MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
FACULTY OF ENVIRONMENTAL SAFETY,
ENGINEERING AND TECHNOLOGIES
DEPARTMENT OF ENVIRONMENTAL SCIENCE

APPROVED TO DEFENCE
Head of the Graduate Department
_____ T. V. Dudar
«_____» _____ 2022

BACHELOR THESIS

(EXPLANATORY NOTE)

SPECIALTY 101 "ECOLOGY",
EDUCATIONAL AND PROFESSIONAL PROGRAM:
"ECOLOGY AND ENVIRONMENT PROTECTION"

Theme: «Study of the climate change effects for plant communities»

Done by: student of EK-411 group, Viacheslav Kondratiuk
(student, group, surname, name, patronymic)

Supervisor: PhD, Ass. Prof. Radomska M. M.
(academic degree, academic rank, surname, name, patronymic)

Standards Inspector: _____ Andrian A. Iavniuk
(signature) (S.N.P)

KYIV 2022

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
ФАКУЛЬТЕТ ЕКОЛОГІЧНОЇ БЕЗПЕКИ,
ІНЖЕНЕРІЇ ТА ТЕХНОЛОГІЙ
КАФЕДРА ЕКОЛОГІЇ

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач випускової кафедри
_____ Т. В. Дудар
«_____» _____ 2022 р.

ДИПЛОМНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ БАКАЛАВРА

ЗА СПЕЦІАЛЬНІСТЮ 101 «ЕКОЛОГІЯ»
ОПП «ЕКОЛОГІЯ ТА ОХОРОНА НАВКОЛИШНЬОГО СЕРЕДОВИЩА»

Тема: «Наслідки впливу кліматичних змін на рослинні угрупування»

Виконавець: студент групи ЕК-411**,** Кондратюк Вячеслав Євгенійович
(студент, група, прізвище, ім'я, по батькові)

Керівник: к.т.н., доц. Радомська Маргарита Мирославівна
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Нормоконтролер: _____ Явнюк А. А.
(підпис) (П.І.Б.)

КИЇВ 2022

NATIONAL AVIATION UNIVERSITY
Faculty of Environmental Safety, Engineering and Technologies
Department of Environmental Science
Specialty, Educational and Professional Program: specialty 101 "Ecology", Educational and Professional Program: "Ecology and Environment Protection"
(code, name)

APPROVED
Head of the Department
_____ Dudar T.V.
«____» _____ 2022

BACHELOR THESIS ASSIGNMENT
Viacheslav Kondratiuk

1. Theme: «Study of the climate change effects for plant communities» approved by the Rector on April 18, 2022, № 388/ст.

2. Duration of work: from 05.09.2021 p. to 19.06.2022 p

3. Output work (project): climatic data, data on the dependence of vegetation on climatic conditions, data on sea level rise in Ukraine, data on the problems of national natural parks of Ukraine.

4. Content of explanatory note: (list of issues): analytical review of the literature on the topic of the diploma. Assess the impact of climate change on plant communities through analytical review.

5. The list of mandatory graphic (illustrated materials): tables, figures, charts, graphs.

6. Schedule of thesis fulfillment

№ з/п	Task	Term	Advisor's signature
1	Getting the topic of the task, searching for literary sources	20.06.2021	
2	Preparation of the main part (Section I)	05.09.2021-03.11.2021	
3	Preparation of the main part (Section II)	10.11.2021 - 01.02.2022	
4	Preparation of the main part (Section III)	07.02.2022 - 12.04.2022	
5	Formulation of conclusions and recommendations of the thesis	15.04.2022 - 25.04.2022	
6	Making an explanatory note to the previous presentation at the department	03.05.2022 - 12.05.2022	
7	Presentation of work at the department	08.06.2022	
8	Consultation with norm control	09.06.2022 - 13.06.2022	
9	Taking into account comments, recommendations and preparation for defense	09.06.2022 - 13.06.2022	
10	Thesis defense at the department	14.06.2022	

7. Date of task issue: September 5, 2021

Diploma (project) advisor: _____ _____
(advisor's signature) (S.N.P.)

Task is taken to perform: _____ _____
(graduate's signature) (S.N.P.)

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
Факультет екологічної безпеки, інженерії та технологій
Кафедра екології
Спеціальність, освітньо-професійна програма: спеціальність 101 «Екологія», ОПП «Екологія та охорона навколишнього середовища»
(шифр, найменування)

ЗАТВЕРДЖУЮ
Завідувач кафедри
_____Дудар Т. В.
«____» _____ 2022 р.

ЗАВДАННЯ
на виконання дипломної роботи
Кондратюк Вячеслав Євгенійович

1. Тема роботи «Наслідки впливу кліматичних змін на рослинні угрупування» затверджена наказом ректора від «18» квітня 2022, № 388/ст. «29»

2. Термін виконання роботи: з 05.09.2021 р. по 19.06.2022 р.

3. Вихідні дані роботи: кліматичні дані, дані про залежність рослинності від кліматичних умов, дані про підвищення рівня моря в Україні, дані про проблеми національних природних парків України.

4. Зміст пояснювальної записки: аналітичний огляд літератури за темою диплома. Оцінка впливу змін клімату на рослинні угруповання за допомогою аналітичного огляду.

5. Перелік обов’язкового графічного (ілюстративного) матеріалу: таблиці, рисунки, діаграми.

6. Календарний план-графік

№ з/п	Завдання	Термін виконання	Підпис керівника
1	Отримання теми завдання, пошук літературних джерел	20.06.2021	
2	Підготовка основної частини (Розділ І)	05.09.2021-03.11.2021	
3	Підготовка основної частини (Розділ ІІ)	10.11.2021 - 01.02.2022	
4	Підготовка основної частини (Розділ ІІІ)	07.02.2022 - 12.04.2022	
5	Формулювання висновків та рекомендацій дипломної роботи	15.04.2022 - 25.04.2022	
6	Оформлення пояснювальної записки до попереднього представлення на кафедрі	03.05.2022 - 12.05.2022	
7	Представлення роботи на кафедрі	08.06.2022	
8	Консультація з нормоконтролем	09.06.2022 - 13.06.2022	
9	Урахування зауважень, рекомендацій та підготовка до захисту	09.06.2022 - 13.06.2022	
10	Захист дипломної роботи на кафедрі	14.06.2022	

7. Дата видачі завдання: «05» вересня 2021 р.

Керівник дипломної роботи (проекту): _____ Радомська М. М.
(підпис керівника) (П.І.Б.)

Завдання прийняв до виконання: _____ Кондратюк В. Є.
(підпис випускника) (П.І.Б.)

ABSTRACT

Explanatory note to thesis «Study of the climate change effects for plant communities»: 42 pages, 18 figures, 4 tables, 35 references.

Object of research – assessment of the impact of climate change on plant communities

Aim of work – analysis of the impact of climate change on plant communities and forecasting the impact of global warming on vegetation in the future.

Methods of research: analytical, statistical.

climate change, global warming, increasing environmental temperature, latitude dependant gradient, elevation dependant gradient, mass extinctions, changes of plant existence areas, plant adaptation, climate change in ukraine, raising the black and azov sea, national nature reserve fund of ukraine, national nature parks of ukraine

CONTENT

LIST OF SYMBOLIC NOTATIONS, ABBREVIATIONS AND NOTIONS

EDG – elevation diversity gradient
LDG – latitude diversity gradient
NNP – national nature park
USDA - United States Department of Agriculture
WWF - World Wildlife Fund

INTRODUCTION

Relevance of the work. Today, human activity is leading to global climate change. The industry emits large amounts of greenhouse gases, which leads to a gradual increase in ambient temperature, which is accelerating with current production volumes. Warming is primarily reflected in living organisms. The study of anthropogenic impact on nature and the elimination of problems associated with it should be a priority for the continued comfortable existence of mankind along with the whole environment.

Aim of the work – to study the impact of climate change on plant communities.

Tasks of the work:

1. To consider the climatic picture of the past, to study the modern climate and to take into account the climate forecasting of the future.

2. Investigate the patterns of distribution of plants on Earth and ways to adapt to changing conditions.

3. Consider the impact of global warming and the threats it poses on the example of national natural parks of Ukraine.

Object of research is climate change on Earth

Subject of research is dependence of diversity, distribution and survivability of vegetation.

Methods of research – analytical, statistical.

Personal contribution of the graduate: a study of the effects of climate change in Ukraine on the example of national nature parks. Data were collected on the vulnerability of the vegetation of each of the parks (according to the vulnerability of the USDA forest ecosystem with changes) and on the problems arising from global warming today (the main part of the data is the official sites of national parks).

Approbation of results: _____

Publications*:* _____

Among the vast expanses of space, among many galaxies, stars, black holes, asteroids and other celestial bodies, our planet is unique. This uniqueness lies in the special content of this planet, namely in the many different forms of life.

The conditions for its creation have evolved over millions of years. And, in fact, by insignificant chance, by a combination of many different conditions, the first living organism was formed. Over time, they became more and more, they gradually evolved, adapting more and more to different conditions on the planet, until at a certain period of Earth time, they did not begin to change these conditions. This "cooperation" continues to this day. Changes in environmental conditions change the number and variety of life forms, and vice versa - living organisms are able to change conditions. One of the most important environmental conditions is climate.

SECTION 1. INTERACTION OF CLIMATIC CONDITIONS AND PLANT ASSOCIATIONS

Climate is an important component of landscaping and biodiversity. Climate is a long-term weather regime that is formed in certain areas of the earth's surface and is the main characteristic of the area [1]. It is characterized by such indicators as wind speed and direction, atmospheric pressure, cloudiness and precipitation, temperature of the upper layers of soil and water bodies, temperature and humidity, solar radiation, snow cover, visibility, water evaporation and others. It is the climate that determines the composition of groups, biodiversity and biomass of certain areas. Under such conditions, global climate change can cause partial or complete transformation of natural and territorial complexes, which in turn will change the properties of the habitat of all other organisms. This is a global problem because according to the World Meteorological Organization, the climate is changing rapidly; The Earth's surface temperature in 2019 was the second hottest in the history of recording temperatures [2]. Such changes increase the number of natural disasters, rising sea levels and threatening the survival of various species and agricultural productivity. The end result could be the decline of the economy and the world market.

1.1 Formation of climate zones of the Earth.

If we look at the planet from north to south and from west to east, we see a great diversity of climatic zones, landscapes and biodiversity, which is unique to certain parts of the earth, and all this is directly affected by climate. Climate formation is caused by five major indicators of climate systems such as the lithosphere (Earth's upper crust), atmosphere (air), cryosphere (ice and permafrost), hydrosphere (water), and biosphere (living things). Thanks to these five component, the climate is formed. Changing at least one system can dramatically affect the climate. The main role in shaping the climate is played by such factors as solar radiation, air circulation, the nature of the underlying surface, the geographical location of the territory.

The climate on Earth depends on latitude, because it determines the angle of incidence of sunlight and, accordingly, the amount of influx of solar radiation. This affects the formation of thermal zones. Solar radiation passes through the atmosphere, in which it is partially absorbed and dissipated. The whole set of scattered and direct radiation coming to the surface is called the total solar radiation. The atmosphere absorbs one-fifth of the sun's radiation, and on cloudy days there is less total solar radiation than on cloudless days [3]. Similarly, during the day most of the solar radiation falls at noon, and in the annual cycle most in summer. Another third of the radiation is reflected from the earth's surface and is called reflected solar radiation. Everything else is absorbed by the earth's surface or water and converted into heat, such radiation is called absorbed. It is the ratio of reflected and absorbed radiation, the albedo of the surface, determines the heating of the atmosphere and the redistribution of heat at the contact boundary.

