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Forest Cover – the Primary Guardian Against Climate Change and Biosphere Security

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ABSTRACT

Due to ongoing global warming on our planet, the frequency of catastrophic natural disasters has increased, resulting in significant destruction and loss of life. In the 21st century, a further rise in temperature is expected, which will accelerate glacial melting, cause a sharp rise in sea levels, and lead to coastal flooding. Freshwater resources and agricultural productivity will decline. Desertification and other negative processes will intensify. Forest cover plays a critical role in climate regulation, oxygen balance stabilization, and biodiversity conservation. However, at present, widespread deforestation and forest fires are reducing forest areas worldwide, decreasing the process of photosynthesis. As a result, the excess thermal energy of solar radiation becomes a cause of global warming, reduced oxygen levels, and the emergence of new viral, bacterial, and chronic diseases. Today, to mitigate climate change and ensure the safety of the biosphere and the environment, all countries must pay special attention to the protection and expansion of forest cover. Everyone must contribute to forest restoration and afforestation. In agricultural fields, protective forest belts should be planted to help increase crop yields.

Key words*: desertification, global warming, crop yield, fresh water*

Introduction

One of the most pressing concerns of the global community today is the increasing frequency of catastrophic natural disasters driven by global warming. These anomalous and destructive events have resulted in extensive damage and significant loss of life. Additionally, as the global population continues to grow, so too does the demand for essential resources such as food, water, housing, energy, and technological goods.

The encroachment upon forested areas and the unsustainable cutting of trees have led to a decline in photosynthesis, which in turn reduces the Earth's ability to regulate solar radiation. This imbalance contributes to rising global temperatures, oxygen depletion, and the emergence of new viral, bacterial, and chronic diseases [1].

In the 21st century, a continued increase in global temperature is anticipated, which will accelerate the melting of Antarctic and Greenland ice sheets, cause a significant rise in ocean levels, and result in the flooding of coastal zones. These changes are expected to trigger profound economic and social disruptions, including crop loss, freshwater scarcity, more frequent flooding, intensified storms, and accelerated coastal erosion [2].

Given that climate change is a global phenomenon, addressing its consequences requires coordinated international efforts. To protect the biosphere and the environment, all nations must take action to mitigate the effects of climate change. Chief among these actions is the rational use of natural resources and the preservation of ecological balance. In this context, forest cover plays a crucial role in climate regulation, stabilization of the oxygen cycle, and the maintenance of biodiversity.

Study Area and Method

Forests are a vital component of the biosphere, consisting of a complex and dynamic system of trees, shrubs, herbs, animals, birds, and microorganisms that are interdependent and collectively influence both the environment and each other. Forest ecosystems play a critical role in atmospheric processes, geological formations, and the development of essential natural resources, including soil, water, wildlife, minerals, energy, and recreational areas. Furthermore, forests are of significant economic importance, serving as sources of raw materials for various industries. Timber is widely used for construction and energy, while forests also provide food, medicinal products, and materials such as paper, cardboard, furniture, and flooring. Globally, over 15,000 types of products are derived from trees. The rapid growth of the world's population and advances in technology have dramatically increased the demand for forest resources [3].

This study is based on the analysis of historical, informational, and literary sources related to forest ecosystems and their ecological functions.

Vegetation – The Origin of Life on Earth

In the early history of the planet, Earth's atmosphere contained very little oxygen and was primarily composed of carbon dioxide, methane, and nitrogen compounds. Around three billion years ago, the first life forms appeared in the shallow regions of the hydrosphere, where sunlight and warmth could reach. These conditions resembling those found in modern tropical zones allowed green plants to absorb carbon dioxide and, using chlorophyll and solar energy, synthesize carbohydrates while releasing free oxygen. This process, known as photosynthesis, enables the conversion of inorganic environmental components into organic matter. The general equation for photosynthesis is as follows [4]:

$$6\,CO_2 + 6\,H_2O \xrightarrow[\text{Green plants}]{\text{Sun's radiation energy}} C_6H_2O_6 + 6O_2 \qquad (1)$$

Here, carbon dioxide and water molecules are diluted, and glucose molecules are formed during their combination, after which free oxygen is released.

The first species of the earliest times were the blue-green seaweeds, which transformed solar energy into chemical energy that contributed to the growth and development of the plant and its fruit. Scientists estimate that, annually, more than 10 billion kcal of solar radiation falls per hectare on Earth, which is used by plants for photosynthesis [5]. Each year, due to the effect of solar energy, approximately 83 billion tons of organic substances are formed on Earth. Of these, 53 billion tons are created on land and the rest in seas and oceans. It is noteworthy that plants accumulate only 0.3% of solar energy. As a result of photosynthesis, the quantity of carbon dioxide in the atmosphere was reduced to 0.03%, and the amount of free oxygen increased to 21% or by 1,000 times [4].

