 people in the Bahamas lost their homes and dozens of deaths were caused by the hurricane. These are recurring phenomena.

Exhibit 2.74 Flooding in New Orleans, USA

Another cause of flooding is the heavier rainfalls we're experiencing. This will cause the rivers and lakes to go up, landslides to take place, drainage systems to be put out of order and towns to be flooded. While some of these phenomena have been recurring during centuries, we now see increased incidents of flooding. When this gets coupled with the rising sea level, we will probably see more serious problems taking place in the future where certain areas around the globe might become uninhabitable.

Serious flooding due to heavier rainfalls have taken place in Rhine-Westphalia, Germany, in New York, USA, in Belgium, Norway, China and many other places resulting in a number of deaths and serious property and infrastructure damages. The worrying issue is that such incidents occur more frequently now and with more severe consequences to an extent that it must now be considered the "new normal". It is estimated that we will have to adapt to such circumstances and that they will turn even more violent with time.

As an example, consider the Roi-Namur Island in the Marshall Islands. If sea level rises 1 meter above current level half of the Roi-Namur will be flooded every year. Besides destroying the possibilities for living in these regions this will also mean that freshwater reservoirs will be at risk and have detrimental effects to wildlife on these islands. The Marshall Islands are home to approx. 70.000 people who would be at risk if global temperatures increased by 2°. This is but one example of thousands of what the future might have in store for us due to heavier rainfalls, hurricanes and rising water levels.

CATEGORY	SUSTAINED WINDS	TYPES OF DAMAGE-HURRICANES
1	119-153 km/h	**Very dangerous winds will produce some damage:** Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days
2	154-177 km/h	**Extremely dangerous winds will cause extensive damage:** Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3	178-208 km/h	**Devastating damage will occur:** Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks
4	209-251 km/h	**Catastrophic damage will occur:** Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to months and most of the area will be uninhabitable
5	252 km/h or higher	**Catastrophic damage will occur:** A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Exhibit 2.75 Categorization of hurricanes
Source: National Hurricane Center, USA

Groundwater supplies diminish

It's not just groundwater reservoirs on exotic islands that will be affected by climate changes. In most parts of the world clean drinking water is a scarce commodity. In other parts of the world like in Scandinavia we're more fortunate to have plenty supplies of ground water for drinking purposes. The effect is that we do not have to bottle water, to transport it, to market it, to fill up the capacity of the refrigerator, to use resources for making plastic bottles, tap systems etc. – or so one would think! But in some places supplies of clean drinking water are dwindling.

One of the reasons is due to contamination of potable water. Most places there are certain standards for groundwater quality. If these are exceeded, it cannot be used for drinking purposes. As water is tested for more and more toxic substances increasing number of groundwater reservoirs have been shut down in Denmark. Recent research seems to indicate that 43% of groundwater resources in Denmark now are contaminated. Agricultural uses of pesticides, toxic waste dumps from industrial operations, sewage treatment plants, lead pipes and use of toxics for gardening are but five of the reasons for such contaminations. In 2019 more than 400 Danish farmers were convicted for using or holding banned toxic pesticides. Some of these substances had never been allowed for use in Denmark. Recently it has been made illegal to use pesticides near places where water is extracted – but *not* where water reservoirs are being formed. This point to another environmental issue – that of risking breaking the law to the detriment of our successors. If economic stakes are high enough to warrant breaching the law some will be inclined to do so thereby lowering the credibility of the agroindustrial sector.

Disturbances in the inland waterway environment

A huge extinction has taken place in our inland aquatic ecosystems due to hydropower plants, toxics, warmer weather, loss of habitats, pesticides, sewage treatment systems etc. These factors have altered the ecosystems composition, their functions and their biodiversity. One of these disturbances actually spawned an environmental consciousness in the US when the Cuyahoga River in Cleveland, Ohio on June 22, 1969, actually began to burn due to being heavily polluted with chemicals. 50 years later the iconic Australian platypus – the only mammal to lay eggs - is on the verge of extinction due to the warming of Australia and the wildfires that has spread as a consequence on the eastern coast of Australia. Turning to another example a hydropower plant (*Gudenaacentralen amba*) was built in 1921 by the river Guden in Denmark. This caused the extinction of the original salmon population while the stock of seatrouts declined by 45%. Formerly this salmon population had been one of Europe's biggest. The adjoining water reservoir of 540 ha formed to feed the power plant destroyed a unique landscape and its biodiversity in the blink of an eye. Since then, the power plant has caused numerous other environmental problems in the river Gudens ecosystem.

We now, however, see a tendency to demolish such hydropower plants in several European countries as well as in the US where e.g., the Elwha River was freed of its former chains and restored with huge benefits for nature and the environment. In almost all instances when "nature is set free" biodiversity will be affected in a positive way – variations, landscapes, aesthetics, interactions and many more issues will benefit from this. In short, biodiversity normally is boosted when nature is set free. The opposite is true when nature is put in chains, deforested, regulated, channelized and homogenized.

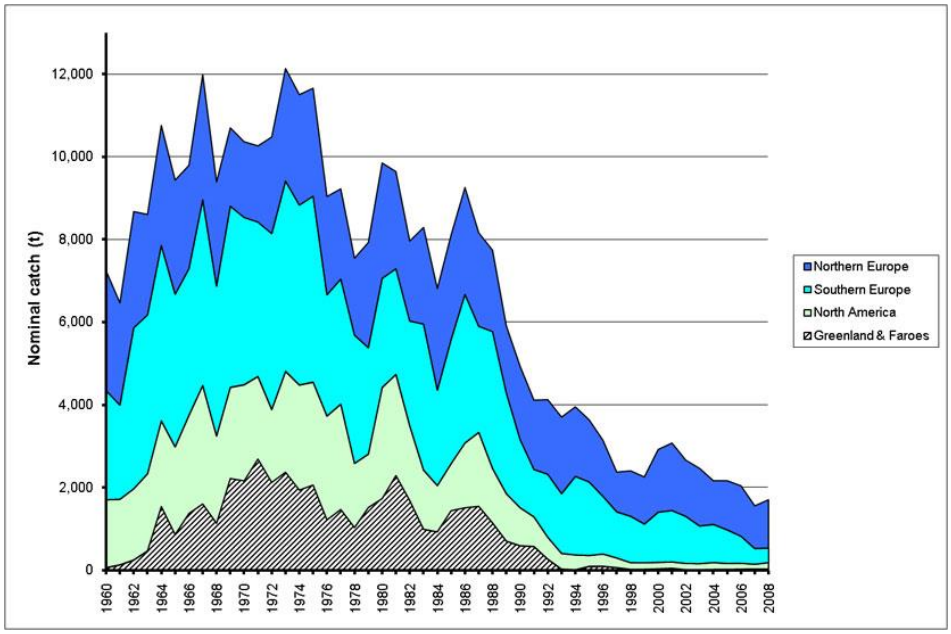


Exhibit 2.76 Salmon declining in Europe and North America
Source: Monitoring for Migratory Fish, Morfish.org.uk.

As an example of what a disturbance in ecosystems can mean the above – although data being more than 10 years old - will act as an example. According to this study salmon populations have declined some 70% during the last 30 years in Europe, North America, Greenland and the Faroe Islands due to overfishing, destroying of habitats, pollution – genetic and otherwise etc. This has vital implications for the fishing industry, for recreational fishing, for the economics of local societies and for the functioning of the ecosystems in general. The same signs would emerge if taking most other species into account. Wildlife and ecosystems are being put under an immense pressure.

If ecosystems are disturbed e.g., through the presence of *invasive species* the ecosystem will change. In 2006 it was discovered that the Zebra mussel had been found in a lake in the river Guden's ecosystem. The Zebra mussel is originally

native to Eurasia (especially the Caspian Sea and The Black Sea in Russia/Ukraine), Consequences have been clearly visible. The water of the river is now much clearer than ever before since the Zebra mussel is an effective animal for diluting the water. The Dam mussel is rapidly vanishing since they compete with the Zebra mussel for the same food source and occupy the same habitats. Plants in the ecosystem have thrived since more light can penetrate the water column due to its crystalline clarity. Whether these effects are good or bad depends on what type of ecosystem you prefer – if you were to decide! It is, however, an example of an invasive species that affects the traditional ecosystem. The river Guden is just one example since the Zebra mussel has spread to nearly all parts of the globe.

Other causes of invasive species are humans letting animals into the wild on purpose or by accident e.g., the Burmese python in the Everglades, USA, the Lionfish creating havoc in US ocean waters etc., ballast water that can contain species foreign to an ecosystem e.g., the Zebra mussel and changed patterns of wildlife migration e.g., the mackerel going north to Icelandic waters, or the Blue finned tuna entering the Baltic Sea. If invasive species find their new environment appropriate, they will thrive and eventually diminish the stock of presently existing species with positive as well as negative impacts to the environment.

If ecosystems are closed systems such as that of a lake only receiving its supply of water from underground wells things can get much more serious than e.g., a river freely flowing into the ocean – an open system.

Wastes

Back in the 1970-1980 we saw wastes freely floating down our river systems, wastes that were left in woods, shores and along our highways. Waste was a big problem. However, many municipalities now collect waste and deposit it, incinerates it, partly recycles it etc. In Europe each individual every year consume approx. 16 tons of materials and of these 6 tons becomes waste 0,5 tons of this being household waste. You can do the multiplying yourself – it is alarming amounts that we throw out and only 40% is reused or recycled. Fines are one measure to combat throwing wastes in public places and in India for example it will cost you approx. $135 if caught. Some wastes are highly toxic, flammable or other and requires special treatment. We term this kind of waste *hazardous waste*. Special facilities handle this kind of waste.

Plastic is a major problem when talking about waste in many parts of the world. Developed as well as developing countries without sufficient means for tackling the ever-increasing amounts of plastic leftover from households, municipalities and companies are hit considerably waste being dumped wherever feasible.

Exhibit 2.77 Plastics totally cover a river's surface in Indonesia
Source: www.news.cn

The problem is that it can affect local habitats negatively and that it later on will end up in our oceans contributing to the ever-increasing amount of plastic deposited here. It furthermore decreases the aesthetic value for humans using nature and its toxic contents can be released to the nearby environment.

Eutrophication

When a water system is exposed to large amounts of nutrients such as *nitrogen* and *phosphorous* e.g., due to fertilizer use, sewage, feces from animals and birds or detergents acting as nutrients for the microorganisms (phytoplankton), algae will bloom. Fertilizers moreover consumes large amounts of energy when being made. Normally a lake will produce between 75-250 grams of carbon per m^2 per year. However, in lakes exposed to increased levels of nitrogen and phosphorous levels this range can reach 750 grams/m^2 per year. This means that the water turns greenish, and photosynthesis is impaired, water visibility will be lowered, and dead organic matter will seep down towards the bottom. Some of these algae can be toxic to both humans and animals (e.g., blue-green algae which form toxins). When dead organic matter seeps down through the water column *sediments* are formed at the bottom. Here bacteria will be vital parts in the decaying process and in that process, they will use *oxygen*. This can mean that the water system so to say is emptied of its contents of oxygen and the fish and plants can eventually die. Threshold for various biological and chemical processes is less than 1 milligram per liter of water. Furthermore, methane can be formed in the process. We term this formation of microorganism's *eutrophication*. Recurring examples pops up each year especially

during hot summers all around the globe. When the weather is warming up this will affect water temperatures in our lakes and rivers. If inland water systems are heated - combined with extraordinary amounts of phosphorous and nitrogen - an increased level of eutrophication will take place. We will see greenish lakes deprived of life in some places where algae bloom will take precedence instead of a experiencing a healthy ecosystem. The algae will be exposed to the process of photosynthesis. If this process gets out of balance dissolved oxygen can become a scarce resource and eventually large parts of a lake can become lifeless. Furthermore, this can also affect the pH level of such lakes thereby contributing to the decline of ecosystem quality.

When algae die, they will sink to the bottom and through a process known as *anaerobic digestion* they will be converted into inorganic matter and in this process methane and other greenhouse gases will form. Bacteria, that performs this process use oxygen and the more dead organic matter the more oxygen is needed. Some of these algae can be toxic to humans, pets and animals and when a lake is heavily infected with algae bloom sunlight will have harder to penetrate through the water column thereby inhibiting the normal process of photosynthesis and detracting from activities undertaken by humans – fishing, swimming, sailing etc. Likewise, biodiversity will be impaired when a water system becomes eutrophic. According to some scientists approx. 50% of European, US and Asian lakes are now plagued by eutrophication.

Exhibit 2.78 Algae bloom in Lake Erie, USA

When air temperatures rise it will impact the temperature of our inland lakes, rivers and reservoirs. Rivers are less prone to that since fast running water does not absorb as much heat as still water. However, there will be exchanges e.g., when rivers run through heated reservoirs. In that instance the excess heat will be transferred to the river increasing its temperature. This temperature rise might affect the ecosystem negatively. Fish stocks and plants are adapted to certain living conditions and if this warming up gets outside their tolerances aquatic life can be disturbed and their reproductive cycle affected since eggs, runs of fish, preying activities to some extents all are connected to water temperatures. This is true especially for species that prefer colder water habitats. So, salmons, trout and other species may in fact begin to die if the water heats up to above 25-30°. Since heating also stimulates the eutrophication process and we will see more algae bloom as a consequence of temperature rises with pH levels being affected.

Overfishing

The European eel can provide an example of what *overfishing* is about. It's now a "Red list-species" indicating that it's critically endangered (IUCN). Spawning grounds are located in the Sargasso Sea and up until now scientists have been unable to discover the eel's reproductive secrets. This means that if the eel is gone, it's gone forever. Along the coasts of especially Portugal and Spain large amounts of eel larvae are being caught each year as they migrate. In many other countries the eel has been fished to the brink of extinction. In Denmark as an example eel catches have dropped from 4.000 – 5.000 tons in the 1960s to approx. 200 tons in 2018. This overfishing is driven by especially Japanese consumer demands.

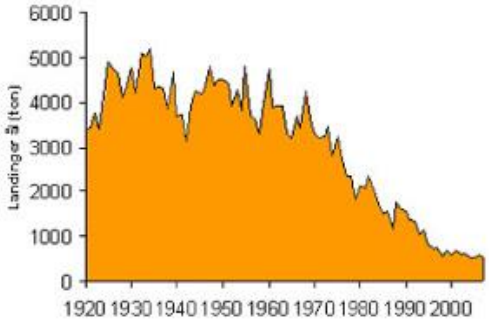


Exhibit 2.79 Catches of eels in Denmark 1920 – 2007 in tons

This decline has also been true for many salmon populations, the char, the brook trout and several other freshwater species. Fish populations are at an all-time low compared to previously. It is estimated that the Norwegian population of wild salmon has decreased more than 50% during the last 30 years. In 2017 it was

estimated that some 530.000 wild salmons would return to the Norwegian rivers and The Norwegian Scientific Council in 2018 stated that:

"*The escaped farmed salmon, salmon lice and infections from salmon farming are the greatest anthropogenic threats to Norwegian wild salmon…. Hydropower production, other habitat alterations, acid rain and introduced pink salmon are also major anthropogenic threats…"*

Toxicity

Toxicity is another major environmental problem in our inland water systems. Toxicity implies lakes and reservoirs being closed down due to e.g. blooming of blue-green algae that can cause stomach pains, diarrhea and in rare instances death to animals and human beings if water filled with blue-green algae's is sufficiently high. Toxicity can also be caused by people deliberately dumping chemicals into our rivers and lakes, by industrial facilities leaking harmful substances, by sewage treatment plants that haven' got the necessary means for tackling chemical substances etc. A recent example was seen when another algae - the golden algae (Prymnesium parvum) - killed over 130 tons of fish in the river Oder in Poland/Germany in July/August of 2022 due to human ecosystem interference.

Hazard Indicators	I	II	III	IV
Oral LD_{50}	Up to and including 50 mg/kg	> 50 thru 500 mg/kg	> 500 thru 5.000 mg/kg	> 5.000 mg/kg
Dermal LD_{50}	Up to and including 200 mg/kg	> 200 thru 2000 mg/kg	>2000 thru 20.000 mg/kg	> 20. 000 mg/kg
Inhalation LC_{50}	Up to and including 0.2 mg/liter	> 0.2 thru 2 mg/liter	> 2 thru 20 mg/liter	> 20 mg/liter
Eye irritation	Corrosive; corneal opacity not reversible within 7 days	Corneal opacity reversible within 7 days; irritation persisting for 7 days	No corneal opacity; irritation reversible within 7 days	No irritation
Skin irritation	Corrosive	Severe irritation at 72 hours	Moderate irritation at 72 hours	Mild or slight irritation at 72 hours

Exhibuit 2.80 Acute toxicity guide for pesticide products
Source: EPA

Toxic releases into our inland water systems can have profound effects on wild-life and humans' possibilities for exploiting water resources as well as inducing severe health problems ranging from allergic reactions to life threatening issues. One problem is that we actually do not know in detail how toxic substances will react with each other once in the water environment - named the "*cocktail-effect*". Since there may be several hundred substances that have infected groundwater resources the behavior of these when reacting with each other are not fully understood concerning both short term and long-term effects. Reactions may occur that are unproblematic, or they may cause serious adverse effects to the environment and human health. When categorizing toxicity, a standard of LD_{50} is mostly used. Toxicity is often used to characterize products and should be exposed when labeling products. An example of standards issued by the EPA toxicity associated with pesticide products can be seen from the previous table in Exhibit 2.80 above.

