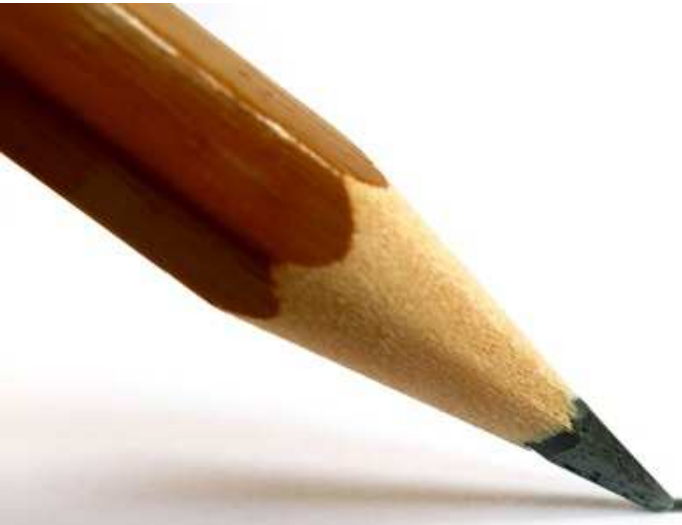


Climate change and biodiversity

INFLUENCING FACTORS

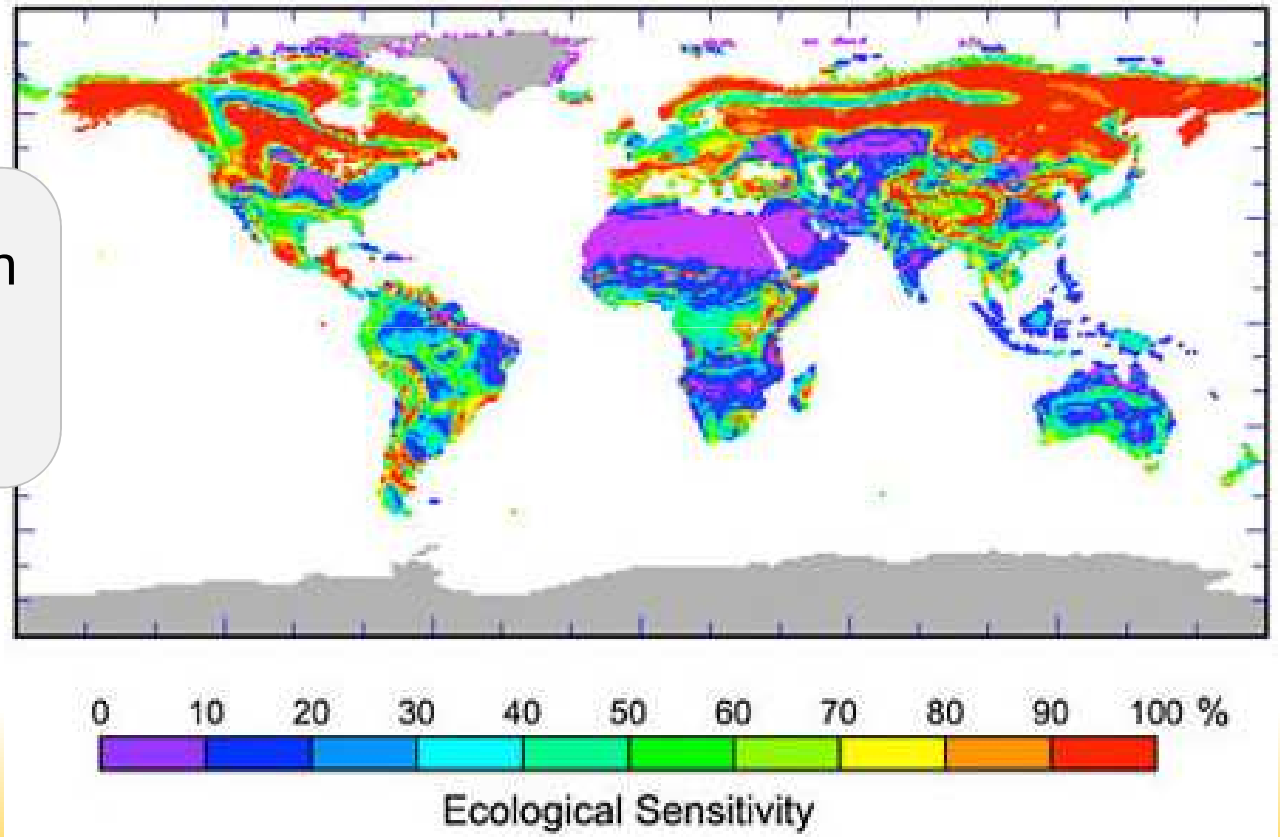
- Geographical location
- Relief
- Geographical latitude
- Circulation of ocean flows
- Circulation of air flows

CLIMATE

- Temperature
- Precipitation
- Solar radiation
- Atmospheric circulation

Global ecological sensitivity during the 21st century

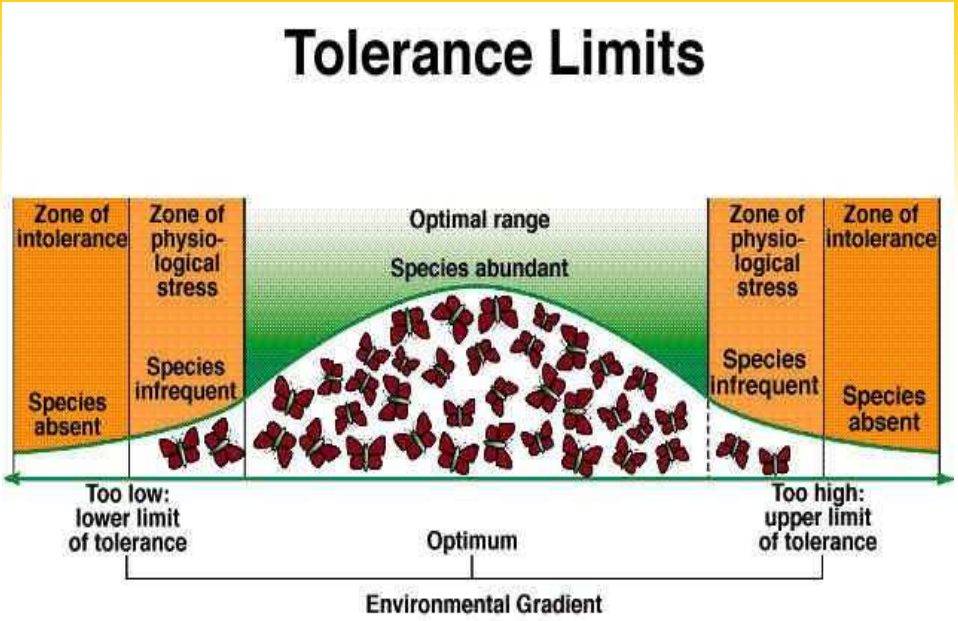
Predicted percentage of ecological landscape being driven toward changes in plant species as a result of projected human-induced climate change by 2100



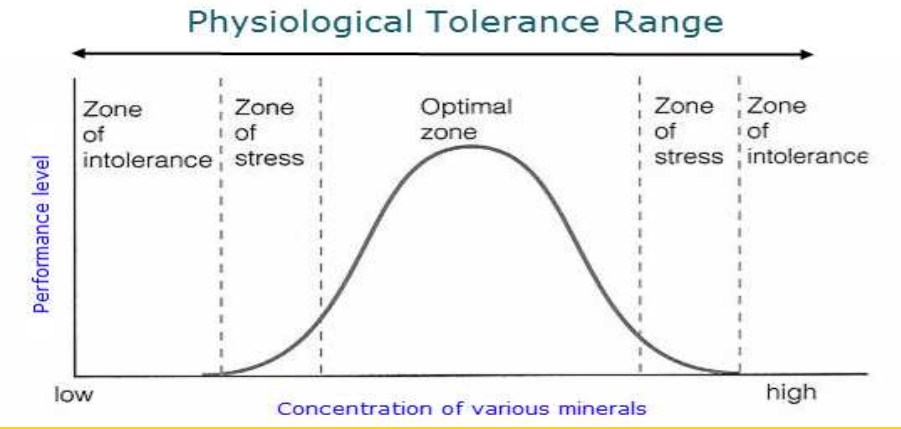
IMPACT OF ENVIRONMENTAL FACTORS ON LIVING ORGANISMS

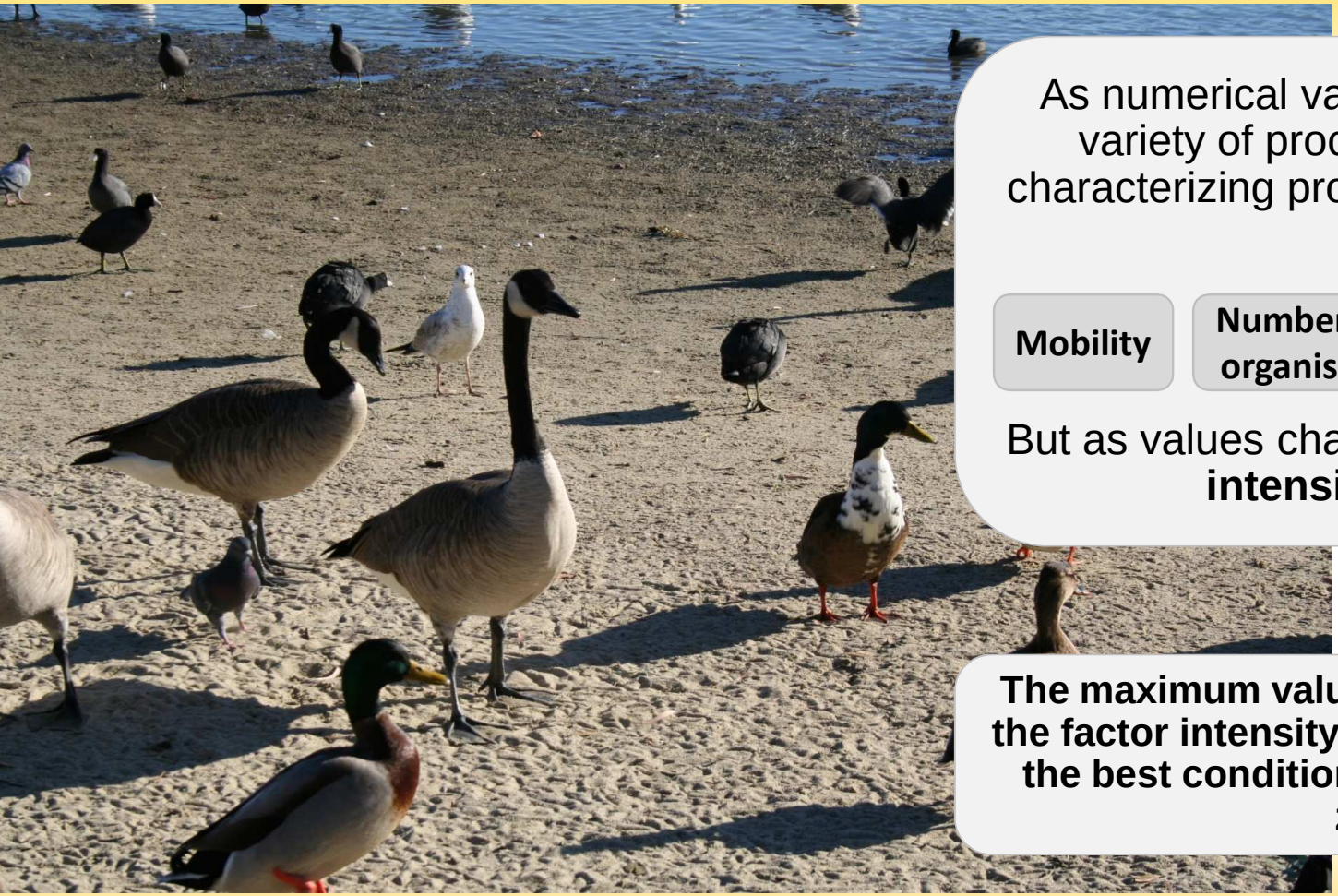
Environmental factors influence living organisms by determining their **spatial distribution, number and species composition at the certain area**

Response of living organisms on each individual environmental factor is described by a **diagram of Shelford's theoretical model**



Shelford's law of tolerance





As numerical values of **organism's response** a variety of processes of living organisms and characterizing properties can be used, for example:

Mobility | **Number of organisms** | **Intensity of metabolism** | **Intensity of reproduction**

But as values characterizing factor's performance – **intensity of a factor –** is used

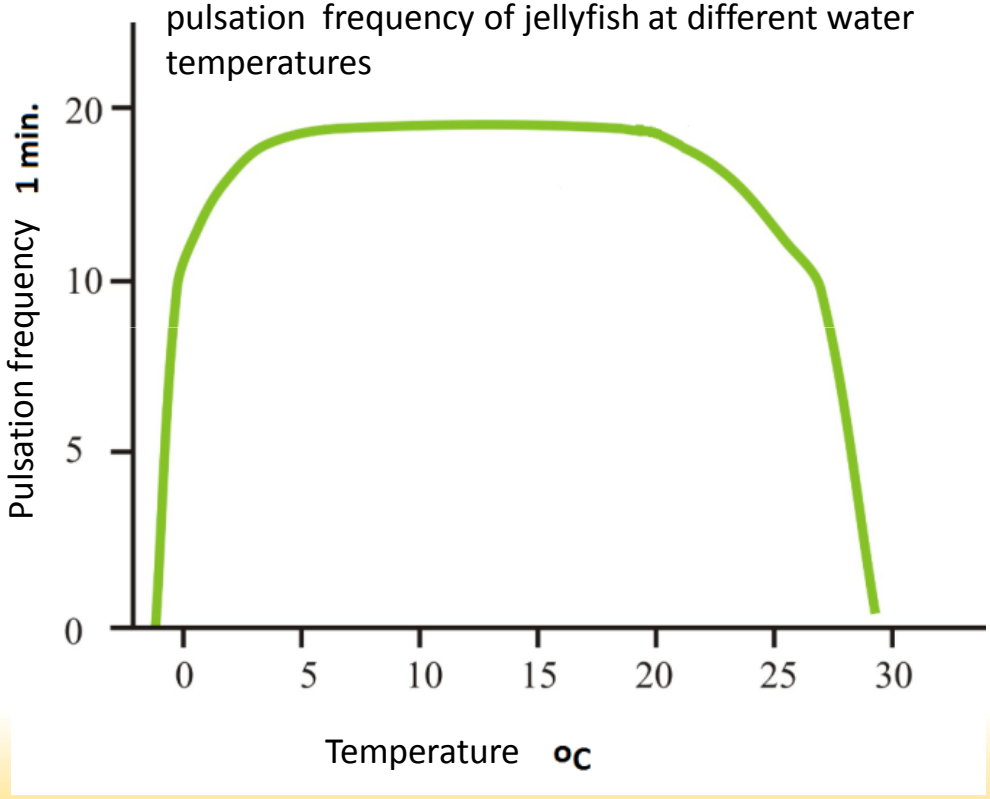
The maximum values of the Shelford's diagram meets the factor intensity values, at which the organism feels the best conditions, thus this is called the optimum zone of the factor

For every organism in relation to a specific environmental factor, certain **limits of endurance (izturība)** exist

The area of the factor's intensity between the minimum and the maximum critical points is called **the tolerance interval of an organism**

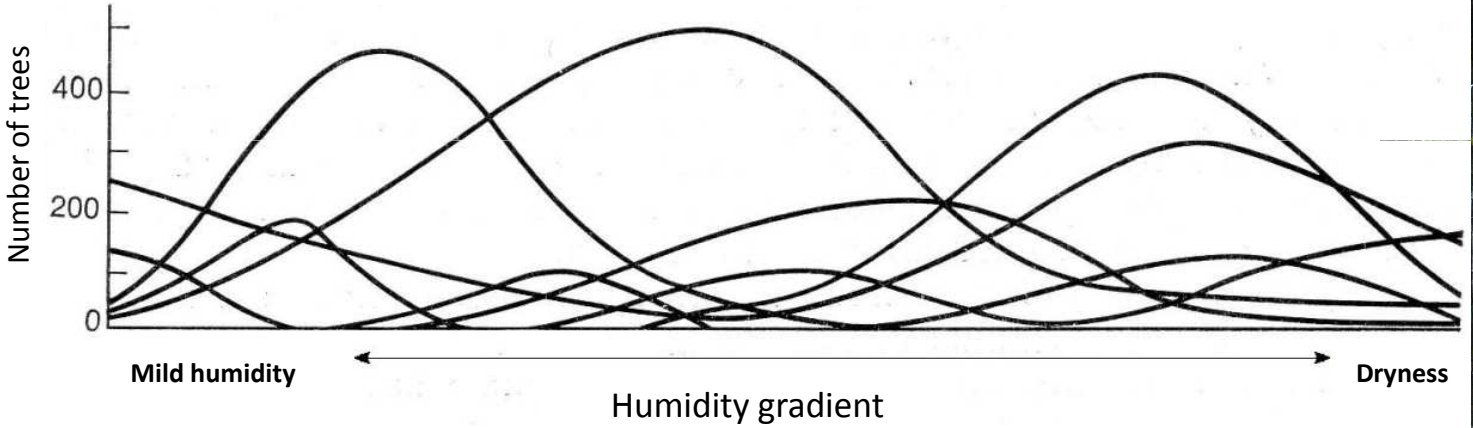
If the factor's intensity is outside the tolerance interval, the organism dies

Tolerance diagram detected at laboratory conditions for jellyfish *Aurelia aurita* reveals body contraction pulsation frequency of jellyfish at different water temperatures



Change of number of different species of trees the sampling plots, formed in soil with humidity gradient in the hillside Visconsine state (USA)