According to F. Ramad [6], 2 billion years ago, the first organisms capable of photosynthesis emerged (prokaryotes: blue-green plants, bacteria, viruses). After 0.5 billion years, higher organisms (eukaryotes) appeared. Consequently, 1 billion years ago, the oxygen content in the atmosphere reached 1% of its current level. Phytoplankton increased, and due to the intensity of photosynthesis, a form of oxygen gas atmospheric ozone was created, which blocked the harmful effects of the sun's ultraviolet rays. This contributed to the development of organic life, first in the upper layers of water, then on land.

Millions of years later, various species of plants evolved, becoming the primary source of food for animals and humans [7]. The vegetation on Earth annually assimilates around 5×10^{10} tons of carbon, absorbs 1.8×10^{11} tons of carbon dioxide, decomposes 1.3×10^{11} tons of water, releases 1.2×10^{11} tons of molecular oxygen, and collects 4×10^{17} kcal of solar energy [8].

It is estimated that 50–60% of oxygen is released by land vegetation, with the remainder produced by phytoplankton. One hectare of forest, in one hour, absorbs as much carbon dioxide as 200 people exhale in the same time. Over one year, one hectare of mixed forest absorbs 15 tons of carbon dioxide and releases 13 tons of oxygen.

The amount of oxygen used by humans depends on physiological condition, age, weight, and sex. In medicine, it is known that a person at rest uses 0.35–0.40 liters of oxygen per minute and about 5 liters per minute during physical work. A person needs 500–600 liters of oxygen per day; therefore, the forest area per person should be at least 0.3 hectares [7].

About 600 million years ago, the earliest autotrophic plants emerged; 500 million years ago plants and insects; 350 million years ago angiosperms and mammals. The development of chlorophyll-containing plants on land, along with the increase in oxygen, contributed to soil formation. Later, due to the increased amount of oxygen, a wide variety of flora and fauna, including humans, developed on Earth. The existence of the biosphere before the origin of humans is called biogenesis, while the stage of societal development is referred to as noogenesis.

Currently, there are about 2 million species of plants and animals, including up to 1.5 million animal species. Among plants, angiosperms rank first in number about 300,000 species; mushrooms are second about 100,000 species.

Although trees comprise less than 1% of all plant species, they constitute nearly 90% of the land's phytomass and account for 64% of its productivity [9]. Among animal species, insects rank first with up to 1 million species; mollusks are second with up to 100,000, followed by vertebrates with up to 50,000 species [4].

In the Bible, it is stated that during the seven-day creation of the universe, among many wonders, God created forests on the third day and brought the axe to all barren trees thereby defining the right to use timber. Yet forests are mercilessly destroyed by people.

Forest, Its Impact and Importance

Vegetation cover serves as a vital source of oxygen, food, and energy, making the survival of humans and animals heavily dependent on the state of forest ecosystems. As the global population continues to grow, so does the demand for food, water, housing, energy, household goods, mobile devices, and other resources. The expansion into forested areas and the unsustainable cutting of trees reduce the rate of photosynthesis, leading to increased solar radiation, contributing to global warming, and causing a decline in atmospheric oxygen levels.

Forest as a Factor in Climate Formation. The importance of the forest is first revealed in the regulation of air elements (air temperature, humidity, wind speed, etc.), which directly affect human health. For example, in summer, temperatures in treeless areas are relatively 3–5°C higher, which results in an accelerated pulse, overheating of the body, and decreased working capacity. Dry air in areas lacking forest also causes dryness in the mouth, throat, and nose, and reduces the body's anti-infective capabilities. High wind speeds in treeless areas negatively affect breathing, blood circulation, and the nervous system.

Thus, the most comfortable conditions for rest and rejuvenation are created in the forest. Furthermore, the beauty and attractiveness of natural forest landscapes have a positive impact on mental health, mood, working ability, and spiritual well-being.

The Sanitary-Hygienic Role of the Forest. In cities, industrial centers, and other settlements, atmospheric air is regularly polluted by harmful chemical contaminants. In such environments, forests play a crucial role in protecting and improving sanitary and hygienic conditions. Tree and plant emissions contain aromatic essential substances phytoncides that can eliminate many microbes and viruses, purifying and improving air quality. As a result, bacteria and microbes are significantly reduced in forests. For example, 1 m^3 of forest air contains up to 500 pathogenic bacteria, while 1 m^3 of city air contains around 36,000. It is estimated that land vegetation releases 175 million tons of aromatic oils annually.

