Simonyan G.S., Sarsekova D.N.

Analysis of ecological state of wood and shrub vegetation in Armenia and Kazakhstan by the Armenian index of environmental quality

Monograph

ISBN 978-5-4480-0506-0

9 785448 005060

Tambov
2024

ukonf.com/mon

Simonyan G.S., Sarsekova D.N.
Analysis of ecological state of wood and shrub vegetation in Armenia and Kazakhstan by the Armenian index of environmental quality: Monograph. Ijevan Branch of Yerevan State University and Kazakh National Agrarian Research University. Tambov: Ukonf Publisher, 2024. 60 p.

ISBN 978-5-4480-0506-0

https://ukonf.com/doc/mon.2024.05.01.pdf

Reviewers:
Margaryan Liana Armenovna, Doctor of Technical Sciences, Associate Professor, Senior researcher, Yerevan State University, Yerevan, Armenia

The Autors:
Simonyan Gevorg Sarkisovich, Ph.D. (Chemistry), Associate Professor, Head of the Department, Ijevan branch of Yerevan State University, Ijevan, Armenia
Sarsekova Dani Nurgisaevna, Doctor of Agricultural Sciences, Professor, Dean of the Faculty, Kazakh National Agrarian Research University, Almaty, Kazakhstan

The monograph is devoted to the creation of models and comprehensive assessment and prediction of the quality of trees and forests. The monograph concludes ten years of joint research by the authors in the fields of forestry, dendrology, environment and geoecology. The monograph contains information about the history, language, geography, population, climate, forests, flora and fauna of the republics of Armenia and Kazakhstan. The diversity indices existing in science are analyzed and the features of the Geo-Ecological Evolving Organized (GEVORG) and Armenian index of environmental quality (AREQ) developed in Armenia are given. The monograph is intended for specialists, graduate students and students in the fields of forestry, dendrology, landscaping, ecology and mathematical modeling

The information about published Monograph is given to the RISQ system (contract № 856-08/2013K).

Electronic version is published in the **Electronic Library** and is freely available on the website: **ukonf.com/mon**

Monograph. Text in author's edition.
Ukonf Publisher. E-mail: mon@ukonf.com
Editorial address: Russia, 392000, Tambov, P.O. Box 44.
Format 60×84/16. Printing terms: 3,75 pp. per sheet.

The monograph is dedicated to the thirtieart anniversary of the Ijevan Branch of Yerevan State University

CONTENTS

Introduction

This monograph concludes ten years of joint research by the authors in the fields of forestry, dendrology, environment, and geoecology. It is dedicated to the creation of models for the comprehensive assessment and prediction of the quality of trees and forests. The developed models enable to carefully study, evaluate and classify the actual ecological state of forests and plants, clearly assess the damage caused by anthropogenic impacts and their consequences, as well as the prediction of changes in the quality of plants.

Due to the constant increase in anthropogenic impact on nature and the reduction of the forest reserves worldwide, it is necessary to create simple, understandable and practical methods for describing and explaining the ecological state of plants, as well as predicting possible changes in the quality of forests. The monograph contains information about the history, language, geography, population, climate, forests, flora and fauna of the Republics of Armenia and Kazakhstan. The diversity indices existing in science are analyzed, and the features of the Geo-Ecological Evolving Organized (GEVORG) (G) and Armenian Index of Environmental Quality (AREQ) (A) developed in Armenia are presented.

A large scientific school of forestry and dendrology has been established in the Republic of Kazakhstan. This scientific school is well-known and respected far beyond the borders of Kazakhstan. The results of their research have been published in more than 100 in scientific journals in Kazakhstan and abroad, and have been presented at more than 30 international conferences and symposiums.

In recent years, the indices they developed have been used in Armenia to determine the quality of various bio- and ecosystems. Thus, a comprehensive assessment of the quality of surface waters and a structural analysis of the state of biological systems at the level of proteins, ribonucleic acid, and cells, as well as a structural analysis of the state of oil and trees, were carried out. The values of the GEVORG and AREQ indices indicate the extent to which chaos or order predominates in the structure of the system.