Each curve corresponds to one tree species



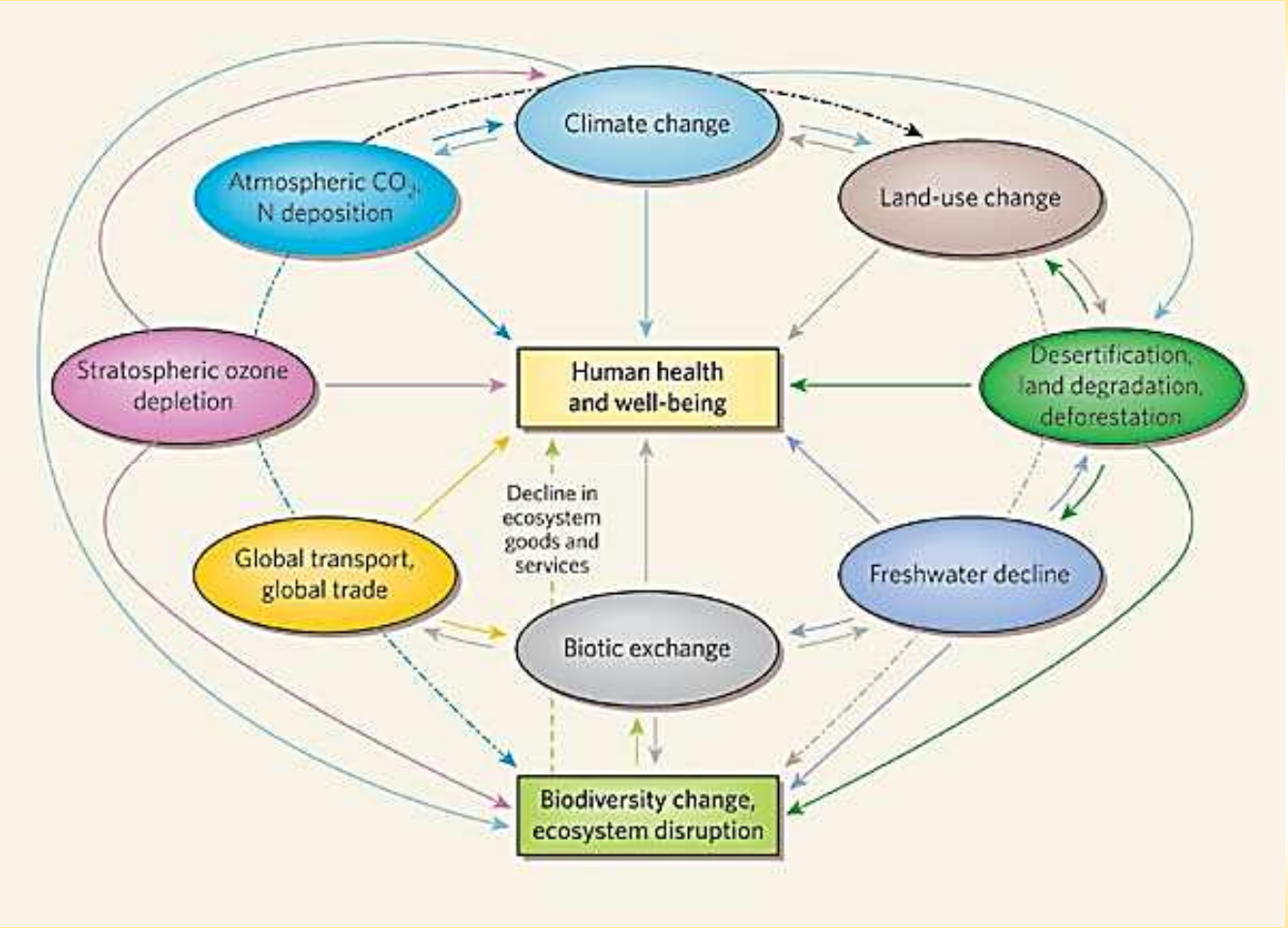
INTERACTION OF ENVIRONMENTAL FACTORS

If analyzing the organism’s response to environmental factors, it should taken into account not as much the influence of an individual factor, but **the influence of interaction of several factors**

Interaction of factors becomes apparent in the way that at the influence of one factor at the same intensity **the reaction of an organism is different**, depending on exposure intensity of other factors

Changes in land use through land degradation, and climate change, are the most prominent factors

Perturbation of «ecosystem goods and services» is just one part of this bigger picture

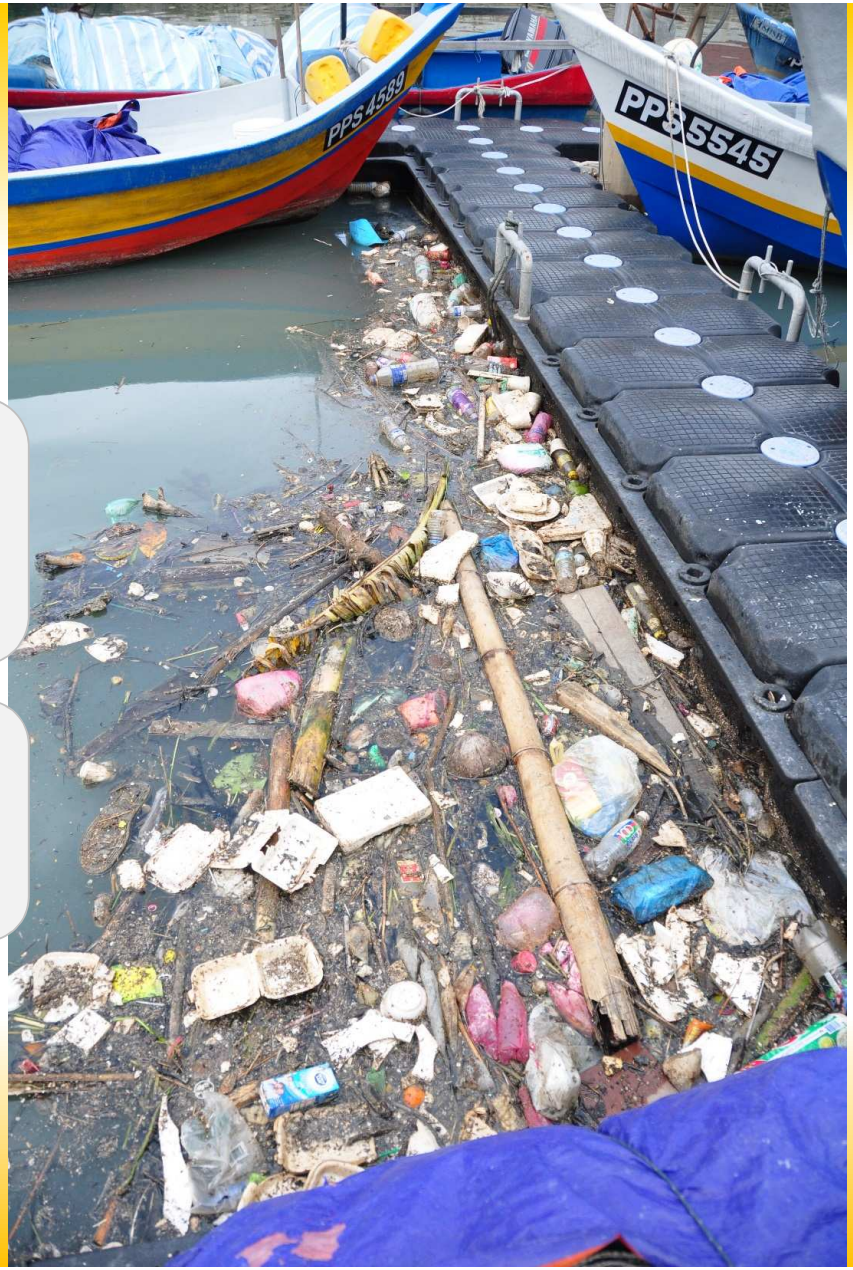


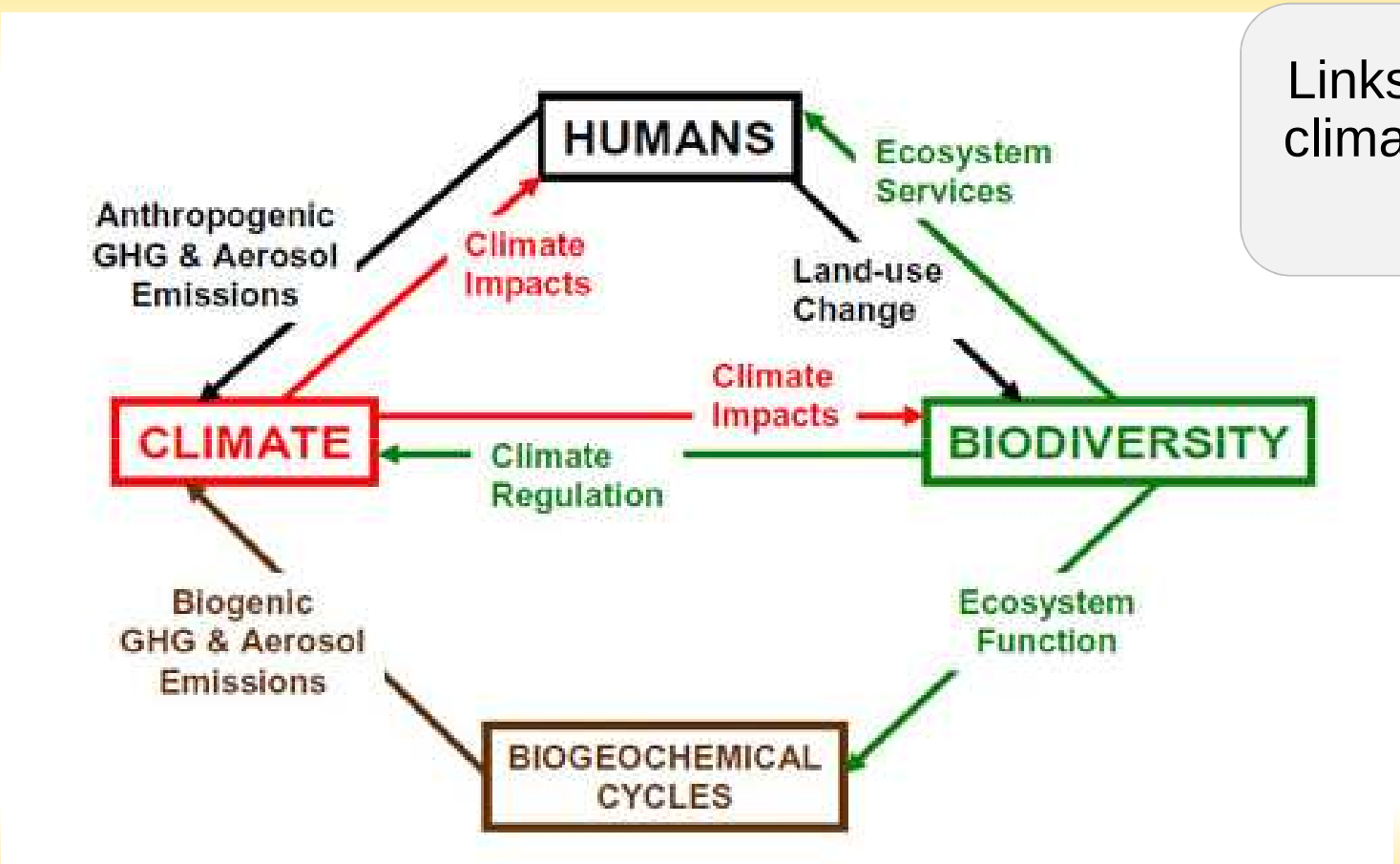
SHELFORD'S LAW OF TOLERANCE

Apart from the influence of various environmental factors, **the functioning of an organism is limited by that factor, which is closer to the minimum or maximum of critical points**

Nowadays, in addition to the natural environmental factors living organisms are also affected by various **anthropogenic factors**:

- **Land management**
- **Construction and transport**
- **Appearance of invasive species**
- **Environmental pollution**
- **Overexploitation of resources**



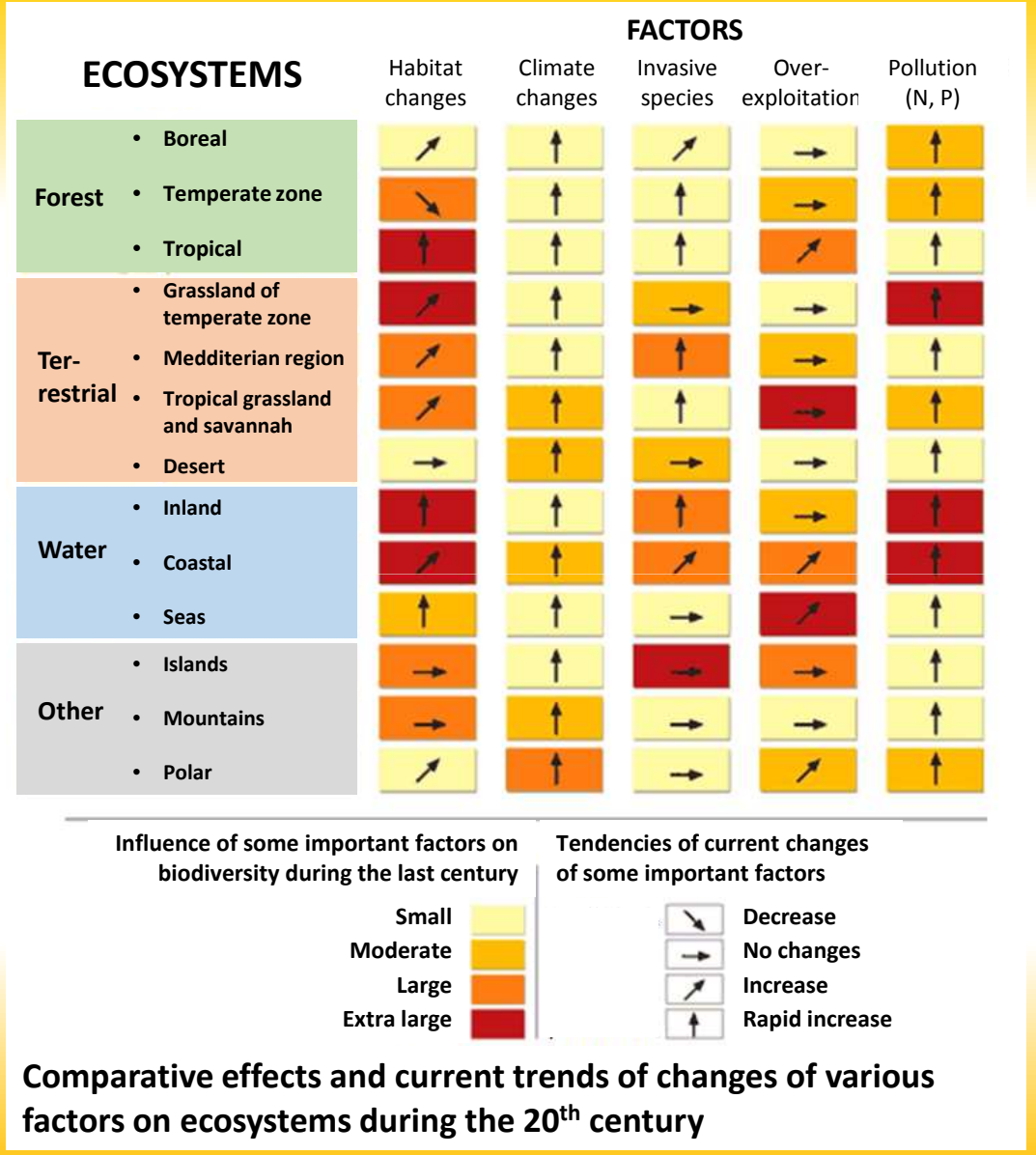


Links between biodiversity, climate change and human well-being

Assessing the impact of climate change on species, particularly important is impact of two environmental factors – **temperature and humidity**

Even in case when all natural environmental factors are optimal, species can die due to environmental pollution or due to changes in its habitat, if anthropogenic activities have changed the ecological conditions as inappropriate for existence of species

On the contrary, if human activities has changed the temperature or moisture regimes or concentration of nutrients in a certain place, it may become suitable for development of another species which can multiply in a greater number



Comparative effects and current trends of changes of various factors on ecosystems during the 20th century

IMPACT OF TEMPERATURE ON LIVING ORGANISMS

If the ambient temperature is below or above a certain critical threshold, an organism is unable to provide the life processes and dies **either from overheating or freezing**

Tolerance intervals of primitive organisms (bacteria and fungi) are generally significantly larger than those for developed organisms

Tolerance to temperature for highly developed organisms is much lower – within the interval from 0 ºC to +50 ºC

Spores of fungi remain viable even at temperatures close to absolute zero (-273 ºC) or considerably higher than the boiling point of water (+100 ºC)

Depending on the tolerance diapason in relation to changes in temperature, organisms are subdivided:

Eurythermal organisms

Most of species in temperate zone

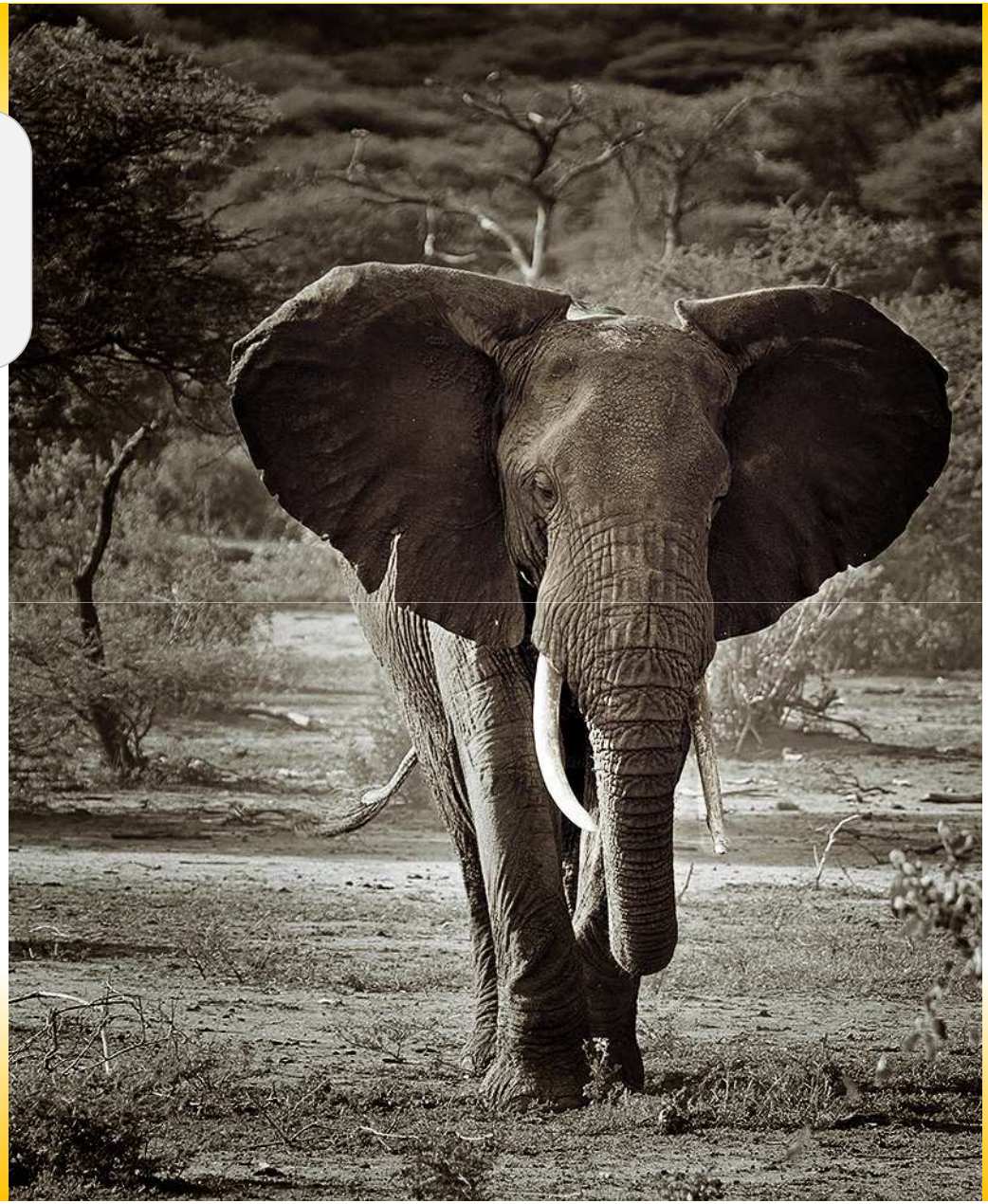
Stenothermal organisms

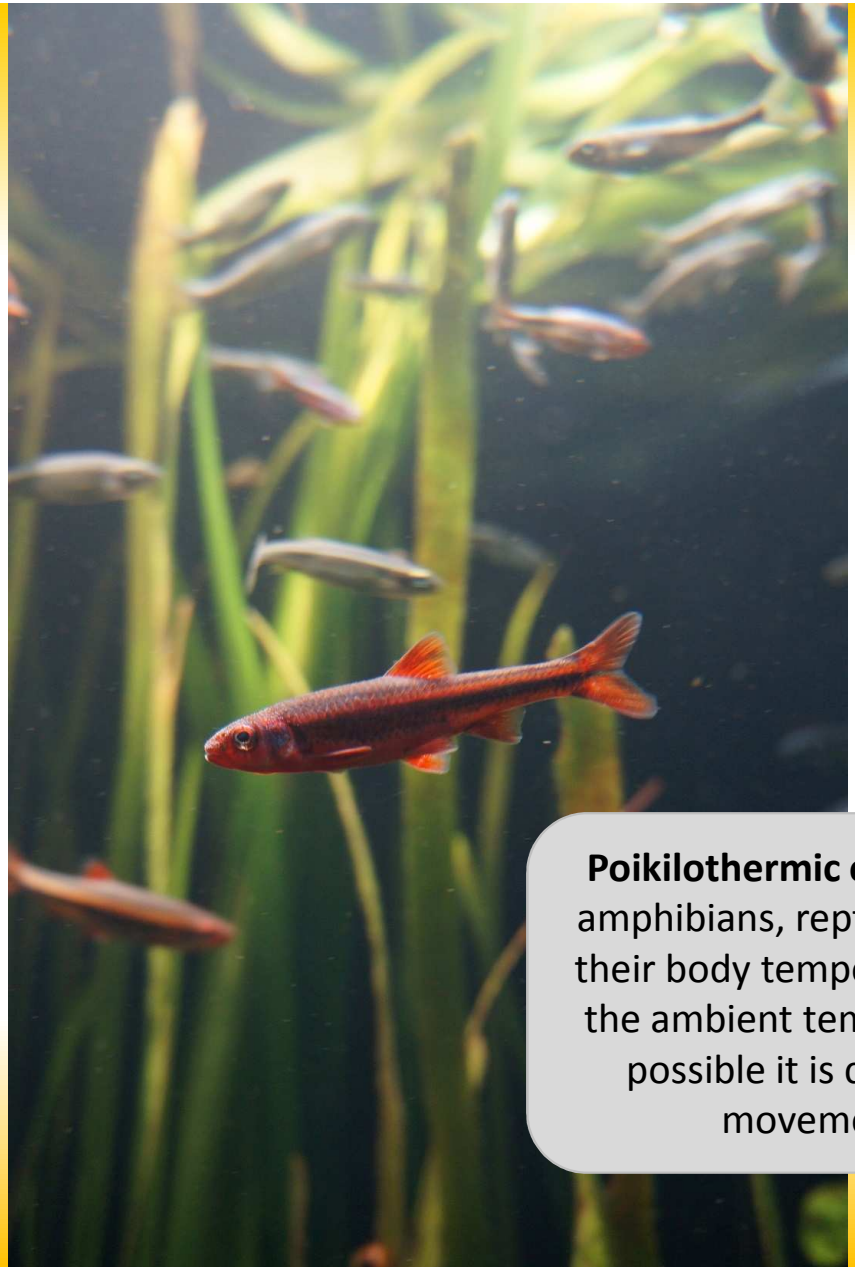
Cryophiles

Thermophiles

Mostly species of tropical zone

Typical thermophiles are some species of cyanobacteria occurring only in hot springs which temperature reaches +80 ºC





Ambient temperature is constantly changing, thus living organisms are often forced to be situated **in sub-optimal, or even in life-threatening temperatures**

For successful existence at variable temperature conditions, species in the evolutionary processes have developed various adaptation ways, which compensate or even eliminate the adverse effects of temperature

Poikilothermic organisms – fishes, amphibians, reptiles, plants, fungi – their body temperature depends on the ambient temperature, as far as possible it is controlled by the movement activity

Homeothermic organisms – mammals and birds – maintain a constant body temperature in any environmental conditions, it contributes to body hair, subcutaneous fat layer, or a specific anatomic structure

Adaptation mechanisms to changes in environmental temperature has been developed over a long evolutionary process of species adapting to temperature regime of certain climatic region

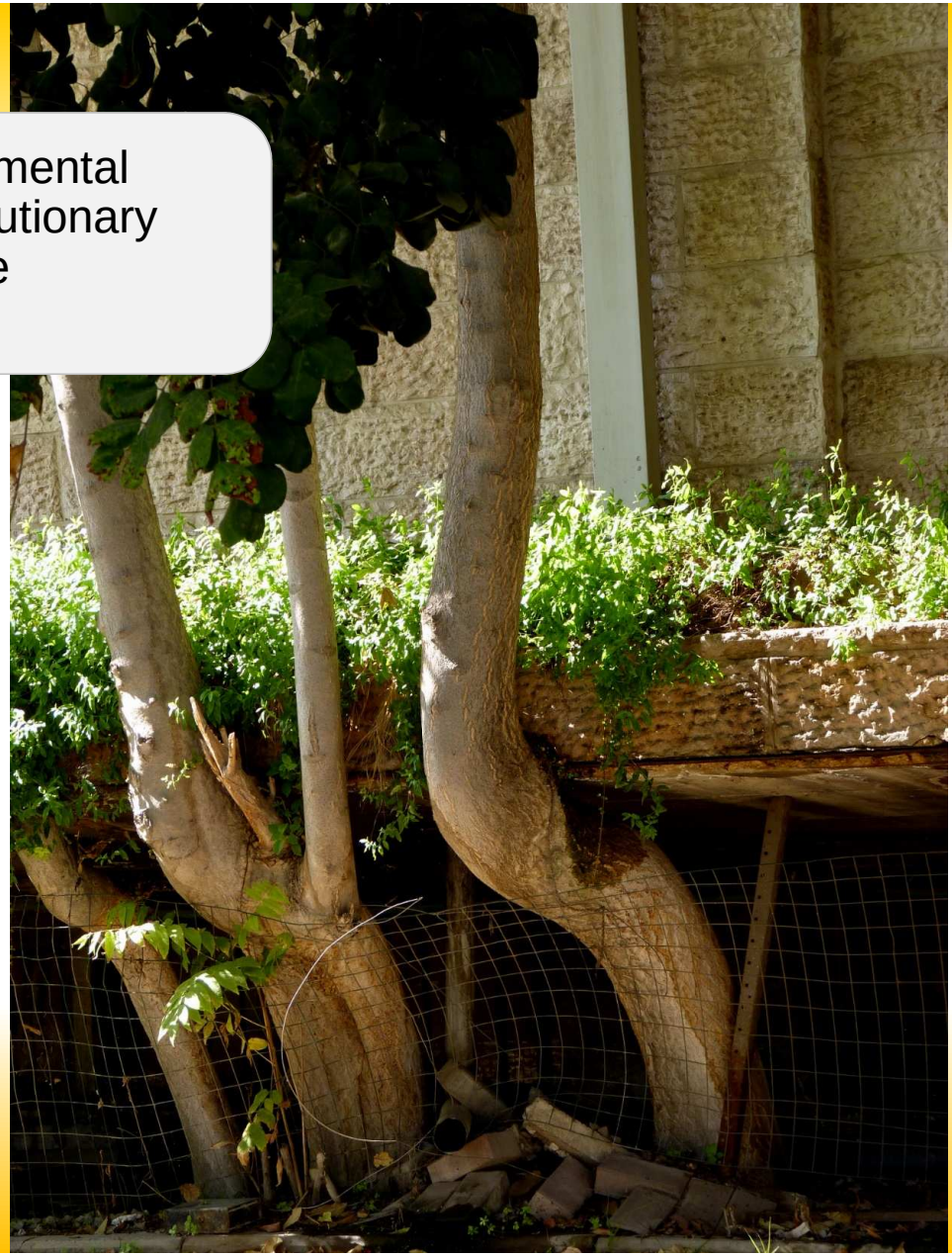
For the existence of a particular species following temperatures are important:

Sum of positive temperatures

Sum of daily or monthly temperature values which **are above the fixed rate**, e.g., +4ºC

Maximum temperature in summer

Minimum temperature in winter



Every species of living organisms has **a tendency to expansion**

Species in their area of distribution is present in larger or smaller groups of individuals **– the populations**

Temperature is one the limiting factors of the species expansion that determine its distribution in boundaries of the area

Climate warming is one of the essential reasons for the expansion of southern species to the northern regions and colder climate loving species extinction in the southern regions

IMPACT OF HUMIDITY ON LIVING ORGANISMS

Humidity (moisture) is the second most important environmental factor affecting distribution of species in terrestrial ecosystems at regional and local level

Humidity is tightly connected with:

Amount of precipitation and groundwater flow

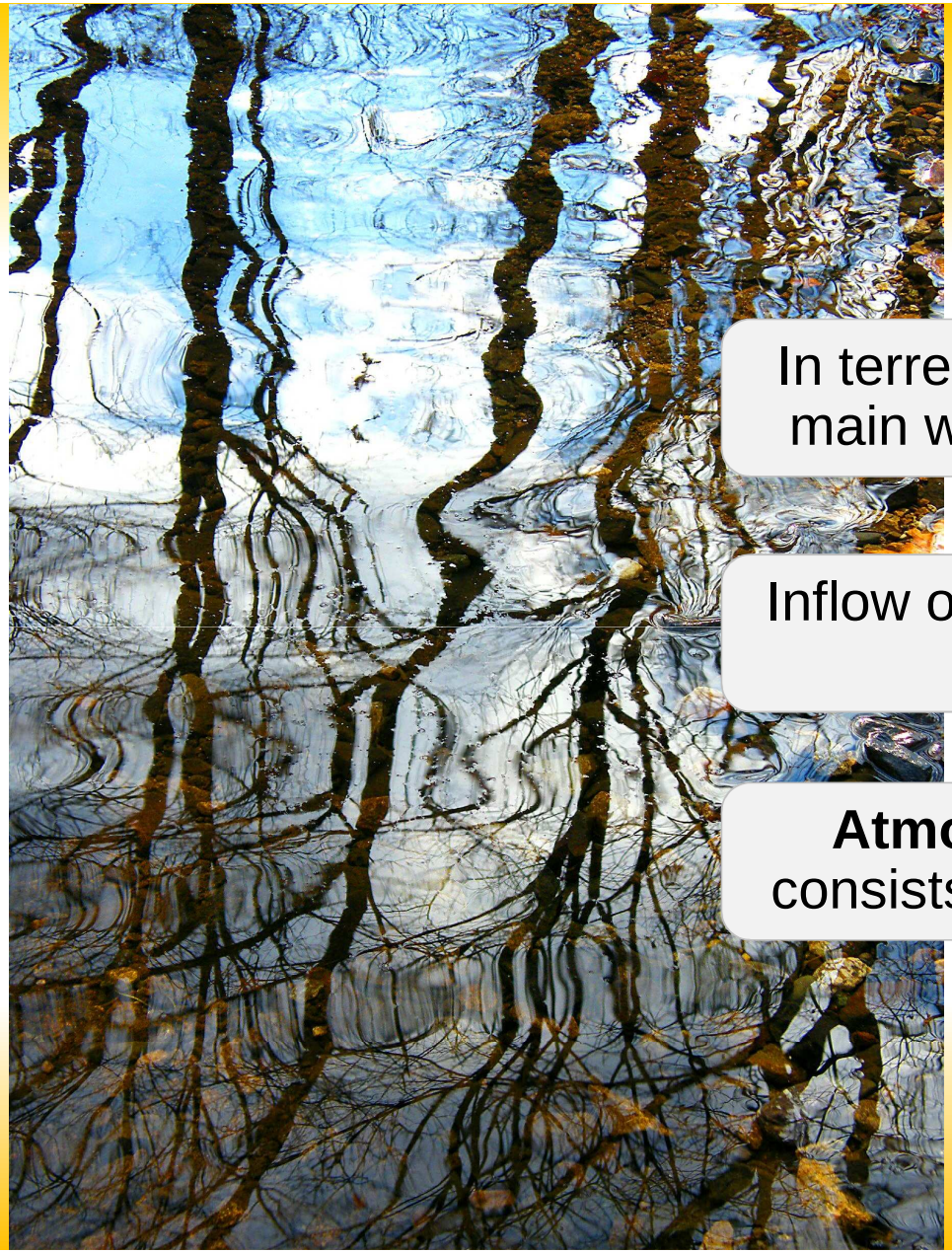
Wetlands

Evaporation

Drought

In temperate and northern regions, where precipitation dominates over evaporation, at lower relief areas swamps (bogs) are formed

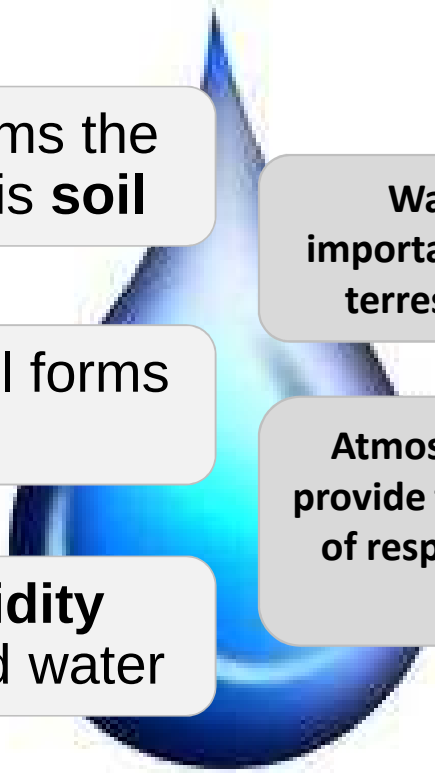
In southern regions, where is a prolonged drought, steppes, semi-deserts and deserts are formed



In terrestrial ecosystems the main water reservoir is **soil**

Inflow of water into soil forms **soil moisture**

Atmospheric humidity consists of evaporated water



Water is of vital importance for the life of terrestrial organisms

Atmospheric humidity provide the humidification of respiratory organs of mammals

Increased evaporation contributes to cooling of animals and plants, thus compensating the impact of thermal solar radiation