Forest as a Filter. In our era, the lower layers of the atmosphere, in addition to carbon dioxide, are increasingly contaminated with harmful chemical and mechanical impurities. Dust reduces the sun's ultraviolet radiation, lowers air transparency, and alters the ionization level. A person breathes about 20 m^3 of air overnight, and if the air is dusty, it can lead to numerous illnesses, such as poisoning, asthma, nasal mucosal atrophy, and erosion. The forest acts as a strong air filter. It is estimated that 1 ha of forest filters 50–70 tons of dust annually. In this regard, specific forest types are especially effective: beech coppices filter about 68 tons per hectare, oak 56 tons, pine 36 tons, and spruce 32 tons [10].

Forest and Technogenic Pollution. Today, large-scale technologization has led to the accumulation of harmful chemical substances in nature. The contamination of air, water, and soil with various pollutants has reached levels that threaten life, including forests, in many parts of the world, leading to the desiccation of large forest areas. Experiments have identified plants capable of removing air pollution (detoxification). Oleaster, ash, acacia, oak, plane tree, maple, and willow are particularly resistant to harmful gases, whereas pine is more vulnerable.

Forest and Noise. Forests also play an important role in absorbing various kinds of noise, which depends on the composition, structure, frequency, and diversity of tree species. Multi-layered, dense forests are characterized by high noise absorption. For example, in a forest copse with a high absorption radius (0.8), noise from a source such as a highway is reduced by 30 decibels at a distance of 80–100 meters [11].

Forest and Yield. Forests have a significant influence on agricultural crop cultivation. With forest cover, crop yields can increase by 20–25% (Armand, 1964). The importance of forests is clearly illustrated in data showing that each hectare of forest strip protects 30–40 hectares of farmland, increasing grain yields by 2–3 quintals per hectare. From such protected areas, an additional 60–80 centners of crops can be harvested, and within 8–10 years, the costs of forest strip construction are fully compensated. The positive impact of forest strips is especially evident during drought periods. As the saying goes: "The forest produces water, the water produces a harvest, and the harvest produces life."

Water Management and Protective Functions of Forests in Mountain Regions. Forests provide natural habitats and essential conditions for life on Earth. In mountainous regions, forests serve as vital protection against various natural disasters. A portion of atmospheric precipitation infiltrates the soil, feeding rivers throughout the year. The higher the seepage rate into the soil, the lower the risk of floods and soil erosion. Thus, forests perform both watershed and protective functions.

In mountain areas, the importance of forests is especially significant, as they possess all the multifunctional roles described above along with additional protective benefits. Forests in mountains regulate river flow. According to statistical observations, high-frequency (>0.8) mountain forests are the main factor facilitating the deep infiltration of precipitation into the soil, thus managing surface runoff, improving water balance, and preventing river desiccation [13]. Most importantly, forests protect populated areas, roads, fields, and soils from dangerous events such as floods, mudflows, landslides, avalanches, and erosion [14].

Ecosystems of the Biosphere

The word *bios* means life in Greek. The biosphere is a combination of living and non-living substances in dynamic equilibrium, where living organisms transform the environment in accordance with their needs. The history of the biosphere's development spans 2.5–3 billion years. During this time, living organisms have developed under various environmental conditions. For example, some single-celled seaweed and bacteria grow in hot springs at temperatures up to 75–100°C; others, by contrast, survive at -6 to -7°C, and mushroom spores can endure 120–180°C [9]. Thus, the biosphere is the layer of Earth where life exists and develops. It includes the entire hydrosphere, lithosphere, and parts of the atmosphere.

The **hydrosphere** is Earth's watery layer. The World Ocean covers 7/10 of Earth's surface and supports life down to depths of 100–200 meters, where sunlight can reach. Only bacteria can survive at greater depths [2].

The **lithosphere** is the solid layer of the Earth, where life typically exists up to a few tens of centimeters. Some organisms live at depths of 2–3 km on land and 1–2 km beneath the ocean floor. The simplest anaerobic bacteria live in underground aquifers and oil-bearing layers at depths of 3–5 km.

The biosphere ecosystem includes plants, animals, microorganisms, and the non-living components of the environment. The main biomes of the biosphere are land, marine, and freshwater biomes [7].

The upper boundary of the biosphere reaches 6 km in the atmosphere, where only chlorophyll-containing plants exist. Above this, only some arthropods survive, feeding on pollen, spores, and microorganisms carried by the wind [8].

Atmosphere. The atmosphere is the gaseous layer surrounding Earth and consists of various gases, water vapor, and dust. It includes the following layers by altitude:

- Troposphere (8–18 km)
- Stratosphere (up to 55–60 km)
- Mesosphere (up to 80–85 km)
- Thermosphere (up to 1,000 km)
- Exosphere (above that)

The **troposphere**, which contains 90% of the atmospheric air mass and 0.5–4% water vapor, extends to 8–10 km at the poles and 16–18 km at the equator. Here, air temperature decreases by 5°C per kilometer of altitude. The troposphere fully transmits short-wavelength solar radiation and absorbs Earth's long-wavelength radiation, which excites the surface layer.