This affects the patterns of atmospheric circulation and air masses transfer, as well as the movement of heat and moisture. Thus, climate varieties are formed and high and low pressure zones are formed. The transfer of air masses occurs in the latitudinal and meridional directions, which is an important part of climate formation, which increases the unevenness of climatic conditions, and hence the diversity of living conditions. In addition to solar radiation, the movement of air masses is affected by the earth's surface, namely the friction of air masses on the earth's surface, which leads to the deviation of air currents. The planet

own rotation around its axis affects air currents, which forms the final form of atmospheric circulation.

The planet is dominated by water (71%), which also makes a significant contribution to the formation of the earth's climate. Local features can be quite influential for the formation of azonal climatic conditions: snow cover, developed river system, swamps and lakes, the nature of vegetation contribute to the formation of climate. The climate is also affected by coastal currents that are warm or cold. They are involved in the formation of cyclones as they further affect our climate, depending on the location.

There are seven main climatic zones and six transitional climate zones on our planet.

The main ones are:

- Equatorial;
- Two tropical;
- Two moderate;
- Arctic;
- Antarctic.

Transients include:

- Two subequatorial;
- Two subtropical;
- Subarctic;
- Subantarctic.

Climatic conditions change from the equator to the poles, and so does biodiversity. Most organisms that are adapted to their living conditions will not be able to thrive in other geographical and climatic zones. For example, Antarctic penguins will not be able to survive in the equatorial belt in the same way as elephants in their habitat.

The closest connection between climate and life is demonstrated by plants, which due to their inability to move in space are so adapted to certain climatic conditions that become part of climatic zones. The interaction between phytocenoses and climate is very important both for the survival of the plants themselves and for the formation of the climate. After all, green plants through photosynthesis affect the concentration of CO_2 in the atmosphere,

which in turn affects the formation of climate. Of course, there are species of plants that can adapt to almost any climate and thrive in a particular area.

The living organisms of the planet have adapted to their living conditions and the expected small fluctuations in climate, which ensures their way of life and prosperity on the planet. Any change in the display of tolerances with a fast gradient tolerance is a direct threat to the stability of all ecosystems, including their biotic components.

1.2. Climate as a factor spatial distribution of plant associations.

The distribution of life on the planet is not uniform due to the influence of climate and habitat. For example, in the desert, in the mountains and in the lower oceans, less life is concentrated than in other parts of the biosphere. Life is most concentrated in the surface layers of the ocean, in the soil, at the bottom of reservoirs and in estuaries, where the three main environments (water, soil and air) are close to each other.

The settlement of species is not uniform and generally shows the latitudinal and altitude patterns. The main reason for the corresponding forms of zoning is the change of climatic zones in the direction from the equator to the poles and from sea level up.

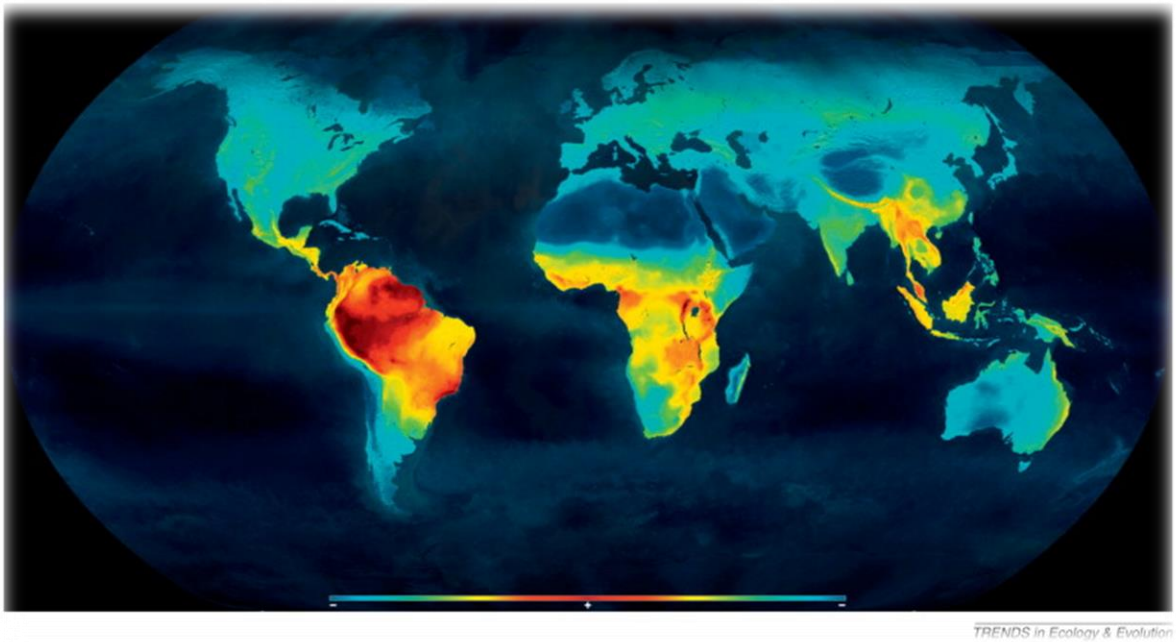


Fig. 1.1 Distribution of extant terrestrial vertebrate species showing the high concentration of diversity in equatorial regions (closer to the red end of the color spectrum), declining polewards (closer to the blue end of the color spectrum) [4].

There are five main hypotheses for the on the spatial and areal characteristics of the tropics.

The middle domain effect was first noted by computer simulations by Cowell and Hurt (1994), Willing and Lyons (1998), Calwell and Liz (2000) that if, within geometric constraints, latitudinal ranges of species are randomly mixed in a limited biographical domain (e.g. terrestrial New World species), the highest density is superimposed on the center of the domain.

Another hypothesis is the based on the geographical area available (Terborgh, 1973): the tropical biome is the largest biome by area and therefore supports more species. That is, because the large habitat in the tropics makes it possible to have large populations, respectively, species with a larger range will have lower extinction rates. Also species with a large range are more likely to experience allopatric speciation, which increases the rate of speciation [5].

The species energy hypothesis states that the increase in solar energy at low latitudes with a large presence of water, leads to an increase in photosynthesis or an increase in net primary productivity.

Another hypothesis is related to climate, that a gradient of latitudinal diversity of the tropics may exist because in other latitudes fewer species cannot physiologically tolerate the climate of other latitudes - hypothesis of severe climate.

Biotic hypothesis claims that ecological interactions of species such as predation, competition, parasitism, mutualism and symbiosis are more common in tropical latitudes than in all others [6].

Separate gradient of biodiversity and biomass distribution is elevation dependant (EDG). The first known and recorded observation of the gradient of altitude diversity was made by Carl Linnaeus, described in his treatise "On the growth of residential land." He suggested that most of the world at one time was flooded, leaving only the heights that were available for earthly life. According to Linnaeus' hypothesis, the highest altitudes would have the greatest life, even when life began to inhabit lower altitudes again. The trend is actually the opposite one, and there are two effects for EDG formation:

1) effect of the middle domain, which is that the richness of species decreases with increasing height

2) mountain-massive effect, which is determined by the correlation between rock mass and the appearance of physiognomically similar types of vegetation.

Again, the reason for the altitude pattern of species distribution is a combination of many factors, most of which are related to climate [7].

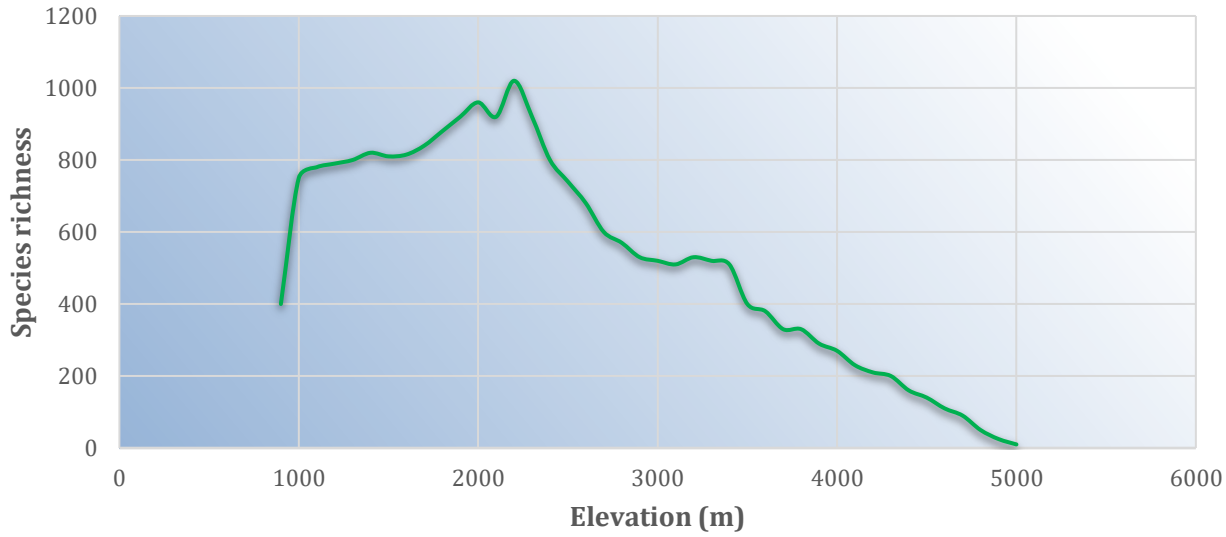


Fig. 1.2 Species richness patterns of different species groups of seed plants along the elevation gradient in the Mt. Namjagbarwa Region (Eastern Himalayas)

[8]

All hypotheses still need to be worked on because there is no reliable proof yet. They can be both confirmed and refuted. But one cannot draw conclusions based on only one specific factor. Only their combination can give a reasoned explanation for this distribution of living organisms. In any case, climate seems to be the most important factor of all in defining communities composition and biomass.

1.3. Temporal dynamics of climate as a factor of plant associations' changes.

In recent decades, a great deal of research has been conducted to find out how climate affects and has already affected the planet's biota. To better understand all the changes of the present, we start from the past or even very old times, to understand how one or another factor has affected living organisms and what to expect from these changes today.

Throughout the history of the planet, there have been both gradual climate changes and sharp changes. In the first case there was a gradual replacement of some plant associations with others, in the second – the mass extinction and disappearance of entire taxonomic groups of the organism. Throughout the history of our planet, we know of five mass extinctions, such as:

- Ordovician-Silurian (450-443 million years ago),
- Devonian (372 million years ago),
- "Great" Permian (253-251 million years ago),
- Triassic (208-200 million years ago),
- Cretaceous (65.5 million years ago).

Of course, we do not know the real causes of those events, it is almost impossible to establish. Using a variety of research methods, including the study of sediments in rocks, a number of hypotheses can be put forward, most of which are inclined to believe that mass extinctions are somehow related to climate change.

For example, due to the high activity of volcanoes, both terrestrial and underwater, significant amounts of greenhouse gases were released into the atmosphere. This has led to global warming, ocean oxidation and oxygen depletion, which has had a negative effect on the diversity of organisms – Devonian and Permian extinctions.

Vice versa, the extinction of the Ordovician-Silurian period, which led to 85% of the extinction of species within one million years, is thought to be initiated by the movement of Gondwana to the South Pole, which led to global cooling, glaciation and subsequent fall in the world's oceans.