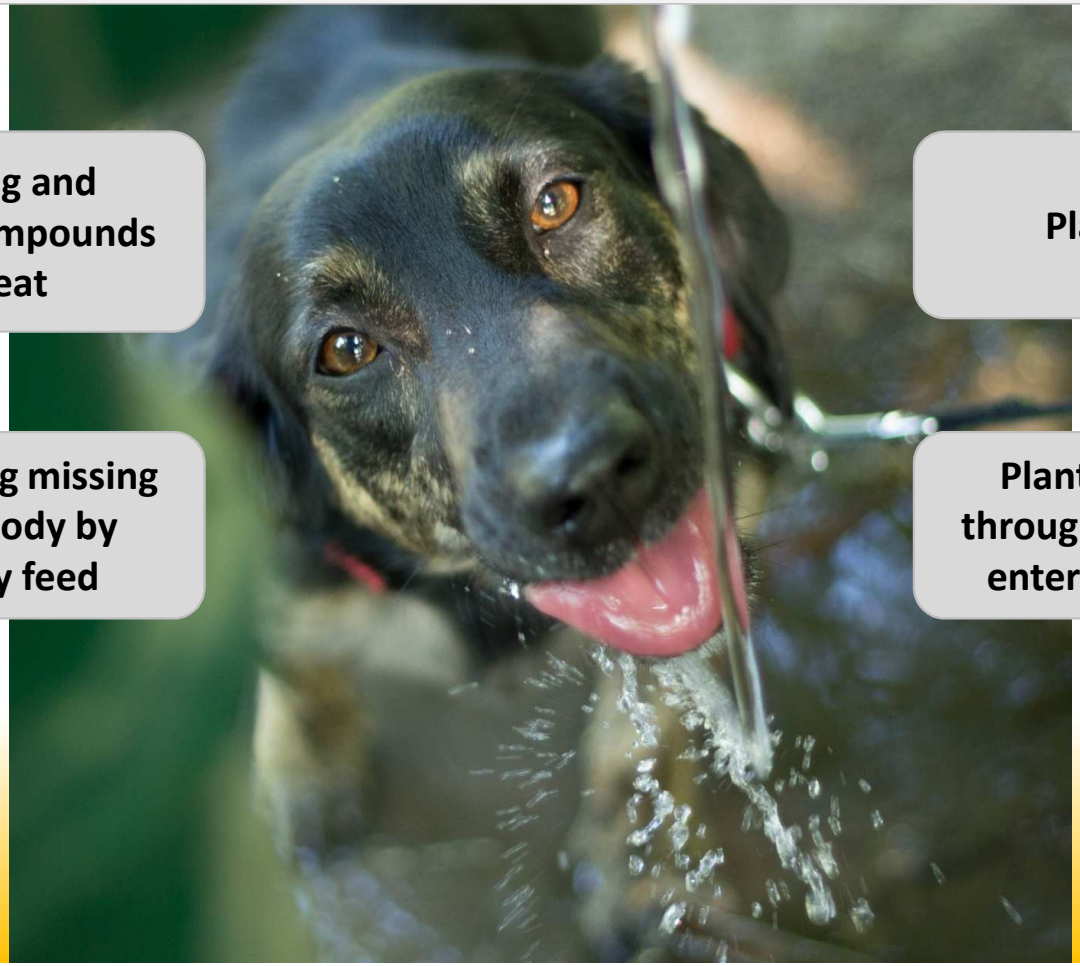
Since humidity is often a limiting factor for terrestrial organisms, in the process of evolution they have developed various adaptations to survive in conditions of insufficient or excessive humidity

Depending on the possibility to regulate the amount of water in cells and depending on water quantity environment, organisms are classified as:

Homoihydric organisms – try to keep a certain amount of water in their body and if it decreases, an organism dies

Poikilohydric organisms (algae, fungi)

Living organisms are constantly losing water and trying to restore the amount of water:



Mammals – by breathing and removing the metabolic compounds by urine, feces or sweat

Plants – by transpiration

Mammals are compensating missing amount of water in the body by drinking or eating a juicy feed

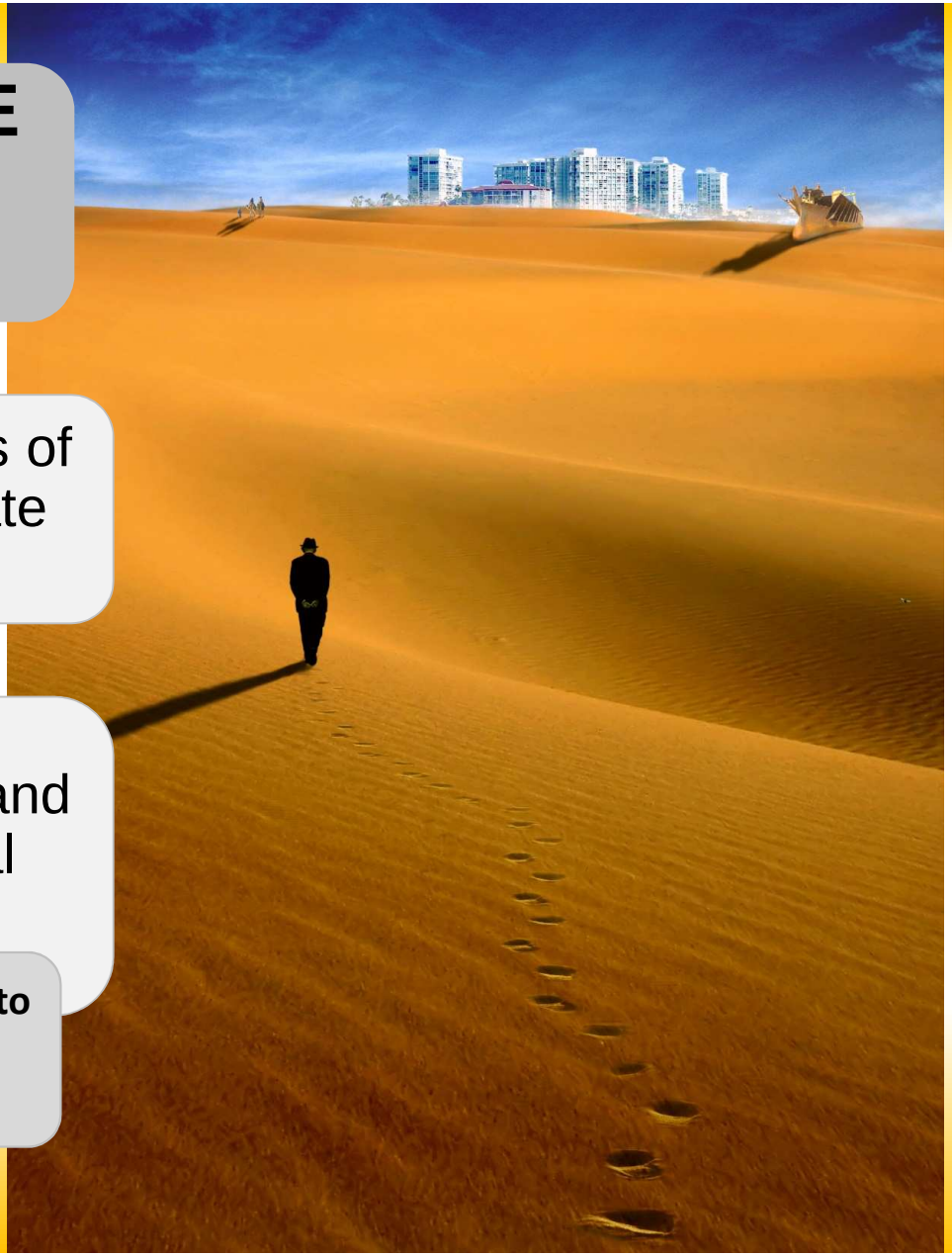
Plants generally absorb water through roots from the soil; water enter into the roots by osmosis

IMPACT OF CLIMATE CHANGE ON THE GLOBAL BIODIVERSITY

At the beginning of he new millennium analysis of meteorological data clearly showed that climate warming is an indisputable fact

There is available a wide range of data on different populations of species, their number and rhythm of life as well as data on phenological changes due to change of temperature

However, for critics these data did not seem convincing enough to be able to argue that the observed changes are indeed attributable to climate warming instead of some local factors

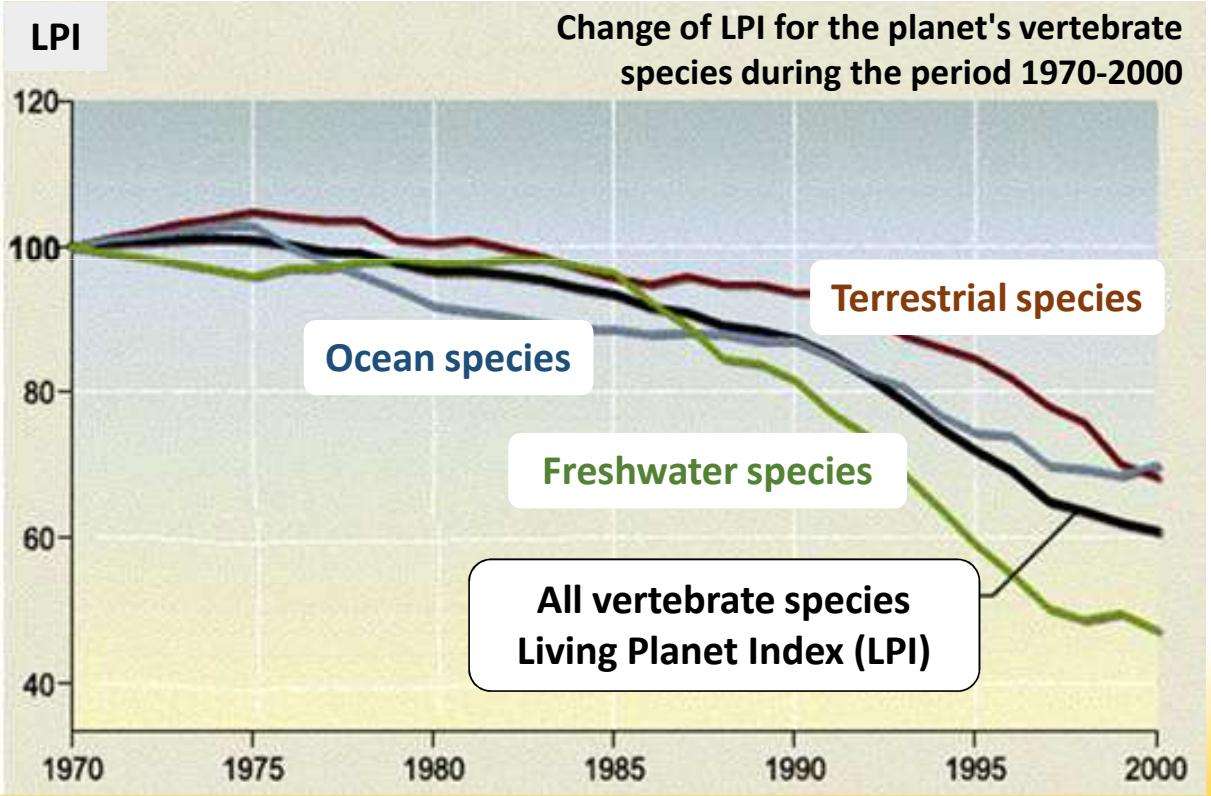


What are the arguments which make people to be concerned about the planet's ecosystems within the ongoing changes in biodiversity ?

Firstly – very fast speed in which climate change is happening

For the characterization of biodiversity changes Living Planet Index (LPI) was developed

LPI index is calculated taking into account decrease in number of the planet's 1145 species of vertebrates since 1970, and it is expressed as a percentage



Secondly – it is important to understand that in the 21st century the ecosystems will need to begin restructuration on the highly unstable base, as human economic activities and environmental pollution have partially or even completely destroyed a plenty of ecosystems

In such a situation, the adaptation of natural systems to climate warming, ocean acidification, reduction of suitable habitats, increasing chemical pollution and impact of invasive species will cause a cascade effect of species extinction

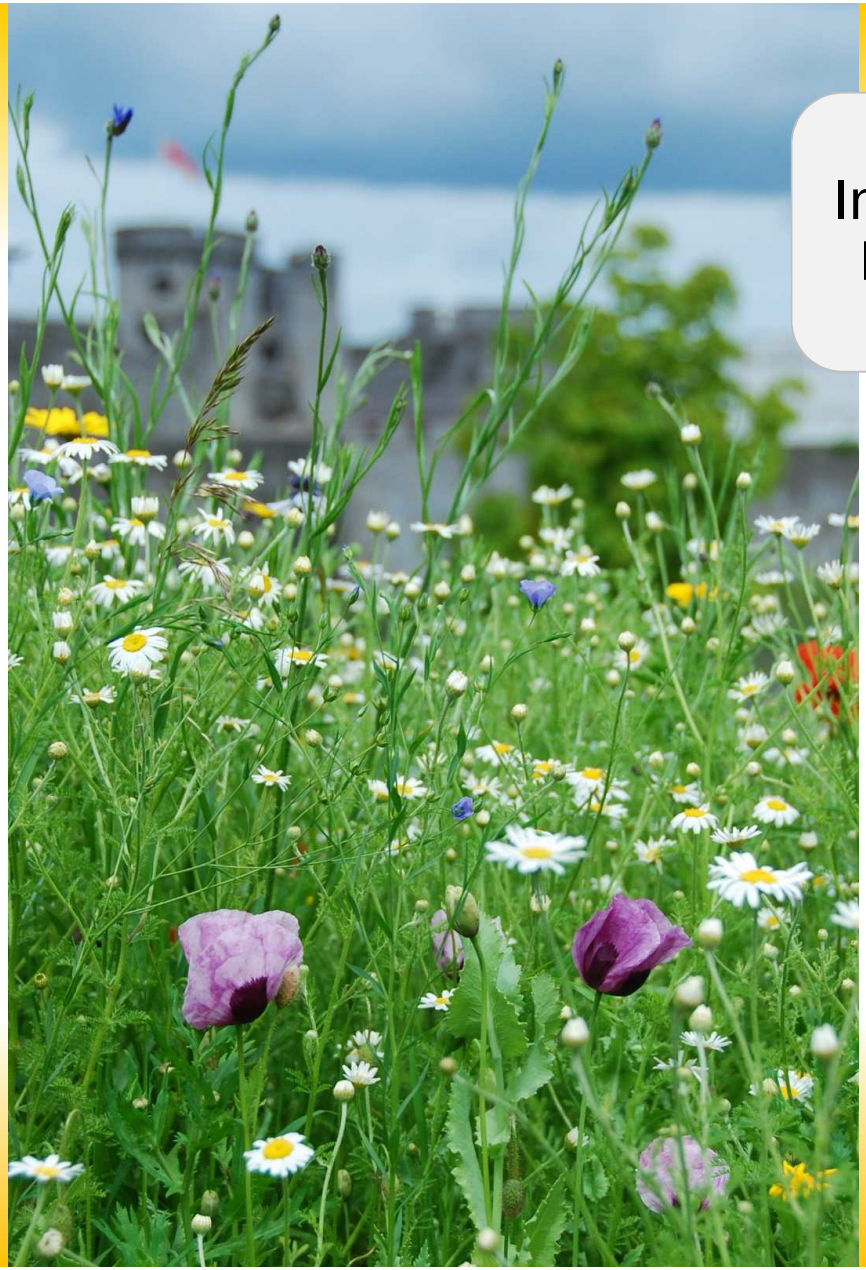
Thus, impact of climate warming on biodiversity, interacting with anthropogenic factors, will be even more drastic

Thirdly – **adaptation of species to climate change in the past took place mostly by shifting of their distribution boundaries to higher or lower latitude, or up and down the mountain slopes, depending on whether the climate became warmer or colder**

Consequently, for populations of species to survive it was necessary to become genetically diverse

But on the background of current climate warming it is no longer possible because for many species just it will not be able to hide

In case of extinction of higher organism species, **life itself on the planet will remain in forms of lowest thermophil living organisms**, but existence of human populations in such conditions will become problematic



In 1993, the network of **International Long-Term Ecological Research (ILTER)** was established

With the main task to carry out the long-term studies on different ecosystems in order to obtain reliable data on changes in ecosystems due to natural and anthropogenic factors

Currently the ILTER network brings together 40 countries of the world, including Latvia

As one of the tasks of the ILTER network studies on biodiversity changes due climate warming were announced

DATE AND VENUE:
9-13 October 2016 in the Kruger National Park, South Africa

Themes:

Nitrogen impacts on ecosystems structure and function.
Carbon and water cycles under climate change.
Towards sustainable usage of ecosystem services (local, regional & global).
Drivers of biodiversity across scales.
Data integration and interoperability linking global scale ecosystem research and environmental monitoring.
Linking local, regional and global Earth system observations and models.
Long-term studies of population dynamics.
Long-term changes in nutrient cycling.