The **stratosphere**, a 40–60 km thick layer above the troposphere, contains dry, rarefied air. In summer, the temperature rises from 0 to 15°C; in winter, from -10 to -5°C [4]. At 20–30 km altitude, this layer contains ozone a form of oxygen that absorbs a large portion of the sun's ultraviolet radiation, which would otherwise destroy living organisms. Thus, the ozone layer is considered Earth's protective shield [5].

The **mesosphere** is 20–25 km thick, with temperatures dropping in summer to -80°C and in winter to -100°C. Due to strong turbulence, wind speeds can exceed 50–100 km/h.

In the **thermosphere**, starting at 80 km altitude, temperature increases by 5°C per kilometer and can reach 2,000°C at 1,000 km. Any object, including meteors, entering at 100–130 km/h burns up as it descends into the mesosphere (around 80 km deep).

The **exosphere** extends for thousands of kilometers, with temperature rising by 1°C per kilometer. Spacecraft fly in this zone, and radio communication is possible here.

Near Earth's surface, dry air consists of 78% nitrogen, 21% oxygen, 0.9% argon, 0.03% carbon dioxide, and 0.1% other gases, with ozone at 10^{-6}. This composition remains constant up to 90–100 km and is called the homosphere. Above 200 km, nitrogen dominates; from 600 km, helium; and from 2,000 km, hydrogen.

The atmosphere absorbs some cosmic rays and most meteorites. Only 48% of solar radiation reaches Earth. Without the atmosphere, the average surface air temperature would be 23°C instead of 15°C [9]. Nearly half of the sun's energy is used for water evaporation, which returns as precipitation.

Ozone Layer and Its Change. Ozone is a blue gas whose molecule (O_3) consists of three oxygen atoms. It forms when ultraviolet radiation splits an oxygen molecule, and the resulting atoms bond with other O_2 molecules [11]:

$$O + O_2 = O_3 \qquad (2)$$

There is "bad ozone" and "good ozone." Scientists call "bad ozone" the photochemical smog found in the lowest atmospheric layer, the troposphere. At certain concentrations, it is hazardous to human health: it irritates the upper respiratory tract, causes vegetative disorders, pulmonary edema, dizziness, cataracts, etc. This "bad ozone" accounts for only 10% of Earth's ozone; the remaining 90% is "good ozone."

"Good ozone" is found in the stratosphere and protects Earth from harmful ultraviolet radiation. Ozone concentration varies by altitude: 60% is located between 16–32 km, with the highest concentration around 25 km. This forms Earth's protective ozone layer, about 3.5 mm thick, which makes the planet suitable for human life. The ozone absorbs a large portion of ultraviolet radiation, which would otherwise destroy living organisms. Thus, the ozone layer is considered the biosphere's protective shield [5].

Ozone levels in the stratosphere depend on geographic location, altitude, and season. Solar radiation and interactions with oxygen, nitrogen, hydrogen, chlorine, and bromine cause ozone breakdown. A key reason for this is the use of chemical compounds especially Freons ($CFCl_3$ and $CFCl_2$) formerly used in refrigerators and air conditioners.

As a result, the ozone layer has thinned by half in many regions, and in the Arctic during summer and the Antarctic during winter, actual holes have formed. Further ozone layer degradation allows more ultraviolet radiation to penetrate the atmosphere, severely affecting living organisms, climate, and increasing natural disasters.

In 1996, factories producing ozone-depleting substances were closed, resulting in a 34% reduction in the ozone hole by 2014.

According to recent information, the ozone layer is expected to recover by 2030 in the Northern Hemisphere, by 2040 in the Southern Hemisphere, and by 2050 at the Earth's poles. It is also noteworthy that since the 1950s, space has accumulated a large amount of debris around 25,000 objects of varying sizes, from small particles to entire spacecraft. These objects move at speeds of approximately 25,000 km/h, and a collision with any spacecraft could result in a catastrophic event.

Climate warming factors and changes

Global warming is the process of the rapid increase in the average annual temperatures of Earth's atmosphere. Scientists propose two different explanations for this phenomenon. According to the first version, it is a periodically recurring natural cataclysm linked to solar activity. This activity determines 11-year, 22-year, and 80–90-year cycles of solar intensity. The current global warming is likely associated with an increased rate of solar radiation, which may eventually decrease.

The second version attributes Earth's warming to human-induced (anthropogenic) activity, which traps heat radiation reflected from the Earth's surface due to the accumulation of certain gases in the atmosphere. Notable among these gases are carbon dioxide, methane, nitrogen monoxide, ozone, and freons (halogenated hydrocarbons). These gases allow solar rays to pass through to Earth but trap the heat reflected back from the surface [15].

Between 1880 and 1930, the average annual air temperature increased by 0.5°C. From 1940 onward, the trend alternated between increases and decreases, but since the 1960s, the temperature has risen steadily [16].