The Cretaceous crisis is known for the great extinction of dinosaurs, but with them died marine reptiles, flying lizards, many mollusks and many seaweeds. In total, 16% of

marine animal families (47% of marine animal genera) and 18% of terrestrial vertebrate families died. Interestingly, this extinction even coincided with progress of flowering plants, and there are some hypothesis, stating, that alkaloids that appeared in flowering plants were the poison for many animals, including dinosaurs. Thus, plants are thought to be the possible driver of one of the biodiversity massive reductions.

These processes contributed to the success of the so called higher green plant on land and gradual decline of diversity and population density of mosses, ferns and algae, along with the loss of numerous groups of animals.

The causes of the mentioned extinction originated mostly from changes in the environment (temperature changes, anoxia, increasing dryness of the climate, changes in ocean currents and sea level) and some catastrophic events (falling meteorites, collisions of the Earth with an asteroid, increasing volcanic activity, sudden methane emissions from the seabed). Still they were gradual in time scale, while the current extinction within all groups of living organisms takes place at high rate, which is initiated by human activity.

According to some scientists, we live in a period of so-called sixth extinction caused by human activity. And if at the beginning of this process, about 12 thousand years ago, the main factors in the extinction of wildlife were hunting and competition with humans for living space, now much more important is anthropogenic climate change, which has accelerated in the last 50-70 years. Therefore, studies of climate change and biota are of great importance for the formation of ideas about modern anthropogenic impact on the atmosphere, biosphere and climate. All studies are not in vain because the importance of climate has been proven. Even minor changes affect our existence, the existence of all living organisms on the planet. Thus, the current research efforts must be also aimed at spotting and tracking of smaller changes, as they have been linked to certain climatic processes of a global scale [9] [10] [11] [12] [13] [14].

Average climatic data of the Paleozoic and Mesozoic eras

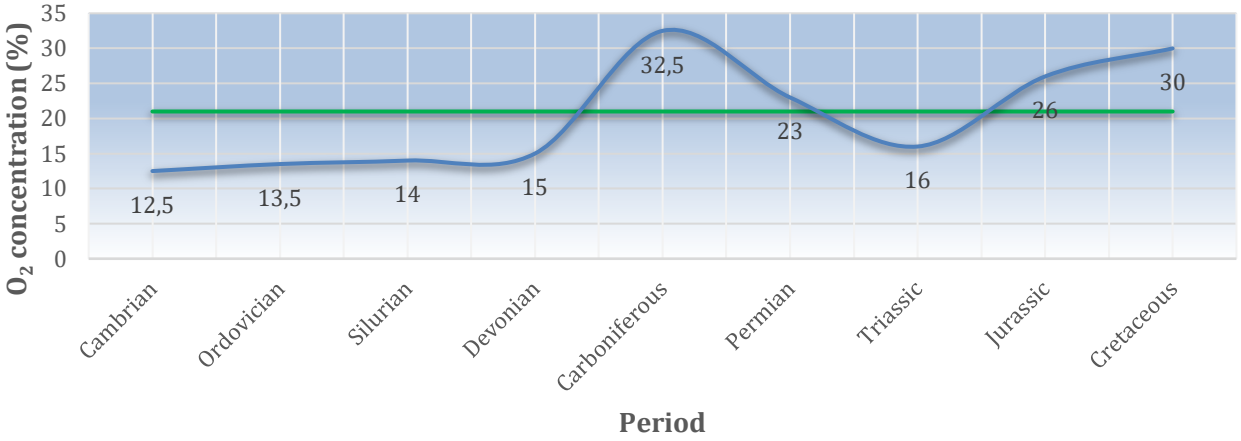
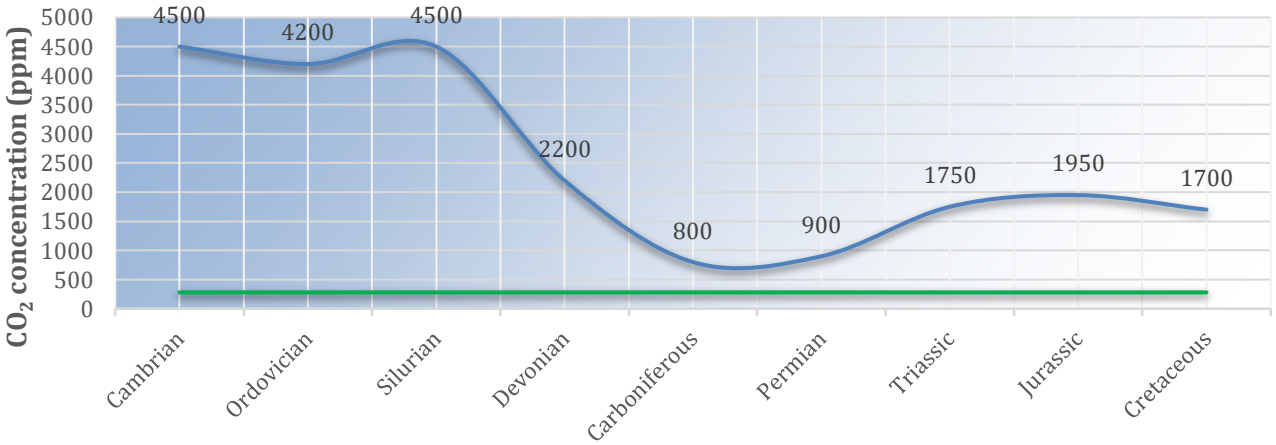


Fig. 1.3 Modern level (21%) — Average oxygen concentration during the period



The level of the pre-industrial period (280 ppm)

Fig. 1.4 Average carbon dioxide concentration during the period

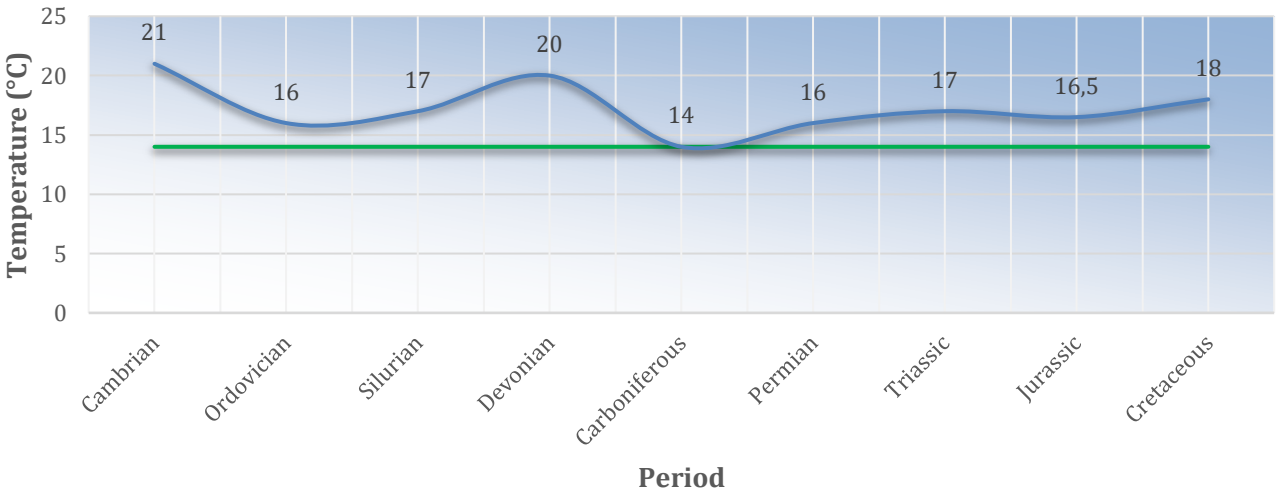


Fig. 1.5 Modern level (14°C) — Average surface temperature during the period

1.4 Factors of modern climate changes, affecting plant associations.

Human activities, namely anthropogenic greenhouse gas emissions, affect climate change and ocean acidity and threaten the diversity of ecosystems and human society itself. To date, the effects of climate change have been well established, in particular by the IPCC Intergovernmental Panel on Climate Change [15]. The cause of warming is the planet's temperature imbalance, caused by an increase in the concentration of greenhouse gases in the atmosphere as a result of fossil fuel combustion, deforestation, soil degradation and wetlands. Since the days of the Industrial Revolution, the global temperature of the Earth has risen by almost 1 ° C.

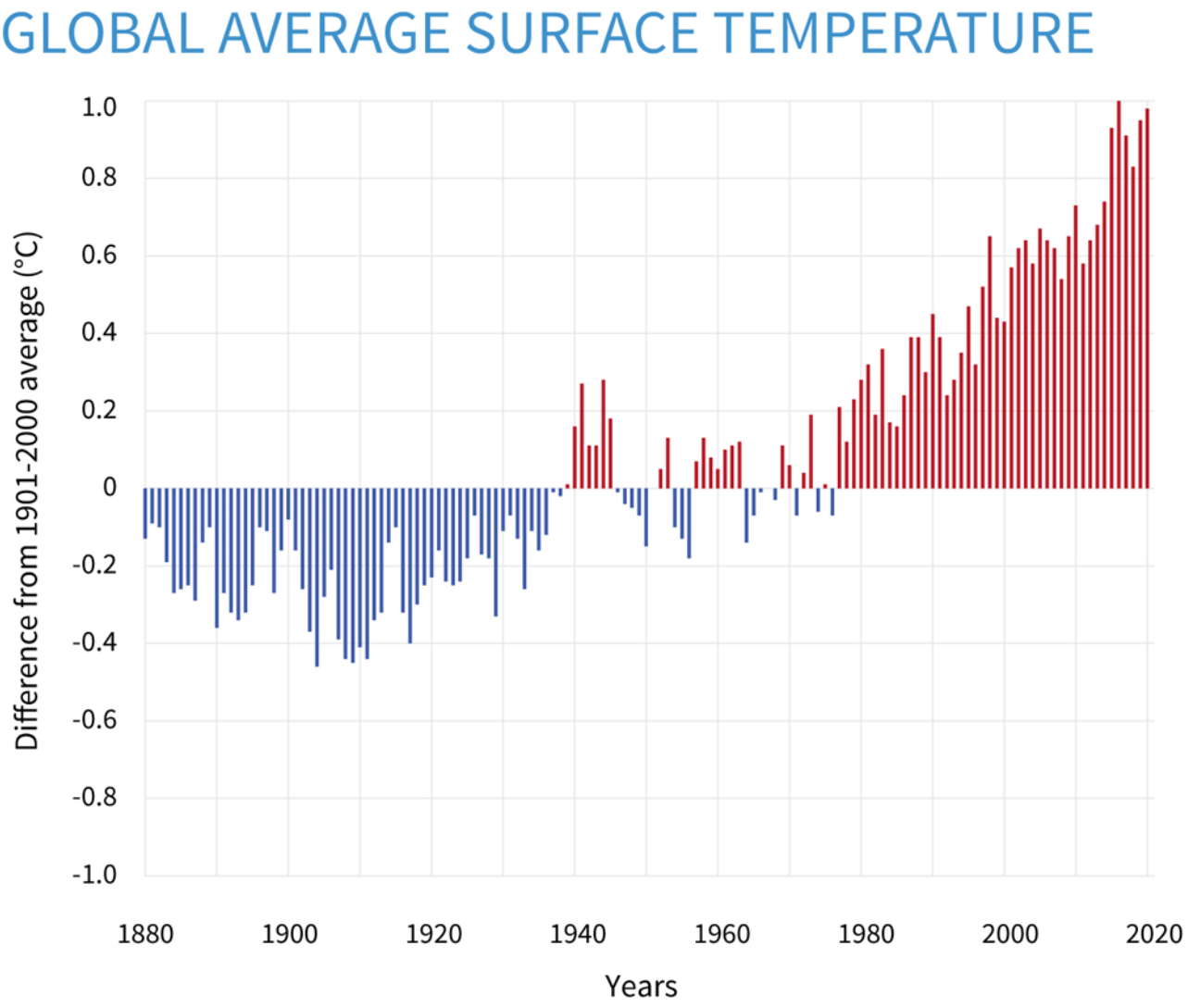


Fig. 1.6 [16]

This increase in temperature significantly affects nature and the human body. There is also an impact on agriculture, fisheries and forestry, access to drinking water and the general drying of rivers, the disappearance of groundwater, as well as the spread of pests and a variety of diseases. Droughts, forest fires, floods, disease epidemics, etc. are more common.