The city of Flint, Michigan in USA is but one example of what can happen if economics comes first and toxics second. In 2014 it was decided to switch water supplies from Detroit Water and Sewerage Department to local water sources from the Flint River to save $5 million over two years. This water contained higher chloride contents than before. Local Flint authorities didn't add orthophosphate to its water supplies from Flint River in order to save costs of approx. $140/day causing severe corrosion in the pipe system and increasing the amount of lead in the water making it turn yellow. If was found that this caused a dramatic increase in the level of lead in children's blood. Virginia Tech found that 25% of Flint households had a lead content above what EPA accepted of 15 ppb. At some places they recorded levels of 13.200 ppb. Being exposed to chemical substances like lead in your early years can mean increasing risks of attracting Alzheimer disease and affect your IQ. General Motors Truck Assembly plant in Flint also made complaints about the water quality since it began to corrode GM's car parts and the company stopped using the Flint River water in October 2014. Many lawsuits have since followed, and the case is far from closed.

Another example with contaminating effects is the use of chemical substances that will inflict damage to the ecosystem as well as pose health problems (e.g. cancer, immune system issues, liver function and affecting the body's natural hormones). The PFOS substance (PFOS = perfluorooctanesulfonicacid) have been used in the foam used for fire drills, in 3M products such as Scotchgard and others. It's now banned but the large amounts of PFOS used have affected the earth layers and cases of e.g., cows containing increased levels of PFOS is now emerging as well as people with seriously increased levels of PFOS who have eaten the meat. This is a worldwide problem and it's assumed that it will take several decades to clean up after PFOS exposure.

Examples all demonstrate that toxicity is a costly, long-lived and hard-fought issue when released into the natural environment and often intergenerational by nature.

ENVIRONMENTAL PROBLEMS – OCEAN AQUATIC SYSTEMS

In 2019 we saw record breaking temperatures in our oceans. Such high global mean temperatures have never been recorded at any time in our previous history. Many of the issues touched upon about the inland aquatic systems could be repeated for the ocean aquatic systems.

The ocean has been used as a dump site for wastes, as a resource that has been unsustainably managed, as a highway for highly polluting logistic operations all across the globe etc. Since the ocean is a much larger place and much further away from human activity than our inland rivers and lakes it is no wonder that the ocean has been at the backend of sustainable measures taken. The notion of "out of sight…" pertains painfully clear to facts put on the table today when it comes to the current health of our ocean aquatic resources.

Oceans form the overwhelming majority of water on the planet, and it affects the climate in various ways. Water – and heat - is transported around the globe by way of ocean currents. The Gulf Stream is an example of that – please refer to Exhibit 2.82 below. The ocean is a major absorber of CO_2 from the atmosphere – it has absorbed some 20% - 30% of human carbon emissions since the 1980s. When more CO_2 is absorbed, however, it will affect the oceans pH level. It will drop and the ocean will become more acidic in the future. Warmer weather likewise will affect the ice sheet covering the land as well as sea ice and if the oceans currents are to change this will have profound effects on human existence in many parts of the world.

Ocean sea level rises

In the future we will have to adapt to rising sea levels caused by *thermal explosion* due to warmer oceans – accounting for 1/3 of sea level rise - and melting of the ice causing approx. 2/3 of sea level rises due to the melting of glaciers and ice sheets.

This rise will not be uniform on a global scale but impact sea levels differently according to regional circumstances. Likewise, we currently see sea levels rising at an accelerating rate. The IPCC has therefore adjusted its assessment of sea level rises by 2100. This is due to an increased melting in the cryosphere. Presently the IPCC cannot rule out that sea levels can rise up to 2 meters by 2100 and by 5 meters by 2150 in their high emission scenario (SSP5-8,5). Looking at year 2300 sea levels might be 3-7 meters higher than by year 1900 and the IPCC cannot rule out a sea level rise of 15 meters. If these projections happen it will have profound effects all over the globe. Rivers and lakes will be affected, coastal cities and huge land masses will be flooded. Recent scientific research furthermore seems to indicate that there is an increasing trend for sea levels to rise.

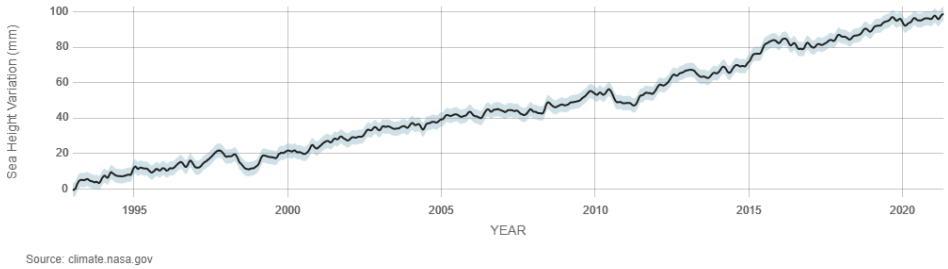


Exhibit 2.81 Global sea level rise in mm 1993-2020
Source: NASA

Global sea level rise measured according to satellite data have risen approx. 3,3 mm per year during 1993-2020. This is 30% more than when NASA did its first satellite measurements in 1992. The increased melting by the poles will further add to the problem and the rate with which these changes have occurred have surprised scientists.

Ocean currents can change

The Gulfstream originates in warm waters in the Mexican Gulf and the Atlantic Ocean and billions of liters of water are then transported up the coasts of Scandinavia and other parts of Europe. During its journey it transmits its warm water to the colder parts of the ocean and due to the Gulfstream e.g., the Scandinavian countries do not experience arctic temperatures during winter. Cold saline water means that its mass and weight increase, and the colder saline water will sink deeper into the warmer ocean and be led up to the northern parts of Europe where it emits its warmer parts. Since the ice is melting this means more freshwater will enter into the system which again will affect the "sinking" effect of the cold-water current. Freshwater parts will so to say cover the ocean and contribute to halting this pump function. This "pump" - or *Thermoline Circulation* - is dependent on the mix of cold and warm seawater – affected by temperatures and salinity - and if this cycle is interrupted it will have large effects on weather systems around the globe. If the Gulfstream came to a halt this would mean that Northern Europe would suffer from changing weather conditions accelerated by the greenhouse effect. The effects could seriously impact the weather system, and the circulation of the oceanic currents would be changed and could even in the extreme case be brought to a hold. This again would impact wild-life, habitats and living conditions of human beings considerably.

So, in fact we're playing roulette with our future by not paying sufficient attention to our ways of living and the causes we induce in our natural ecosystems. Recent research from March 2021 publicized in *Nature Geosciences* suggests that the Gulfstream Thermoline Circulation (or Atlantic Meridional Overturning Circulation

- AMOC) now is at its lowest in over 1.000 year. Scientific evidence suggests it to have decreased by approx. 15%.

The Thermoline circulation is an example of interconnected causes and effects that profoundly will change the world if this vital vehicle for maintaining temperatures, living conditions and ecosystem exchanges should be seriously changed or broken. Precipitation will be changed, and less rain will fall over Europe so that forests areas will decrease and areas with herbs etc. will increase by a slowdown of the AMOC. This will have rippling effects of wildlife and human societies. Other recent scientific evidence as well collected by e.g., the Swedish Meteorological and Hydrological Institute seems to suggest the slowdown of the AMOC to be a real phenomenon. There is probably no credible way to calculate the serious impacts it would have on a global scale but if the AMOC is changed it will most likely have large scale effects. Species that are not able to adapt to the changed circumstance will become extinct, parts of landmasses will become inhabitable, the finely tuned equilibriums in our ecosystems will be challenged and the number of environmental refugees could exceed tolerable levels. Once again, it's important to note that these might be very likely consequences of the climate change – specifically possible changes in the AMOC that might be what we're witnessing right now.

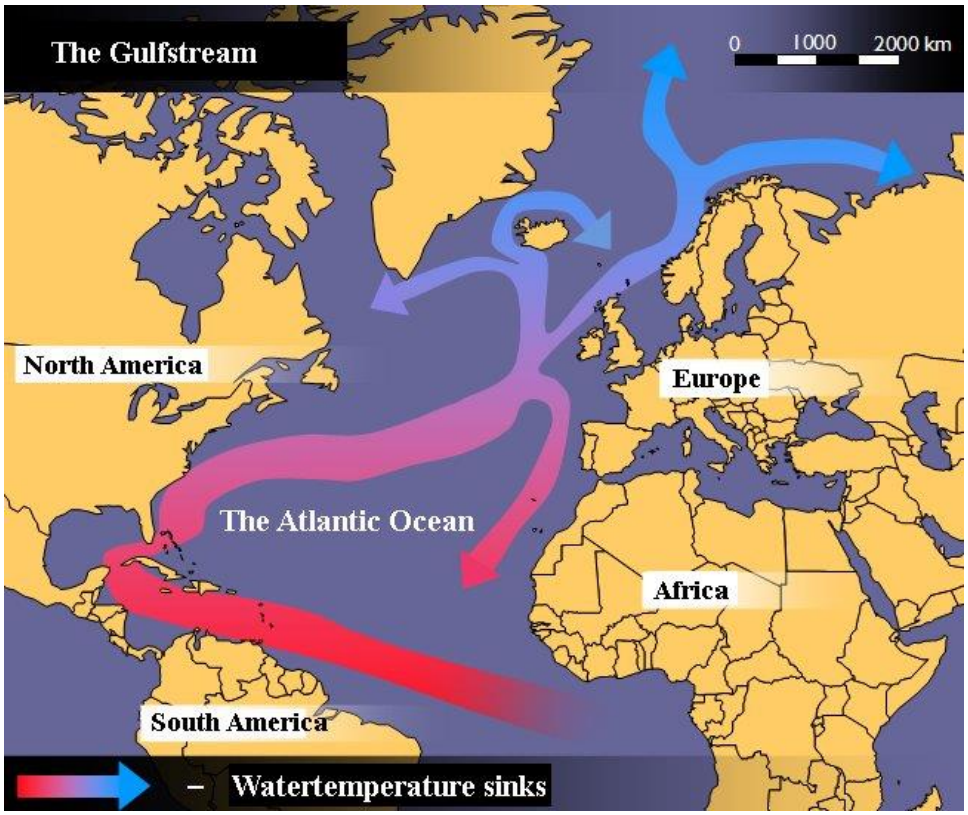


Exhibit 2.82 The Gulfstream – passage in the Atlantic Ocean

Warming up of oceans

The oceans play a major role for our climate and 2022 saw the warmest oceans ever recorded. In March 2023 average world oceans temperatures stood at 21° C. [16] The various ocean currents transport heated water to colder parts of the globe and vice versa. It transports nutrients etc. for ocean organisms. It evaporates moisture into the air and receives precipitation. It absorbs and emits temperature changes, and it's the largest storage facility for aerial CO_2 contents accounting for some 30% of the atmospheric CO_2 uptake. Marine "heat waves" is expected to rise by a factor of 50 in the high emission scenario the IPCC has put forward compared to the end of the 19th century. When a warming of the ocean occurs the oceans mass expands, and it also changes the marine ecosystems as well. When temperatures are rising dissolving oxygen at the surface becomes harder and less oxygen will reach the lower oceanic levels. However, research done by Princeton University in 2018 also seems to indicate that e.g. The Southern Ocean around Antarctica during winters will actually *emit* CO_2 and thereby lessen the Southern Oceans uptake of CO_2 by some 34%. The reason is that during winters the deep currents in sea water rises to the ocean surface and these will then release its centuries-old carbon contents. So, science is just beginning to understand what is going on in these oceanic systems. The El Nino phenomenon is possibly affected by the warming of oceans. With intervals cold nutrient rich water in the Pacific is lifted to the ocean surface by strong winds thereby increasing the fish population on which the Galapagos penguins feed.

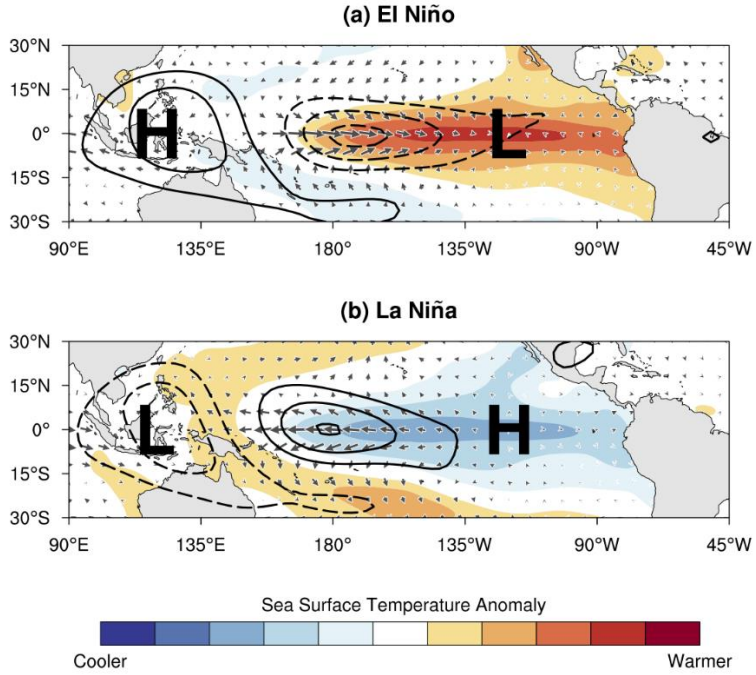


Exhibit 2.83 The El Nino and El Nina phenomena

[16] See *"Earths oceans are showing early…"* Washington Post, 23 March 2023

In El Nino years low-pressure westerly winds being weaker than normal causes warmer surface temperatures and less upwelling of nutrients. If El Nino is altered by rising temperatures this will affect the penguin population. The very strong El Nino phenomenon in 1982-83 and the resulting decrease in food supply led to a decrease in the Galapagos penguin population by 77% and in 1997-1998 to a decrease by 65%. Now the El Nino is a natural occurring phenomenon, but climate change might impact it and consequences can be dire for wildlife in the Pacific. The La Nina represents the other extreme of the Pacific water circulation as can be seen form Exhibit 2.83 above. Scientifically it has not yet been possible to predict how climate changes exactly will affect the El Nino/La Nina phenomena, but indications of a shifting weather make it a potentially threat to wildlife in the Pacific.

Acidification of oceans

When ocean absorbs CO_2 it will affect the level of acidity. Seawater is slightly basic having a pH of >7, however, when increasing amounts of carbon dioxide is absorbed it will lower the pH level thereby affecting the equilibrium state.

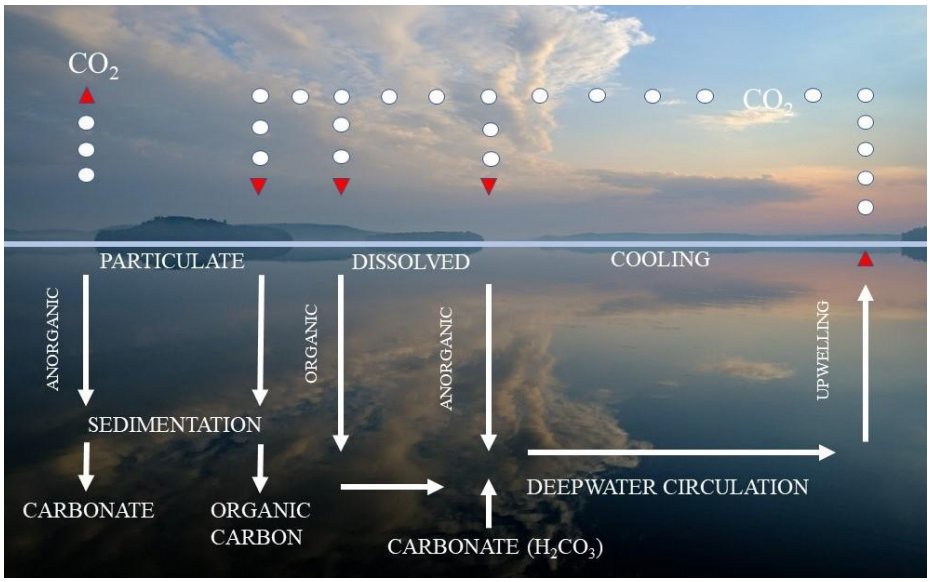


Exhibit 2.84 Biological and physical pumps of carbon dioxide

It is this increased acidification combined with warmer waters that actually make coral reefs bleach and eventually die. Some scientists have found the path of acidification of the ocean to be the largest during the last 300 million years, so there is cause to be alarmed by the things that presently occur with our coral reefs. They effectively act as the singing canary that something is completely wrong with our ecosystems. This acts both as a warning and a real game changer for the marine ecosystem – changes that are not requested.

The current level of pH is approx. 8,2 and some projections say that in 2094 this will have dropped to 7,8. Since all changes takes place at the borderline this seemingly small change, however, can have a profound effect on marine life and its ecosystem. Let us look at an example. Krill are small invertebrates that constitute the basic food for fish and other marine life. The shells of these krill's will be affected when pH drops since calcium carbonate now will be less available due to greater intake of CO_2. This occurs in the upper parts of the sea surface and shallower waters will therefore be much more exposed to such changes of acidification, and this is where the krill are found. If this system is interrupted marine life can be at risk and hence marine fishing opportunities can deteriorate substantially.

Phytoplankton is the prime source of food for these krill's (*zooplankton*) and generally the first part of the food chain – a primary producer. This phytoplankton absorbs sunlight by their chlorophyll contents and use photosynthesis to turn this into chemical energy. In the process they use the carbon dioxide stored in the water and subsequently releases oxygen back into the water. Acidification of our oceans and rising ocean surface temperatures will impact the krill's supply of phytoplankton. Some species will tend to die out while other will flourish. How this actually will unfold remain to be seen. However, there seems to be severe changes underway when it comes to the most basic food supply of them all - the phytoplankton.