Over the past 1.5 centuries, with technological development, the concentration of carbon dioxide (CO_2) in the atmosphere has increased by one-third, while methane (CH_4) has increased 2.5 times. Methane is 20–25 times more effective than carbon dioxide at trapping heat.

The rise in methane is linked to pipeline and bog leakage and livestock. Methane is produced by special bacteria in the stomachs of livestock and released from their dung, which is also used as fuel. The 1.5 billion cows on the planet emit 18% of greenhouse gases more than the entire transport sector. This is why eco-activists worldwide promote vegetarian diets, arguing that without livestock, such problems would not exist. One-third of atmospheric methane is generated by livestock [15].

The increase in carbon dioxide is associated with industrial development, and the burning of wood and coal. Each year, humanity burns 4.5 billion tons of coal and 3.2 billion tons of oil, gas, peat, and other fuels. Carbon dioxide emissions rise especially from cars and aircraft. Outdated vehicles and poor-quality fuel are among the main sources of harmful substances.

Due to industrial activity, it is estimated that 27 billion tons of carbon dioxide are released into Earth's atmosphere annually. Its atmospheric concentration has increased by 38%. Of this, 30% is absorbed by the world ocean, 13% by the biosphere and soil, while 57% remains in the atmosphere, contributing to further warming. Since the beginning of the industrial era, the atmosphere has accumulated 770 billion tons of anthropogenic carbon dioxide.

Through photosynthesis, 1 hectare of forest absorbs 5–10 tons of carbon dioxide and releases 10–20 tons of oxygen. The thermal energy of solar radiation falling on 1 hectare of land annually is about 10 billion kcal, 93.8% of which is absorbed by green vegetation [18].

The excessive emission of harmful gases from anthropogenic activities contributes to the expansion of the ozone layer in the atmosphere, a very dangerous phenomenon for living organisms and directly related to global warming. These effects intensified with the advancement of space technology. It is estimated that the launching of space missiles damages and disrupts the ozone layer, leading to increased solar radiation and temperature.

World Forest Cover

Forest Cover in the Past. The oldest known vegetation cover is found in Australia and is estimated to be around 395 million years old. Approximately 370 million years ago, plant life began to take the form of shrubs. Early forests were relatively low, with the tallest trees reaching about 7.5 meters and consisting mainly of primitive ferns. Around 345 million years ago, at the onset of the Stone Age, dense and widespread forests emerged, composed of trees of varying heights and early seed-bearing plants.

By 280 million years ago, under dry climatic conditions, primitive conifers had become widespread. Sequoia trees and flowering seed plants appeared around 225 million years ago. Between 135 and 65 million years ago, the ancestors of today’s rubber trees, magnolias, oaks, willows, and maples became dominant.

During the Paleogene period, forests in the Northern Hemisphere began to resemble the modern tropical and temperate forests. Arctic-type flora prevailed in the far north, while tropical vegetation expanded near the equator during the Tertiary period.

In the Neogene period’s dry climate, forest coverage declined, and grasslands spread across many regions. Coniferous plants became dominant. The Quaternary period, which began 1.8 million years ago and continues to the present day, has been marked by alternating glacial and interglacial periods, resulting in significant forest reduction [19].

Forest Cover in the Epoch of Civilization. Over the past 800,000 years, humans have eliminated around 50% of the world's forest area. These lands have been converted into croplands, pastures, settlements, and other uses. Several hundred years ago, global forest area was approximately 7.2 billion hectares, covering 48% of the Earth's land surface. Today, vegetation covers 12.2 billion hectares, of which 4.1 billion hectares are forests. Only 3.8 billion hectares are covered by trees, while the remainder consists of bushes, marshes, and rocky terrain. 75% of this forest loss occurred in the 20th century, during a period of global demographic explosion. Additionally, 80% of existing forests have been altered by the introduction of cultivated trees [19].

According to FAO estimates (Table 1), in 2015 forests covered 4,000 million hectares of land, or 31% of Earth's total area. Another 1,488 million hectares included sparse forests, bushes, and roadside trees, which are not officially categorized as forests. The world’s forests are home to nearly 30,000 species of trees and shrubs, along with thousands of animal and bird species.

In the early 20th century, there were about 2 hectares of forest per person. By 2015, this figure had decreased to only 0.6 hectares per person. The total biomass of living forests is 1,509 billion tons, of which 25% (377 billion tons) consists of roots, leaves, and fruits, and the remaining 1,132 billion tons is timber. Global timber reserves amount to 360 billion cubic meters, with an annual increment (productivity) of 3,200 million m^3 [10].

FAO's regular forest inventories show that forest area has been declining rapidly:

- From 1990 to 2000: 16 million hectares lost annually
- From 2000 to 2010: 13 million hectares lost annually
- From 2010 to 2015: 16.5 million hectares lost in total, or 3.3 million hectares annually

In 2016, 29.7 million hectares of forest were destroyed.