The stability of the Earth's climate system is increasingly being disrupted, manifesting itself in unexpected or atypical weather for any area. Thus, due to global warming there is a sharper change of seasons and changes in the properties of the seasons in general. For example, winter is not so early and not snowy enough, and spring itself is not warm enough, summer changes from very hot and dry to rainy and fast changing cold autumn. If spring, summer and autumn come earlier and winter does not, it means that the cold season is getting shorter and shorter, while the growing season from early spring to dormant vegetation is getting longer. According to the meteorological service, for the thirty years from 1991 to 2021 it is on average 18 days longer than the average for the previous thirty years. This means that winter is now on average almost three weeks shorter. Therefore, if global warming spreads at the same rate, winter in Ukraine may disappear completely, and it will be more like autumn. Some organisms will be able to adapt, and some plants will disappear if they do not adapt to the changing seasons, they will be replaced by others who were previously unable to survive under previous conditions.

SECTION 2. THE RESPONSE OF PLANTS TO CLIMATE CHANGE.

Environmental conditions play a key role in the spread of plants. Their changes and climate change have long had a significant impact on the external structure, diversity and distribution of plants. It is believed that climate change will be a major factor in biodiversity change in the future [17].

The climate on our planet has undergone constant change. Continuation of history on Earth, the temperature, humidity and content of O_2 and CO_2 in the air have been constantly changing. All these processes and changes were reflected in plants. For example, grasslands dominated during the ice age and forest communities during the interglacial period. Plants have also contributed to climate formation and change. And today plants play an important role in shaping the climate and are themselves dependent on climatic conditions. In cities, they provide thermoregulation, sound insulation and air filtration. Maintain the balance of the microclimate and prevent the effects of harmful diseases through human activities.

With the increase of temperatures, the habitat ranges of many species are moving northward in latitude and upward in elevation. This means habitat expansion for one species and shrinking for others. It may also put some species at the verge of extinction, since they fail to thrive in less hospitable habitat or increased competition. Some species have nowhere to go because they are already at the northern or upper limit of their habitat.

2.1. Displacement of habitats.

One of the important concepts in ecology is the habitat of species. This means the area of the Earth's surface or water area, within which there is a certain biocenosis or taxon. As a result of active or passive settlement, certain species and individuals fall outside their natural range, respectively, the concept of range does not include places of accidental entry of organisms.

Habitats of species are diverse in both shape and size. Living organisms are found all over the earth, it depends on the adaptation and comfortable living conditions that determine

which organisms occupy each habitat. Among the species there are species with a small habitat area, which are called endemic, and which occupy a large area are called cosmopolitan. For example, the cosmopolitan species are southern reed (*Phragmites australis*), fennel pondweed (*Potamogeton pectinatus*), common water-plantain (*Alisma plantago-aquatica*) etc. These are mainly aquatic plants; their large habitat can be explained by the greater uniformity of growth conditions of these species. Among the terrestrial plants there are also species that would have a wide range of existence, due to the great variety of living conditions in the terrestrial environment. An example of a wide range is the fern (*Pteridium aquilinum*).

Climate and habitat are related. Climate change has negative consequences for many species, which will not be able to adapt quickly to new conditions or are endemic to a certain area of the Earth. For example, consider endemic *Pinus stankeviczii*, which grows only in two places in the Crimea. Endemism is due to two reasons: the reduction of habitat due to its extinction or due to the emergence of a species not in the distant past that has not yet had the opportunity to spread. Due to climate change, habitats can be destroyed and species endangered, threatening their very existence. This can be caused by the division of the area as well as flooding, the formation of continents and mountains, changes in relief and even invasive species [18].

According to the observations of scientists, climatic zones are shifting further and further to the poles and thus living organisms will be displaced in search of the optimal environment for their existence. In the animal world, migration is easier than in plants, but we must not forget that many animals depend on plants that are a source of nutrition and protection. Many plants will not be able to move to other habitats, which will endanger their existence and the species that depend on them. Competition and displacement by more progressive species of local flora and fauna or less competitive species will increase. Biological invasions are short-term movements of species that occur over one or more generations and as a result form new parts of the range [19].

Displacement will also affect people, especially in agricultural activities. It will be necessary to select the optimal environment for growing different types of crops and

livestock. There will be a growing need for plant breeding to make them more resilient to the conditions and productivity of the crop [20].

WWF scientists have estimated that most species on this planet (including plants) will have to "move" faster than 1,000 meters per year if they want to stay in the climate zone they need to survive. Many species will not be able to redistribute quickly enough to keep up with future changes. Global warming is likely to have a pervasive effect on ecosystems, filtering out species that are not very mobile, and preferring less diverse, more "weedy" vegetation and ecosystems dominated by the first, invasive species [21].

The EPA reports that boreal forests are expanding to tundra, reducing habitat available for tundra species. Other observed changes in the United States include expanding oak-hickory forests stepping on maple-beech forests, while spruce-fir forests are generally shrinking in area [22].

Climate change is changing ecological niches, forcing species to change their habitat by tracking their ecological niche. These shifts allow species to survive, but may harm the existing species in these areas. The understanding the positive and negative aspects is necessary to ensure effective biodiversity management [19].

2.2. Changing the species composition of plant communities.

Over the past few decades, there has been a sharp warming of the climate, which has led to changes in the distribution of many species. Such reactions are likely to continue or even intensify in the near future. In addition, global warming may lead to an increase in plant species richness in temperate or cool regions and a decrease in dry or tropical regions.

Forecasts suggest that by the end of the 21st century, the potential range of many European plant species could shift several hundred kilometers in a northerly direction. This is several times faster than in the past. The distribution of tree species is also likely to change significantly: forests are expanding in the north and declining in the south, and deciduous species will replace local conifers in Western and Central Europe [23].

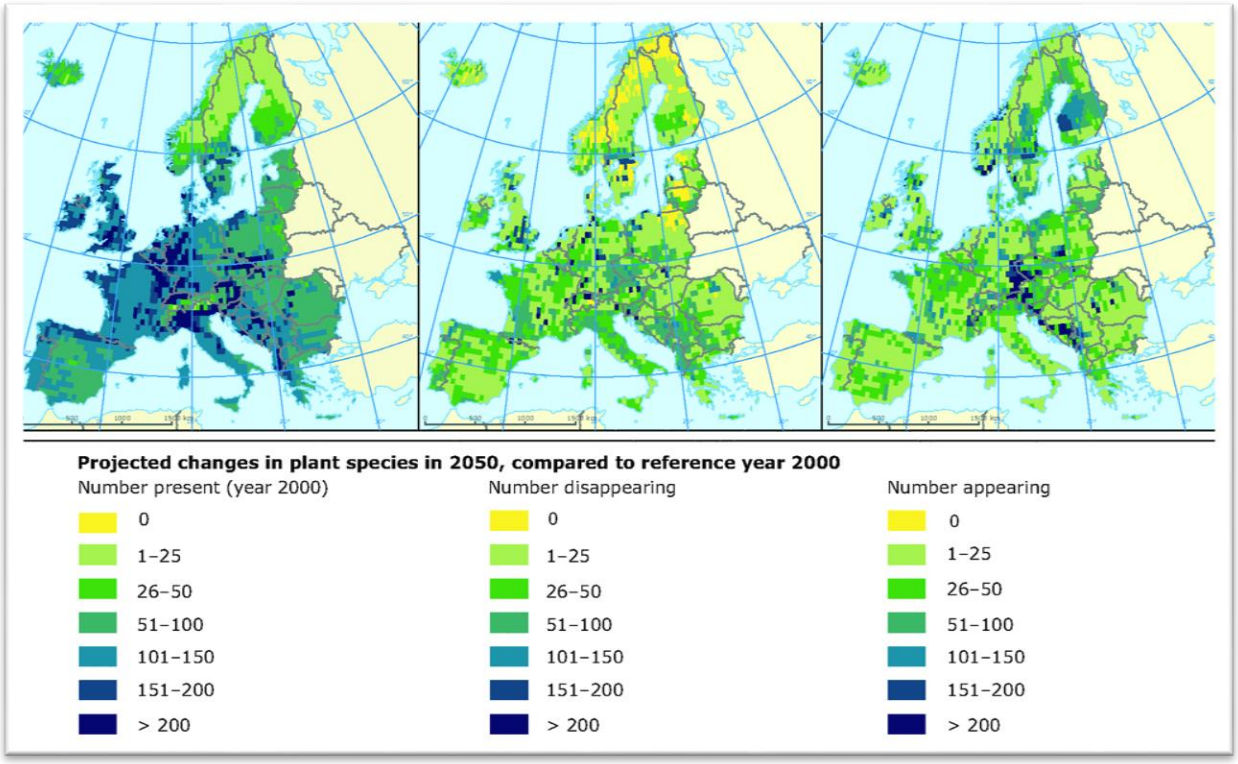


Fig 2.1 Prognosis trends in the development of plant communities in EU

Climate change poses a threat to the world's forests. That is, the productivity of the tree is reduced if the characteristic climatic thresholds of a particular species are exceeded. Significant climate changes that negatively affect the productivity of trees are mainly related to the so-called hotter droughts. In combination with biotic pathogens, hotter droughts cause higher tree vulnerability and hence mortality. As a result, global forests are expected to undergo significant changes during climate change. Changed climatic conditions can, on the one hand, locally lead to more frequent extinction of certain tree species, but on the other hand will allow other – local but absent species – to establish themselves, thus potentially changing the diversity of local tree species.

Climate change impacts are projected to increase, potentially matching land-use change as the main threat to biodiversity. Current efforts aimed at predicting the consequences of climate change tend to focus on range shifts and on community change following local colonization and extinction of species. These predictions are explicitly or implicitly based on the niche concept - that is, species typically tolerate a restricted range of

environmental conditions6, defining the ‘niche space’ so that if the environment changes, species either adapt, move or eventually decline and go extinct.

If we take into account the Ukrainian forests and all vegetation in general, we will also observe the transition of plants to another habitat. The species listed in the Red Book of Ukraine and the World Red Book are the most vulnerable. Because they are already on the verge of extinction and significant climate change or competition with more productive species will lead to their extinction.

Many plants will be able to change their habitat through the migration of animals that will spread their seeds. But there are vulnerable species that will not be able to migrate and there will be a question of adaptation or threat of extinction. Often, when the climate shifts, plants reduce their habitat, remain in the most optimal conditions. On the territory of Ukraine there are many different habitats as well as a variety of relief that accompanies the richness of plant species. In our area, we can observe and study how certain species respond to warming. An example is the Askania Nova Biosphere Reserve. There are species of animals and plants that are in the Red Book of Ukraine and the world and not from this habitat. Przewalski's horses, zebras and others feel great in the animal world. We have a rich biodiversity, from the south of Ukraine and the steppe zone to the Polissya deciduous forests, and we can perfectly observe the transition of vegetation and predict their future movement and survival.