Impact of climate change on biodiversity can be **direct and indirect**

Climate affects both, spread in space and time of species and the necessary resources (water, nutrients etc.) for their existence

Impact of climate change on global biodiversity is mainly associated with the increase of temperature, but as an important side factor the amount of precipitation is mentioned

For living organisms the interaction of these two factors is vitally important

As indirect effect, significant role is attributed to the ratio of nutrients and invasive species

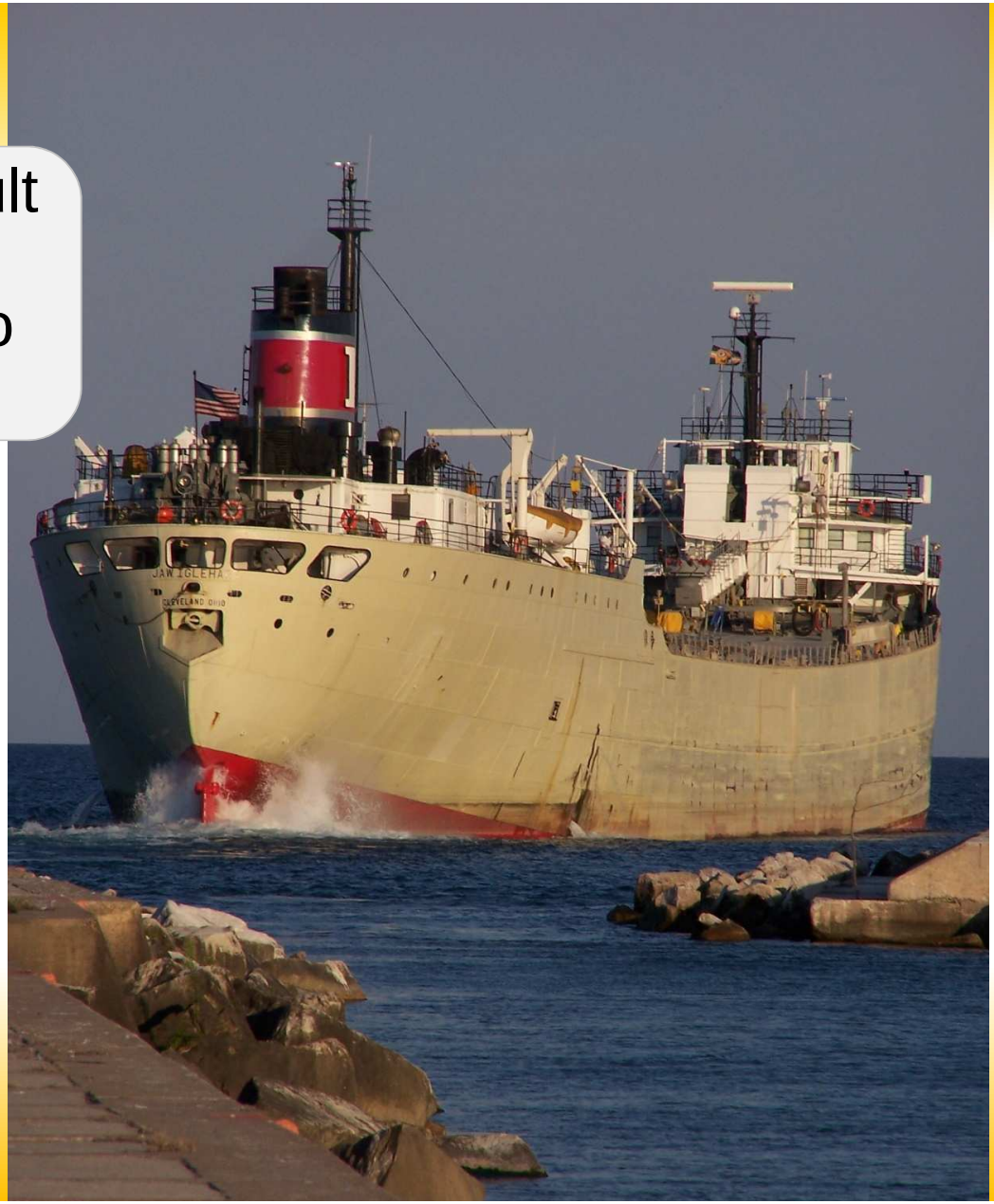
If a predator's tolerance to changes of temperature or humidity is large enough, but a victim - an object of a predator's nutrition, is more sensitive to these changes, the impact of climate change on a predator will be indirect

As a species-newcomers often do not have any natural enemies in a new ecosystem, they often multiply in huge quantities and may suppress or completely outrival native species

Invasion of species occurs as a result of **intentional or unintentional human activities**, as well as due to migration of species

Intentional introduction of alien species is associated with agricultural activities such as introduction of ornamentals and replenishment of fauna for hunting

Unintentional introduction occurs due international and intercontinental transport by ballast water of ships, railway and containers



In general, the data that world of researchers obtain on changes of species diversity due to the climate warming are still incomplete

Most of available observation data are related to large, conspicuous or economically important species, as well as to those species which are preserved by a special protection status

As the strongest evidence for the impact of rising temperature on living organisms are considered phenologic observation data:

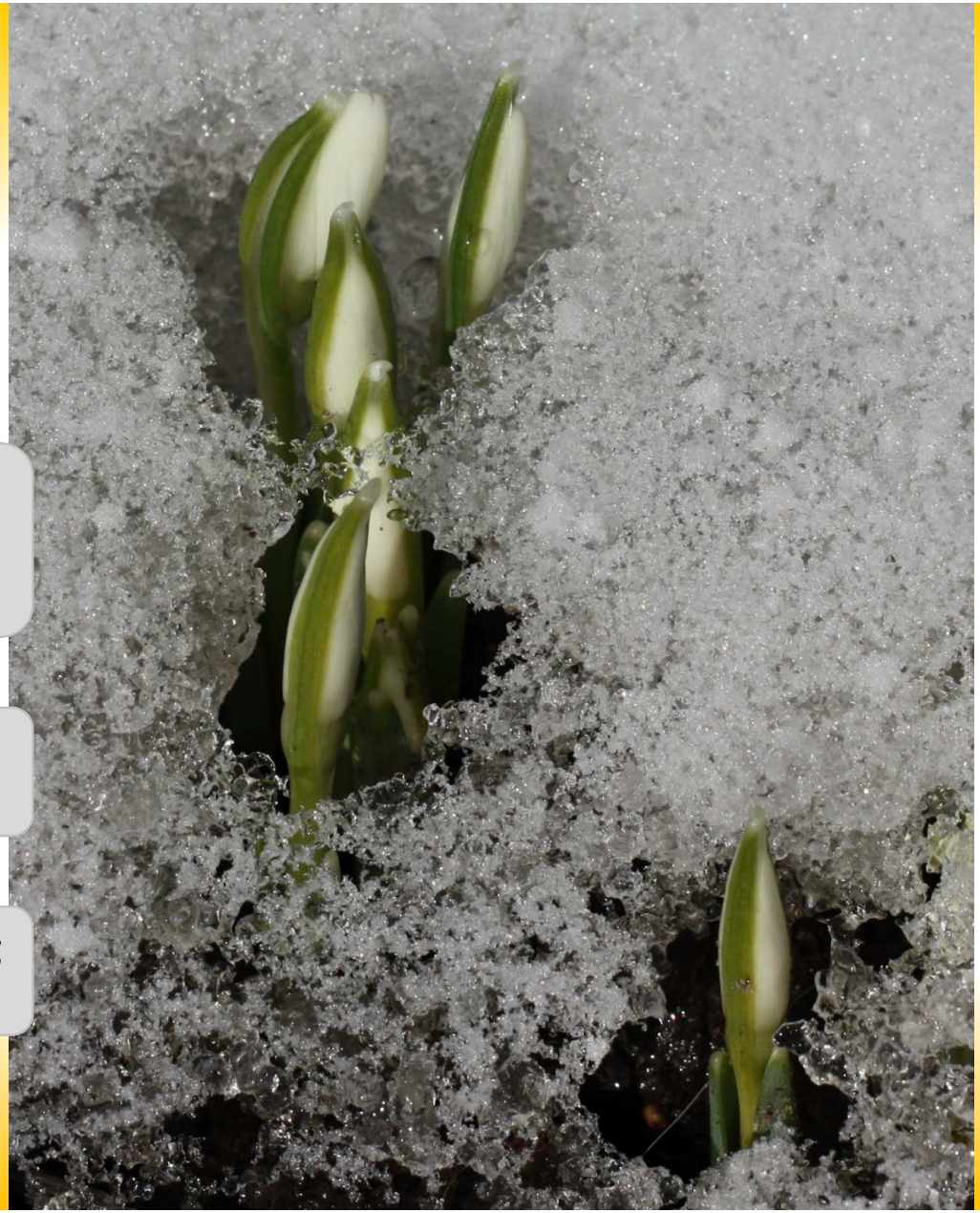
the beginning of plant flowering and leaf unfolding in spring and leaf coloring in autumn, migration time of birds etc. are important signs observed by phenology

Phenologic observations reveal:

In the Northern Hemisphere, the vegetation season during the last 40 years has extended by 1-4 days, especially at higher latitude

In Europe, leaf unfolding starts earlier by an average of 6.3 days, but leaf coloring delays by 4.5 days

In general, duration of vegetation period from the beginning of 60ties have increased by and average of 10.8 days



Phenologic phenomena in autumn, in contrast to the spring events, are much less offset in time, thus -

in overall, v**egetation period tends to be extended**, which contributes to the positive sum of temperature increase and provides survival of southern species that have entered temperate regions

By changes in phenology of different species, synchronicity of the life processes between the segments of ecological nutrition chain has been disrupted, for example:

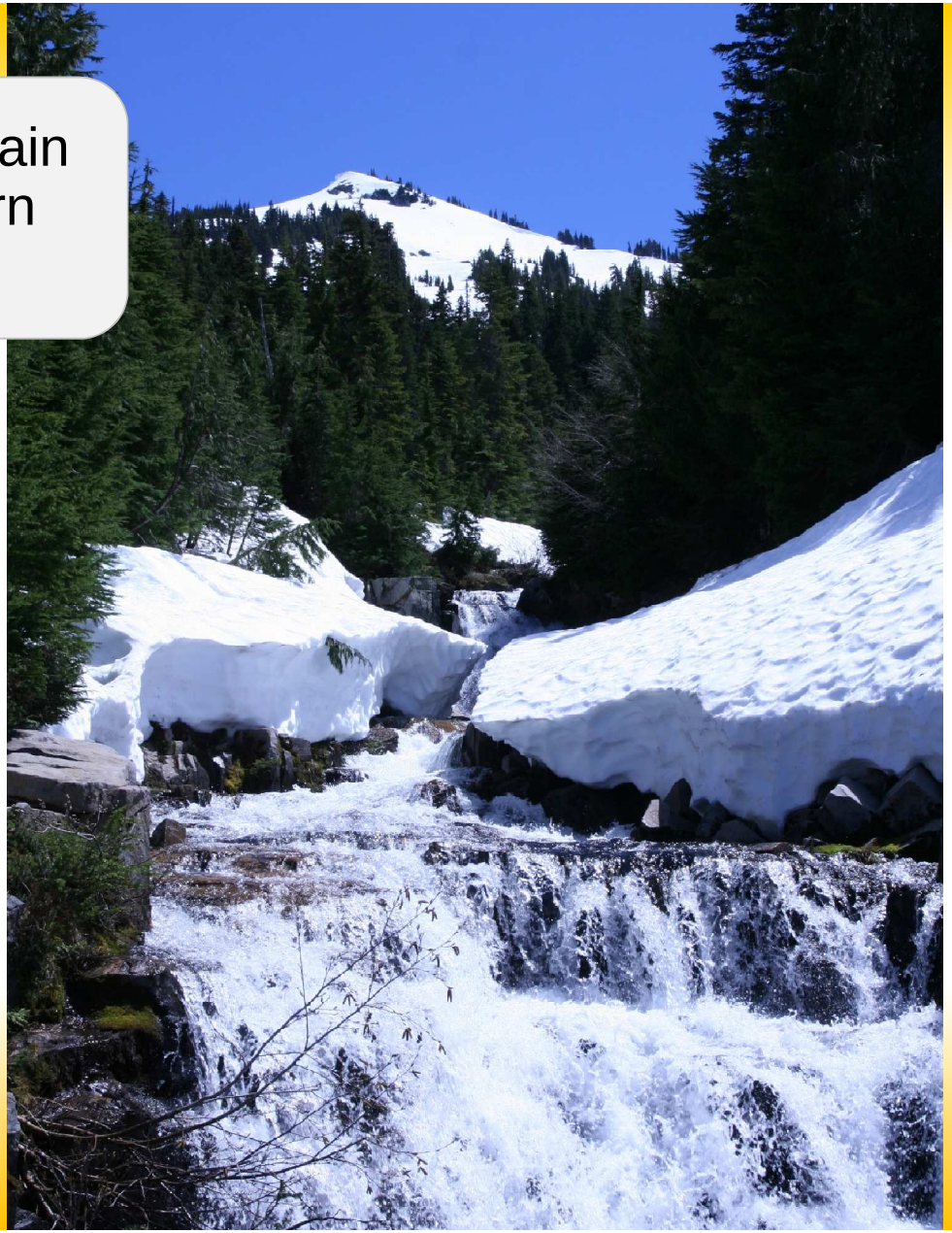
Hatching time of birds is no longer coincide with insect activity and increase, thus leading to decrease of birds' survival

If in temperate and northern regions as the main impact factor is temperature, then in southern districts - precipitation and humidity

Gradual melting of high altitude glaciers is of particular concern, threatening by a decrease of water from mountain rivers in future

For example, the Himalayan glaciers are important water resources for large ecosystems of southern Asia regions and essentially provide the agriculture in these areas

As due to the global warming rapidly melting of Arctic glaciers is going on, water level of global ocean is gradually rising causing a risk of flooding in number of regions worldwide



Arctic dwellers are facing critical situation

The research reveal that in recent decades, distribution range of polar bears is shifted further to north to places where the sea is ice-covered year-round

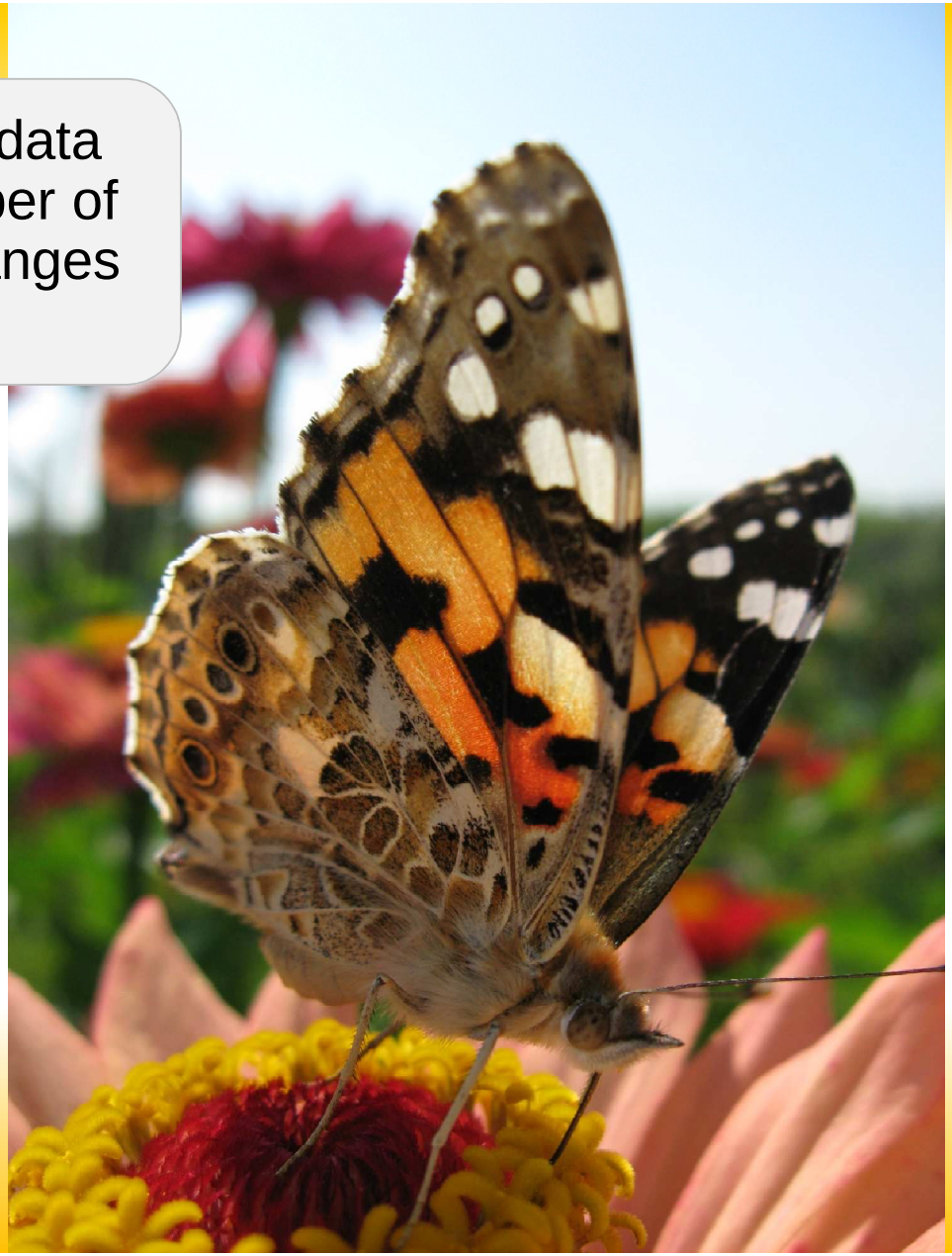
Migration routes of the polar bear population generated after the genetic analysis