A study undertaken by Canada's Dalhousie University indicates that approx. 40% of the phytoplankton has vanished since 1950. [17] The warming of the oceans also affects other wildlife. For example, sea turtles are migrating further and further north along the US north-east coast most probable due to higher water temperatures. However, in autumn when the weather gets colder the turtles will actually be trapped in an "ice cage" and go into a state of chock and eventually die. So, there is a direct linkage between rising ocean temperatures and problems to wildlife.

Noise in the ocean

We know that dolphins, whales and other marine mammals communicate by complicated sound signals and use sound for echo-localizing and by doing that they find prey, locate and signal each other for mating and locate habitats. In fact, sound is the prime way of communicating in the oceans travelling long distances under water. The frequency by which these animals communicate is often so low that it's not possible to detect for the human ear but with the help of technology we have during recent years learned that sound communication is much more widespread than first anticipated.

[17] See Laureen Morello, Climatewire on July 29, 2010 published in Scientific American

With the heavy traffic occurring in certain places this communication will be made more difficult – they simply can't hear each when the ocean is filled with disturbing noise or the signals can get flawed and not understood by the whales, dolphins etc.

Discharges into the ocean

Oceans have for long been used as a worldwide dump site. Heavily polluted wastewater has been discharged, radioactive material has spread e.g., due to the accident at Japanese nuclear plant Fukushima, garbage as well as chemicals have been dumped from ships and discharged from land, excessive amounts of nitrogen and phosphorous from agro-industrial operations have poured into the ocean and huge areas is now floating with plastic and micro-plastic – known as the "*The Great Pacific Garbage Patch*". 80% of this trash stems from land based operations. This in turn has created excessive problems for marine life. Marine mammals, birds and fish all can mistake e.g., plastic debris for food and nesting materials and once this happen their stomachs and internal organs can be put out of function and cause a painful death, they can get trapped and their offspring can suffer. Numerous examples of this can be found from all over the world. Turtles can get trapped in lost or discarded fishing nets floating around, birds, fish and marine mammals can get entangled in plastic leftover, nets and so on. Besides these issues plastic contains toxins that will accumulate in the food chain and thereby pose a health risk to human beings. This causes serious problems since plastic will deteriorate through time – sometimes hundreds of years - and eventually will wind up as micro plastics and become a part of the regular food chain.

Algae blooming is another consequence of having too many nutrients discharged to ocean waters. This can cause massive problems for ocean life. When areas are hard hit fish will die, shells, mussels, crabs and lobsters will suffer.

A number of measures have been taken into account to combat our pollution of the oceans but far from enough. Oceans acts as a splendid "out of sight, out of mind" mechanism. We are not witnessing the desperate struggles by marine mammals are undergoing to free themselves of fishing nets, we're not documenting the sufferings by fish having their internal organs destroyed by toxins or plastic debris, we do not see seabirds starve to death because their habitats have been ruined.

We do not see, and we do not feel – and that might be the biggest problem. Humans are accustomed to using their eyesight to a large degree in order to evoke emotions, compassion and other feelings. That's why the panda is so popular, and the Seychelles forest scorpion is not though the latter is critically endangered and the former is not. The ocean is a convenient vehicle for hiding unpleasantries.

Exhibit 2.85 Albatross with stomach full of plastic and other materials

Some of these issues stems from *non-point sources* (e.g., sewage treatment plants) other from *point source pollution* (e.g. oil spills, wastes from ships etc.). *All* stems from industrial, agricultural, public as well as private sources and most are subjected to ocean currents spreading the wastes all over the ocean. Consequences are that our oceans will react to this in form of downside ecosystems effects such as eutrophication, destruction of habitats, harmful and sometimes detrimental effects to marine wildlife and changes in the chemical composure of specific ocean areas. Beaches can become polluted, swimming areas can be closed to the public, fishing

can deteriorate, and aesthetics can become impaired etc. so we all have a stake when it comes to discharges into our oceans.

Overfishing

Some marine species are on the verge of becoming substantially reduced in numbers. This counts for the Atlantic Blue-fin tuna, the Baltic and the North Sea cod, and the Atlantic Halibut – all three are on the list of endangered species (the IUCN "Red list").

Exhibit 2.86 The Atlantic Bluefin Tuna is an endangered species

Such stocks are of commercial value to the fishing industry. However, fish without this commercial value are also dwindling e.g., the Angular Rough shark and the Angel shark. The fishing fleet is now so effective, the ships so big and the logistics so advanced that they unlike earlier can impact stocks of fish everywhere on the globe. If fishermen's catch is above sustainable limits, it will mean that stocks are being depleted. Over 90% of the oceans big predators have in fact been eradicated by now. This will inevitably affect the whole food chain and ecosystem.

Another problem is that of *by-catches*. Some species are not permitted to be caught due to regulations but will enter the nets of the fishermen anyhow and the only thing to do is to throw the by-catch overboard. And it's not only by-catches that end up in the nets, sea turtles, protected marine species and others marine animals can also wind up in the fishermen's nets impacting biodiversity.

Since modern fishing boats have gotten so technologically advanced and so big, they are able to vacuum the ocean floor for fish and thereby harming local fishermen's possibilities for making a livelihood and seriously impact fish stocks. Another important issue is that of failing or inadequate measures for protecting marine life through the use of strict quotas and employing methods that can reduce or avoid harm to the ocean crust. However, even if such quotas exist there will still be problems with upholding the system. *Illegal fishing* is one of the big issues here. Japanese, Korean, Chinese, Taiwanese, Russian and Spanish fishing boats have routinely been caught in submitting false data on their catches. This is further complicated because various state subsidies for boats and fuel etc. are available in some areas e.g., in Asia and Europe. On a yearly basis some have estimated this to amount of $30 billion. This is followed up by changes in consumer demand, people becoming more affluent and more aware of health problems as well as rising prices each of which also will stimulate activities within the fishing industry. Sharks are being decimated because some like to eat shark fin soup and because local fishermen can thrive economically by catching them often leaving the rest of the fish to rot.

Today only 5% of the world's oceans are protected and we urgently need to raise that percentage in order to preserve and increase the rapidly declining fish stocks of the oceans. The newly adopted UN High Seas Treaty from March 2023 greatly gives hopes for this by expanding this territory and protecting 30% of ocean waters by 2030 - after more than two decades of talk! This must be considered a significant step forward.

Use of toxins

Another problem is due to the use of toxins for fishing. In the coastal region of Cameroon for example a toxic - Gamalin – is used for fishing purposes. It was actually introduced as a pesticide in the agro-industry but now has found its way into fishing as well. The toxic is poured into a river or seawater and after some time dead fish will begin to emerge which are then collected and eaten or sold on local markets. All aquatic life within reach of this toxic will be eradicated – small fish, non-commercial fish, and endangered species and so on and the life cycle of the populations will be broken. Furthermore, some of the toxic substance can still be found in the dead fish with health hazards to the local population.[18] Others have used dynamite or other explosives for catching fish with the same devastating effects on the fish populations and ecosystem. These methods are illegal to use but that doesn't deter some of the local population to use them anyhow.

[18] Julien Chongwang, Gilbert Nakwaya & Ghislaine Deudjui, *Poisons used to make food more beautiful, last longer,* scidev.net, 03.07.2020

Fish farming – a problem in the ecosystem

Fish farming in the ocean is not illegal – yet. It is generally recognized that fish farming does have major impact on the marine environments in our fjords and nearby coastal waters. Feces, urine, medication, nutrients, chemicals, antibiotics, decomposed fish etc. are reasons why the water and oceanic crust gets polluted, and habitats destroyed. Let us give an example. Danish fish farm company *Musholm AS* is 100% owned by Japanese investors *(Okamura Foods Co. Ltd.).* They produce eggs from rainbow trout put into nets in near-coastal areas. The cycle begins in spring when trout with a weight of 500 – 1000 g are being transported from inland fish farms and put into the ocean nets. The trout grow extremely fast being fed with pellets and by the end of autumn they are ready to be slaughtered and the eggs taken, cleansed and canned and then send to Japan where they are a treasured delicatessen. The environmental issues that confront this kind of fish farming are numerous.

The first issue is that the ocean bed can get exposed to leftover from feeding the fish, from feces, urine and medication. This will influence eutrophication in the ocean as well as disturbing the nearby habitat. The other issue is that the companies use substances that are intended to inhibit algae and mussels to stick to the nets. If this happens the free water flow is inhibited, and nets could ultimately sink to the bottom of the ocean. This requires chemicals that detract algae and mussels from their natural way of behavior. These chemicals will add to the pollution of the ocean water.

Yet another issue stems from the fact that e.g., salmon lice are abundant in these nets, and this can eventually impact the stocks of wild fish. The pellets that are used for feeding the fish also pose problems since they partly are made of e.g., soybeans grown in South America, partly of wild fish caught in the ocean. In fact, most of these wild fish resources are used for fish farming and agriculture. It is estimated that aquaculture consumes 53% of the world's fish flour and 87% of the world's fish oil stemming from herring, mackerel, anchovies and sardines. It's questionable whether this method is efficient since approx. 3 kg of foraged fish goes into making 1 kg salmon and 5 kg into making 1 kg cod and 20 kg of making 1 kg blue-finned tuna – these figures, however, can vary around the globe.

The monitoring, slaughtering and transporting the fish requires resources before the eggs end up in Japanese restaurants as luxury dishes. Due to their perceived high quality the Japanese consumer is willing to pay premium prices for the eggs and Musholm A/S then generates a profit from this operation. In other words, the Danish coastal and inland waters are bearing the environmental costs of this operation and the Japanese consumer and Musholm A/S reaps the economic and other benefits. Danish politician Jacob Jensen, presently Danish Minister for Food, Agriculture and Fisheries have been a member of the board of the company from 2013-2019. Politics, money and power links very well in certain instances.

All over the world we see huge fish farms impact the environment and results are similar – the environment is polluted, and ecosystems viability are impaired or destroyed. If regulations are regularly neglected there is ample room for using illegal substances. This also pertains to the Chinese fish farm industry. Right now, alarm bells are sounding concerning the Chinese use of antibiotics:

"*The unregulated use of antibiotics has affected the development of our country's mariculture industry and damaged the image of our aquatic products in the international market*,"

is a quote made by Peking University professor Wen Donghuilet so let us have a look on the issue focusing on the Norwegian salmon industry below. [19]

Antibiotics – the fish farm industry

The fish farming industry is a heavy polluter of our oceans and narrow straits and fjords. As an example, salmon fish farms use chemistry to combat the salmon lice. Such chemicals (nervous poisons such as *deltametrine* and *cypermetrine*) are poured into open water at the cages and will spread through the water system and eventually be absorbed by e.g., seaweed. Sheep along the coast of Iceland (the area of Porkeri) eat such seaweed and thereby get exposed to the chemicals. In 2019 this resulted in 50% of the sheep having a miscarriage compared to a normal level of 2% - 3%. This is but one example of the problematic environmental effects due to fish farming. The quality of the salmon meat is another issue. Some restaurants have banned using fish farmed salmon due to their perceived lower quality being floppy, fat and less tasteful. To this should be added that The Danish Veterinary authorities recently have warned against feeding babies under the age of 2 with farmed salmons due to their perceived relatively high contents of possibly harmful chemicals. The Norwegian salmon farm industry is the world's largest producer and exporter of salmon products. The deep Norwegian fjords provide a good environment for the more than 3.400 cages along the west coast of Norway. However, this industry has also been criticized for their harmful environmental effects including:

1) Use of 67.000 tons each year of problematic substances like formalin, hydrogen peroxide etc. that have caused changes to the marine ecosystem nearby the salmon cages. One problem is when a substance reduces the keratin shells of the salmon lice in order to kill it, it will also affect the shells of crabs, lobsters and amphipods in the area. This means that the natural stock of invertebrates and others that take

[19] "*Overuse of antibiotics threatens China's fish farms, scientists warn*", by Stephen Chen, South China Morning Post, 2nd April, 2021

care of the feces and leftover from the cages eventually will be missing and fishing for these will deteriorate.

2) The use of large doses of chemicals have made some salmon lice resistant which means that even more powerful substances will have to be used in order to combat the lice. Another chemical used is that of *astaxanthin.* If this wasn't added a farmed salmon would have white meat. In order to get the normal red/orange color of the salmon astaxanthin is added to the fodder.

3) The large numbers of salmon lice will affect the small migrating salmons when they enter the sea. These so-called "smolts" are not capable of combating large numbers of salmon lice transferred from the cages and will eventually die thereby affecting the natural stock of salmon found in the Norwegian rivers. Scientific estimates suggest that the wild salmon population in Norwegian rivers amounts to just 50% of its former population compared to 1993.

4) Norwegian investments in fish farms in Canada have affected the populations of the Pacific salmon negatively. The same is true for the population of Norwegian seatrouts. When farmed salmons escape their cages they will furthermore mix with the wild population of salmons, and this can weaken the genetic code of the wild stock experiencing infertility and less resilience. In some Norwegian rivers attempts to kill the present stock of salmon has therefore been made in order to restore the original wild salmon population.

5) Salmons are fed with a protein rich diet consisting of e.g., 20% soybeans. These soybeans are produced in South America implying rain forest possibly being cut down to make room for the soybean production and the use of problematic toxins such as *endosulfane.* Some of the fodder used to feed the salmons contains up to 70% vegetable contents which means that the important Omega-3 fatty acids will be lower in farmed salmons than in the stock of wild salmons while fat contents will be more widespread in farmed salmons. Transporting soybeans from South America to Europe poses other environmental problems.

These issues impose important problems to the fish farm industry. However, the Norwegian salmon farm industry is a multi-billion-dollar industry and any intervention into its operations can affect the Norwegian GNP. Fortunately for the fish farm industry the former Norwegian Minister of Fishery Lisbeth Berg Hansen as well as the former Norwegian Director of Fishery Liv Holmefjord were co-owners of a part of the Norwegian salmon farm industry! In Norway they try to tax corporations within the salmon farming industry as one way of combatting the problems and to a lesser extent questioning whether or not the salmon industry in fact is a sustainable business to undertake in an open systems environment?

Exhibit 2.87 A salmon farm in Tasmania, Australia

Marine ecosystem collapse

The consequences of rising temperatures are already in full swing when it comes to the Great Barrier Reef around Australia and other areas whose shorelines are dominated by corals. These corals are very sensitive to temperature changes which mean that they can ultimately bleach and die. The best-known example of a marine ecosystem collapsing is that of the Great Barrier Reef – becoming a part of UNESCO's list of World Heritage Sites in 1981. The corals are vanishing, and they are vanishing fast. An article in *Nature* in 2019 for example documented that 89% of baby corals was gone due to the 2016 and 2017 mass bleaching and a study in The Royal Society Journal in autumn of 2020 documented that 50% of the corals of the Great Barrier Reef now has gone since the mid-1990s. Marine heat waves as well as the crown-of-thorns starfish are the two main culprits. However, a report from The Australian Institute of Marine Science from summer 2022 also indicated that parts of the northern and central parts of the reef seems to be recovering reporting the highest amount of hard Acropora coral reef in nearly four decades.

When temperatures rise corals will react by expelling symbiotic algae and thereby lose its natural food source. When this happens, the corals will turn white ("bleach") and eventually die. The wonderful colors of the corals are in fact due to these algae's and not the coral itself. Numerous videos and documentaries stemming from the Great Barrier Reef has shown us the wonderful and complicated life of these organisms. In the future they might very well be the only thing we have left of these magnificent ecosystems.

Exhibit 2.88 Corals bleaching in Hawaii

These prolonged ocean heat waves, as well as the crown-of thorns starfish are credible evidence of the mass extinction of coral reefs. Another reason is the use of sun lotions. Some of these products contain chemicals (e.g., oxybenzone) that are harmful to the coral reefs. As a result, the island of Palau in the Pacific Ocean in 2020 banned the use of such harmful sun lotions. If caught using these, you can expect severe fines. As of the end of 2020 The Great Beerier Reef is considered critically endangered by IUCN.

Exhibit 2.89 Corals are intensely colorful animals due to the algae living here

Another ecosystem, on the verge of collapse would be the Arctic region. A vital source of food to e.g., polar bears are seals resting on the sea ice. When the sea ice melts it will mean that the ecosystem changes accordingly – the polar bears will be starving, and this will alter their behavior. They will try to find new hunting grounds in order to feed themselves. Starved polar bears are now beginning to emerge more frequently in the Arctic and the influx of polar bears into human settlements more visible. Seals in the Baltic Sea normally give birth to cups when ice covers the water. Now the ice is gone, and mortality of seal cups has risen. Yet another issue in the Arctic region is that of indigenous people fishing for halibuts in near coastal waters. Due to the number of small boats the halibut stock has been under pressure and sustainable fishing is not undertaken. Problems are that the quotas in place are 60% above sustainable catches, that fishing is the only source of income for the indigenous people and that the number of boats fishing is too large. This is a problem that shows the challenges that has to be faced when coming up with viable solutions. If this current trend continues the stock of halibuts will ultimately disappear from the waters and the magnitude of the problems will accelerate.

We've seen the same thing happen all around the globe. When the fish stock is being depleted fishermen and their families will move and ghost towns emerge. But many other examples are documented. Problems are due to pollution, overfishing, marine farms, invasive species etc. Most of these, however, are reversible problems that can be altered if the political establishment is committed for doing so.