2.3 Adaptation through morphological and physiological changes.

Climate warming will have a huge impact on vegetation, as temperature is the main regulator of many physiological processes. Given this, they may need to make physiological adjustments for productive functioning under high temperatures. Most plants have this ability and in response to warming can reduce respiration rate, increase the total area of leaves, increase the rate of assimilation, and increase carbon sequestration. Such changes are called "thermal acclimatization".

Also, most species can change their thermal optimum for photosynthesis (i.e. move the most optimal temperature for photosynthesis in the direction of growth). This change allows plants to work at higher temperatures without reducing the rate of photosynthesis.

As the ambient temperature increases, the frequency of plant respiration increases, which leads to greater carbon losses. Adapting to global warming, plants reduce their respiration rate at higher temperatures. These devices, in turn, can greatly reduce the negative effects of global warming.

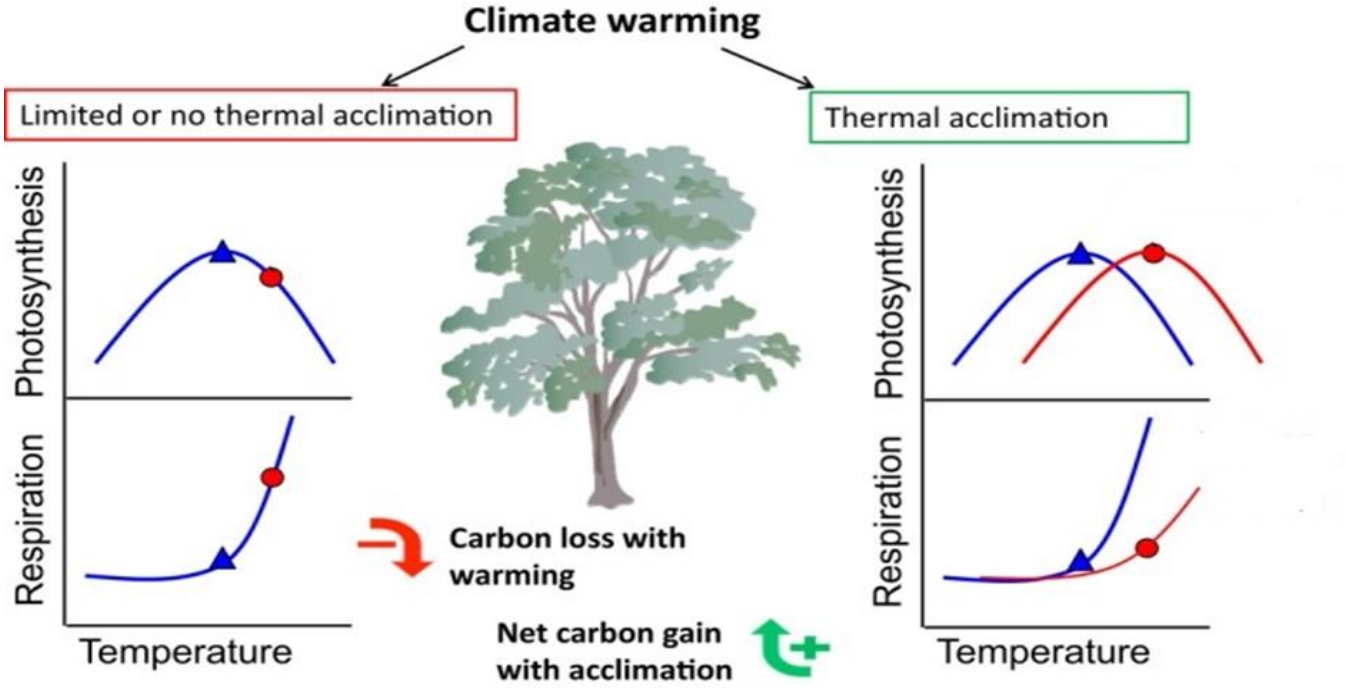


Fig.2.2 Physiological adaptations of plants to climate warming. Blue dots indicate the temperature to which the plants are already adapted. Red dots indicate increased temperature.

But different species show different possibilities of adaptation. It depends in part on the climate to which the plants are already adapted. According to research, in cool climates there is a tendency to a positive response to warming, along with increasing the rate of photosynthetic capacity. On the contrary, in warmer climates, as the temperature increases, the photosynthetic capacity decreases, and plant growth decreases. These data indicate the limited ability of some plant species to adapt. Equatorial species have less adaptability because they have adapted to stable thermal conditions throughout the year compared to species at higher latitudes, where temperatures vary greatly depending on the season.

Growth of plants is highly dependent on a number of factors: a plant's immediate general environment; its biome, characterized by the site biota; the abiotic conditions such as soil type; water availability; and in particular the local meteorological conditions. Air temperature and humidity, soil temperature and moisture content, wind, solar radiation, and precipitation have direct and indirect influences on them. Weather conditions fluctuate and sometimes include extremes, which damage plants. However, plants are well adapted to these fluctuations and even to the extremes to some extent [24].

The timing of weather events has effect on local vegetation, especially seasonally adapted vegetation types. As a result, the plant community at a particular site generally reflects the normal weather conditions, and at a higher scale – climate. Thus, one of the most prominent and clear evidence of climate changes are shifts in the timing of plant activity. While changes are widely observed and common, shifts vary in magnitude and direction within and among species. The probable factors, which affect the magnitude of the shift includes: latitude, elevation, habitat type, species' seasonality and generation time.

The change in temperature pushes the spring thaw earlier, and delays the first frost until later in the fall. As a result, these environmental changes cause many trees and flowers to bloom earlier than typical (Fig. 2.3). These may create additional problems, since they may deviate from the normal schedule for pollinators loosing chance for fertilization. Furthermore, animals can miss part of their nutritional base, which threaten their reproduction success [25].

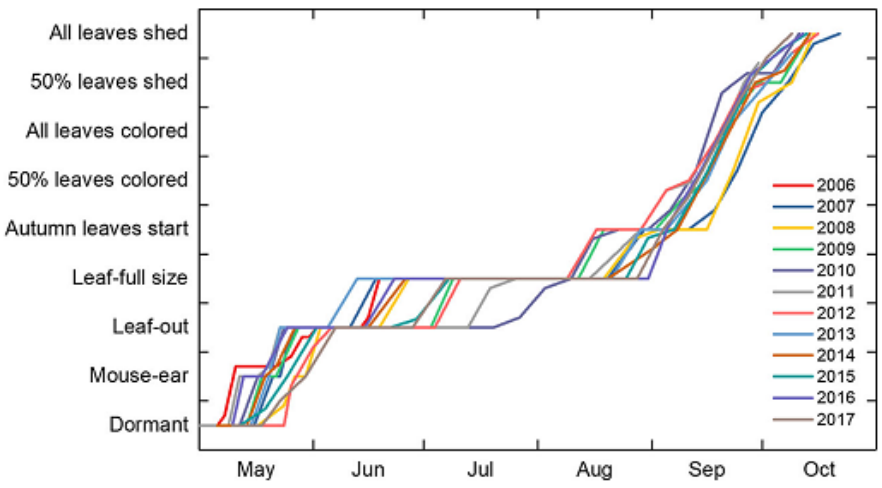


Fig. 2.3

SECTION 3. EFFECTS OF CLIMATE CHANGES ON PLANT COMMUNITIES OF NATIONAL NATURAL PARKS OF UKRAINE.

3.1 Global warming trends in Ukraine

Global climate change does not bypass Ukraine either. Moreover, the rate of rise in air temperature in Ukraine is even ahead of global trends. The average annual temperature has risen in our country by 1.2 ° C.

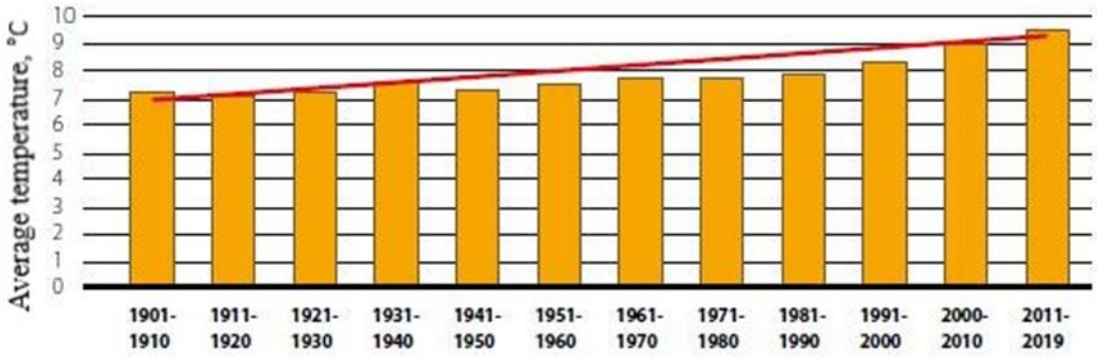


Fig. 3.1

Since 1991, each subsequent decade has been warmer than the previous one: 1991-2000 - by 0.5 ° C, 2001-2010 - by 1.2 ° C, 2011-2019 - by 1.7 ° C.

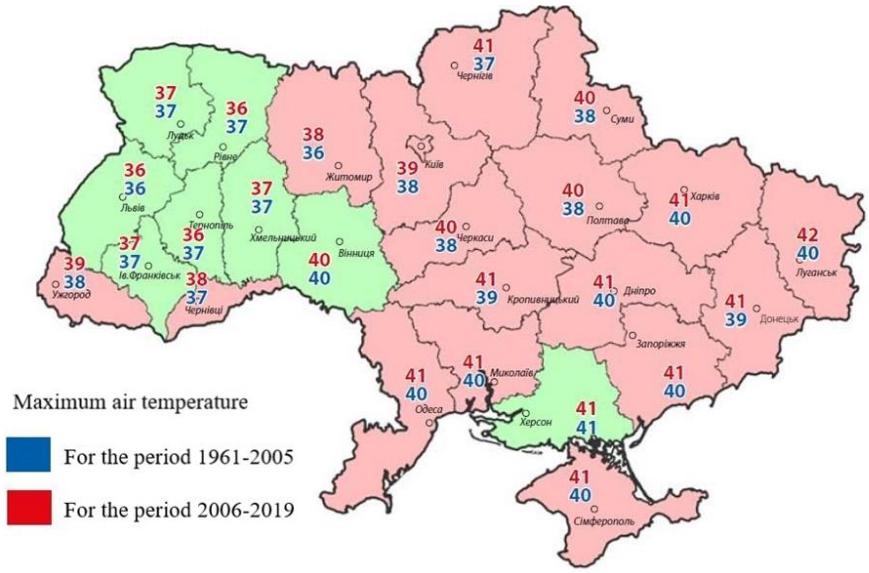


Fig. 3.2

As a result, droughts are likely to intensify and spread, and areas prone to desertification are to increase. Already, the climate has become drier throughout Ukraine and there is a tendency to increase the area with insufficient rainfall.

But at the same time, since 1990, Ukraine has seen a real reduction in greenhouse gas emissions. This reduction is not so much a consequence of targeted climate policy, but a reduction in the use of energy resources due to the decline in GDP, population decline and economic restructuring.