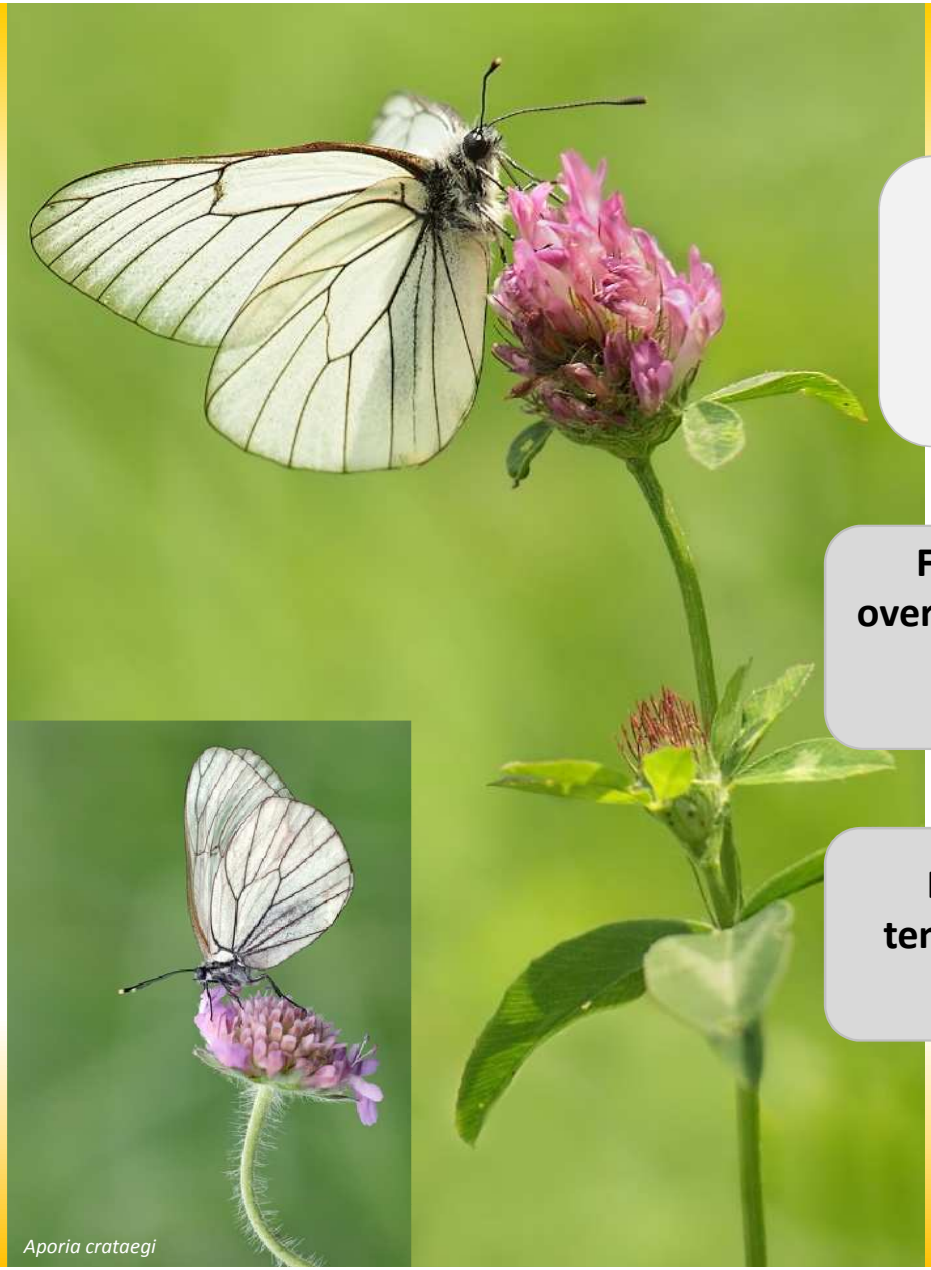
In terrestrial ecosystems, the most complete data about invertebrates are available on the number of species of butterflies and their distribution changes in the UK

Due to the increase of temperature, distribution area of many species of butterflies is moved to north and, consequently, diversity of butterfly species has increased in the northern regions

In overall, the diversity of species has increased regarding the eurybionts – species with wide tolerance ranges against vitally important environmental factors

Many species of stenobiont with narrow tolerance ranges are unable to adapt because they simply do not have a suitable habitat in these areas





Aporia crataegi

Up to now, there are very little data on the **indirect effects** of climate change on living organisms

For example, a species of butterfly *Aporia crataegi* is unable to overcome its upper boundary of habitat in the mountains of Spain, as hawthorn, the base of their feed, does not grow higher than 1800 m above sea level

Due to the changes in distribution area of species sometimes, temporary increase in its reproduction can be observed in the new place while there are no natural enemies

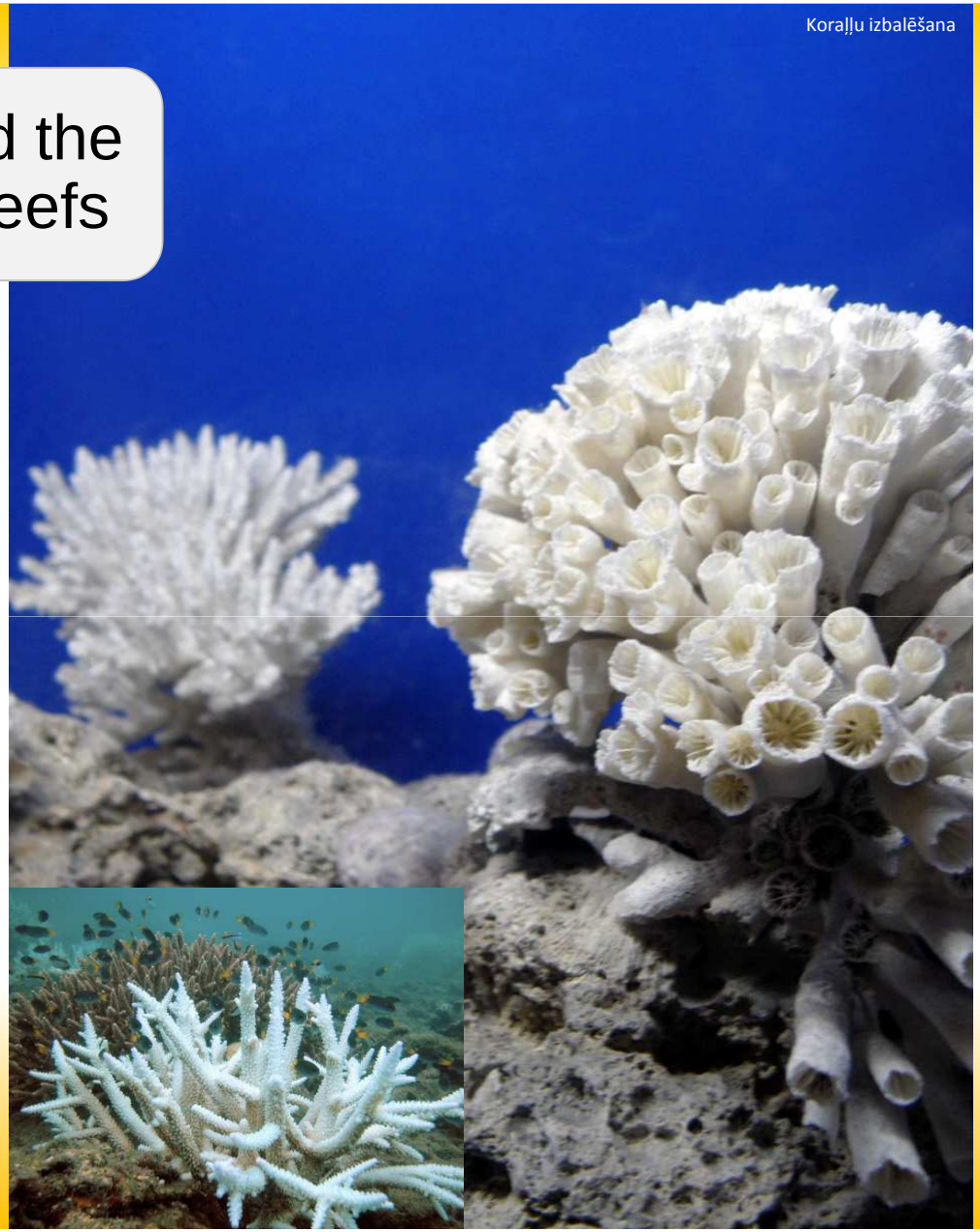
Climate warming has seriously affected the ocean ecosystems, particularly coral reefs

Corals are stenothermal animals which optimum temperature for existence is from +25 °C to +29 °C, but due to the increase of temperatures corals die

As the remains of corals their white calcareous skeletons are left, thus, coral death is called as coral fading

Formation of calcareous skeleton of corals attracts a significant amount of dissolved CO_2 in the ocean, thus mitigating the greenhouse effect

Therefore, corals have significant role in the carbon binding in the ocean that is comparable to the role of forests



HYPOTHESIS AND FORECASTS

The fact that the changes in the biosphere has emerged due to the climate change, now no longer is denied even by skeptics

Development of forecasts is based on expert assessments and mathematical models

Concerning the changes of biodiversity, it would be very useful to gain the predictive models that allow to forecast range of changes in species distribution –

Indicating the threats to agriculture, forestry, public health and environmental protection due to the changes of regional biodiversity

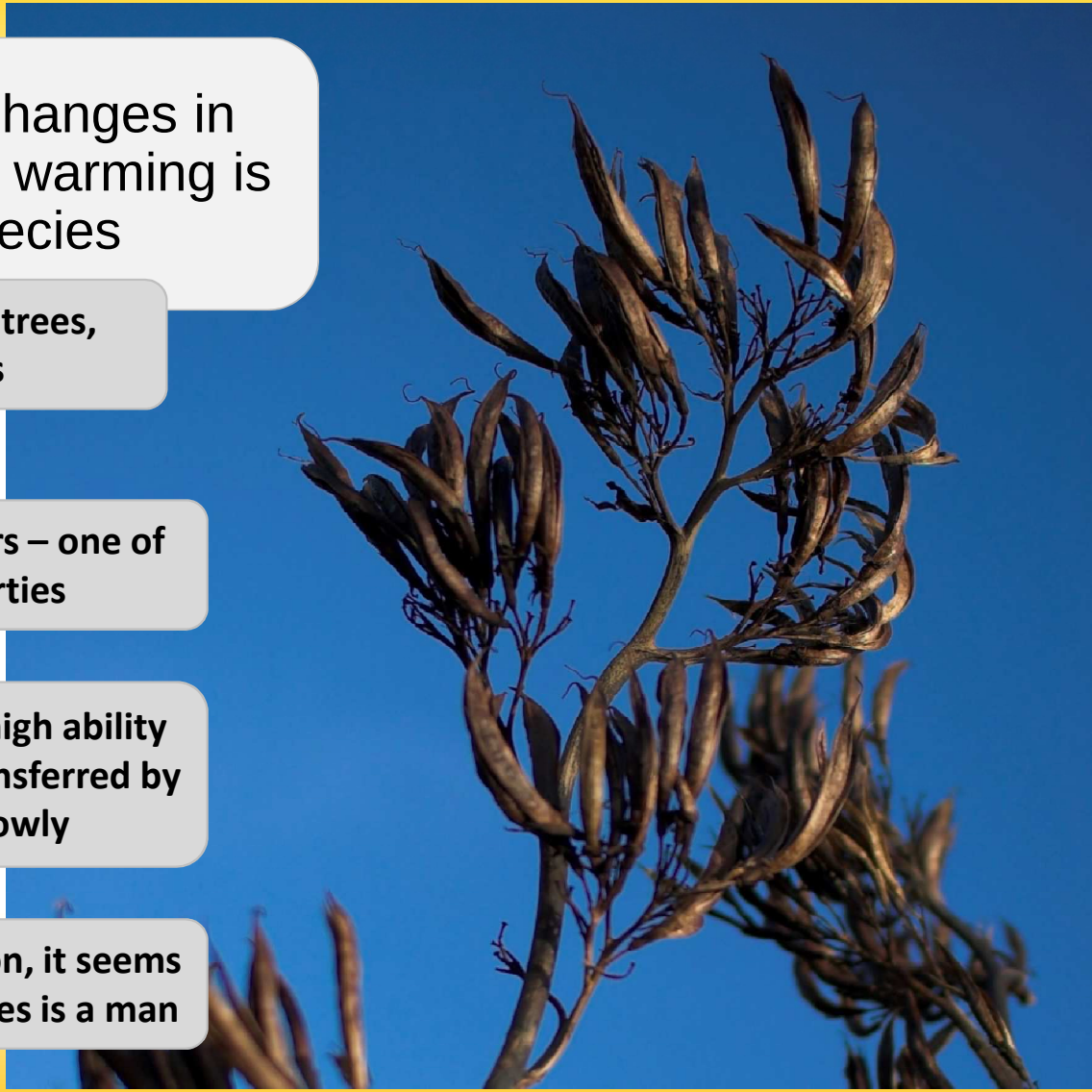
Modeling as a tool for forecasting the changes in distribution of species due to the climate warming is possible only for a well-studied species

Several well-studied species are known among trees, butterflies, amphibians, reptiles and birds

Spreading of tree species depends on several factors – one of the most important factors is the seed properties

Trees with small seeds distributed by wind have a high ability to spread, but species with heavy seeds that are transferred by animals or water – are spreading relatively slowly

However, when assessing history of species migration, it seems that the main factor in the movements of tree species is a man



To forecast changes in the composition of forests, there are developed several mathematical models in Europe

Most of them foresees that within the next 60 years distribution area of nemoralis species will expand to north, displacing the northern species, including *Pinus sylvestris*

These forecasts are based on the climate change scenarios, which predict increase of temperature in north Europe and longer periods of drought in central Europe

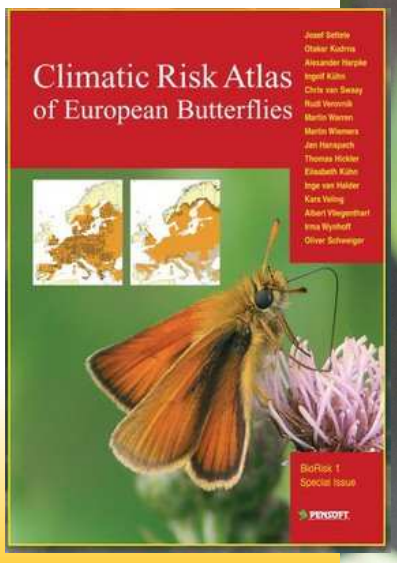
It is expected that in southern part of Europe tree species characteristic to Mediterranean areas will be spread

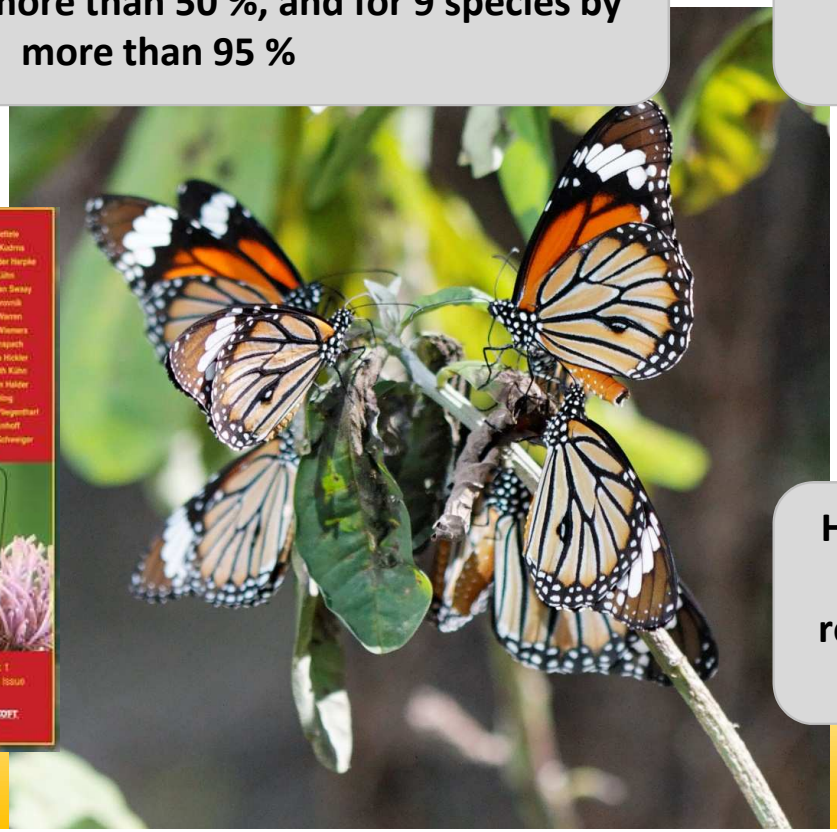
larch – lapegle - *Larix decidua*

For European butterflies **climate risk atlas** has been developed that forecasts distribution of 294 butterfly species according to three climate warming scenarios

Assuming that until 2080 the average temperature will increase by 2.4 °C , distribution area for 140 species will decrease by more than 50 %, and for 9 species by more than 95 %

If the temperature will increase by 4.1 °C, the expected outcome is even more dramatic – distribution area for 229 species will decrease by 50 %, and for 70 species by 95 %, which in practice means that they will be on the brink of extinction





If the distance between areas with appropriate living conditions for species exceeds 10-50 km, movement of species to new areas becomes impossible

Habitat of endemic species are small areas on islands or mountain slopes – hence, they have nowhere to retreat, if climate change is becoming unfavorable for further existence

It is foreseen that climate change threatens a number of insect species belonging to the list of Berne Convention

For habitat of the great capricorn beetle *Cerambix cerdo* grubs big and rarely growing trees are required, that forms rare forest pasture landscapes in some places in Europe

A beetle species *Osmoderma barnabita* which inhabit only in old oak groves, is unable to carry out long distance migration in fragmented landscape