The monograph is intended for specialists, graduate students, and students in the fields of forestry, dendrology, landscaping, ecology and mathematical modeling.

Chapter 1.
Study area

1.1. Armenia [1, 2]

Armenia

The original native Armenian name for the country was Հայք (Hayk’); however, it is currently rarely used. The contemporary name Հայաստան (Hayastan) became popular in the Middle Ages with the addition of the Persian suffix-stan (place). However, the origins of the name Hayastan trace back to much earlier dates and were first attested in the 5th century in the works of Agathangelos, Faustus of Byzantium, Ghazar Parpetsi, Koryun, and Sebeos. The name has traditionally been derived from Hayk (Հայկ), the legendary patriarch of the Armenians and a great-great-grandson of Noah, who, according to the 5th-century AD author Movses Khorenatsi (Մովսես Խորենացի), defeated the Babylonian king Bel in 2492 BC and established his nation in the Ararat region. The further origin of the name is uncertain. It is also postulated that the name Hay comes from one of the two confederated, Hittite vassal states – the Ḫayaša-Azzi (1600–1200 BC).

The exonym Armenia is attested in the Old Persian Behistun Inscription (515 BC) as Armina. The Ancient Greek terms Ἀρμενία (Armenía) and Ἀρμένιοι (Arménioi, "Armenians") are first mentioned by Hecataeus of Miletus (c. 550 BC – c. 476 BC). Xenophon, a Greek general serving in some of the Persian expeditions, describes many aspects of Armenian village life and hospitality in around 401 BC. Armenia (/ɑːrˈmiːniə/ ar-MEE-nee-ə), officially the Republic of Armenia, is a landlocked country in the Armenian Highlands of West Asia. It is a part of the Caucasus region and is bordered by Turkey to the west, Georgia to the north, and Azerbaijan to the east, and Iran and the Azerbaijani exclave of Nakhchivan to the south.

Yerevan is the capital, largest city, and financial center

Armenia is a unitary, multi-party, democratic nation-state with an ancient cultural heritage. The Armenian Highlands have been home to the Hayasa-Azzi, Shupria, and Nairi. By at least 600 BC, an archaic form of Proto-Armenian, an Indo-European language, had diffused into the Armenian Highlands. The first Armenian state of Urartu was established in 860 BC, and by the 6th century BC, it was replaced by the Satrapy of Armenia. The Kingdom of Armenia reached its height under Tigranes the Great in the 1st century BC, and in the year 301 became the first state in the world to adopt Christianity as its official religion.

Figura 1. Flag and coat of arms of Armenia

Armenia still recognizes the Armenian Apostolic Church

The world's oldest national church, as the country's primary religious establishment. The ancient Armenian kingdom was split between the Byzantine and Sasanian Empires around the early 5th century. Under the Bagratuni dynasty, the Bagratid Kingdom of Armenia was restored in the 9th century before falling in 1045. Cilician Armenia, an Armenian principality and later a kingdom, was located on the coast of the Mediterranean Sea between the 11th and 14th centuries. Between the 16th and 19th centuries, the traditional Armenian homeland composed of Eastern Armenia and Western Armenia came under the rule of the Ottoman and Persian empires, repeatedly ruled by either of the two over the centuries. By the 19th century, Eastern Armenia had been conquered by the Russian Empire, while most of the western parts of the traditional Armenian homeland remained under Ottoman rule.

During World War I, up to 1.5 million Armenians living in their ancestral lands in the Ottoman Empire were systematically exterminated in the Armenian genocide. In 1918, following the Russian Revolution, all non-Russian countries declared their independence after the Russian Empire ceased to exist, leading to the establishment of the First Republic of Armenia. By 1920, the state was incorporated into the Soviet Union as the Armenian SSR. The modern Republic of Armenia became independent in 1991 during the dissolution of the Soviet Union. Armenia is a developing country and ranks 85th on the Human Development Index (2021). Its economy is primarily based on industrial output, and mineral extraction.