2.5.3 THE LITHOSPHERE

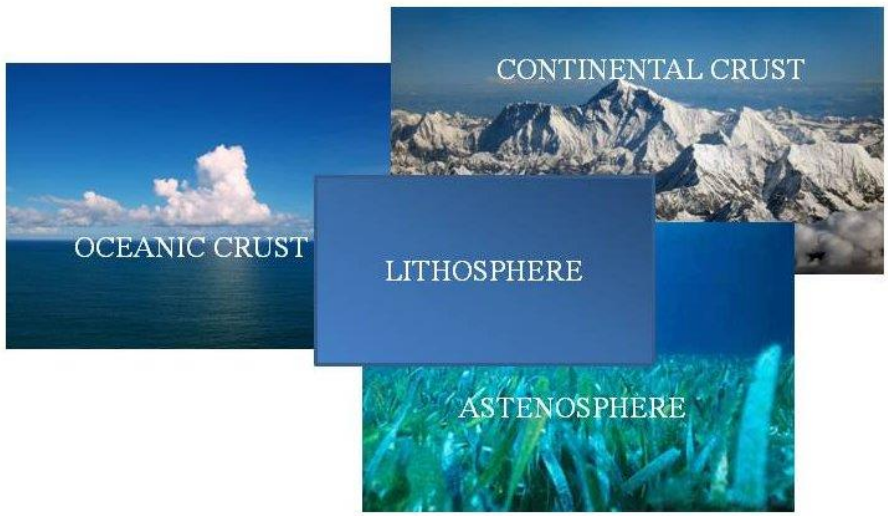


Exhibit 2.90 Elements of the lithosphere/pedosphere.

The lithosphere is another name for the *earth's crust* and *uppermost mantle*. Roughly it's about 100 km deep and consists of the rocks, sand, mud, soil and so on that we partly can see. The *continental crust* embraces mountains, woodlands, deserts, human settlements etc. while the *oceanic crust* is comprised of the oceanic bed consisting of sand, sediments and rock formations etc. The upper solid part of the *asthenosphere* roughly about 2900 km deep also affects the lithosphere. The boundary of the asthenosphere and the lithosphere is often termed LAB and is defined according to temperature. If it's below 1300º and exhibiting solid structure its part of the lithosphere if not it's a part of the asthenosphere. It's thought that the 7 *tectonic plates* "floats" in the upper part of the asthenosphere and scientific evidence suggest that e.g., Denmark once were positioned around equator. A lot of the volcanic activity we see around the globe is due to the plates moving creating tension that ultimately will feed volcanic eruptions and accompanying tsunamis. In fact, *Iceland* positioned right above two tectonic plates is in the process of being torn apart between the US and the European tectonic plates. This causes – sometimes massive – volcanic activity. However, these movements are all parts of a natural cycle. The outermost part of the continental crust is called the *pedosphere* basically consisting of soil. It interacts with the other elements in finely tuned relationships and all terrestrial life happens in the pedosphere. It is here terrestrial habitats and wildlife is formed.

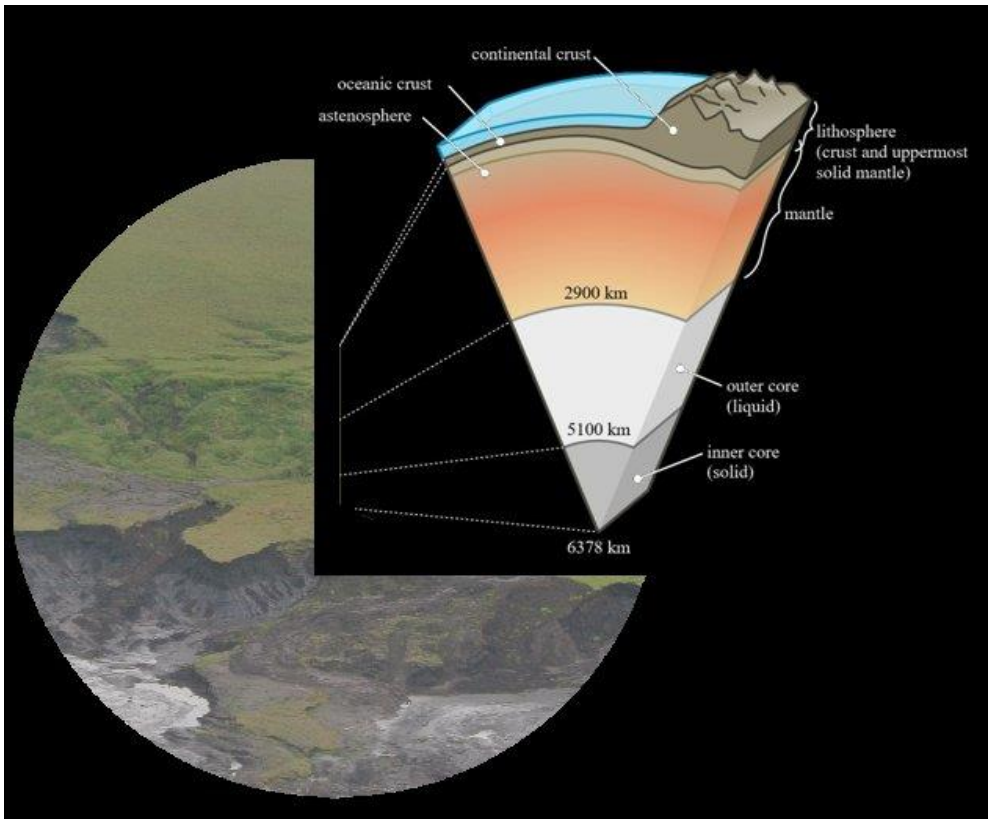


Exhibit 2.91 The lithosphere

So - not counting the atmosphere - the lithosphere is where we extract our resources, contaminate them, toxicate them and use them for our own purposes. A very basic question is therefore *how* do use the land and for what purposes? Both issues involve future priorities to be made with serious implications for those involved.

THE CONTINENTAL CRUST

A lot of the earth's crust is covered by forests – approx. 31% of the earth's land surface - and these are a vital part of the global ecosystem.

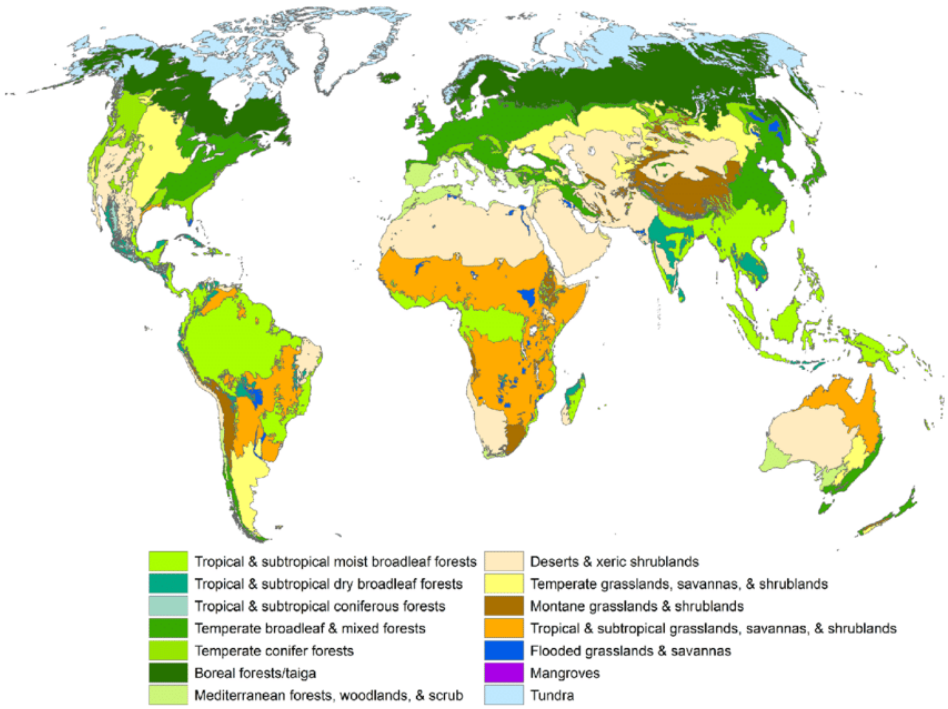


Exhibit 2.92 The coverage of woodlands, deserts, grasslands etc. on earth
Source: Researchgate

Forests are important because they absorb CO_2 and emit oxygen, because they act as an integral part of the workings of different ecosystems, because they can be used for human purposes and because the forest itself is a major part of the world's ecosystems. Forests contain more than 60.000 species of trees and are habitat for more than 80% of amphibian species, 75% of bird species and 68% of mammal species. Right now, we're seeing both positive and negative developments. The Amazon is about to being heavily diminished giving way to human activities and some tree species are endangered and part of "Red-lists" like Brazilian rosewood

and other rosewood species. On the other hand, we see that more and more trees are being planted all around the globe and more and more woodlands are being preserved in order to develop without human interventions.

Beside forests the continental crust is made up of a variety of ecosystems – deserts, flatlands, mountains, valleys, highlands etc. They all interact and play a vital role in the workings of linked systems like these of the biosphere. It is here that we find the most mammals, the most comprehensive system of flowers, bushes, grasses etc.

BUILDING BLOCK OF THE LITHOSPHERE - PHOTOSYNTHESIS

We will categorize *photosynthesis* as a phenomenon occurring in the biosphere as a process involving elements from and to the atmosphere, the lithosphere and the hydrosphere. It exists as a necessary part of the *natural cycle* of life on earth. *Photosynthesis* works the opposite way human beings do. Plants absorb CO_2 from the atmosphere and emit oxygen (O_2). This is undertaken by the process of photosynthesis. This process can be written as:

$$6\ CO_2 + 12\ H_2O + photons \rightarrow C_6H_{12}O_6 + 6\ O_2 + 6\ H_2O$$

(carbon dioxide + water + solar energy ➔ glucose + oxygen + water)

During photosynthesis e.g., a tree will absorb 6 carbon dioxide molecules, 12 water molecules and light energy in the form of solar light (photons). The tree then transforms this into sugar, starch and celluloses as well as emitting 6 oxygen molecules and 6 water molecules (respiration). Measured as dry weight 50% of the tree consists of carbon. Carbon is stored in the tree's roots, trunk including its bark and crown in various proportions – most of the carbon will be stored in the trunk.

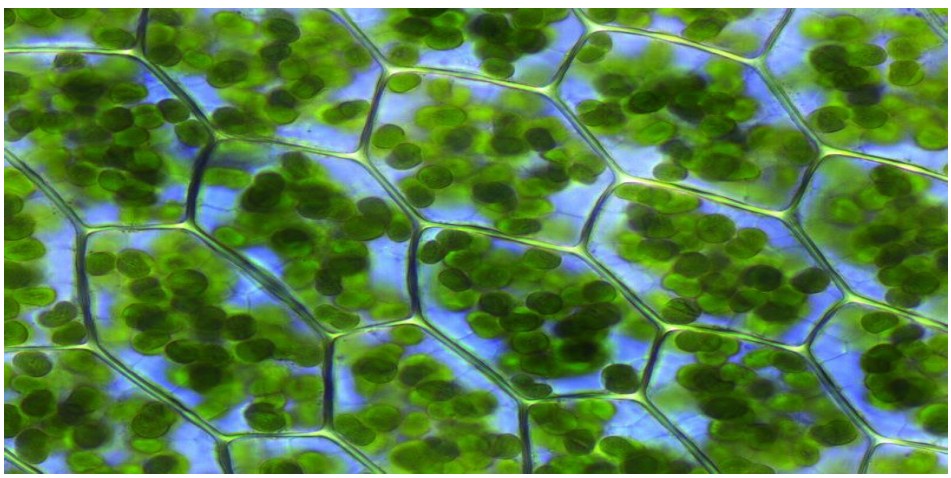


Exhibit 2.93 The manufacturing plant of photosynthesis

How photosynthesis actually is carried out is due to the so-called *chloroplasts* found in the cells of plants and other *eukaryotic* systems. A pigment called *chlorophyll* captures the energy of sunlight and converts and stores it into the molecules ATP and NADPH while freeing oxygen (O_2) from water in plant cells. We can furthermore say that if 1 kg of carbon (C) is going to be transformed into carbon dioxide (CO_2) we will need 2,67 kg of oxygen (O_2) in the process. The atomic weight of carbon is 12 and that of oxygen is 16 so the atomic weight of CO_2 is 1 x 12 + 2 x 16 = 44. So, if 12 kg carbon is completely combusted it will result in 44 kg CO_2 or seen in another way: 1 kg of combusted carbon (C) will result in 44/12 = 3,67 kg CO_2.

BUILDING BLOCK OF THE LITHOSPHERE - COMMUNICATION

Recently it has been discovered that trees might actually able to "communicate" with each other – some have called it the "Wood-Wide-Web". German scientist Peter Wohllebend illustrates this idea in his book: *"The life of Trees: What they feel, How they Communicate"* issued in 2016. So, trees might not be the sole, lonely standing units of wood compartments we're accustomed to think, they actually help each other and are connected through their root system and by the help of others into collective, mutually dependent organisms. They form so-called mycorrhizal networks. They do so by the help of fungi – mushrooms for lack of better. Through the finely organized hair like root system coupled with the fine filaments of the fungi, they send signals to each other – they communicate. The fungi "get paid" in the form of 30% of the sugar the trees are able to produce. So, it's a win-win for everybody. But not only does the fungi benefit. The young saplings of the trees are also connected to the web and excess sugar will enter the root system of these young saplings.

Communication takes place in the form of chemical, hormonal and electric signals in their root system but also by pheromones and scent signals send via air. This radical new way of perceiving trees opens up for a whole new understanding of what trees are, what they do and how they do it. It puts a new perspective into our ways of dealing with forestry and deforestation and a range of other important ecosystem issues.

When elm and pine leaves for example are attacked by caterpillars the trees detect the caterpillar's saliva and then release pheromones that attract parasitic wasps. The wasps then lay their eggs inside the caterpillar which is eaten alive by the larvae. The wasps get fed and the tree gets rid of the threat – a winner for both. This kind of symbiosis is also undertaken by trees sharing the communication system. If one tree standing next to another dies there is an increased probability of the other tree will die as well. Another example is that of giraffes eating leaves from acacia trees. The trees will warn each other by expelling doses of ethylene gas and at the same time filling their leaves with poison. The gas will warn other acacia trees nearby about the herbivores. That is why the giraffes will jump trees nearby and eat from

trees not warned by the ethylene gas and leaves not infected by the distasteful poison.

Exhibit 2.94 Trees "communicating"
Source: National Geographic

BUILDING BLOCKS OF THE LITHOSPHERE - STORAGE OF CARBON

There is a huge difference in trees capacities for storing carbon. Carbon storage is dependent on a tree's height, its width and its mass. Spruce is able to store much less carbon than e.g., a beech. A red spruce of 50 cm in diameter with a height of 26 meters will be able to store 2,19 $CO_{2\text{-}e}$ while a beech of the same size is able to store 4,30 $CO_{2\text{-}e}$. However, beeches will generally grow much higher and older than spruces (up to 400 years) and therefore will be able to store a comparable larger amount of $CO_{2\text{-}e}$ during its lifetime (70-80 years for red spruce compared to +100 years for beeches) On the other hand red spruces grow faster than beeches and are therefore able to store more $CO_{2\text{-}e}$ per year (12 m^3/ha/year compared to 8 m^3/ha/year for beeches). Taking an average measurement red spruce will be able to store 232,1 tons $CO_{2\text{-}e}$/ha while beeches will store 481,8 tons $CO_{2\text{-}e}$ /ha. To that should be added that much of the carbon storing effect – *fixation* - takes place under ground in the root net.

All such measurements are based on an "inventory" point of view. In the end all carbon will be emitted back into nature. It's just a question of how fast the process will be. It's therefore essentially a question of which trees we're growing and how many, the way we handle these forests and the way we use the wood from such

forests that will actually impact the level of CO_2 in the atmosphere. Since in the end it will all boil down to a zero-sum game only by planting relatively more trees can we hope to increase the uptake of CO_2 from the atmosphere.

Uses of wood can pose problems

When we talk about carbon storage one thing is the ability to store carbon, however, the next important issue is how we use the wood derived from these trees? If used for buildings, musical instruments, and furniture etc. carbon will be stored until such products are worn out and burned. If recycling or reclaiming woods the carbon storage facility can in theory, go on forever. However, if woods are used for heating purposes, incinerated, destroyed by wildfires, eaten or destroyed by wildlife or other it will be released back into the atmosphere considerably faster than otherwise. To this should be added that during such processes other processes comes into play e.g., the release of methane from wildlife and livestock feeding on leaves (carnivores) etc. So, in essence carbon is converted to gasses that are much more harmful to the climate than CO_2.

Exhibit 2.95 A guitar stores carbon for decades even centuries

BUILDING BLOCKS OF THE LITHOSPHERE - SOIL

Soil is the most important element of the earth's crust. This is where we plant renewables – maize, wheat, grass etc. Generally, soil is composed of minerals (45%), organic matter (5%), water (25%) and air (25%) but varying considerably depending on the time of year, place, exposure to weather conditions etc. Minerals and organic matter hold and stores nutrients and the water are used by plants for transporting nutrients into the growth and decaying cycles. The air content of the soil is an important ingredient as well since microorganisms need air to perform the natural biological processes that will release additional nutrients into the system. Soil is composed of various types of clay, silt, sand, mud etc. each with different attributes for forming the soil and providing the basic element for growing various kinds of crops.

The soil is also in fact a very fragile element and will change over time and managing it has been a keystone in agriculture and horticulture. However, this way of managing the soil has also brought added problems. We've used fertilizers, pesticides, toxins and other to improve growth conditions for our crops and we've compressed the land used - this ultimately will come at a cost.