Forest destruction is increasing geometrically each year. Beyond logging, forests are lost due to land-use conversion (to agriculture, towns, roads, etc.). Natural disasters such as landslides and avalanches also destroy forests, and in many cases, tree regrowth does not occur.

According to *National Geographic*, 80,000 m^2 of green cover is damaged annually, causing not only economic losses but also human casualties. For example, forest fires in Indonesia resulted in 100,000 deaths. In 2017, about 100 people died in forest fires in California, Portugal, and Spain. Particularly devastating fires occurred in California in November 2018, where over 70 people died, 1,400 went missing, up to 100 hectares of forest were burned, and around 80,000 homes were destroyed.

It is important to note that during such fires, in addition to human casualties, a significant number of animals and other living beings that inhabit forests also perish.

Wildfires also devastate biodiversity, killing countless forest-dwelling species alongside human populations.

Table 1. Areas of the world forest and their dynamics

Region	Common area, mln ha	Forests of local species, mln ha	Forest, % from the total area	Dynamics of forest areas, mln ha		
				Change of forest area 2010 - 2015		Forest Plant Area
				Total	Annual	2015
World	3999	1277	31	- 17	- 3,0	290
Africa	624	135	23	- 14,2	- 2,4	16
Asia	593	117	19	- 3,4	0,8	129
Europe	1015	277	34	1,9	0,3	82
North America	751	320	33	0,4	0	43
South America	842	400	49	- 10,1	- 2	15
Oceania	174	27	23	1,5	0,3	4

In addition, fires cause excretion of excessive carbon in the atmosphere, which negatively affects water quality, forest structure, and biodiversity.

With the destruction of forest from the beginning of XXI century, forest cover will be increased by artificial forest (3,3 million hectares) or naturally restored forest (27 million ha a year). From 2000 to 2010, forest area in Asia grew by 2,2 million ha, mainly due to the intensive cultivation of forest in China. Forest areas in Europe have grown annually by 700 thousand ha.

Forest Cover of Georgia

Forest Layout and Composition. Georgia is located in the southwestern Caucasus, where the climate and landscapes are diverse: from wet sea subtropics in the west, to steppe-continental in the south, and constant snow and glaciers in the highlands of the north. Mountain slopes in Georgia were historically covered with dense forests, which produced many varieties of fruits and hosted numerous species of animals and birds. For this reason, Georgian peasants relied on the forest for sustenance, protection, and livelihood. Thus, the forest industry was established early on in Georgia.

Forest cover begins at the seashore and extends up to 2100–2200 meters, and in some cases, up to 2500 meters above sea level. In 2010, Georgia's total forest fund amounted to 3,007.6 thousand hectares, representing 43.2% of the country's territory, though it is distributed unevenly: 58% in the west and 42% in the east. About 73% of forests are located at elevations above 1,000 meters, and more than 80% are spread over slopes steeper than 20°. Of the state forest fund, 2,770 thousand hectares are covered with forests, and 86 protected areas encompass 600 thousand hectares [20].

Georgia's forests include coniferous and deciduous, evergreen and deciduous trees, shrubs, giant trees (up to 60 meters tall and 2 meters in diameter), lianas, parasitic plants, mushrooms, fruits, berries, and plants used for medicinal and technical raw materials. Many relic and endemic plant species are found here. Of the 400 types of woody plants, 61 are native to Georgia, and 43 are endemic to the Caucasus. In the forest composition, conifers account for 16%, hardwood deciduous trees 68%, softwood deciduous trees 7%, and other species 10%. Notable species include the giant Caucasian fir (70 m tall and 2.5 m in diameter) and the eastern beech (50 m tall and 2 m in diameter), which are considered extraordinary for the temperate climate zone. Chestnut, oak, maple, zelkova, walnut, box-tree, and other valuable timber species are also prominent [21].

In the high mountain valleys and hard-to-reach gorges, untouched forests (566 thousand hectares) still remain. According to World Bank experts, there are few countries in Europe where natural landscapes of such unique beauty are so seamlessly complemented by ancient cultural landscapes. It is noteworthy that Georgia's forests serve as a refuge for pre-Ice Age flora and fauna relic species that link us to ancient geological epochs. The loss of these forests would be a great tragedy not only for Georgia but for all of humanity.

Forest Resource Potential of Georgia. Forest resources are very important in terms of the average forest characteristics: age 98 years, height 22 m, diameter 36 cm, Bonita III, frequency 0.54. Timber supplies 1 176 m^3 per hectare, ripe and overripe copse 244 m^3, coniferous 288 m^3. Forest's total timber reserves are more than 535 million m^3. But, 66% of reserves are in the unattainable zone, where the slope incline is greater than 25 °C [22].