While Armenia is geographically located in the South Caucasus, it is generally considered geopolitically European. Since Armenia aligns itself in many respects geopolitically with Europe, the country is a member of numerous European organizations including the Organization for Security and Co-

Operation in Europe, the Council of Europe, the Eastern Partnership, Eurocontrol, the Assembly of European Regions, and the European Bank for Reconstruction and Development. Armenia is also a member of certain regional groups throughout Eurasia, including the Asian Development Bank, the Collective Security Treaty Organization, the Eurasian Economic Union, and the Eurasian Development Bank. Armenia supported the once de facto independent Republic of Artsakh (Nagorno-Karabakh), which was proclaimed in 1991 on territory internationally recognized as part of Azerbaijan, until the republic's dissolution in September 2023.

Geography

Armenia is a landlocked country in the geopolitical Transcaucasus (South Caucasus) region that is located in the Southern Caucasus Mountains and their lowlands between the Black Sea and Caspian Sea, and northeast of the Armenian Highlands. Located in West Asia, on the Armenian Highlands, it is bordered by Turkey to the west, Georgia to the north, Azerbaijan proper to the east, and Iran and Azerbaijan's exclave of Nakhchivan to the south. Armenia lies between latitudes 38° and 42° N, and longitudes 43° and 47° E. It contains two terrestrial ecoregions: Caucasus mixed forests and Eastern Anatolian montane steppe.

Topography

Armenia has a territorial area of 29,743 square kilometres. The terrain is mostly mountainous, with fast flowing rivers, and few forests. The land rises to 4,090 metres above sea level at Mount Aragats, and no point is below 390 metres above sea level. Average elevation of the country area is tenth highest in the world and it has 85.9% mountain area, more than Switzerland or Nepal. Mount Ararat, which was historically part of Armenia, is the highest mountain in the region at 5,137 meters. Now located in Turkey, but clearly visible from Armenia, it is regarded by the Armenians as a symbol of their land. Because of this, the mountain is present on the Armenian national emblem today.

Languages. Armenian-language writing

Armenians have their own distinct alphabet and language, which is the only official language. The alphabet was invented around AD 405 by Mesrop Mashtots and consists of thirty-nine letters, three of which were added during the Cilician period. The main foreign languages that Armenians know are Russian and English. Due to its Soviet past, most of the old population can speak Russian quite well. According to a 2013 survey, 95% of Armenians said they had some knowledge of Russian (24% advanced, 59% intermediate) compared to 40% who said they knew some English (4% advanced, 16% intermediate and 20% beginner). However, more adults (50%) think that

English should be taught in public secondary schools than those who prefer Russian.