ENVIRONMENTAL PROBLEMS - THE CONTINENTAL CRUST

We experience the effects of environmental problems every day. Underground water reservoirs used for drinking purposes are increasingly being contaminated, wastes are being discarded of one way or the other, rivers have been tamed due to energy considerations, contaminations of the soil are still going on due to deposits made many years ago. A number of other problems have manifested themselves during our lifetime with overwhelming speed.

Discharge of carbon, nitrogen and phosphorous

One of the problems that have been experienced in our waterways are excessive amounts of nitrogen and phosphorous giving rise to increased eutrophication. Aerial emissions of carbon will be another associated issue. The reason for this lies in the way the soil works. If not absorbed by plants substances such as carbon, nitrogen and phosphorous will eventually end up being washed out or emitted into the air adding to the greenhouse effect and eutrophication of our rivers and lakes.

Especially low laying areas rich in organic carbon are prone to this and when such land is plowed and worked on, they will be major emitters of substances such as carbon compared to other soil types. If taken out of production the soils water content will rise and thereby halt the oxygen uptake from the air which leads to lower or a possible stoppage of carbon degradation and hence decreasing aerial emissions that could prove harmful especially concerning the greenhouse effect.

Drought/desertification

At the end of 2019 Australia experienced a severe drought and precipitation hasn't been as low since 1994. Now drought in Australia is a recurring phenomenon but climate change has made Australia become warmer, and heat waves more prolonged. A record average temperature of 41,9° Celsius was recorded in Australia in late 2019 and this year became the hottest year ever recorded on a global scale. This has led to more droughts, more wildfires and flooding in certain areas in Australia. Droughts can be deadly. In 2022 some 43.000 people died in Somalia due to drought and 100.000 of people have fled the area – sufferings have been tremendous. In some places on earth deserts are becoming more widespread. The Sahara Desert in Africa has seen an expansion twice the size of France during the past 100 years. This means less fertile land and less biodiversity. We see this desertification happen other places on earth as well. Especially Africa will be hard hit according to the IPCC when the progressive effects of climate change unfold in the future with huge blows to its GNP, its wildlife and its weather system.

Since climate change is affecting the earth's weather system as well one of the consequences is that more land will be exposed to this desertification. It's simply not raining enough compared to previous times in specific areas. This is increasingly visible in North Africa, the Middle East and East Asia. This will impair living conditions for people in these regions. Today it's estimated that approx. 0,5 billion people live in areas which have experienced desertification between 1980 – 2000 and the UN has estimated that the livelihood of 1 billion people in some 100 countries are threatened by desertification.[20] This will cause people to find new ways to subside their existence - including migration – in other words they become eco-system refugees. Desertification will make huge impacts on wildlife, biodiversity, fertile land and settlements. Drought means that water levels in rivers will be lowered or run dry causing problems to shipping traffic, farming as well as local wildlife. Italy's longest river in the Po valley has in the summer of 2022 seen the longest drought in 70 years lowering water levels 7 ft below normal.

Deserts, however, are just one element of what is called *dry lands*. An overview will reveal that approx. 41,3% of the land surface consists of dry areas as shown by the table below.

Common name	Aridity	Area (million km^2)	Percentage
Desert	Hyper-arid	9,8	6,6
Semi-desert	Arid	15,7	10,6
Grasslands	Semi-arid	22,6	15,2
Rangelands	Drysub-humid	12,8	8,7
Total		**60,9**	**41,3**

Exhibit 2.96 World's Dry lands

[20] UN 2010-2020 Decade for Deserts and the Fight Against Desertification

Exhibit 2.97 Wildfires can be caused by drought

But why is drought occurring altogether? Well, the answer to this according to many scientists is that the climate is changing. And it's changing fast. In areas that normally will experience regular precipitation things have changed and now years can pass without seeing rainfalls in such areas. The air is warming up and for more lengthy periods. Rivers and brooks run dry and ground water levels deteriorate. Vegetation dies out leaving more room for the sunlight and these elements in combination paves the way for droughts to occur more frequently and for more prolonged periods of time. At the same time greenhouse gas emissions in e.g., Australia continues to be the one of the highest in the world where Australia's 0,3% of world population accounts for 1,3% of the world's greenhouse gas emissions.

Wildfires

Wildfires arise naturally as well as being caused by humans, the latter reason being the most common at least in Europe and North America. Such natural wildfires are often thought to help keeping the environment in a viable and healthy state. However, these fires are becoming more and more widespread because dry material are building up and because temperatures are rising. In august 2021 we saw what devastating consequences it could have when the Pleine des Maures in Southern France went up in flames. It covers 5.000 ha so on a worldwide scale it's just a tiny piece of land but anyhow a unique natural wonder housing some 10.000 of the 15.000 land turtles in the Var region and having a unique wildlife. Wildfires will

furthermore emit enormous amounts of CO_2 into the atmosphere. In 2021 its estimated that wildfires caused emissions of 6.450 Mt CO_2 while EU's total emissions from fossil fuels in 2020 amounted to 2.600 Mt according to CAMS (Copernicus Atmospheric Monitoring Service) - just to put things in perspective.

Exhibit 2.98 Desertification - an environmental problem in some parts of the globe

Hormone and other disrupting substances

When a fetus is exposed to hormone disrupting substances during the first stages of pregnancy research seems to indicate that in later stages of life it can develop specific types of cancer (e.g., testicular cancer), the development of the brain can be affected, and exposure to such substances can influence development of sperm quality, obesity and diabetes. So, exposure during the early stages of life can have far-reaching effects on a person's health later on. The problem is that people are exposed to such substances during daily life (e.g., phthalates, flame retardants, dioxin, atrazine, styrene and several hundred other potential substances). These substances are a part of cords, pesticides, toys and many other products. So, it's not your own decision to risk exposure it's almost totally impossible to avoid it whether we like it or not.

Another issue is that of radon (Rn). This is a noble gas buried in the underground that is odorless and can form radioactive radiation. In fact, 1 out of 10 cases of lung cancer is due to radon and its radioactive contents seeping into houses from underground sources. Yet another substance that can be listed under hormone

disrupting substances is fluor. It's used in a number of industrial as well as consumer products and some of these fluorescent substances are suspected to contain a potential for harmful effects e.g., cancer, immune system and hormone balance problems.

Loss of biodiversity

According to many scientists we're in the middle of the 6th mass extinction known to man. However, while the first five were caused by natural phenomena - mainly by volcanoes erupting - the 6th mass extinction is caused by human beings. While the first 5 periods of mass extinction were caused by huge amounts of CO_2 emitted from volcanoes the 6th mass extinction is seeing amounts of CO_2 emissions that are 100-fold the magnitude of previous carbon emissions. At the moment we're seeing decreased levels of biodiversity that can only cause alarm. Of the chemo products used for treating cancer some 75% of their components originally stems from plant material found in the Amazon Forest. This says something about the importance of maintaining a rich biodiversity and genetic variation in nature, not just for its own sake but for the sake of treating serious human illnesses. If removing biodiversity and the genetic variation, which is still not known how to use by science, we are in fact selling the future of our children and grandchildren when burning down the Amazon Forest. Loss of biodiversity can have dire consequences.

Some scientists are beginning to compare the current status of the earth's biodiversity with the climate crises. An alarming amount of especially insects - both regarding species as well as numbers - have begun to vanish from our natural ecosystems. Since insects are of paramount importance in the food chain the consequences will begin to unfold within other species as well. Some scientists have calculated the European biomass of insects to have fallen by some 80% between 1980s until now. According to some sources e.g., bees are pollinators when it comes to 70 of 100 of the world's most important plant species feeding approx. 90% of the earth's population. So, the falling number of insects can have profound effects on life on earth if this trend continues. Biodiversity will be lower throughout the entire ecosystem. So, if we can equate decline in biodiversity with biomass loss, things look pretty scary.

We can look at a specific example concerning the hoverfly population in Germany. Altogether 162 hoverfly species were researched (*Diptera: Syrphidae*) amounting to 19.604 individuals. Data were collected from 6 nature reserves in 1989 and 2014 respectively and the results speak for themselves - both numbers of species as well number of insects within a species have seen devastating developments. A drop like this will have cascading effects. Pollination will be affected. The food chain will be affected. The species themselves will be affected. This will leave a number of disturbances in the ecosystem and for sure be detrimental to biodiversity. Now this picture is just a mirror of similar developments seen all over the world – we're about to destroy wildlife around us irrespective of whether we want to or not. The

problem is that this might just be a warning signal – a wakeup call – that something is completely wrong, and nobody apparently wants to fix it. We're in the midst of it and nobody still seems to care. Like Gretha Thunberg said: *"How dare you!"* There are a whole lot of good reasons why we see this picture emerge. Exhibit 2.99 shown below details some of the reasons for this mass extinction we're now witnessing.

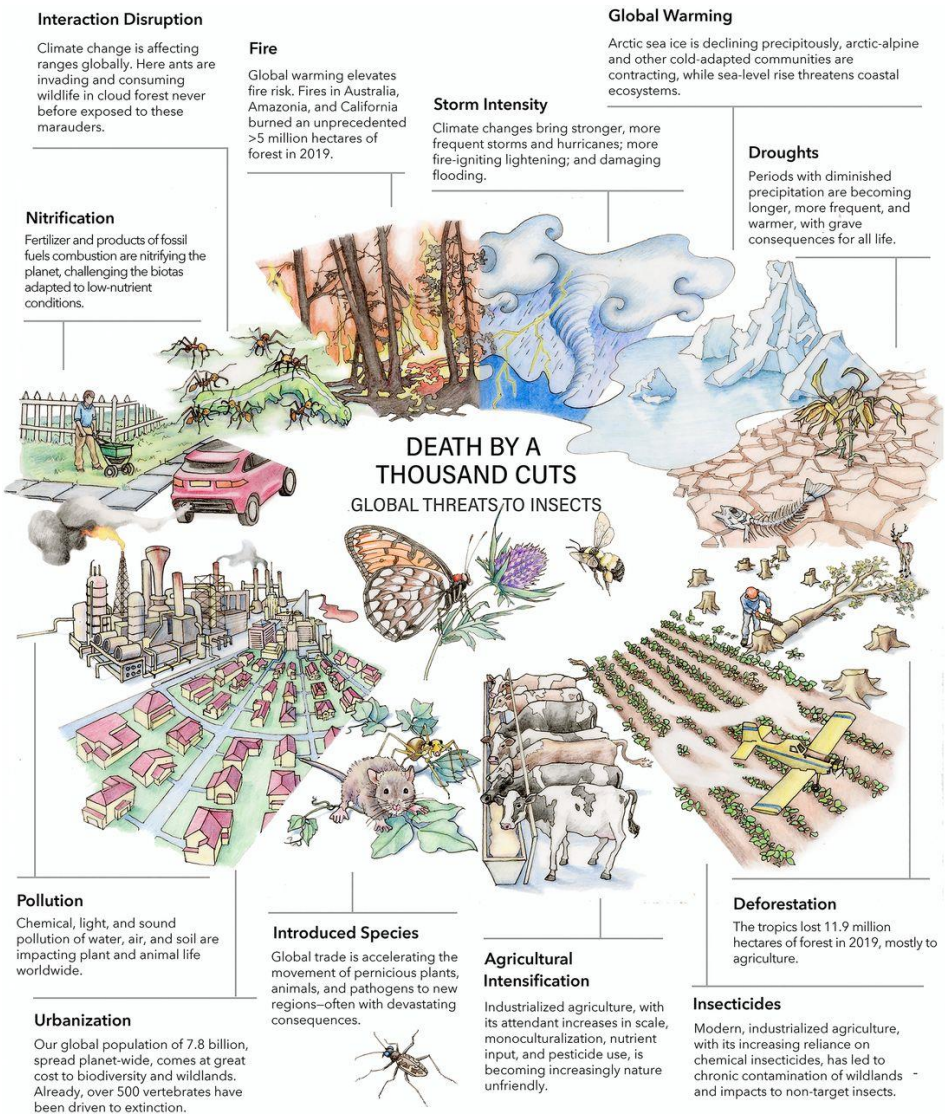


Exhibit 2.99 Global threats to insects
Source*: Insect decline in the Anthropocene: Death by a thousand cuts*
by David L. Wagner, Eliza M. Grames, Matthew L. Forister, May R. Berenbaum, and David Stopak, PNAS, January 12, 2021

Increasing areas of the Amazon are still being cut down leaving room for areas meant for agriculture. The actual deforestation witnessed in the Amazon Forest for the past 20 years is actually comparable to the size of Spain. For every acre of new agricultural land biodiversity will drop. Such loss of biodiversity will have profound effects on humans as well. In the Amazon researchers from pharmaceutical companies have found useful organisms that can be exploited in producing medical products, enzymes etc. So, cutting down the Amazon Forest may very well be an example of shooting ourselves in the foot if such resources should vanish forever. If you like chocolate, as an example, you probably know that it stems from the cocoa beans harvested in the tropical region. Now, pollination of the flowers of the cocoa plant is undertaken by small flies that requires high humidity. Just 2% of the cocoa flowers, however, are pollinated by these flies and if climate change, deforestation, pesticides, wildfires etc. affects the life cycle of these flies the cocoa plant will vanish and so will the cocoa beans. A recent report has just stated that in the future cocoa beans will probably be rarer than caviar. So, it could be time to say goodbye to your favorite chocolate biscuits.

Exhibit 2.100 The Amazon forest is the world's largest

Other places around the Earth rainforests are being cut down at an alarming speed. In Borneo the wild orangutan is in jeopardy because large parts of the rainforest of Borneo are being eliminated giving space to enormous areas of oil palm plantations.

The loss of biodiversity in the future will mean serious limitations and obstacles to the ways we are used to living right now. The cocoa beans are just an example, one could come up with dozens of others. To document such trends the IUCN's (International Union for Conservation of Nature) "Red List" for 2018 covered 10.189 species of which almost 28% are threatened by extinction due to climate change, poaching and invasive species etc. As an example, 7 tons of ivory from poachers in Angola was confiscated in Vietnam in the spring of 2023. Such facts should set the alarm bell going by decision makers all over the world.

Species being decimated or becoming extinct

Human interventions have affected biodiversity on earth. Populations of wildlife have decreased dramatically most places and for some species it has meant extinction. A report from WWF issued in September 2020 stated that 68% of wild-life has vanished during 1970 - 2016. Some examples can provide a glimpse into the loss of animals due to human interventions – please refer to Exhibit 2.101. The reason for such decline is due to game hunting, loss of habitats, changing environment, pollution, consumer demand, poaching and a number of other factors. The drivers behind these changes are human settlements - expanding cities as well as farmland, cutting down forests and opening them for human beings by building roads and other parts of an infrastructure, performing industrial activities and so on. When such species are considerably reduced in numbers, ecosystems will change as well. When plants, invertebrates, animals become extinct this is definitive. We will not see them again, nor will our children or grandchildren – just to avoid misunderstandings. Stellars Sea Cow, the Passenger Pigeon, The West African Rhinoceros *are* gone - not to come back. As of March 2021, the African elephant has now been listed as a critically endangered species by IUCN.

No. of species - decreased	Previously	2019
Tigers - India	100.000	2.967
African Elephants	10.000.000	372.271
Blue whales	300.000[1]	5.000 – 12.000
African Lions	200.000	20.000 – 30.000
American Bisons	60.000.000[2]	31.000
Bluefin Tuna	100%	5-15%
No. of species - extinct		
West African Black Rhino	Unknown	0
Baiji White Dolphin	Unknown[3]	0
Pyrenean Ibex	50.000	0
Passenger Pigeon	Approx. 4.000.000.000	0
Tasmanian Tiger	Unknown	0
Stellars Sea Cow	Unknown	0
The river Guden salmon	> 100.000	0

Exhibit 2.101 Reductions in populations sizes by species - examples

1) Estimated population size before whaling began
2) Population before commercial hunting began
3) Not officially recognized as extinct but haven't been seen since 2002

Altogether 134.425 species has been put on IUCN's RED list by 2021 of which 37.480 species are threatened by extinction. Of that number 8.188 species are critically endangered and 79 species are now extinct in the wild. Evidence is mounting up as to our negative influence on wildlife. IUCN works with 5 (6) classifications:

- *Extinct or Extinct in the Wild*
- *Critically Endangered, Endangered and Vulnerable:*
  species threatened with global extinction.
- *Near Threatened:*
  species close to the threatened thresholds or would be threatened without ongoing conservation measures.
- *Least Concern**:***
  species evaluated with a lower risk of extinction.
- *Data Deficient:*
  no assessment because of insufficient data.
- *Critically Endangered (Possibly Extinct) or Critically Endangered (Possibly Extinct in the Wild):*
  these are not IUCN Red List Categories, but are tags developed to identify those Critically Endangered species that are in all probability already extinct but for which confirmation is required; for example, through more extensive surveys being carried out and failing to find any individuals.

The same can be said about *monocultures* that dominates the agroindustry. Such monocultures are much more prone to risks from break down in the normal natural cycle. If a certain insect vital to pollinating a specific type of plant is hit by extinction, sickness or loss of habitats it will affect monocultures to a much larger extent than a culture dominated by rich biodiversity. Having e.g., many species of bees is in fact a kind of nature's insurance policy. If one species becomes extinct others are ready to take over. A recent study published in Science [21] also documents the interconnectedness of biodiversity and species extinction. Many animals and birds carry the seeds of plants and flowers over great distances. This is a measure of how the plants try to combat climate changes. According to this study the ability has been lowered by an estimated 60% on a global scale due to the lowering of e.g., big animals. The tapir in the Amazon rainforest has been reduced due to new sugarcane plantations and cattle ranching, the African elephant has likewise been reduced heavily due to poaching. When such species are gone their ability to transport plant seeds will also be gone. Things are connected in ecosystems.