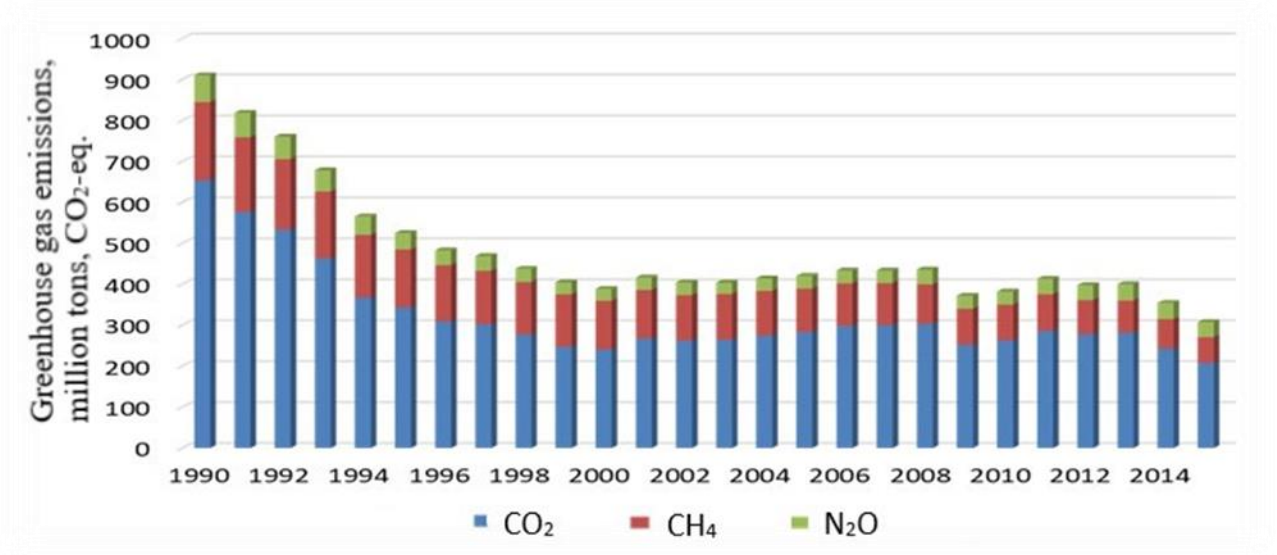


Fig. 3.3

During the last decades (in comparison with the base period of 1961-1990) there was a redistribution of precipitation by regions of Ukraine and by seasons. In general, the average annual rainfall has not changed much, but there are changes in the intensity and nature of precipitation: for example, when a few hours or half of the monthly rainfall may fall in a few hours [26].

Rising temperatures and changes in the humidification regime will lead to further changes in the water flow of rivers, and, accordingly, the water supply of some regions. During the XXI century, for the vast majority of administrative regions of Ukraine there will be a decrease in surface water runoff due to warming (increase in surface air temperatures, increase in evaporation) and decrease in precipitation.

According to Ukrainian scientists, in the Dnieper River for the period 2030-2040 will be less water by 29%, and in the Dniester River - by 37%.

In addition to desertification, global rising temperatures could lead to forest fires.

Another consequence of warming may be increased atmospheric circulation in the Black and Azov Seas, which will increase the frequency of extreme weather in Ukraine.

Frequent downpours and floods can cause a deterioration in drinking water quality, leading to an increase in the incidence of intestinal infections (salmonellosis, hepatitis A, leptospirosis, etc.).

Also due to changes in air and soil humidity and groundwater balance, catastrophic shifts and deformations in mountainous areas may intensify.

Taking into account all the above possible consequences of warming, it can be concluded that the most vulnerable areas will be the coastal areas of the Black and Azov Seas, the Crimean and Carpathian Mountains, as well as the steppe regions of Ukraine [27].

Climate change will primarily affect flora (due to the inability to move to a more habitable site as needed), and later, as a result, fauna. The largest centers of wildlife in Ukraine are nature reserves, biosphere reserves, nature parks and reserves. Accordingly, it is on these objects of the nature reserve fund that warming will be reflected first and foremost. Due to droughts, and in other regions on the contrary - excessive rainfall, the number of species will decrease significantly, and a large variety of species will give way to a smaller variety of invasive species. A huge number of plants and animals that are listed in the Red Book of Ukraine may simply disappear forever.

3.2 Sea level rise in Ukraine.

Rising sea levels should be singled out among the risks of global warming. Ukraine, which is bordered by the Black and Azov Seas and has more than 2,500 kilometers of coastline, will not avoid the problems associated with rising sea levels due to global warming. The magnitude of sea level rise is determined by global factors, such as warming and melting

glaciers, and regional features, in particular, the water exchange system between the seas, changes in rainfall and river runoff, and modern vertical movements of the earth's crust. Potentially, the steady-state water level in 2100 could be 0.82 meters higher than it is now. Due to floods and storms, the level of the Black and Azov Seas can rise by almost 1 meter, reducing the area of land and changing local conditions.

The study of the vegetation of the North Sea spit of the Sea of Azov revealed an increase in meadow-halophytic, wetland and inland estuarine aquatic vegetation against the background of reducing saline, sandy-shell and coastal vegetation for 70 year period (Fig. 3.4) [27].

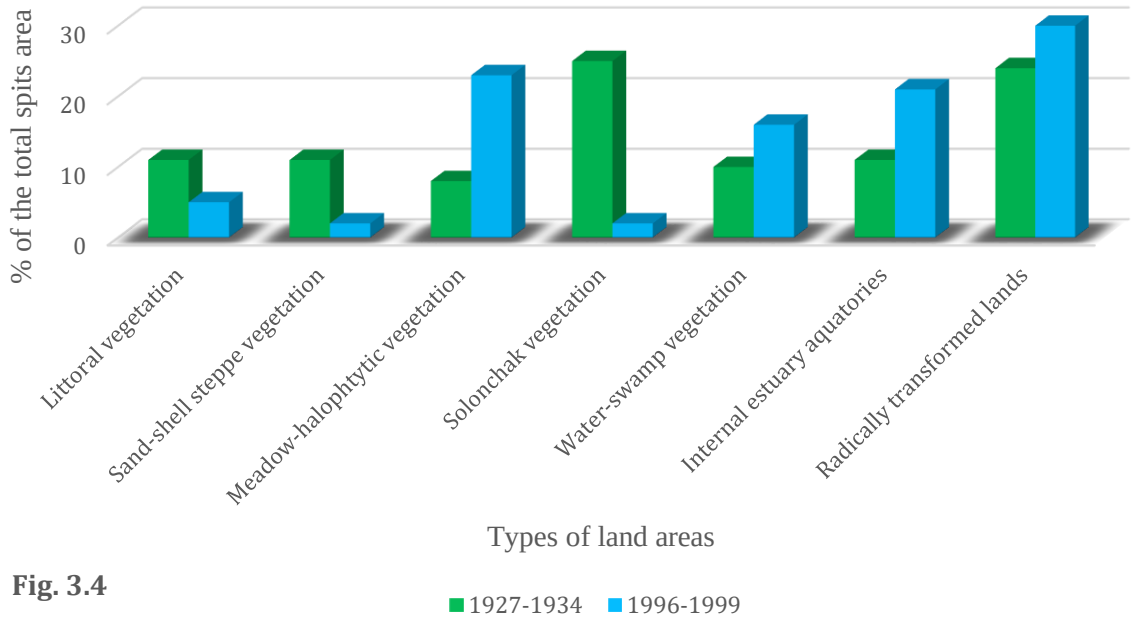


Fig. 3.4

Such changes indicate the general trends of changes in the coast and its specific formations, as spit and firth – their flooding and leaching. Scientists believe that such changes are due to the intense rise in ocean levels caused by climate change.

In order to prepare in advance for the possible consequences of flooding of coastal areas, it is important to conduct research and calculations. Such studies show that the coastal areas of the southern regions of Ukraine are intensively affected by sea level rise. By 2100, it is estimated that the area of almost 1.5 million hectares (over 800,000 hectares without reservoirs) should be flooded. Crimea (Northern part of the peninsula) and Kherson region (the area between the Dnieper Estuary and Tendriv Bay, the valley of the mouth of the

Dnieper), and Odesa region (Danube Delta) would be most affected (Fig. 3.5).

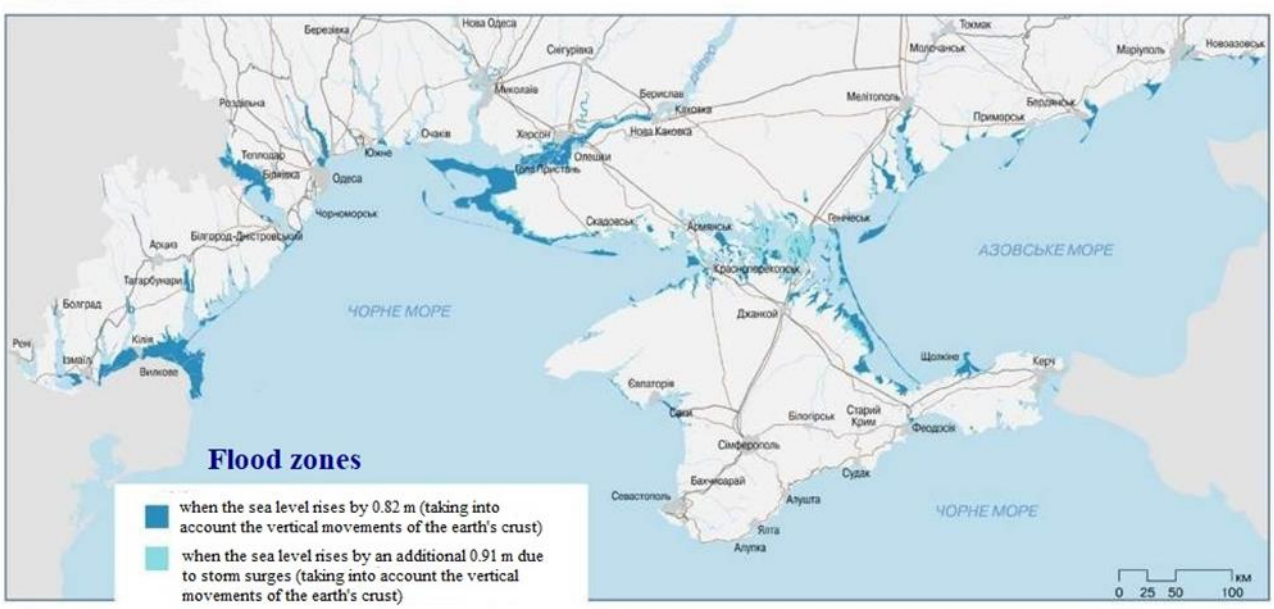


Fig. 3.5

Among the natural landscapes, aqua landscapes deserve special attention - reservoirs and watercourses that are affected by sea level rise. The largest watercourses in the risk zone are the mouths of the Danube, Dnieper and Dniester (along with numerous lakes, estuaries and deltas), estuaries Dnieper-Bug, Dniester, Sasyk (Kunduk), Tuzla estuary group, Hadzhibeysky, Kuyalnitsky and others, Lakes Cahul, Kugurlui Yalpug, Katlabug, China, Sasyk-Sivash and others, - about 5,000 reservoirs of various types totally.

Ecosystems that are undergoing significant transformation due to flooding and inundation also include wetlands, including 13 sites of international importance protected by the Ramsar Agreement. These are, in particular, “Aqualian-rock complex of Cape Kazantip”, “Tendrivska Bay”, “Eastern Sivash”, “Bilosaray Spit and Bilosaray Bay”, “Obitochna Spit and Obitochna Bay” and others.