In addition to timber, more than 150 forest plant species produce fruits, berries, nuts, and other resources, the utilization of which could make a significant contribution to economic development. More than 110 plant species are used in medicine. Two-thirds of Georgia's 48 medicinal and 200 recreational resorts are located in or surrounded by forests. Their existence in the forest is also aesthetically justified. As a result, ecotourism and resort-recreational farming are well developed in Georgia. Furthermore, the potential for hunting tourism in Georgian forests is also considerable.

Results of Anthropogenic Impact on Forests

No one disputes the great importance of green forest cover, but the proper attention it deserves is still lacking. The main reason is the enormous increase in demand for forest resources due to population growth and technological advancement. As a result, the extraction and use of forest resources worldwide increase annually. Such an approach leads to forest destruction, particularly in tropical and coniferous (taiga) regions. It is noteworthy that forest exploitation has not only affected vegetation but also led to the reduction of unique species of animals and birds.

The consequences are particularly severe in mountainous areas, where deforestation alters river water regimes, increases catastrophic floods and torrents, and intensifies erosive and landslide processes, soil and rock erosion, and the evolution of snow and glaciers [23].

In addition, trees are often cut not only in forest coppices but also in urban areas and planting strips. This results in a decrease in oxygen production and the loss of water retention and catchment functions, causing the drying up of springs, rivers, and lakes. Areas that are no longer forest-covered begin to desertify, which is accompanied by a decline in food production [24].

Thus, the reduced green cover can no longer effectively absorb and regulate solar thermal energy. This leads to an increase in atmospheric carbon dioxide and intensifies climate warming. Consequently, ecological disasters become more frequent, resulting not only in environmental destruction but also in the loss of human and animal lives.

The accumulated excess of harmful gases resulting from anthropogenic activities returns to Earth in the form of acid rain and radioactive compounds. Sources of acid precipitation (rain, snow, fog) include the burning of fuel and biomass, metallurgy, motor transport, and other industrial activities. Over the past 100 years, the acidity of precipitation has increased significantly.

Acid precipitation negatively affects ecosystems, as such water harms fish eggs and phytoplankton, thereby reducing aquatic species in reservoirs. Additionally, acid rain causes corrosion of machinery, buildings, and cultural artifacts. Plants are also affected, exhibiting leaf loss and root rot. In the 1990s, damaged forest areas reached 50% in Germany and the Netherlands, 35% in Switzerland, 30% in Austria, and 600,000 hectares in Russia [4].

Thus, the cosmic ecological function of forests is being weakened. It is estimated that the cosmic environmental value provided by forest green cover exceeds the material revenue from forest resource use by 3 to 5 times.

Conclusions and Recommendations

The forest is a complex ecosystem of trees, plants, and living organisms, which, along with water, air, and soil, guarantees the preservation of the cosmic, ecological, economic, and sustainable environment of the Earth's biosphere. The forest absorbs carbon dioxide and releases large amounts of oxygen, and it regulates the microclimate (humidity, temperature, and wind). It is a powerful filter for purifying air and water from harmful impurities and is characterized by antimicrobial, ionizing, and sterilizing properties. By doing so, it creates a healthy and friendly environment that benefits humans and other living organisms. Forests also provide various types of food and medicinal products. Therefore, the forest is a crucial factor in improving environmental sanitation and hygiene conditions with a broad spectrum of biodiversity, earning it the name "green lungs."

In addition, forests protect agricultural lands and populated areas from strong winds. They are also a key factor in regulating water resources, improving groundwater quality, and increasing water retention. In mountainous areas, forests protect communities, roads, and farmlands from floods, mudflows, erosion, landslides, and avalanches. Forests also contribute to increasing agricultural yields.

Forests are of great importance in agriculture, not only for their protective role but also as a source of raw timber, which is used in various industries. With the increase in population and farming activities, the demand for timber continues to grow. As a result, forests are being cut down, and forest areas are reduced by 0.3% annually worldwide. In the last decade, approximately 25,000 plant species and over a thousand animal species have become extinct. This has been caused not only by technological development but also by an exploitative approach toward forests. A portion of society sees nature as a resource to be used for profit even at the cost of environmental degradation. Such attitudes are causing the destruction of forests.

In addition to logging and disease, forests are also damaged by fires, which have become increasingly frequent in various countries due to human negligence and climate warming. It is important to note that fire prevention is much more cost-effective than dealing with the aftermath yet this principle is often neglected. As a result of these factors, the world's diminishing green cover is no longer able to regulate solar thermal energy. Consequently, atmospheric oxygen levels decrease, carbon dioxide levels rise, and the climate heats up rapidly.

According to expert assessments, global warming will continue throughout the 21st century, and Earth's temperature may rise by 2–4°C, which would cause severe damage to ecosystems and the economies of many countries. Thus, while technological progress improves human well-being on one hand, it threatens the future on the other. The processes of self-purification, self-regulation, and self-restoration are weakening not only in individual ecosystems but on a planetary scale.