[21] *The Effects of defaunation on plants' capacity to track climate change*, by Evan C. Fricke and Alejandro Ordonez, vol 375, 13. jan, 2022

Our resources are being depleted and this process has been going on during the entire industrial era. Irrigation, deforestation, mining, overfishing and many other issues are drying up our access to vital resources if the natural regeneration cycle is not maintained. However, new mining activities are undertaken around the globe, new deposits are found and the ongoing thawing of glaciers, ice sheets etc. in Greenland and Siberia are opening up for finding new resources. Even the moon and other planets are now in focus for mining activities. The search for non-renewable resources are still going on. However, we also know that this is just a delay in a process that will ultimately mean the end of non-renewable materials on earth.

Exhibit 2.102 Are tigers worthless to us?

RESOURCE DEPLETION

It's an old truth that the earth is a place with limited resources – non-renewables. This fact seemingly does not interfere with the consumption patterns currently taking place. It seems like we're still living as if resources are continuously replenished. Well, there is an end to everything even non-renewables.

a) Non-renewables - metals

Back in the 1970s a report from *The Club of Rome* entitled "*Limits to Growth*" concluded that we are about to be at the end of many natural resources. 50 years have passed since that report emerged, and it still holds important conclusions about

the state of our natural resources. Since then, reuse and recycling, opening of new mining sites and new discoveries has become more prominent but this doesn't detract from the fact that we have a finite number of resources on earth and these reserves get exhausted every day. Some metals are *scarce* or *rare.* This includes cobalt, gallium, indium, tantalum and platinum metals. Manufacturing batteries, catalytic converters, magnets, circuit boards for mobile phones and other products are heavily dependent on such scarce or rare metals. The EU's JRC (Joint Research Center) in 2010 showed that among others tellurium, indium and gallium are critical in low-carbon technologies such as wind, nuclear, solar and biomass production and that these resources show a high risk of shortage. In order to give an overview of these scarce resources the following Exhibit 2.103 will give an overview of suppliers of these scarce resources.

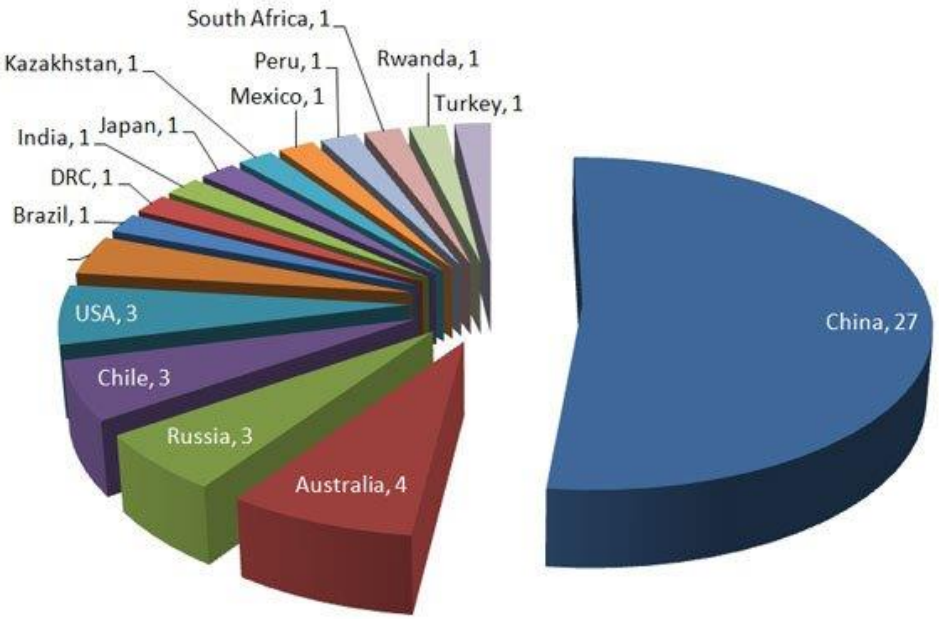


Exhibit 2.103 Countries of origin – scarce or rare metals
Source: Adapted from *Earth's Rarest Metals Listed in Supply Risk List*, by Deborah Braconnier, Phys.org., September 14, 2011

Another way to look at the metals being critical to our e.g. sustainable energy production and use is to look at a matrix of importance to cleaner energy and supply risk measured along an axis of 1 (low risk) – 4 (high risk) – please refer to the Exhibit below. It shows that metals like neodymium and dysprosium are high risk elements when it comes to their potential use and supply. Neodymium is used for magnets used in computers, cell phones, wind turbines etc. Dysprosium is used for instance in nuclear reactors and data storage applications.

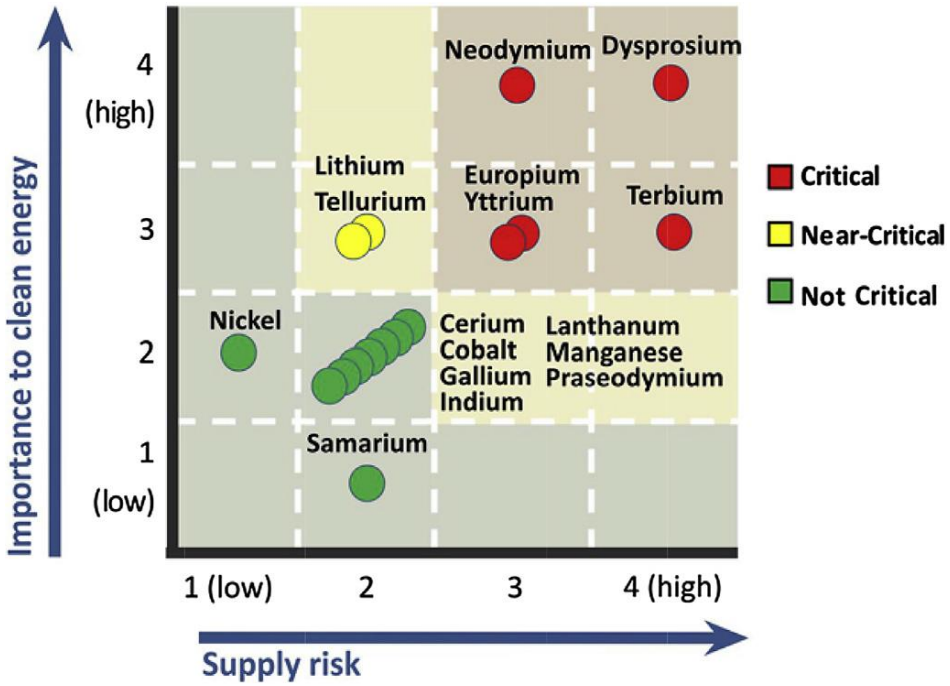


Exhibit 2.104 DOE medium term (2015-2025) criticality matrix, showing the five most critical rare-earth elements (Y, Nd, Eu, Tb, Dy). Reproduced with permission from U.S. Department of Energy, 2011.
Source: *Recycling of rare earths: a critical review*, by Koen Binnemans, Peter Tom Jones, Bart Blanpain, Tom Van Gerven, Yongxiang Yang, Allan Walton, Matthias Buchert, Journal of Cleaner Production 51, 2013

Their specific attributes make them very hard - or impossible - to replace. This will of course give suppliers an advantage when pricing such metals or reserving them for domestic use. The scarcity of these metals furthermore makes it problematic if these supplies should run dry when thinking of replacements. Currently we see this phenomenon unfold. The car industry now experiences problems due to lack of chips that are manufactured using these scarce metals. This means that the normal supply of new cars is cut down which eventually have caused the prices of used cars to go up. In order to demonstrate which elements are at risk the following table shown in Exhibit 2.105 has been issued, showing their relative supply risk. The first group “Rare Earth Elements” contains substances such as *neodymium, dysprosium, terbium, europium and yttrium*. The problems here are that these metals are selected due to their properties and not easily replaceable. As can be seen from Exhibit 2.105 below the overwhelming part of our scarce metal’s stems from China. This is beneficial to Chinese industry but can pose a risk to other manufactures in the world if e.g., trade wars, embargos etc. should break out.

Element or group	Relative Supply Risk Index	Leading producer	Top reserve holder
Rare earth elements	9,5	China	China
Antimony	9,0	China	China
Bismouth	8,8	China	China
Germanium	8,6	China	
Vanadium	8,6	China	China
Gallium	8,6	China	
Strontium	8,3	China	China
Tungsten	8,1	China	China
Molybdenum	8,1	China	China
Cobalt	8,1	DRC	DRC
Indium	8,1	China	
Arsenic	7,9	China	
Magnesium	7,6	China	Russia
Platinum group elements	7,6	South Africa	South Africa
Lithium	7,6	Australia	Chile
Barium	7,6	China	China
Carbon (graphite)	7,4	China	China
Beryllium	7,1	USA	
Silver	7,1	Mexico	Peru
Cadmium	7,1	China	
Tantalum	7,1	Rwanda	Australia
Rhenium	7,1	Chile	Chile
Selenium	6,9	Japan	China
Mercury	6,9	China	
Flourine	6,9	China	South Africa
Niobium	6,7	Brazil	Brazil
Zirconium	6,4	Australia	Australia
Chromium	6,2	South Africa	Kazakhstan
Tin	6,0	China	China
Manganese	5,7	China	South Africa
Nickel	5,7	Indonesia	Australia
Thorium	5,7		USA
Uranium	5,5	Kazakhstan	Australia
Lead	5,5	China	Australia
Iron	5,2	China	Australia
Carbon (diamond)	5,2	Russia	Australia
Titanium	4,8	Canada	China
Copper	4,8	Chile	Chile
Zinc	4,8	China	Australia
Aluminium	4,8	Australia	Guinea
Gold	4,5	China	Australia

Exhibit 2.105 Supply Risk List
Source: Earth's Rarest Metals Listed in Supply Risk List, by Deborah Braconnier, Phys.org., September 14, 2011

b) Deforestation and lack of storage of carbon dioxide

Madagascar is the fourth largest island in the world and originally a land covered by forests. 90% of its forests have now been cut down either illegally or to make room for agriculture and for sale of precious hardwoods. Previously the forest acted as a sponge that contained a lot of the water that rainfalls poured over the country. Now the woods and the sponge are gone, and water is now running freely creating flooding all over Madagascar and draining off the precious topsoil making the land infertile at places. This has been devastating to farmers as well as wildlife. The famous lemur only found in Madagascar has been deprived of many of its habitats and are now only living in a tiny area. Huge plantations of sisal crops have shot up everywhere and are now a material used for environmentally friendly packaging solutions. Poverty and living conditions are extreme in Madagascar partly as a result of this unmanaged way of handling its precious resources. Madagascar is just one example of how the grid of economic greed-poverty-habitat destruction-species extinction-flooding-deforestation unfolds.

Exhibit 2.106 Illegal logging of Madagascar rosewood

The Amazon Forest is another prime example of what can happen when deforestation begins to unfold. A record number of fires have been recorded in the Amazon region in 2019, partly due to natural fires, partly due to farmers and others wishing to open up the Amazon rainforest for agricultural purposes, mining,

logging and other operations. Science now seems to suggest that the resilience of the Amazon Forest is about to vanish. The ability for the forest to recover from drought and wildfires – to bounce back – is about to be lost and a tipping point might have been reached. [22]

One of the problems of storage of carbon is interference by human beings. In a system in equilibrium the amount of carbon absorbed and emitted would be fairly constant over time, however, when people begin to burn wood, make biomass out of it, increase deforestation by burning down the rainforest etc. we get an imbalance into the system. However, if using trees for buildings, furniture, musical instruments and so on the carbon contents are actually preserved and continue to be stored and if reused or recycled the stored carbon contents can be upholding for centuries. It is estimated that deforestation activities release approx. 0,8-2,2 Gt carbon per year into the atmosphere, or approx. 20% of global CO_2 emissions.[23] So deforestation is important when tackling global climate change. The two main drivers of deforestation are infrastructure and local agriculture for subsidizing the local population. However, 40% of tropical deforestation was caused by large scale agroindustrial operations like cattle ranching and producing products from soybeans and oil palms. [24] The loss of forests from 1990 – 2020 amounted to 178 million hectares and though deforestation has decreased in recent years the world is still not on the right path in order to fulfill UN's strategic goal of increasing forest areas by 3% in 2030 as compared to 1990. Of the 60.000 wood species found in our forests the IUCN has put 20.000 of these on its Red-list of endangered species. 8.000 of these are globally threatened and 1.400 of these critically endangered. In august 2021 a report released by *Botanic Gardens Conservation International (BGCI)* increased the number of tree species threatened by extinction to 30.000 in a five-year study. Asia, Africa and South America are the most vulnerable areas with species such as magnolia, ebony, rosewood, oak and maples being at risk. Over 440 trees are on the brink of extinction with fewer than 50 individual trees left for future generations. The problem is that trees are a vital part of the ecosystem and if they're gone biodiversity is also down the drain and climate change is increased.

c) Land based exploration of oil and gas resources

Oil and gas – or hydrocarbons - are the remnants of forests and other formerly living organisms being compressed through hundreds of thousands of years. It comes in several variations like crude oil, light oil etc. and once extracted can be made into a number of substances that have beneficial qualities for lubricating, propelling, greasing and burning. When using hydrocarbons, they will release the carbon once stored in the earth or oceanic crust for thousands of years and thereby contribute to the greenhouse gas effect. That way they induce an element into the

[22] See, *Ecologist*, March 2022
[23] See, *Nature's role in climate change*, EU, august 2009
[24] See *In Brief. The State of the World's Forests. Forests. Biodiversity and People*, FAO, UNEP, 2020, p 10

carbon cycle that nature didn't foresee. So, we see a buildup of excessive amounts of especially atmospheric carbon that have spurred the climate crisis.

Venezuela is the world's richest country when it comes to existing oil reserves. However, sadly enough this has not been visible if looking at the country's current position measured as GDP, household income, poverty or similar measures. Producing oil is an area that poses a set of problems. The oil from the Middle East is fairly easy to extract being stored in huge underground *reservoirs* while oil in Canada mostly stems from *tar sand*. The latter is a lot more costly to extract.

One method for extraction is called *fracking* – or *hydraulic fracturing* - and consists of rock (often sandstone) being fractured by injecting a pressurized liquid. This will pave the way for freeing gas resources and for extracting oil found in the rock layers. It was first tested in 1947 and then developed to become an important technology for exploiting hitherto non-available oil and shale gas resources.

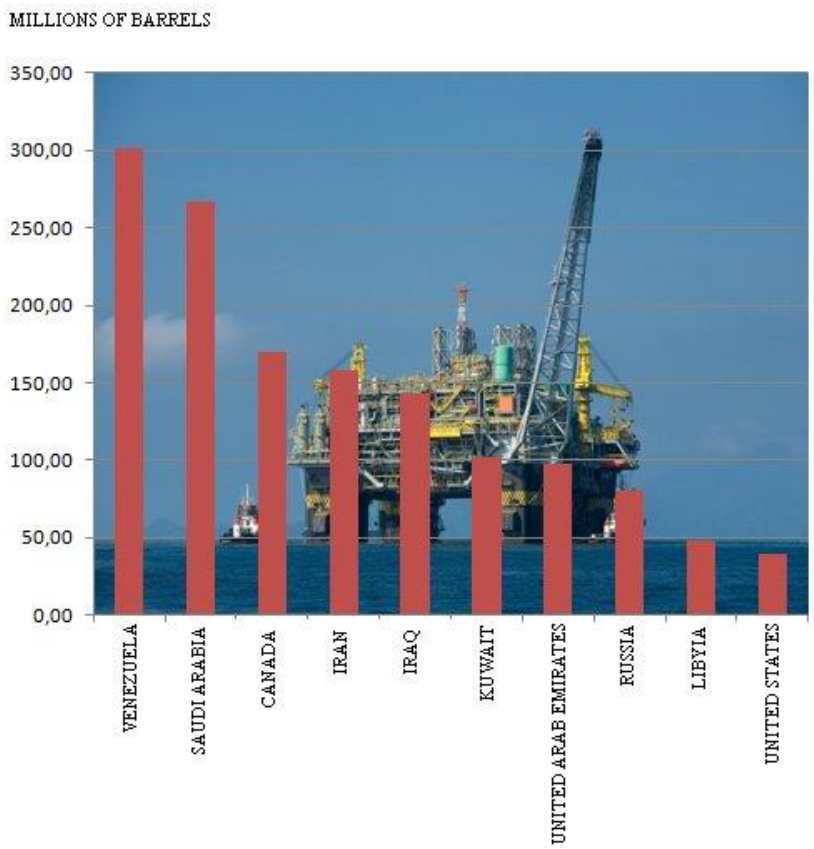


Exhibit 2.107 The Worlds 10 largest holders of oil reserves
Source: Worldatlas

Environmental problems regarding fracturing technology are caused by the fluid used for injecting into the stone containing chemicals (approx. 0,5%) that can harm the environment. On average over 150.000 liters of chemicals are used for each fracturing operation.

The US EPA has documented that this can impact ground water resource negatively. A second problem pertains to the fact the underground rock formations can become porous and methane can escape and add to the greenhouse effect. Furthermore, studies seem to indicate that fracturing operations can have harmful health issues attached including an increased risk of leukemia to those exposed.

d) Coal production and reserves

From history we know coal has been used as a source for heating and generating steam and electricity in both mining underground and by way of surface mining and coal even to this day still constitutes an important source of energy being mined in over 50 countries world-wide.