Other coastal natural landscapes are also negatively affected by sea level rise. In particular, the ecosystems of the estuaries of the Northern Black Sea, sandy spit of the Sea of Azov, the bays of Sivash, many bays along the coast, as well as marine ecosystems are under threat. Most of them are protected by the Berne Convention for the Conservation of European Wildlife and Natural Habitats and require special measures for their protection and conservation.

The coasts of the Azov and Black Seas, which are at risk due to rising sea levels, are

home to many endemic species of plants and animals that are not found anywhere else in the world and are listed in the Red Book of Ukraine. Coastal habitats also play an important role as a resting place for dozens of species of rare migratory birds on their way from North to South.

Adaptations of these ecosystems to climate change and sea level rise will be significantly hampered by anthropogenic pressures – uncontrolled recreation, construction and agricultural and industrial use of the coastal zone.

This high level of biodiversity is due to the large number of nature reserves located on the Black and Azov Seas. Most of them fall partially or completely into the projected flood zone – a total of 98 protected areas, including 2 biosphere reserves, 4 nature reserves and 7 national nature parks.

Special mention should be made of 31 objects of the Emerald Network of Ukraine, which fall into the zone of possible flooding due to rising sea levels [28].

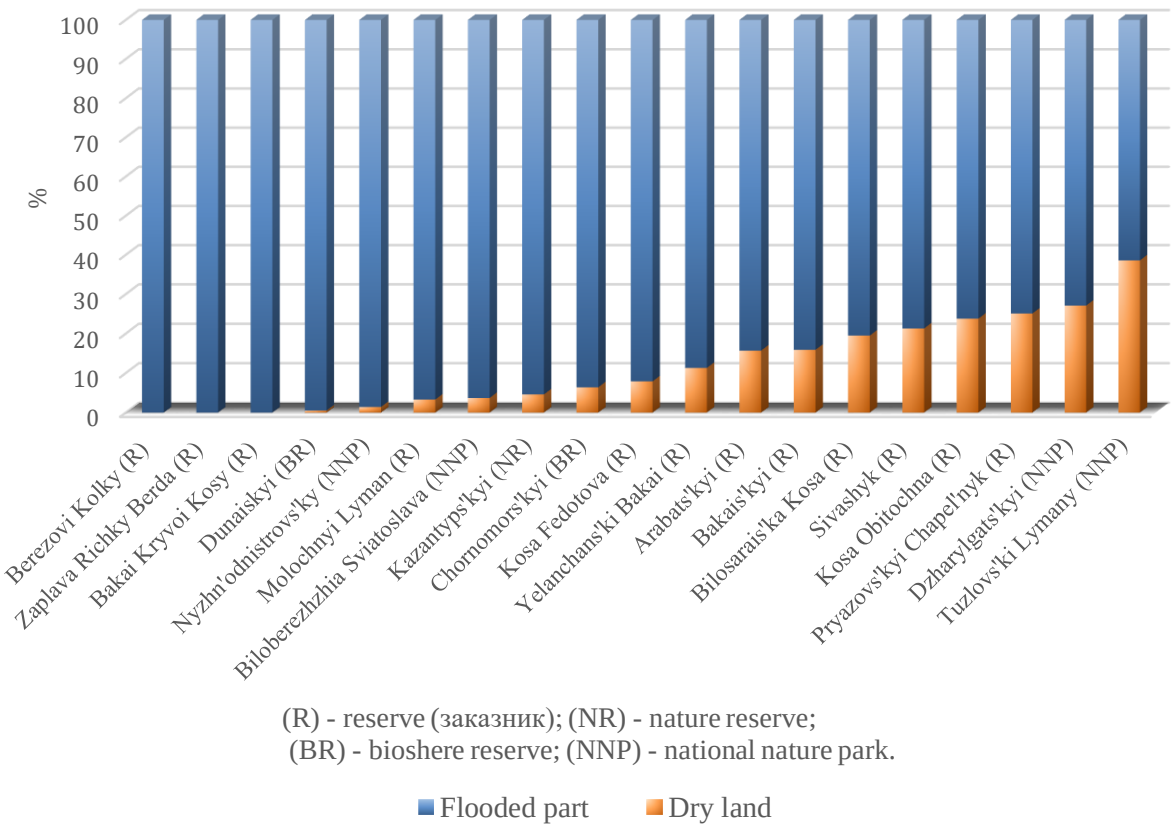


Fig. 3.5 Objects of the nature reserve fund with the largest share of flooding

3.3. Impact of climate change on the nature reserve fund of Ukraine

In Ukraine, 8633 territories and objects of the nature reserve fund are 6.8% of the country's area. It consists of 5 biosphere reserves, 19 nature reserves and 53 national nature parks.

To illustrate the impact of global warming, the example of one of Ukraine's national nature parks, namely the Shatsk National Nature Park, was used. Studying the data of the meteorological station Svityaz, one can notice a tendency to increase the average annual temperature during the period from 1976 to 2019 (Fig. 3.6). The graph of minimum temperatures (Fig. 3.7) shows the absence of a trend component.

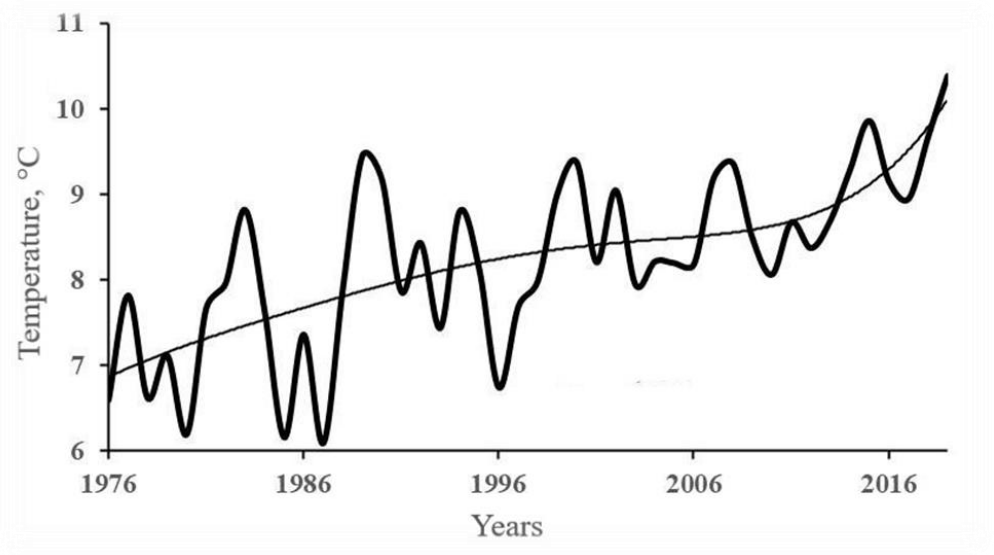


Fig. 3.6

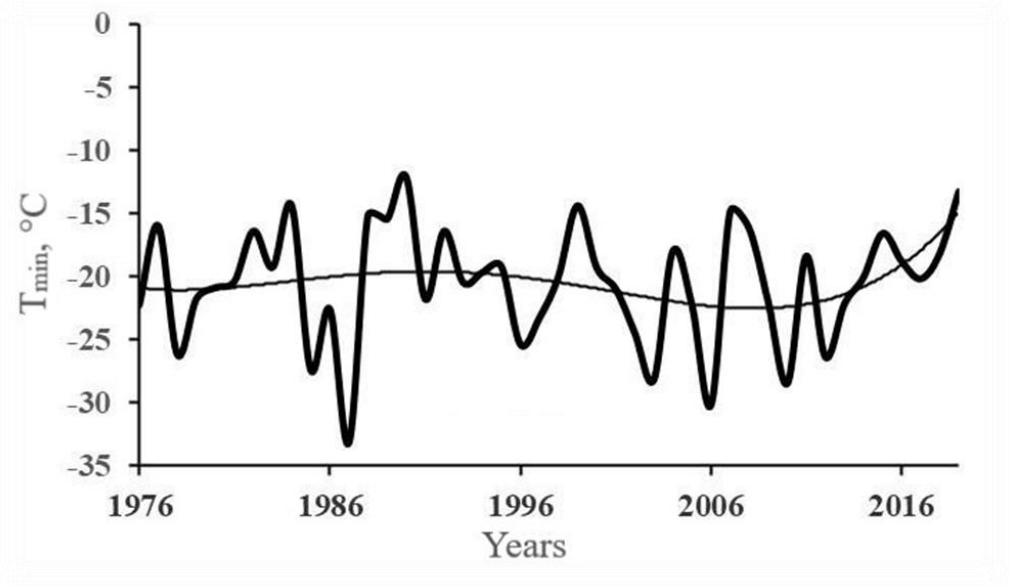


Fig. 3.7

But the dynamics of maximum temperature also shows a clear positive trend throughout the period (Fig 3.8).

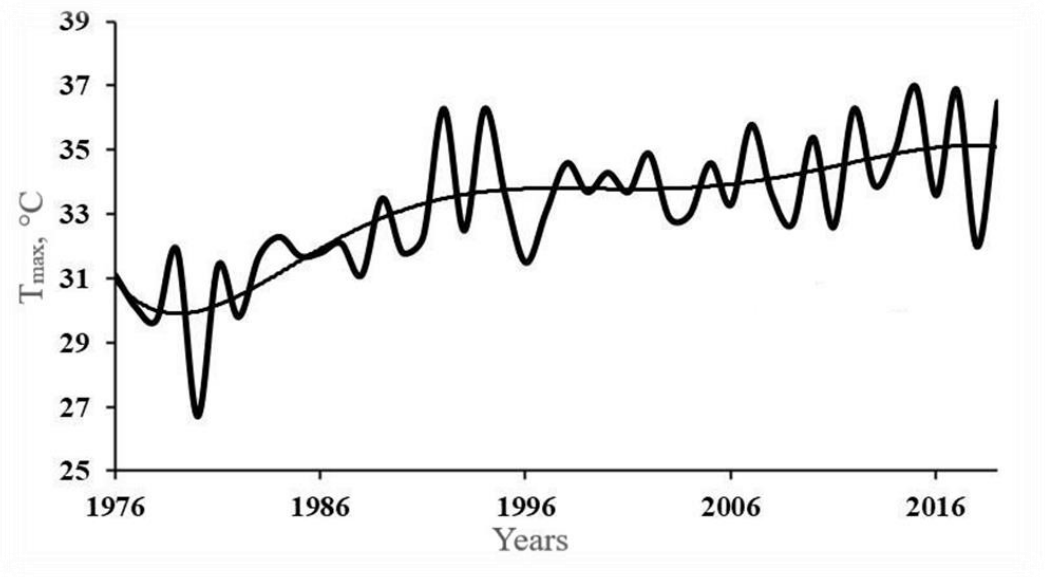


Fig. 3.8

Shatsk National Nature Park is known for its numerous system of lakes. Specifically for them, the threat is the shallowing of water bodies, which is already observed in Ukraine. In addition, changes in climatic indicators will be accompanied by gradual changes in the soil profile. The progressing dryness of the summer season will cause the constant reduction of phytomass, which will reduce the capacity of the humus horizon and the content of humus in it. The wet cold season will increase the leaching regime of soils with a corresponding decrease in the share of humic substances in them. This means the soil in the region will gradually lose fertility.

Increasing the intensity and amount of precipitation in the cold period of the year in unprotected fields will be accompanied by intensification of planar and linear leaching processes with physical removal of humus from the surface of watersheds and watershed slopes to their feet with a corresponding decrease in soil fertility.

Climate change affects not only one park, but the entire territory of Ukraine and the world. A study of all 53 Ukrainian national parks, allowed us to see all the threats that are already present and potential. The data about display of climate changes were taken from the official information of NNP, or related research papers.