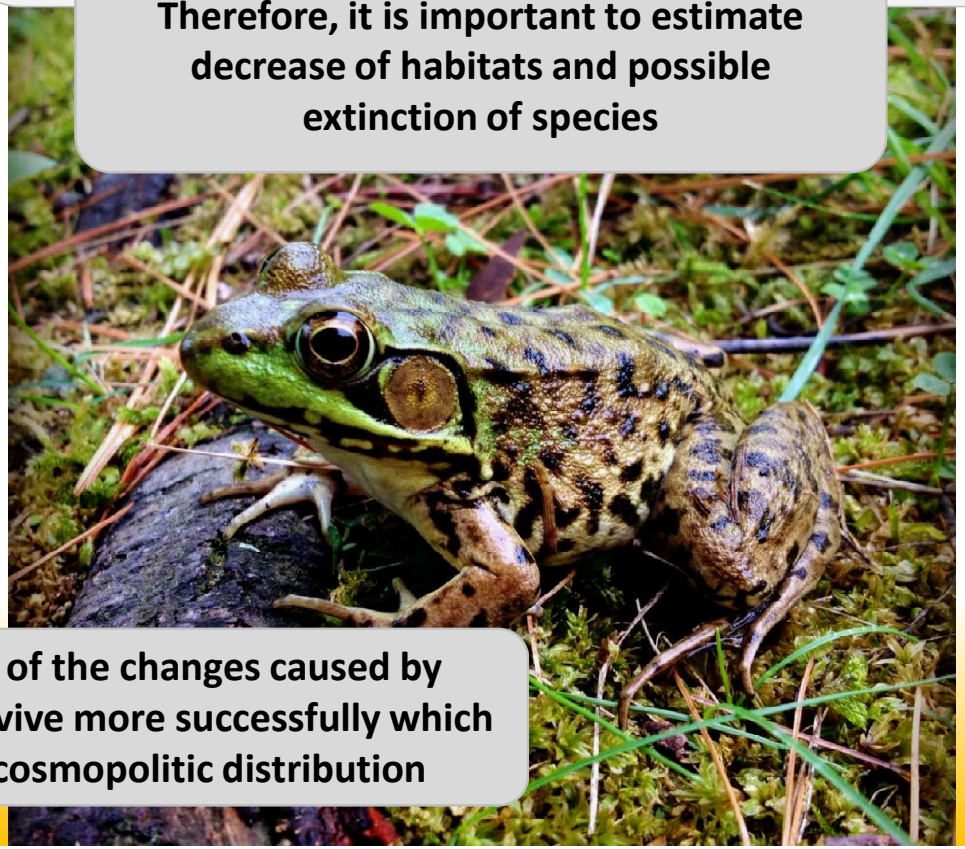
Both species are specially protected and included in the Red Book of Latvia

The atlas of the nesting birds in Europe has been created that reveals changes in birds' habitats modelling medium, pessimistic and optimistic climate change forecasts

According to the average forecast, area of the European bird habitats will move to north-east by an average of 550 km and will decrease by about 20 %

Unlike birds and insects, many of which are able to migrate in case to avoid adverse impacts of climate change, **migration of amphibians and reptiles** is very limited

Therefore, it is important to estimate decrease of habitats and possible extinction of species



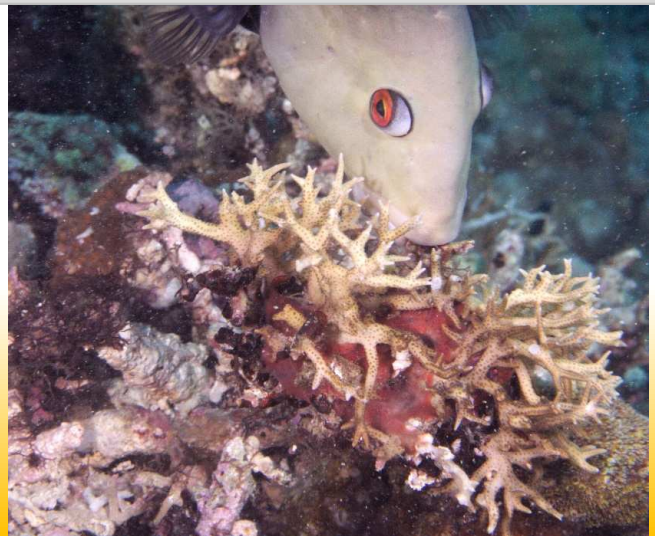
In overall, it is expected that in case of the changes caused by climate warming those species will survive more successfully which have a high reproduction rate and cosmopolitic distribution

According to the forecasts, it is expected **that 2-30 % of the currently known plant and animal species will be unable to adapt** to the increase of average temperature and this would lead to changes in their natural habitats

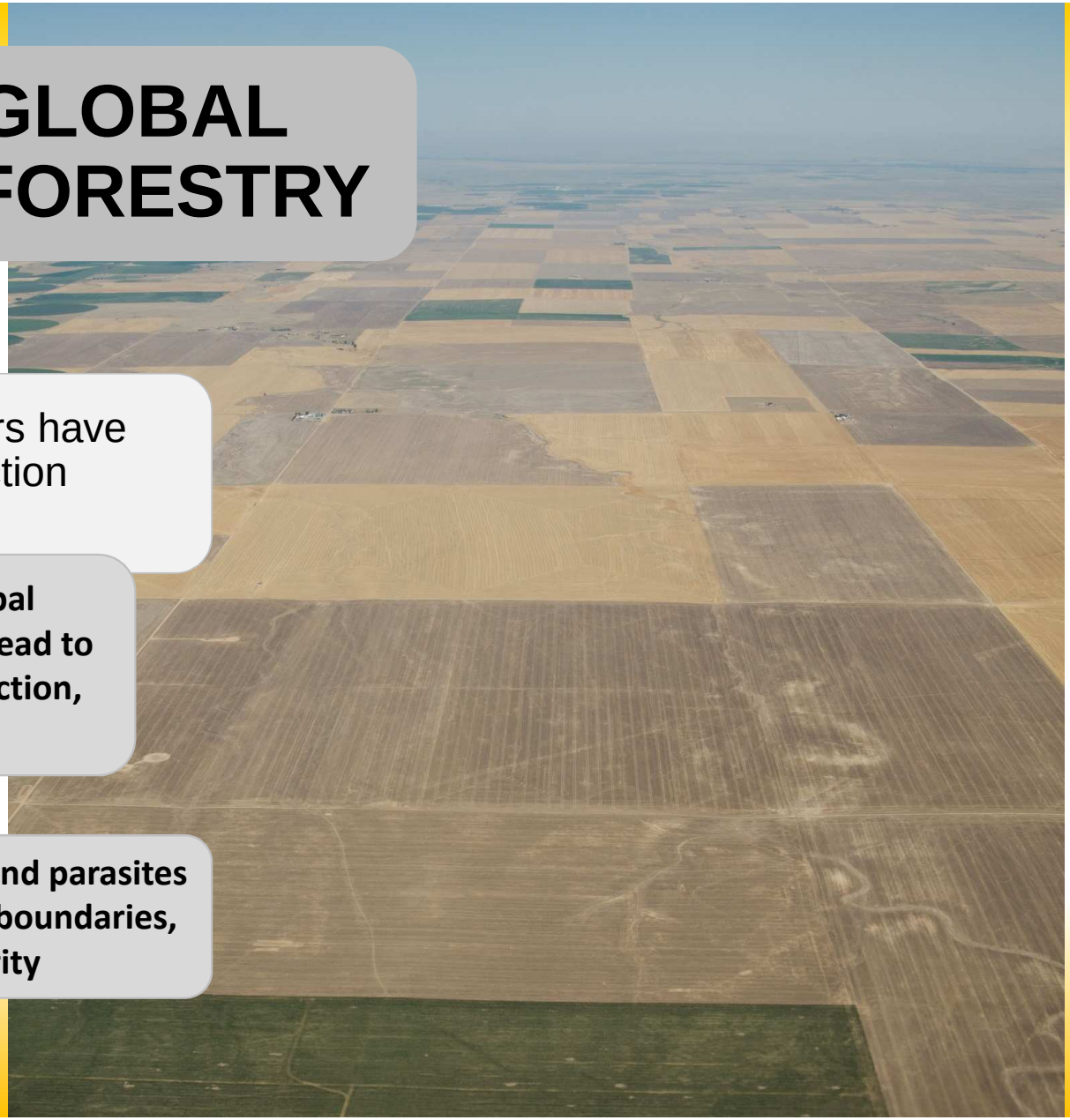
The most of all change will affect polar mammals - polar bears, seals, walruses and birds, especially, penguins that have restricted migration options

Warming in the ocean water has reached a depth of 700 m – many marine mammals feel comfortable in cooler waters, therefore they will be pushed to move to northern parts of the ocean

By dying of coral reefs, die out also those organisms that are associated with corals in the food chain - a variety of invertebrates and fish - decrease of their number will lead to a disastrous impact on coastal and island fishing



THREATS TO THE GLOBAL AGRICULTURE AND FORESTRY



Climate change over the past 30 years have reduced global agricultural production by 3-15 %

Recent research has revealed that global temperature increase only by 2 ^{o}C would lead to catastrophic decline in agricultural production, especially in tropical regions

Due to climate change pet and crop pathogens and parasites are migrating across geographical and national boundaries, threatening food production and security

There is a high probability that a new or an introduced plant disease could completely destroy one of the three most important global cereal crops – rice, wheat or corn

The first signals are already detected, e.g., wheat yellow rust *Puccinia striiformis* that destroys wheat crops

In Europe so far already there are listed 11 species of insects - pests of agricultural plants, which have spread mainly due to the climate warming

For example, the increase of spread has detected for two subspecies of *Icerya purchasi* that are found on 50 different plant species

***Chloropulvinaria floccifera*, formerly known as a pest found on various crops in the Mediterranean countries, now has increased its range of distribution to north of Europe and is found on 34 plant species**

Climate change is considered as one of the main factors of worldwide cross-border spread of pests, livestock diseases as well as invasive aquatic organisms

However, international trade and transport in this process has a very important impact

Adaptation of living organisms in areas where they have not inhabited before is dependent on their ability to survive and start reproduction

In many cases pests have adapted easily inducing large financial losses for countries where it has happened

Examples can be mentioned:

Foot-and-mouth disease in northern Europe and South America, swine fever in Europe, Rift Valley fever in Africa

Coffee leaf rust *Hemileia vastatrix* which is spread throughout the world in coffee grower countries, soybean rust *Phakopsora pachyrhizi* in America etc.

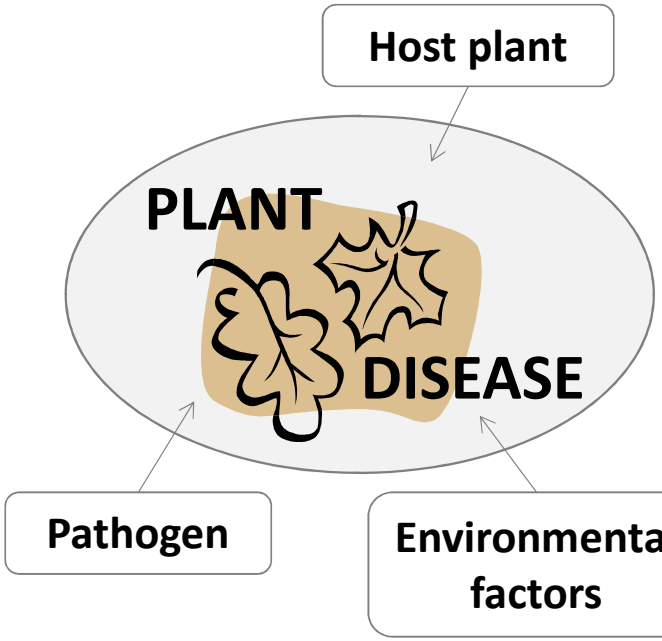
Temperature increase is an essential precondition for prevalence of pests and diseases, but mutual interaction between a pest and a host on a background of environmental factors is also very important

Environmental factors such as temperature, humidity and amount of CO_2 affects development of plant diseases in different ways, therefore, it is very difficult to predict the impact of climate change on plant diseases

Studies have revealed that sensitivity of such crops as wheat and oats to damage caused by microscopic fungi at higher temperatures increases, while some feed herbaceous species – on the contrary, reduces

In general, for development of plant pathogenic fungi moderate temperatures are optimal

Therefore, the temperate climatic zone due to the worsening of climate will become more suitable for the development of pathogenic microorganisms



Development of plant disease depends on three factors – pathogen, host plant and environmental factors, including interaction between temperature and moisture

Climate change can lead to **significant problems in forestry** - increase of temperature in interaction with precipitation, storms, floods, as well as changes in sensitivity and competitiveness of tree species may become **a cause of destructive spread of tree diseases** in the temperate climatic zone and northern regions

For many pathogenic fungi these changes will provide particularly favorable environment particularly for spore production and distribution in forests

Climate warming will provide better conditions for development of fungi *Heterobasidion annosum* – spore formation period will be extended and, hence, risk of tree infection will increase leading to loss of wood

During the recent years, there have been registered activity of a subspecies of this fungi that is able to infect not only coniferous but also deciduous trees

An additional factor promoting the development of tree pathogenic fungi are tree pests, whose activities weakens the trees and opens the way for infection - higher temperature has beneficial effect on many pests, including development of pine wood nematodes and bark beetles

IMPACT OF CLIMATE CHANGE ON ECOSYSTEMS AND BIODIVERSITY IN LATVIA

Similarly like worldwide, also in Latvia there are not many long-term systematic research data available, which would give clear indications of the impact of climate change on ecosystems and biodiversity

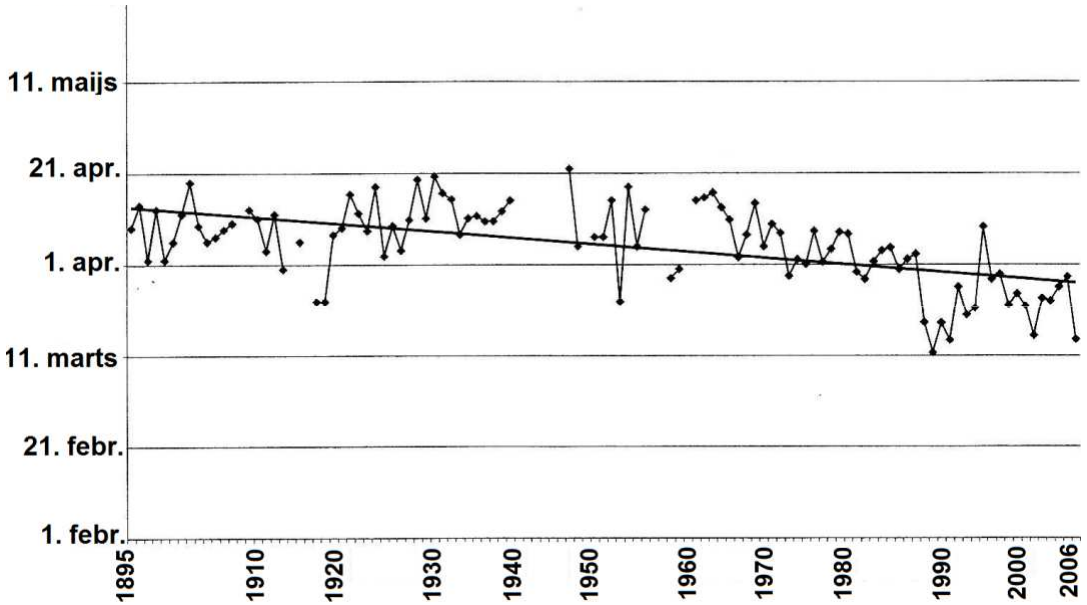
Also in Latvia phenologic observations are considered as the strongest evidence of impact of rising temperature on living organisms

Some phenologic data have been stored even since the end of the 19th century, owing to observations of enthusiastic voluntary naturalists

Analysis of phenologic phases of 9 plant species revealed that in the last 30 years there is a tendency to intervene more and more earlier

During the period 1971-2000, the beginning of spring and summer, as assessed by the plant phenologic phases, have occurred on average by 4 days earlier

Changes of average arrival time of cranes (dzērves) *Grus grus* during the period 1895-2006, according to the Ornithological Society data

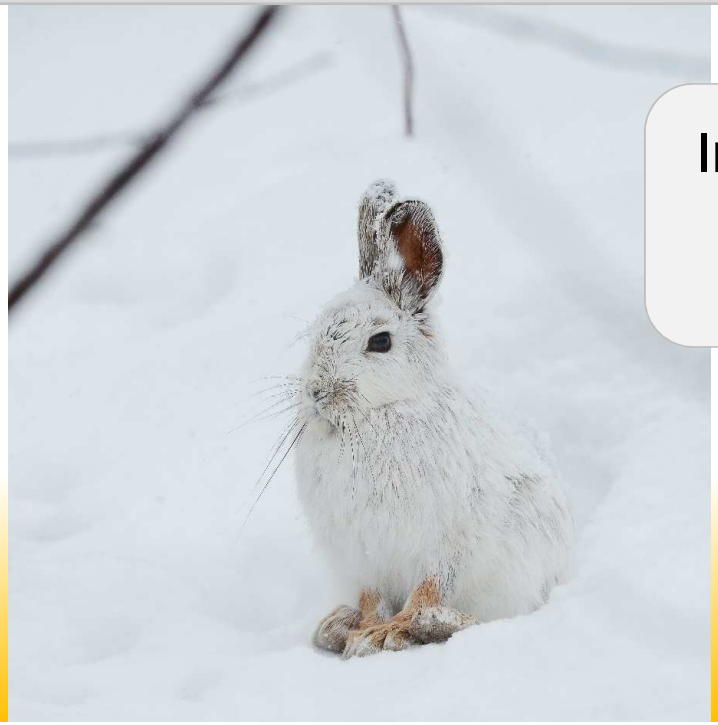


Many species of migratory birds are returning to Latvia at snowmelt time, but since the 70-80ties of the 20th century there is observed an earlier arrival tendency

In Latvia, climate warming is associated with the changes in population of white hare *Lepus timidus* and elk *Alces alces*

In recent decades, more frequent are winters with little snow cover, thus, white wool of a hear no longer serves it as a camouflage colour and it becomes more easy catchable for predators

Decrease of elk population is explained by displacements of the quality of elk's nutrition plants interacting with the animal's feeding cycle



In 2013 in Latvia, the first golden jackal *Canis aureus* was hunted, which mainly inhabit in the eastern Mediterranean, the Middle East and South Asia

In the case of plants, it is very difficult to name the species which introduction in flora of Latvia could be attributed solely to climate warming