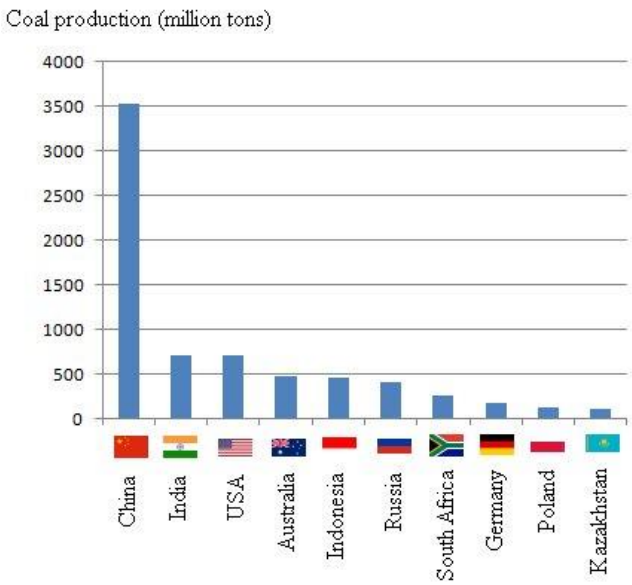
Today USA is the largest *holder of coal reserves* in the world (22%) and the *EIA (US Energy and Information Administration*) has calculated that the recoverable reserves of US coal will last for approx. 325 years with present consumption rates while other estimates the worlds reserve of coal will last for approx. 150 years. No matter what the coal resources of the world are rapidly vanishing, and more environmentally friendly alternatives must be developed. The US coal reserves is followed by Russia (16%), Australia (14%), China (13%) and India (9%).

The massive development of the Chinese infrastructure and economy has meant a substantial need for energy resources. The use of coal has been one of the Chinese measures taken for boosting their considerable economic growth and China is emitting about 50% of the world's coal emissions. Recently the Chinese have banned investments in coal-fired power plants outside of China, but China is nevertheless still in process of building new coal-fired power plants in homeland China.

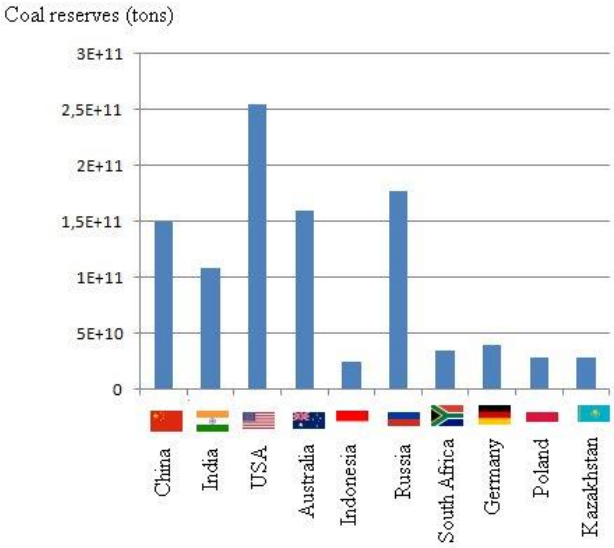
A country like Japan is also heavily dependent on coal after it has cut most of its nuclear power plants after the tsunami incident and the meltdown of the Fukushima nuclear power plant in 2011 and it's furthermore pursuing a policy of funding new coal fired power plants in developing countries in Asia.

Other issues relating to the coal industry is that of government subsidies for supporting employment and local economies in e.g., the US coal industry. According to the IEA (International Energy Agency) coal fired power plants were

singled out as the largest contributor to emissions growth in 2018, so the adverse effects of these plants are evidently clear. Economic growth and jobs are at stake here – not rising temperatures and adverse environmental effects.



Chinese growth has resulted in the Chinese being the World's biggest coal consumer – other countries are lagging considerably behind



When looking at coal reserve holders the picture changes. USA is the World's biggest holder of coal reserves followed by Russia and Australia

Exhibit 2.108 The top 10 producers/reserve holders of coal - 2018

The picture changes a bit when measured as yearly *production* of coal on a global scale. Please refer to the Exhibit above. When extracting coal one problem is that

methane is formed and eventually must be vented out of the underground mines. This methane accounts for approx. 9% of US methane emissions and 1% of total US greenhouse gas emissions (measured as GWP).

When operating surface mines, the environmental impact on the landscape, the soil, the vegetation etc. can be considerable. When *burning coal* some of the environmental issues concerns emitting:

- sulfur dioxide (SO_2),
- nitrogen oxides (NO_x),
- particulates
- carbon dioxide (CO_2)
- mercury and other heavy metals
- fly ash
- acid mine drainage

When emitting such substances, a number of environmental and health issues can emerge including respiratory illnesses, neurological damage, lung diseases (black lungs or CWP), acid rain, smog and haze. People have been accustomed to wearing face masks in part of the world due to that. Coal emissions causes thousands of deaths each year all around the globe due to coal being cheap and abundant so the incentive for using coal was and is ever present.

The massive amounts of greenhouse gases emitted, however, make coal a devastating resource to the environment. It comes at a huge price when using this resource. England might serve as an example of the decline of the coal industry. In 1920 there was 1.191.000 people employed in the coal mining industry. In 2015 barely 2.000 were employed and the last deep coal mine in England closed on 18th December 2015. For other coal reserve holders, the same strategic phasing out coal will be relevant in the decades to come.

Germany has in early 2020 decided to abandon its coal fired power plants by 2038 so we might see political and practical signs of leaving the era of coal in Germany. The current geopolitical tensions make this a bold move and ways will have to be found due to the banning of Russian oil and gas that for decades have been the backbone of the European energy grid. Nearly 50% of EU gas imports came from Russia in 2021 and Russia was the largest supplier to the EU of petroleum oils.

Changes in technology changed the global picture of the coal industry as well and competition has made closures of coal mines inevitable. This in turn has affected the whole coal mining industry in the US.

Exhibit 2.109 Surface coal mining in the Rhineland, Germany
Source: Wikimedia Commons

e) Land degradation

Resource depletion is also a question of land being degraded. According to the IPCC *"¼ of the ice-free area is subject to human induced degradation".* This happens e.g., during agricultural processes and logging operations. When fields are formed wildlife will more or less vanish, landslides will occur etc.

A wheat field is an example of a monoculture. This will affect the former wildlife on the place as well as neighboring areas. In other words, biodiversity will decrease. When fauna and flora is gone, we will also experience that the carbon uptake will be lowered. When fields are fertilized some of the phosphorous and nitrogen not stored by plants will seep down through the earth layers and eventually end up in our groundwater reservoirs. This can affect wildlife in a greater part of the water system by causing eutrophication and rising pH levels. When fields are sprayed with insecticides, herbicides and fungicides some of the chemicals from these activities will penetrate deep down into the earth's layers and eventually end up in groundwater reservoirs used for drinking water resources. At first a newly formed field will have a rich nutritious content with microorganisms and nutrients for plants. Eventually when the field has been worked over and over by heavy machinery the earth layers will begin to be compressed. This results in water not being able to penetrate the layers thereby giving rise to increased water levels, run offs and possible flooding.

Exhibit 2.110 When forests are clear cut it opens up for landslides to occur

Agricultural uses of the land also spawn soil erosion. When fields are replacing natural habitats there will be no more root material to hold onto the upper level of soil. It will be exposed to the elements – wind, water, ice and so on – the first two counting for about 84% of the world's soil degradation. Eventually the rich upper soil level (humus) can be gone, landslides can occur etc., and farmers will have to find new fields to farm. In extreme cases this can result in desertification and enormous dust clouds. If this furthermore happens near rivers and lakes some of the soil can furthermore be washed away as well during heavy rain falls. Besides agriculture and forestry land degradation can also occur due to the climate changes we see which will imply heavier rain falls, rising sea levels etc. Land degradation can also occur due to building roads and urbanization.

Wastes

All around the world wastes are piling up. Household wastes represent a major portion of such wastes. It is estimated that we annually dispose of more than 2 billion tons of household wastes – that's approx. 60 tons each second and it is estimated that in 2050 we will throw 3,4 billion tons out each year. This number should be related to upstream waste production amounting to 70 kg for every kilo household waste thrown out. This puts a strain on our resources, on our environment and our wildlife. Since wastes often are incinerated, it will contribute

to the greenhouse effect and in 2050 incinerated waste will presumably account for 5-10% of global $CO_{2\text{-}e}$ emissions.

Exhibit 2.111 Wastes is still a growing problem

Nuclear waste is another part of the waste problem. When nuclear material is discarded it must be handled very carefully since nuclear waste can be active for hundreds, even thousands of years. Often nuclear waste is buried in underground pits and encapsulated in cylinders that will halt the radiation. The nuclear waste problem as well as the Fukushima melt-down in Japan in 2011 has led Germany to abandon their nuclear facilities by 2022. With Germanys decision to abandon its coal fired power plants by 2038 as well as consequences of reducing European dependency of Russian oil and gas this will require massive investments in a totally new energy infrastructure. The transitional phase and the strategies followed will be something that other countries will experience in the decades to come.

Refugees - emigrants and climate refugees

In the aftermath of World War II refugees became a big concern since many had lost their homes, families and belongings. A new major stream of refugees now seems to be underway – people who flee their homeland due to unsustainable environmental conditions – manmade or natural. Some parts of the globe are being flooded for good, some parts are becoming increasingly warmer, and some parts are turned into deserts making them uninhabitable. Such developments are due to changes in the ecosystem's behavior, so these people become *climate refugees*. Today some people flee their homelands due to poor economic conditions, some from war and in the future probably most of the refugees will be climate refugees.

Exhibit 2.112 Syrian refugees – fleeing has many faces…

Even when people must flee due to environmental induced changes the administration steps in. In international politics it's important to distinguish between a *refugee* and an *immigrant.* Refugees have an international right to be protected and housed while immigrants do not. So, there have been some measures taken from various countries to try to label these people as immigrants and *not* as refugees making the probable numbers of real climate refugees being underestimated. International policies will be playing a big part in the decades to come ultimately impacting the possibilities offered to climate refugees and international cooperation seems inevitable if this growing problem is to be solved. We know water levels are rising – "*high water everywhere*" like blues singer/-guitarist Robert Johnson sang about in the 1920s. We'll be hearing the same song in the years to come and increasingly so. According to the International Displacement Monitoring Centre 26,4 million persons have been displaced due to storms, flooding, droughts or earthquakes since 2008. This is a number that is bound to increase during the next decades.

Contamination of resources etc.

Contamination of resources is a problem that affects both humans and wildlife. One of the problems is that such contamination can take decades if not hundreds of years to unfold. So, sins of past times can now emerge even today and if we continue down this path the contamination that is now occurring can be seen as a "gift" from us to our descendants with far-ranging consequences. Industry is reliant on use of thousands of chemical components. When such substances are released

into nature or humans are exposed to it, it can cause serious problems, and the problem is that we are not fully aware of the effects it causes to the environment and human beings when hundreds of chemical compounds are mixed together in various proportions. Other issues are that of how we treat our livestock and ecosystems. Yet another issue is that of contaminating assets transported around the globe e.g., shipping containers. Let us have a look at a couple of those issues.

a) Pesticides - herbicides, insecticides and fungicides

In 1962 Rachel Carson wrote a book called *Silent Spring*. It was written because she didn't understand why birds sang no more when spring arrived in the US. She found out that spraying with toxic substances such as dioxin and DDT killed the birds and hampered fertility and ultimately spring went silent all across the USA. In 1970 the stock of the baldheaded eagle had dropped to just 20 in Virginia, USA. In late 2019 the stock was at 1.070. Now, there is a common explanation to these two problems – that of banning the use of pesticides - the real problem that Rachel Carson got the whole world to notice – and then partly forget - in 1962.

Exhibit 2.113 How much would you pay to hear songbirds singing once again?

The *agroindustry* uses various insecticides, fungicides, herbicides and other toxins in order to combat unwanted organism in their fields in order to protect the yield of crops. One problem can arise due to this - *groundwater contamination*. This can pose a huge problem in intensively cultivated areas where reservoirs of freshwater below ground can absorb these toxins. This process can take decades to occur so

doing something about the problem now will still mean that we will see groundwater sources being closed down due to seepage of these toxic substances in the future. When being mixed with groundwater reservoirs used for drinking purposes this again can mean human exposure to such substances that can cause cancer and other health problems. Unlike many other countries Denmark has access to an abundance of relatively clean drinking water resources. However, more and more wells are now being closed down due to contamination problems primarily from e.g. pesticides used in the agroindustry.

Another related problem by using pesticides concerns *the resistance of bacteria*. A recent Danish study has revealed an increased resistance by a fungus (Aspergillus fumigates) when e.g., wheat is sprayed to combat risks of fungi. The problem has been detected world-wide, especially in the Netherlands. When fungi become resistant to antibiotics it can pose severe risk of human lives and especially infants and elderly, weakened people are exposed to the problem. This seems to be reinforced with the advent of increasing amounts of antibiotics used. In worst cases multi resistant bacteria can become immune to any treatment at all. In the EU and EEA (EU + Iceland, Lichtenstein and Norway) it is estimated that approx. 33.000 people die each year as a result of resistant bacteria according to the ECDC (European Center for Disease Prevention and Control). Especially Italy and Greece are hit hard by this failing possibility for treatment with antibiotics due to resistant bacteria.

Exhibit 2.114 Agriculture includes reaping benefits from and harming nature

b) Contamination of livestock – the MRSA problem

Another issue within the agroindustry is the MRSA problem (MRSA is an acronym for the bacteria *Staphylococcus aureus*). Today all livestock (except turkeys) are infected with the MRSA bacteria in Denmark. Within the pig farm industry between 83%-89% of the stock are infected and these numbers are rising. MRSA does not affect the animals themselves, but humans are exposed and serious infections as well as blood poisoning – in some cases deadly - can occur. It's harder to treat MRSA than other bacterial infections being resistant to several antibiotics normally used. In 2018 we saw 3.678 incidents of people infected with MRSA in Denmark of which 7 people died within 30 days as a consequence of having attracted MRSA. Some of these deaths were caused by MRSA from the agroindustry. These deaths could have been avoided if the industry had acted in due time. They did not.

c) Use of zinc and copper in the agroindustry

The level of zinc and copper in the environment has risen during the last 25 years and today 25% of our rivers in Denmark contain levels of these metals above the EU prescribed water quality norms. For a large part – 80-90% - increased levels of zinc and copper probably stems from the agroindustry in particular the manure used to fertilize fields. Use of zinc happens when piglets are taken from the sow in order to lessen the risk of diarrhea. Zinc is contained in the fodder; some is infused as medicine. Parts of the zinc will be transferred to the urine and hence ultimately to the soil and river systems. High concentrations of biodegradable zinc in the water can adversely affect most living organisms. As of 2022 the European Medicines Agency (EMA) has banned the use of zinc in medicine within the EU but not in the fodder.

d) Domesticated animals

Human beings have for thousands of years had livestock as a natural part of their lives when we converted from being hunters and gatherers to become farmers. We've kept pet animals for the same period. A recent study from the University of Copenhagen from August 2021 concluded that approx. 85% of all chickens in Danish chicken farms will have had fractures of their keel bone. The reason is thought to be that of the egg lying process. In the wild a normal chicken will lay around 20 eggs per year. In Danish chicken farms they will lay 320 eggs per year. This puts a strain on their body because the eggs in fact become too big resulting in fractures to the keel bone. This causes pain to the chicken and healing the fracture can take long.[25] There is basically no difference whether these chickens are kept as ecological or conventional farmed chickens.

[25] See Ida C. N. Thøfner, Jan Dahl & Jens Peter Christensen, "*Keel bone fractures in Danish laying hens: Prevalence and risk factors"*, august 2021, PLOS One

This is no isolated case. For the last 10 years between 21-24% of all piglets born in Danish farms have died or approx. 25.000 piglets every day year round. Sows are restricted in their movements and calves are kept in small cages until they're ready for slaughtering. These observations should come as no surprise. Domesticated animals are in fact not seen as animals but as *production units* and sometimes this means that they are treated as mere things not living objects. The agroindustry have tried to optimize such production units – more milk per cow, more meat per production unit, higher number of eggs, shortening the number of days before a chicken is ready for slaughter, giving birth to an increased number of piglets, increased efficiency of the fodder etc. The reason that this have not made the public cry out loud is due to the way animals react when experiencing pain. They do not yell or scream, they keep quit and suffer in silence. The same is true concerning the pain we are exposing oceanic creatures to. Hear nothing, feel nothing, see nothing – do nothing.