The vulnerability assessment was conducted according to the recommendations of the USDA for forests and transitional territories. The climate change vulnerability is

predisposition to be adversely affected by climate change, due to inability to adapt to them.

The climate change vulnerability of natural plant communities depends on the following factors, accounted in this estimation:

- total area of community
- share of territory, transformed by human activity;
- climate change adaptation plan at the NNP;
- survey of the display of climate change effects;
- composition of community (correlation between grasses-trees;
- intensity of recreation and economic activity [29].

The characteristics were evaluated separately with giving scores by each parameter. The final rating was calculated as the sum of scores and rated as follows:

vulnerability level 1 (low), vulnerability level 2 (moderate), vulnerability level 3 (increased), vulnerability level 4 (hight).

If the factors were not sufficiently provided with relevant information, they were ranked as “0”.

3.3.1 Mixed forest (Polissya)

Polissya is a natural region within the Polissya lowland, in the basin of the rivers Pripyat and the Western Bug, which is characterized by extremely wet, wooded and swampy terrain, dense river network, low population density. The typical vegetation of the area is mixed forests. Natural conditions have led to weak urbanization, isolation of settlements, and as a result preservation of many elements of natural plant communities.

The major threats from climate change for the given region are soil and atmospheric droughts in summer, increased precipitations in winter, increased average temperature, and more dramatic fluctuations of water tables in local water systems. The area includes 10 NNP with the level of vulnerability from increased to moderate (Table 3.1). Typically, objects, which include wetlands, are more affected*.

Table 3.1

Climate change effects and vulnerability of the NNP in the mixed forest region

Mixed forest (Polissya)			
№	**National natural parks**	**Vulnerability assessment (0-4)**	**Display of climate changes***
1	Holosiivsky National Nature Park	3	Drying of trees
2	Derman-Ostroh National Nature Park	3	Relocation of natural borders between forest and forest steppe areas
3	Zalissia National Nature Park	2	Acceleration of successions
4	Mezynskyi National Nature Park	3	Changes in hydrological regime of oxbow lakes
5	Nobelsky National Nature Park	2	-
6	Prypiat-Stokhid National Nature Park	3	Imbalance in wetlands, drying of spruce
7	Tsumanska Puscha National Nature Park	2	-
8	Shatsk National Natural Park	3	Water table fluctuations, shallowing of reservoirs
9	Halych National Nature Park	2	Threats to aquatic plants communities
10	Northern Podillia National Nature Park	2	Threats to boreal plant species

3.3.2 Forest steppe

The forest-steppe is a transitional natural zone between the zones of mixed forests and steppe, where forest and steppe areas alternate. The forest-steppe climate is temperate, usually with moderately hot summers and moderately cool winters. Evaporation is slightly higher than precipitation. When moving south, the forest-steppe gradually contains fewer trees and more steppe areas, the climate becomes hotter, less precipitation, and the forest-steppe turns into steppe. Trees that can be seen: wild pear, oak, aspen, beech, alder, hornbeam, maple, linden.

The major threats from climate change for the given region are growing continental character of climate, increasing average temperature, change of air circulation, change of correlation between types of precipitations in favor of rains. The area includes 18 NNP with diverse level of vulnerability ranging from increased to low (Table 3.2). Typically, objects, which include wooded areas, are more affected, while those with typical landscapes and more cultural importance are less threatened*.

Table 3.2

Climate change effects and vulnerability of the NNP in the forest steppe region

Forest steppe			
№	**National natural parks**	**Vulnerability assessment (0-4)**	**Display of climate changes***
1	Ichnia National Nature Park	2	Change of dominating species in forest plantations
2	Yavorivskyi National Park	2	Relocation of natural borders between forest and forest steppe areas
3	Biloozerskyi National Nature Park	2	-
4	Hetman National Nature Park	2	Changes in hydrological regime
5	Homilsha Woods National Nature Park	3	Reduction of floodplain associations
6	Dvorichanskyi National Park	2	Intensification of erosive processes
7	Desna-Starohutskyi National Nature Park	3	Imbalance in wetlands
9	Karmeliukove Podillia National Nature Park	3	Threat to relic plant and sub-Mediterranean associations
10	Kremenets Mountains National Nature Park	3	Expansion of forest or shrub vegetation, which threatens unique rock hill plant associations
11	Lower Polissia National Park	2	-
12	Sulynsky National Nature Park	2	Imbalance in wetlands
13	Podilski Tovtry National Nature Park	3	Change in grasses composition
14	Pyriatyn National Nature Park	3	Imbalance in wetlands
15	Sloboda National Nature Park	2	Threat to unique wetland plant communities
16	Khotyn National Nature Park	1	-
17	Dniester Canyon National Nature Park	2	Threats to unique plant formations on rocky hills
18	Kholodny Yar National Nature Park	1	-

3.3.3 Steppe

Ukrainian steppe is a steppe natural zone in Ukraine, located in the south, center and east of the country. The steppe is almost completely plowed; the remnants of former vegetation are preserved in reserves and partly on the slopes of beams and river valleys. Due to its flat terrain it is very hot in summer and very cold in winter.

The major threats from climate change for the given region are irregularity of precipitation patterns and increased rainfall, growing temperatures and intensified evaporation, causing droughts; rising sea level at the coast. The area includes 13 NNP with diverse level of vulnerability ranging from increased to low (Table 3.3). The region and its NNP are potentially the most affected by climate changes and the signs of desertification are the characteristic attribute of the region*.

Table 3.3

Climate change effects and vulnerability of the NNP in the steppe region

Steppe			
№	**National natural parks**	**Vulnerability assessment (0-4)**	**Display of climate changes***
1	Azov-Syvash National Nature Park	4	Expansion of dessert plants and xerophytes, reduction of steppe communities
2	Biloberezhia Sviatoslava National Nature Park	4	Reduction of residual forested spots
3	Buzk's Gard National Nature Park	4	Changes in hydrological regime
4	Great Meadow National Nature Park	4	Imbalance in wetlands
5	Dzharylhach National Nature Park	4	Sea level rise
6	Kamyanska Sich National Nature Park	2	-
7	Kremenetsky forest	3	Reduction of wooded area
8	Meotyda National Nature Park	4	Increasing salinity and reduction of floodplain swamps, estuaries
9	Nyzhniodniprovsky National Nature Park	2	Reduction of floodplain forests
10	Lower Dniester National Nature Park	2	Reduction of estuary vegetation
11	Oleshkivski Pisky National Nature Park	4	Reduction of the of birch groves area
12	Kuyalntysky National Nature Park	2	-
13	Tuzly Lagoons National Nature Park	4	Reduction of estuary communities

3.3.4. Carpathian mountains

The Ukrainian Carpathians are part of the mountain system of the Eastern Carpathians in Western Ukraine. Mountain ranges, separated by longitudinal basins and delimited by deep transverse valleys, stretch mainly from northwest to southeast.

The climate is temperate continental, warm, with cyclonic and anticyclonic invasions of Atlantic air. The Carpathians are the wettest region in Ukraine: most rain in spring and summer, snow in winter. In spring, the snow lies for a long time (sometimes until mid-June) on the rounded peaks of the mountains.

Under the conditions of sufficient and excessive moisture, a dense (up to 1.5 km / km^2) hydrographic network is formed.

High-altitude landscape differentiation of vegetation and soil cover is clearly expressed in the Ukrainian Carpathians. Deciduous forest (primary oak forests, complemented by hornbeam, linden, maple, beech) grows at the foot of the lowlands and hills, on the slopes of the mountains. At the next altitude area conifers (white fir and European spruce) appear and beech predominates. Higher to the top the forest becomes coniferous and in addition to spruce and fir, it includes larch. Conifers are more cold-resistant than deciduous. The forest is dark and humid.

In the highlands there are two variants of the upper limit of the forest in the Ukrainian Carpathians: beech and spruce. On the high slopes and peaks of the Carpathians, coniferous forests are replaced by shrubs and subalpine crooked forests of mountain pine, juniper, green alder and other species in the fields and high watersheds.

The highest are the subalpine mountain meadows and wastelands - mountain meadows covered with colorful flowering herbaceous plants. It should be noted that forests, especially on mountain tops, have been cut down or burned for a long time to expand pasture area. Thus, the upper limit of the forest is significantly underestimated, and the meadows that arose on the site of forests are artificial, secondary plant communities with depleted species composition.

The forest cover of the mountains exceeds 50%.

The major threats from climate change for the given region are increased temperature;

reduction of precipitations; reduction of snow cover duration and capacity; changes in circulation patterns. The area includes 12 NNP with diverse level of vulnerability ranging from increased to low (Table 3.4). The region and its NNP are characterized by untypical climate conditions on a limited area of mountain region. Therefore, it is rich in endemic species and species with narrow tolerance range to the environment condition. This makes the NNP of the Carpathian Mountains enter active succession processes and may lead to complete transformation of local plant associations*.

Table 3.4

Climate change effects and vulnerability of the NNP in the Carpathian Mountains

Carpathian mountains			
№	**National natural parks**	**Vulnerability assessment (0-4)**	**Display of climate changes***
1	Boikivschyna Natio16nal Nature Park	2	-
2	Verkhovyna National Nature Park	2	Expansion of thermophilic tree species
3	Vyzhnytsia National Nature Park	4	Reduction of meadow plant associations
4	Hutsulshchyna National Nature Park	4	Change of dominant tree species
5	Zacharovanyi Krai National Nature Park	4	Reduction of Primeval Beech Forests
6	Carpathian National Nature Park	4	Reduction of river valley plant communities and threats to cypress association
7	Korolivsky Beskydy National Nature Park	3	-
8	Synyohora National Natural Park	3	-
9	Skole Beskids National Nature Park	3	Reduction of natural forest plantations
10	Synevyr National Nature Park	3	Changes of aquatic communities
11	Uzhanskyi National Nature Park	4	Reduction of Primeval Beech Forests
12	Cheremosh National Nature Park	3	-

* Based on information at official web-pages and research papers [27] [28] [30] [31] [32] [33] [34] [35]

CONCLUSION

1. The research and observation data prove that the climate is changing on the Earth. Researchers invest their efforts in making prognosis on what kind of climate picture we will see in future generations. The analysis of past climatic trends and studying regularities of natural communities, biomass and biodiversity distribution are crucial for the correct assessment of potential threats and losses.

2. All the effects of global warming can be seen on plant communities, since they are the most tuned to climate conditions and their changes. The signs of climate change are seen in the shift of plants habitats, changing composition and population density of plants, changes of their phenophases and other physiological processes like photosynthesis. The final outcome of climate changes is extinction of some species.

3. Climate change effects are valid for Ukraine as well as other countries. The most prominent effects are changing precipitation patterns, change of seasons, periodicity of weather phenomena and extreme events frequency, sea level rise and of course growing average temperatures. All this factors will have detrimental effect on plant communities.

4. The analysis of national natural parks of Ukraine was conducted to assess their vulnerability to climate changes and define the trends in display of climate changes. The assessment of vulnerability was based on the factors contributing to inability of NNP to adapt to new changes. The parks were considered in terms of natural zones attribution, since the set of climate change impacts has zonal differences.

5. It was defined that almost all parks are vulnerable to climate change impacts and demonstrate signs of changes in response to climate. In order to increase the resilience of NNP in the face of climate change it is necessary to establish long-term survey programs at NNP to trace any effects caused by this phenomena in order to develop efficient plans for the protection of biodiversity in Ukraine.

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