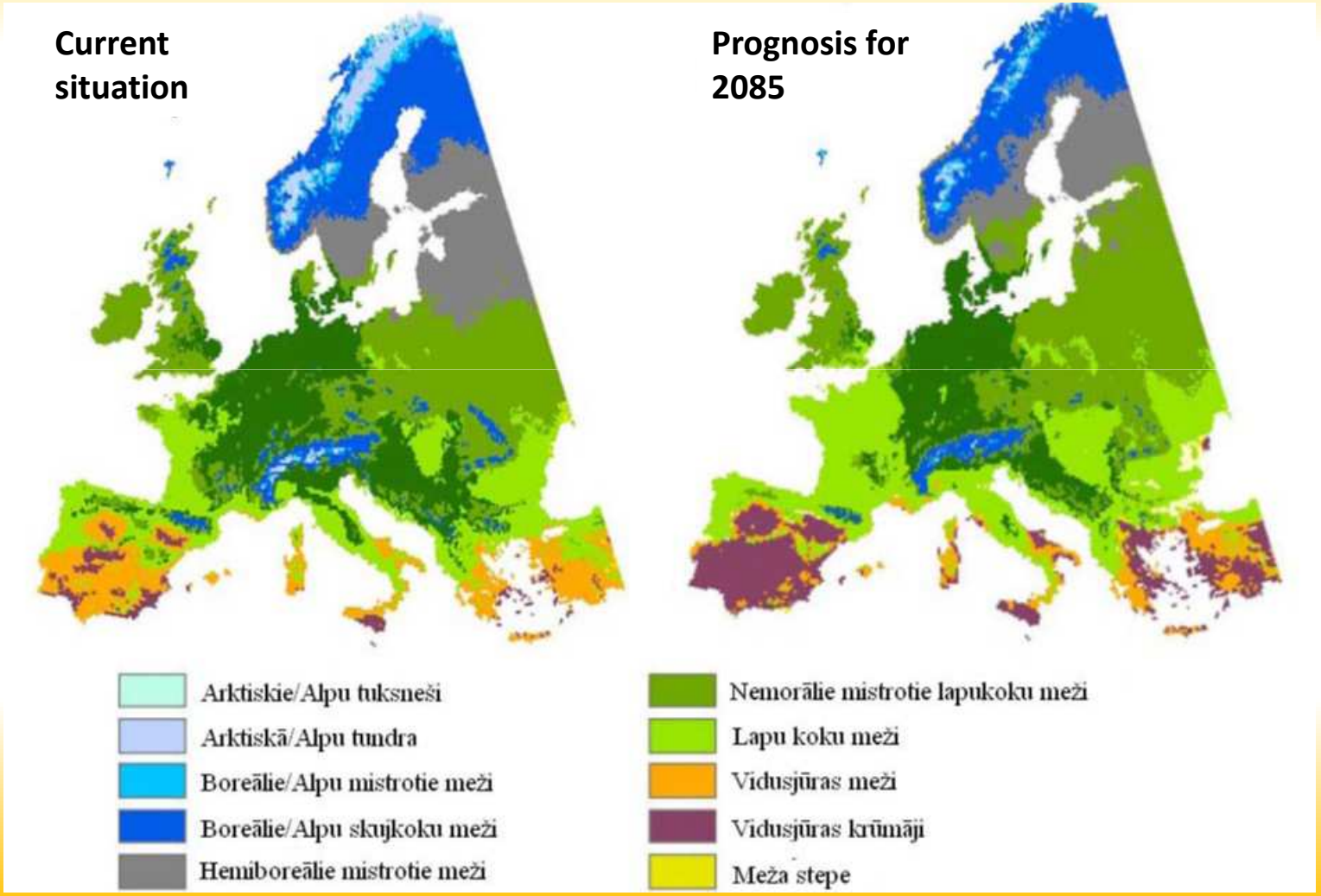
Approximately 2/3 of contemporary flora species in Latvia over the centuries has been intentionally or unintentionally introductions of alien plants

The forecasts reveal that with the increasing temperature, the habitat area of many European plant species could move for several hundred kilometers to north and north-east

This trend is expected concerning also tree species, resulting in increased distribution of broad-leaved trees such as beech (dižskābardis) *Fagus sylvatica*, rocky sessile oak *Quercus petraea* etc., as well as linden *Tilia cordata* and maple *Acer platanoides* in forests of the Baltic Sea region

These changes will affect other plant and animal species connected with mentioned tree species, for example, coniferous trees, for which suitable climatic conditions in Latvia are foreseen in the 21st century, are larch *Larix* spp.

Modelled vegetation changes in Europe during the 21st century



The only **systematic long-term data**, which record distribution of individual bird species and changes in their populations are collected by the Institute of Biology at the University of Latvia during the national long-term ecological research network research program

In recent years, in Latvia, a rapid increase in population of sea raven or cormorant *Phalacrocorax carbo* has been observed

The ecology of these birds, nesting in large colonies and consuming a large quantity of fish, has led to serious problems in surroundings of ponds and lakes as well as on forests in islands where the birds have settled

A single colony of birds in a short time is able to degrade completely a wood plantation by saturating the soil with their excrements

Insects and mites are the groups of organisms that can be affected the most of all by climate change due to their rapid reproduction, short development periods and high sensitivity to changes of temperature and humidity

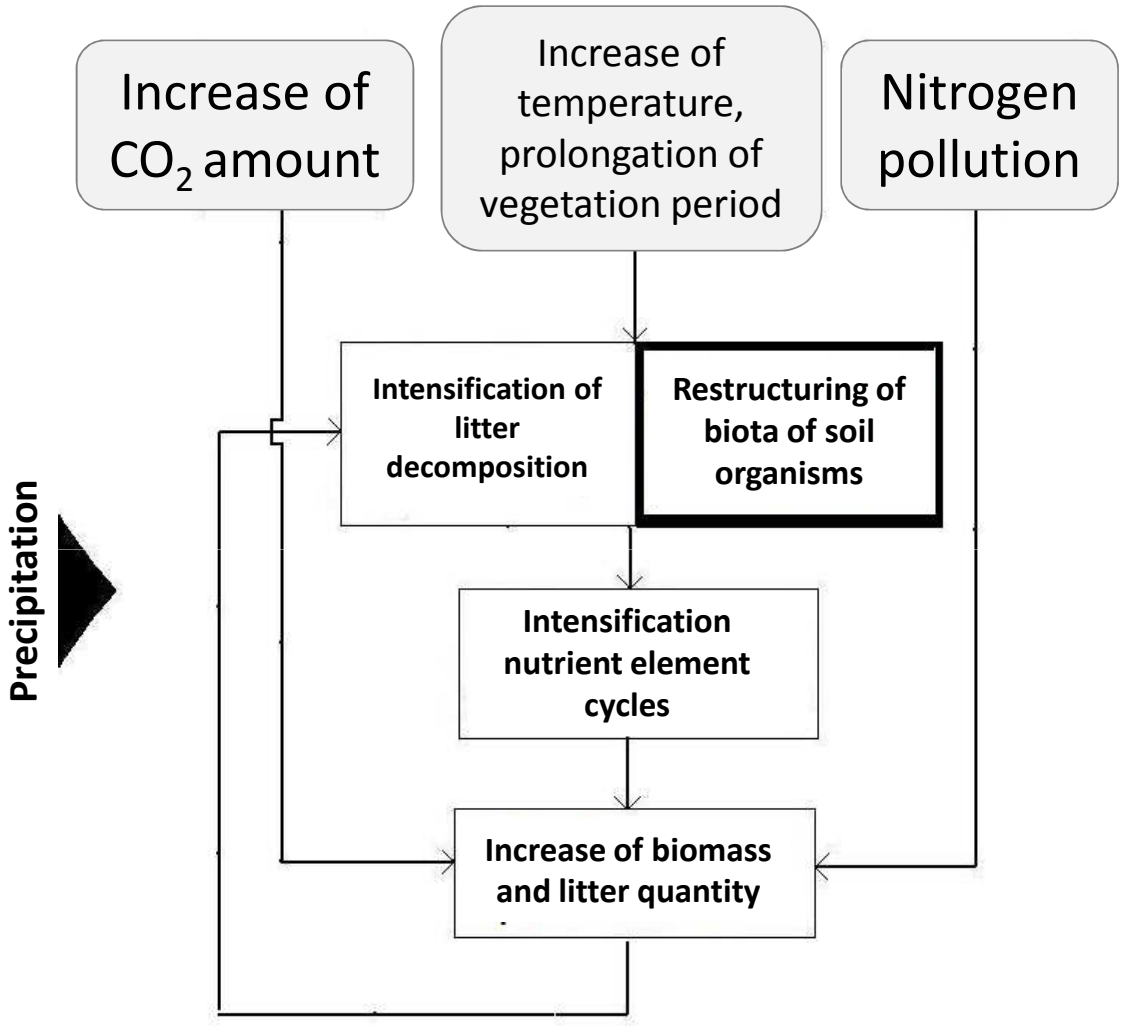
During warmer winters lead to better survival of parasitic bloodsucking ticks, which may carry vectors of serious diseases such as encephalitis and borreliosis or Lyme disease

By climate getting warmer, ticks (ērces) become active already in March and retain high activity until late autumn, thus increasing the probability of human infection

The scheme which characterizes the hypothesis of complex effects of climate warming and anthropogenic factors on soil organisms

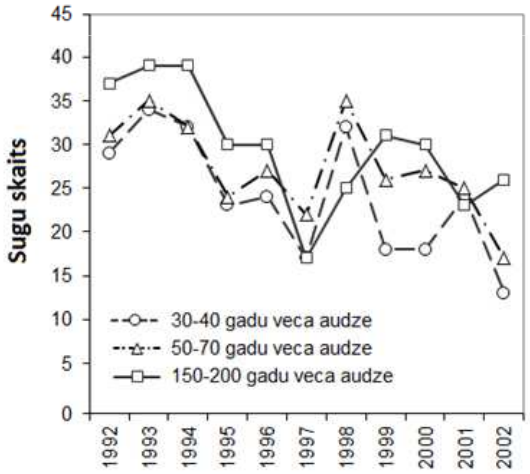
Four environmental factors are directly or indirectly involved in the changes: temperature, precipitation, increase of CO_2 in the atmosphere and nitrogen pollution

The last two factors on the background of climate warming and prolongation of vegetation period contributes to increase of plant biomass and litter quantity

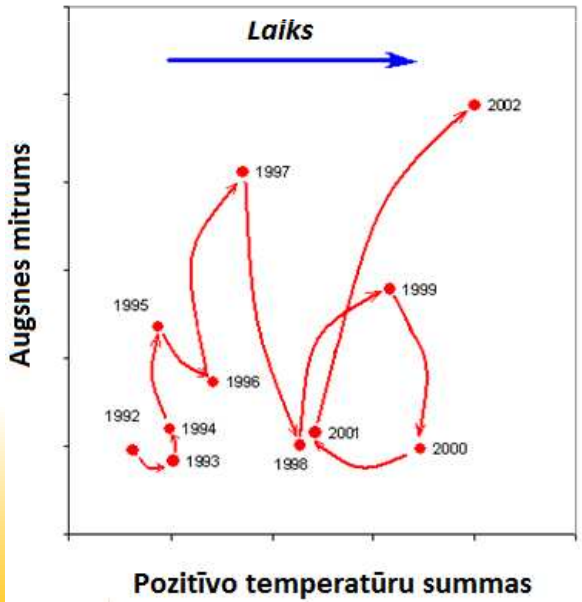


The decline of number of species in the ecosystem in any case is assessed as a negative process, which reduces the stability of ecosystem and its resistance to various external negative impacts

For example, the ecology of springtails (kolembola) makes to consider them as «an indicative signal» for interferences of forest soil formation



Changes in number of springtail species in soils of pine forests of different age soils during the period 1992.-2002 near Mazsalaca (Latvia)



Springtail

Structural changes in springtail communities interconnected with the sums of positive temperature (x) and soil moisture (y)

Changes caused by climate warming in terrestrial ecosystems will inevitably affect the agricultural and forestry sectors in Latvia

Increase of sum of positive temperature could enlarge many agricultural crop yields

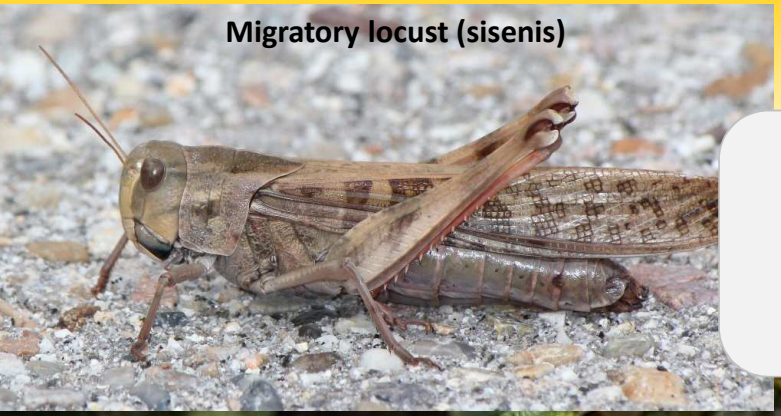
The prolongation of vegetation period is expected up to the end of the century by about 30-40 days from the end of March until the beginning of November

In Latvia, it may enable a good progress in possibilities to cultivate a number of southern crop species

Longer vegetation period will contribute to productivity increase of grass and forage legume (pākšaugi)

Increased concentration of CO_2 in the atmosphere will contribute to better photosynthesis and plant productivity - it can be expected that crop yields will rise by 34-54 %

Longer vegetation period will contribute to higher productivity of grass and forage legumes; but longer period of warmth will reduce the cost of livestock maintenance and breeding



Migratory locust (sisenis)

On the other hand, a warmer climate will bring new, uncharacteristic for Latvia climate crop pests and diseases as well as introduction of invasive species

Therefore, it will require a greater use of pesticides and veterinary preparations for the treatment of livestock disease

In Latvia, several plant pests such as cherry fly *Rhagoletis cerasi* and *Cameraria ohridella* already are identified which usually are species of southern regions

During recent years, also *Locusta migratoria* from middle Europe as well as other species, e.g., *Argiope bruennichi* that are typical species of southern regions have started to expand to northern regions

wasp spider (lapseņu zirneklis)

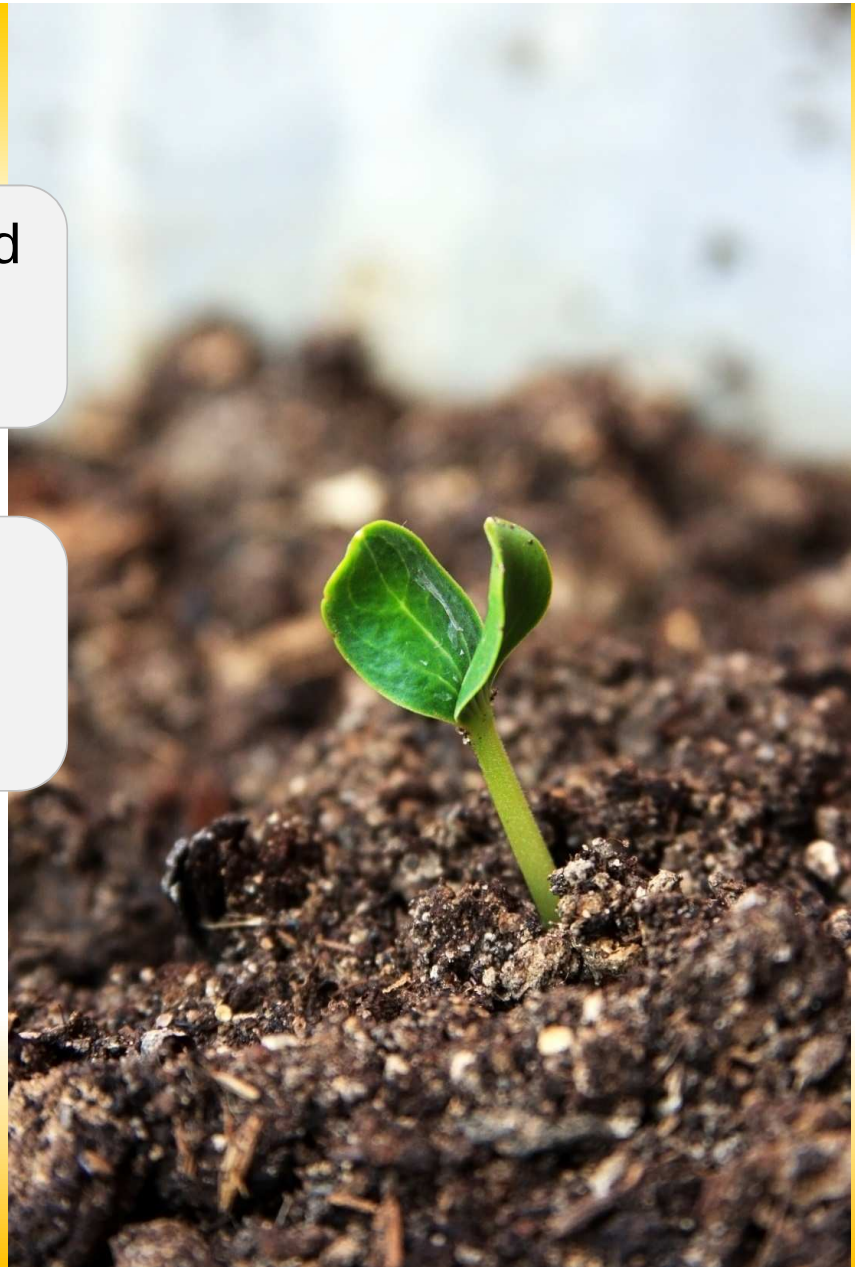
Chestnut-tree bacterial cancer -kastaņu bakteriālais vēzis

Warmer and wetter climate will contribute to spread of microscopic fungi, and increased possibility of mycotoxins presence in trading in foodstuffs

By climate getting warmer, the changes in soil, which is the basis of agricultural production, will take place; by winters becoming softer, the topsoil will not freeze

Thus, the soil will retain biological activity for longer period, decomposition of organic matter and mineralization processes will be more intensive

If temperature will increase by about 2 ^{o}C, for agriculture in northern Europe it could be beneficial, but then, beyond this level, according to forecasts, the environmental situation will deteriorate



Thank you for the attention!