Farmers have done it because they can make more money by doing so and because the consumer is demanding low-priced products. Money is at the bottom of things. So, if you talk of Danish farmers as being among the most efficient in the world it comes at such costs as documented here. This does not imply that Danish farmers are not fond of their production units just that we have a long way to go world-wide if the signs emitted from the Danish agroindustry are credible – they are in fact!

e) Fencing ecosystems

In 2019 Denmark decided to put up a fence at the German border stretching all across the borderline. This was due to evidence that wild boars in Poland and other EU countries had been contaminated with the African Swine Fever (ASF). In order for the ASF not to infect Danish pig farms it was decided to erect the fence. Now the ASF cannot infect human beings so preventive measures are made solely for protecting the income of pig farmers. However, setting up a fence will actively cut of animals of the entire ecosystem excluding them from moving between habitats of the two countries as they've done for centuries. Setting up a fence could be seen as a "contamination" of the existing ecosystem. It will prevent wild-life migration, inhibit genetic variation, cause suffering by animals caught in the fence etc. Once again money trumps the environment due to agricultural considerations and local and regional biodiversity suffers. We see the same the same thing happens when fences are erected between the US-Mexican border and elsewhere.

f) Infections

The way we treat wild and domestic animals is a problem that has all to do with sustainability. The most recent example is that of the Corona virus, but many other examples exist. The Spanish flu in 1918 killing between 50-100 million people began in the US and is thought to have originated in handling chickens. The bird flu is another example where people might get infected by the treatment of birds. The

Corona virus originated in Wuhan, China maybe due to the handling of wild animals. In China and other Asian countries markets exists for wild animals. They are stacked in cages upon each other under conditions that most would find appalling. Most are used as a food source – "bush meat" - but according to popular belief some animals are used for medical, sexual, ceremonial and other purposes as well. The tiger and rhino horns, elephant bones etc. are thought to have attributes that increases virility. Others are considered beneficial for treating various illnesses. There is absolutely no scientific evidence for this, but lack of education, formal tradition and culture make sale and procurement of such – sometimes endangered – animals a sign of a business still continuing and thriving. Huge prices are often paid for endangered animals which make it attractive for poachers and others to trade in them and even open e.g. "bear clinics" where bears are stripped of their gallbladder contents for use in traditional Chinese medicine. The bear's liver will be affected, and animal well-fare is generally non-existent. Once again, the power of money coupled with uninformed incompetency is clearly visible. In other words, this is a systemic issue. However, the Chinese authorities have now banned the "bush-meat" trade which will have a huge impact on Chinese culture and supply of foodstuffs in certain places. If they succeed in enforcing this kind of legislation a vital source of infections will be send out of circulation and animal welfare greatly improved.

The economic effects of such outbursts of pandemic viruses can be huge. As of November 2020, it was decided to kill all mink in Denmark due to the COVID-19 virus. Denmark was the world's most important market for selling mink hides and annually grossed approx. DKK 5 billion. Owner of mink farms and their families, skinning factories, auctions etc. were all hit by this decision. However, the story has another serious point since it was discovered that the COVID-19 virus had mutated – called "cluster 5" - when mink was exposed, and this mutation then spread to people. The problem was that while the vaccines could prove effective concerning the COVID-19 virus they were suspected not to be effective concerning the mutated virus. So, in effect, if the mutated virus began spreading it could in fact be a new departure for a new pandemic. The authorities therefore demanded that all mink in Denmark be exterminated in order to stop the mutation. This further resulted in 7 counties being closed down in Denmark with serious economic effects attached. So, one might expect that farmed mink is a history of the past in Denmark. This is just one example of the economic consequences of COVID-19. The costs to the world of the pandemic are astronomical – but Danish minks are relieved of their misery.

The positive consequence on the other hand taps into the question of farmed animals and what kind of animals we actually will use for human purposes. It goes without saying that the space available for these animals is very limited and that their natural instincts – if any left – will not be met in such an environment. On the other hand, mink is a renewable product and much more environmentally friendly than clothes made out of synthetic fibers. So, it all boils down to a question of animal ethics and how we see our own role regarding this industry. Are the customer's wants always something that should be met? Other benefits include the reductions in the huge amounts of ammonia released from the farms and a stop to

the fodder containing soybeans from the Amazon and huge amounts of fish contained in the fodder.

The spreading of viruses and bacteria can take many forms and one of these concerns securing international sea shipping operations called *phytosanitary measures.* This is a joint effort by the IPCC taken to prevent pest infestation to take place.

Exhibit 2.115 The days of having a new Danish mink fur might be over

GMO's (Genetic Modified Organisms)

Genetic engineering is a way to change - speed up - the process of natural selection. It has been used for cloning animals, for installing new genetic attributes into existing organisms, for medical purposes and other. Existing genes of the organism in question will be changed when genetic engineering is undertaken and can be passed on to coming generations.

Some people have been opposed to using GMO's. They fear that GMO's ultimately can find their way into the natural ecosystem and thereby give rise to species with unknown consequences for our ecosystems. Furthermore, such changes will be passed on to all other generations of that species without knowing how this will affect the ecosystem and furthermore they claim that not all issues regarding GMO's have been sufficiently researched especially with regard to their long-term effects. Such fears, however, are not always scientifically founded. As an example, one could point to the world's first GMO certified so-called AquaAdvantage salmon that in March 2019 was released for retail sale in USA and Canada. The Atlantic salmon has been genetically modified with genes from two other species – the Chinook salmon and the ocean pout - meaning that it grows considerably faster (50%) and with less fodder (25%) than the wild salmon. All GMO salmons are sterile females and will therefore not be able to reproduce in the wild. Since USA imports large quantities of farmed salmon from Chile and Norway this will greatly reduce emissions caused by transporting farmed salmons. Furthermore, the AquaAdvantage salmons are produced in closed-loop land-based circuits that prevent harm to any natural surroundings. It provides us with a good example of the benefits of the GMO technology. So, genetic engineering can have dramatic effects when it comes to increasing yields, combating diseases, and finding new ways of manufacturing goods. The backside is of a more philosophical nature; is artificial produced products the right way to manage our food supply or should we avoid any interference with our foodstuffs by tampering with nature?

ENVIRONMENTAL PROBLEMS - THE OCEANIC CRUST

The oceanic crust is affected by drilling operations for oil and gas. These offshore drilling operations go on all around the world. Now that the Arctic and Antarctica is melting new fertile grounds for exploration opens up to the oil and gas industry. It's also affected by commercial fishing including fish farming, previous dumping of toxic wastes, extraction of rocks and gravel at the ocean bed and other. So let us look a little bit closer on these issues.

Off-shore drilling - oil and gas

Oil and gas are in fact natural deposits of CO_2 and other substances from millions of year's way back and the minute we begin to extract these resources we are interfering with the natural ecosystems and the carbon cycle itself. It is estimated

that the world emits approx. 21,3 billion tons of CO_2 each year and nature is only able to absorb half of that amount meaning that 10,65 billion tons of CO_2 will enter into the atmosphere until changed by the natural cycle. This will considerably contribute to the greenhouse effect.

Fossil fuels are examples of *non-renewable* materials. Once they are gone, they are gone forever. In other words, it is a finite supply. Extraction of oil and gas has only occurred for the past 150 years and if looking at what's in store for us the necessity for developing *renewable* fuels like wind, biomass, thermal and solar energy are apparently striking. It only takes us a second to exhaust these deposits that nature have taken millions of years to store. Furthermore, the extraction of these non-renewable resources poses huge environmental problems.

Off-shore operations began in 1897 off the coast of California, USA and nearly all platforms in the US are situated in the central and western Gulf of Mexico. National borders extend from the shore and end a given numbers of km from the shore. After that it becomes *international waters* and not eligible for oil and gas explorations. Drilling here is more problematic than land-based operations. Oil spills can occur due to leaks or accidents polluting the ocean, use of chemicals likewise. But the overall problem is that we interfere with the natural carbon cycle when extracting these resources instead of focusing on generating renewable resources. The widespread use of these oil products, however, makes the switch between non-renewables and renewables challenging. These resources are used for heating, electricity, lubrication, tires, gasoline, carbon fiber, food products, plastics and thousands of other essential consumer products. So, replacements for thousands of products have to be found when giving up on oil resources.

Pollution of the ocean bed, sediments etc.

Things that cannot float will ultimately sink to the bottom of the ocean. This can have a positive effect e.g., when sunken ships provide artificial habitats for a number of fish, when whales die and creates a food source for marine life etc. However, things can also pollute the ocean bed e.g., when ships discharge solid wastes, flush toilets, lose fishing nets, throws plastics overboard etc. Previously chemical wastes were just dumped in the ocean; however, this have fortunately been banned.

Trawl fishing

Tools for commercial fishing vary but one tool is especially harmful to the ocean bed – that of *trawling*. At the end of 2019 there were huge protests from fishermen in Denmark concerning Dutch trawl ships fishing in the Skagerrak. When trawling the ocean's bed is torn up and species occupying the ocean floor is in danger of losing their habitats, fish are maimed and other fishermen – e.g., coastal fishermen -

are in danger of losing their jobs. Such trawling boats have big and heavy chains that plow the oceanic crust and create destruction of the habitats. The energy – oil and gasoline - needed for dragging such chains is considerable. After trawling has taken place scavengers such as the witch flounders rush in and start cleaning the table. So, trawling activities has devastating effects on the oceanic crust and the habitats involved and in some small parts of the ocean it's forbidden to use trawling.

Another issue of trawling is that of *by-catches.* Trawling will take everything from the ocean bed dependent on the size of the nets; that is small fish, endangered fish or non-commercially viable fish. If quotas are in place such fish will just be thrown overboard and will not have a chance to enter the life cycle. Just as bad is the common practice of *illegal trawling* in protected marine areas e.g. when fishing for giant prawns along the shores of Bangladesh, or trawling for protected species or outside of "windows" when fish stocks are protected. The problems are huge. They are international and the means for ensuring that only legal fishing takes place are in many cases non-existent. Some experts furthermore consider deep-sea trawling to be the main threat to *marine archeology*. When big nets are dragged over shipwrecks valuable antics, parts of vessels, marine graveyards etc. can be ruined or scattered all over the ocean bed and might be gone forever. However, a new trend has seen daylight due to previous harsh methods of fishing – that of *sustainable fishing* where fish are caught not by nets but by way of conventional angling gear. This provides for a much more animal friendly way of catching the fish.

Exhibit 2.116 Pristine ocean bed (left) and results of trawl fishing (right)

Extracting other resources from the oceans crust

Besides oil, gas and marine fish and mammals' other resources are also extracted from the oceanic crust. Stones, rocks, sand and gravel extracted from the ocean beds have been used for building houses, roads, and coastal fences etc. This has meant that parts of the marine ecosystem have been seriously damaged. The understanding of coastal reefs as an important source of marine biodiversity is now

slowly beginning to emerge. In Denmark we've begun to rebuild the stone reefs that previously were extracted and used for construction work. This has paid off and these formerly dead stone reefs are now teaming with life – lobsters, crabs, fish, mollusks and a number of other species are now populating the rebuilt artificial reefs. Such reefs offer protection to smaller fish that otherwise would have fallen prey to other species, it creates a habitat for shellfish and others and attracts several other fish species.

The Arctic is now beginning to attract the interest of major countries like Russia, USA, Canada and China. One reason why is the perceived richness of the oceanic crust when it comes to oil and gas. Norway is beginning to search for oil and gas in the Arctic as well which has been questioned by environmental organizations. Norway – as one of the very few – has in fact adopted sustainability into its constitutional requirements. Government has maintained by court settlement that this does not hinder Norway from drilling after oil and gas in the Barents Sea in the Arctic. Former Prime Minister of Norway Erna Solberg has in fact stated that Norway wants to continue its oil and gas production for decades to come because Norwegian oil and gas is a better alternative than using dirtier European coals – so, the race towards the bottom is still ongoing. In passing it should be mentioned that Germany has decided to totally abandon its coal production by 2037. Article 112 of the Norwegian Constitution says that:

"Every person has the right to an environment that is conducive to health and to a natural environment whose productivity and diversity are maintained. Natural resources shall be managed on the basis of comprehensive long-term considerations which will safeguard this right for future generations as well. In order to safeguard their right in accordance with the foregoing paragraph, citizens are entitled to information on the state of the natural environment and on the effects of any encroachment on nature that is planned or carried out.

The authorities of the state shall take measures for the implementation of these principles."

You could in fact accuse the Norwegians to take the breath out of their own constitution. Once again, the controversy is about environmental versus economic considerations. Thousands upon thousands of jobs are related to the Norwegian oil and gas industry the largest employer being state controlled Equinor. According to Norwegian Petroleum 225.000 people were directly or indirectly employed within the industry in 2017 nationally or globally. This constitutes a large part of the Norwegian population of approx. 5 mio. people. Exploring and commercializing the Arctic would of course strengthen employment in this sector and add to Norway's gigantic riches stemming from its oil and gas reserves, however, to the detriment of the environment. Once again it is pertinently clear what the outcome will be when the environment is put up against elements of money and power.

As resources are dwindling concerning land-based mining activities attention has now been focusing on extracting raw materials from the ocean bed and from the ocean itself (*Seabed Mining* or *SBM*). 60% of the current supply of magnesium and magnesium salts are extracted from seawater via electrolysis and salt is removed from seawater in order to supply populations with freshwater while sand, rocks and gravel is extracted for construction purposes. Due to lack of land-based gold mines gold is now being mined in the ocean as well and there are plans to mine both gold and copper resources at depts of 1.000 to 1.500 meters (*Deep Sea Mining* or *DSM*) Exploration of the seabed is governed by the *International Seabed Authority* and UN has issued its *Convention of the Law of the Sea (UNCLOS)* but though giving a certain protection it's still a question of whether seabed mining activities will profoundly affect biodiversity, ecosystems, fisheries as well as the local populations economic and social opportunities.

Exhibit 2.117 The Giant Panda – icon, diplomat or cute moneymaker….?

2.6 BASIC CONCLUSIONS

What has been stated in the chapter above should hopefully have created some sort of awareness about the state of affairs of the environment we're experiencing at the beginning of the 21st Century. The conclusion is readily at hand: we are about to destroy our own habitats and the resources being entrusted to us.

This has occurred within a very short span of human history and with overwhelming impacts on all life on earth. Warnings have been made by the scientific community but not taken seriously by most politicians, business leaders or influential people in public government and associations around the globe. Talks have been abundant actions few. It has only taken us about 200 years in making some of nature's wonderful creatures extinct and demolish the environment for future generations to come.

The results of this can now be seen to unfold all over the world. Habitats are still being destroyed, wildlife is vanishing, the food chain is being interrupted, people are still dying or becoming ill due to environmental problems, our climate is under pressure, most natural resources are vanishing, people on earth requiring increased standards of living is rising, the number of environmental refugees are growing, and the state of the atmosphere, hydrosphere and lithosphere are still suffering at an ever-increasing pace.

In 1992 scientists warned about this. Some 30 years after the challenge has not been met. The question is now whether we - like the Titanic - are on the verge of hitting

the imaginary iceberg or whether we want to change course radically to adhere to the warnings issued by nature as well as these scientists?

Like in many other instances – revolutions, overtaking government, abandoning obsolete political ideas and systems, wars, scientific ideas etc., - such changes do not just come from well-planned, top-down incidents. They also come from the most unlikely sources that then set the world ablaze by thriving on underlying forces that are driven by an insight into the problems at hand. One such incident might be a 15-year-old Swedish school girl by the name of Gretha Thunberg.

In 2018 she began arranging a "*Fridays for Future*" campaign protesting against the lack of concrete actions to combat climate change by world leaders. This quickly caught the attention of the media, and she has become an important part of the public outcry of the current lack of will and resources to provide for the future well-being of these young kids that are about to inherit the world we leave them. 1.700 scientists alarm bells couldn't get decision makers to wake up – Gretha Thunberg might have been able to do it. This tells us something really profound about the qualities of the people we've previously elected to run our governments, to lead our companies and to manage our environment.

Exhibit 2.118 Major environmental problems in the Earths spheres

The previous sections should likewise and hopefully document those problems within the natural world are serious and warrants serious actions to be taken before it's too late. This message is not new. The problems of diminishing resources, pollution, contamination, loss of biodiversity etc. coupled with the rising global

population make it the most serious problem to be dealt with by future politicians and business leaders – far more serious than issues associated with lower economic growth and development. To this should be added that in the future we will most likely see changes that are not foreseen today or will unfold in later stages of the climate and biodiversity crises. We can only hope that these will be of lesser impact than those we know of today. Environmental problems in the lithosphere, the atmosphere and the hydrosphere are widespread, they are urgent, and they are serious. These facts will mean considerable consequences to the biosphere. New environmental issues pop up continuously and the costs of cleaning up after the industrial revolution will continue for decades and centuries to come and these costs will have to be borne by future generations.

It's a fallacy to think that economic growth is the means for combating environmental problems. This is what many economists and politicians want us to believe. Economic growth is the cause of many of the problems we experience today. The real problem is the lack of sustainable development, ethics and consequently of values that is preferences and priorities. This fallacy has been repeated to the point of exhaustion; however, it doesn't hide the real truth that we are just on the tipping point to seriously impacting the globe if nothing is done by responsible politicians and other leaders. People have been misguided before but hopefully misguidance will not have a part to play in the future. We do still have time to set the sails anew. Environmental improvements have for sure been seen during these past 30 years. Major regulatory measures have been implemented all over the world. Formerly destroyed rivers are being brought back to life. Many whale species are now thriving again. Environmental beneficial technology is about to capture a major part of the world's energy market. Protests movements as well as green political parties have sprung up all around the globe. New environmental treaties and conventions have been signed. There might be hope for the future. However, this hope hangs on a fine balance stretched out between human beings' preferences and the environments capacity to honor such preferences. So, either these preferences must be changed or otherwise we're bound to go down the road currently sketched and in the end that might not be what human beings really prefers. This calls for visionary leaders in politics, business life and within public authorities – and they'll have about 10 years to do the job. The environmental challenge is real, it's immanent and it's vital. NASAs rover Perseverance in October 2021 discovered evidence of rivers and lake systems on Mars. The turn of Mars into a lifeless cold planet was due to a natural physical process. Let's hope that planet Earth shall not end the same way due to human interactions.

On 2nd December 2020 UN Secretary General Antonio Guterrez at Columbia University in New York said: "*The planet is broken*" and added *"we are on the verge of a climate catastrophe*". There is good reason to heed the warnings issued by Guterrez like there was when 1.700 scientists issued their warning some 30 years ago. The world is right now in intensive care.