Today, protecting nature and using its resources rationally is a matter of vital human importance. It is a necessary precondition for the existence of the biosphere. Therefore, all countries must prioritize the protection and expansion of forest cover. The population and local administrations in every settlement must take responsibility for the care and restoration of their forests. Beneficial plant varieties should be selected for reforestation, and selective cuts should be limited to the annual growth increment to ensure natural regeneration. Protective forest strips should be planted in agricultural fields to increase yields. To ensure the rational use of forest resources, production and processing must be conducted using complex, non-waste technologies.

To protect forest biodiversity in the long term, a system of biomonitoring should be established, along with timely forest restoration and effective management. It is necessary to develop long-term programs for the sustainable use of forest resources, aiming to improve both forest productivity and qualitative composition. The comprehensive use of timber including the introduction of advanced processing techniques and non-waste technologies and the creation of protected areas are crucial for preserving biological and landscape diversity.

Finally, public awareness about nature and its rational use must be raised. Proper education and the fostering of a love for nature among young people can help save the biosphere and the natural environment, ultimately contributing to global ecological balance and economic prosperity.

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ტყის საფარი - მთავარი მცველი კლიმატის ცვლილებისა და ბიოსფეროს უსაფრთხოებისა

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რეზიუმე

ჩვენს პლანეტაზე მიმდინარე კლიმატის დათბობით გაიზარდა კატასტროფული სტიქიური მოვლენები, რამაც გამოიწვია დიდი ნგრევა და მსხვერპლი. XXI საუკუნეში მოსალოდნელია

კვლავ ტემპერატურის მომატება, რაც უფრო გააქტიურებს ყინულების დნობას, მსოფლიო ოკეანის დონის მკვეთრ აწევას და სანაპიროების დატბორვას. შემცირდება მტკნარი წყლის რესურსები და მოსავლიანობა. გაიზრდება გაუდაბნოება და სხვა ნეგატიური პროცესები. კლიმატის რეგულირების, ჟანგბადის ბალანსის სტაბილიზაციისა და ბიომრავალფეროვნების შენარჩუნების მიზნით, განსაკუთრებული მნიშვნელობა აქვს ტყის საფარს. მაგრამ სადღეისოდ დედამიწაზე ტყეთა ფართობების დაკავება, ხეთა ჭრები და ხანძრები იწვევს ფოტოსინთეზის პროცესის შემცირებას და შედეგად მზის სხივების ჭარბი თბური ენერგია ხდება მიზეზი გლობალური დათბობისა, ჟანგბადის შემცირების, ახალი ვირუსული ბაქტერიული და ქრონიკული დაავადებების გაჩენისა. სადღეისოდ, კლიმატის ცვლილების პროცესის შესარბილებლად, ბიოსფეროსა და გარემოს უსაფრთხოების მიზნით მსოფლიოს ყველა ქვეყანაში განსაკუთრებული ყურადღება უნდა მიექცეს ტყის საფრის დაცვასა და გაფართოებას. ყველამ უნდა იზრუნოს ტყის განახლებაზე და გაშენებაზე. სასოფლო-სამეურნეო მინდვრებში კი, უნდა გაშენდეს ქარსაცავი ტყის ზოლები, რაც ხელს შეუწყობს მოსავლიანობის გაზრდას.

საკვანძო სიტყვები: გაუდაბნოება, გლობალური დათბობა, მოსავალი, მტკნარი წყალი

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Резюме

На нашей планете из-за текущего потепления климата, увеличились катастрофические стихийные явления, которые вызвали большие разрушения и жертвы. В XXI веке ожидается опять увеличение температуры, что вызовет активизацию таяния ледников, резкое повышение уровня океана и затопление побережья. Уменьшатся ресурсы пресных вод и урожайности, увеличится опустынивание и другие негативные процессы. Для регулирования климата и в целях сохранения стабильности кислородного баланса и биоразнообразия, особенное значение имеет лесной покров. Но, на сегодняшний день на Земле освоение лесных площадей, вырубка лесов и пожары, вызывают уменьшение процесса фотосинтеза и в результате, насыщенная тепловая энергия солнечных лучей, становится причиной глобального потепления, уменьшение кислорода, появление вирусных бактериальных и хронических заболеваний. На сегодняшний день, для смягчения процесса потепления климата, в целях безопасности биосферы и окружающей среды во всех странах, особенное внимание следует уделить на защиту и расширения лесного покрова. Все должны заботиться об обновлении и разведении леса. На сельскохозяйственных полях нужно развести ветрозащитные лесные полосы, что будет способствовать увеличению урожайности.

Ключевые слова: глобальное потепление, опустынивание, пресная вода, урожайность