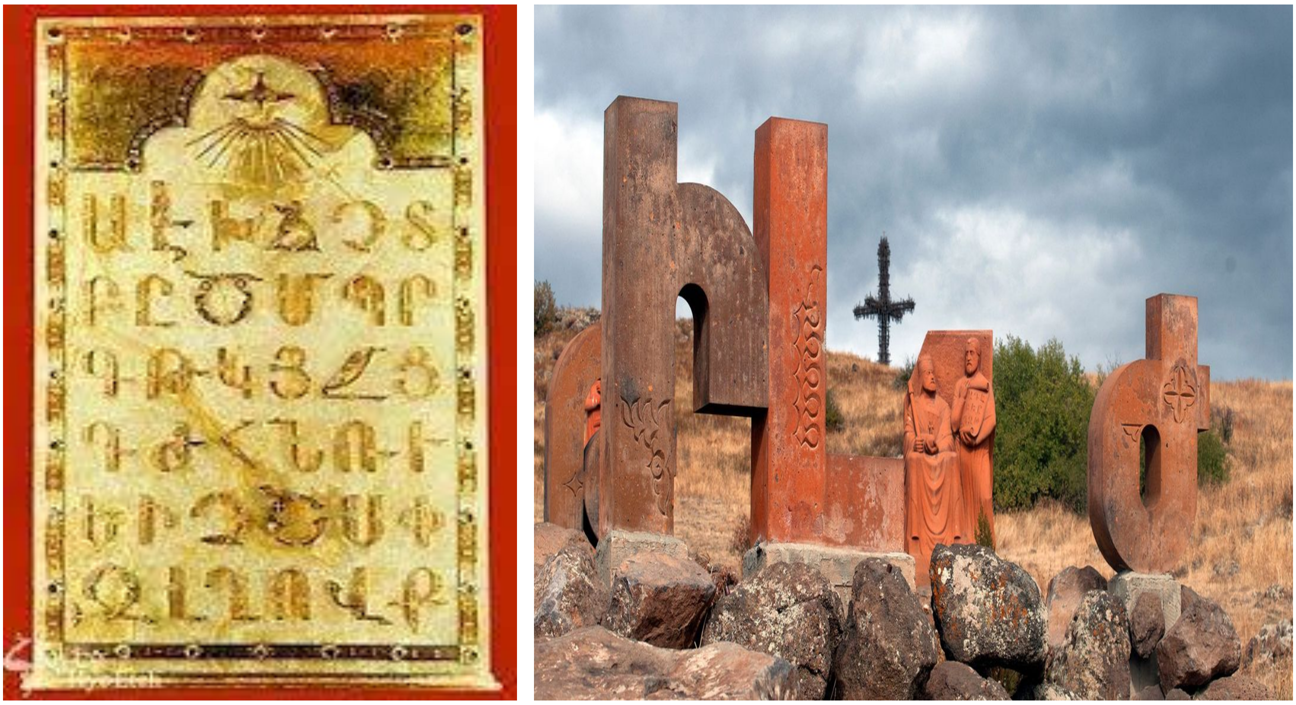

Figure 2. The Armenian Alphabet

Demographics

Armenia has a population of 2,932,731 as of and is the third most densely populated of the former Soviet republics. There has been a problem of population decline due to elevated levels of emigration after the break-up of the USSR. In the past years emigration levels have declined and some population growth is observed since 2012. The Armenian population around the world. Armenia has a relatively large external diaspora (8 million by some estimates, greatly exceeding the 3 million population of Armenia itself), with communities existing across the globe. The largest Armenian communities outside of Armenia can be found in Russia, France, Iran, the United States, Georgia, Syria, Lebanon, Australia, Canada, Greece, Cyprus, Israel, Poland, Ukraine and Brazil. 40,000 to 70,000 Armenians still live in Turkey (mostly in and around Istanbul). About 1,000 Armenians reside in the Armenian Quarter in the Old City of Jerusalem, a remnant of a once-larger community. Italy is home to the San Lazzaro degli Armeni, an island located in the Venetian Lagoon, which is completely occupied by a monastery run by the Mechitarists, an Armenian Catholic congregation.[228] Approximately 139,000 Armenians lived in the de facto independent country Republic of Artsakh where they formed a majority before 1 October 2023, when almost the entire population of the region had fled to Armenia.

Ethnic groups

Ethnic Armenians make up 98.1% of the population. Yazidis make up 1.1%, and Russians 0.5%. Other minorities include Assyrians, Ukrainians, Greeks (usually called Caucasus Greeks), Kurds, Georgians, Belarusians, and Jews. There are also smaller communities of Vlachs, Mordvins, Ossetians, Udis, and Tats. Minorities of Poles and Caucasus Germans also exist though they are heavily Russified. As of 2022, there are 31,077 Yazidis in Armenia.

Climate

Because of Armenia's position in the deep interior of the northern part of the subtropical zone, enclosed by lofty ranges, its climate is dry and continental. Regional climatic variation is nevertheless considerable. Intense sunshine occurs on many days of the year. Summer, except in high-elevation areas, is long and hot, the average June and August temperature in the plain being 25 °C; sometimes it rises to uncomfortable levels. Winter is generally not cold; the average January temperature in the plain and foothills is about – 5 °C, whereas in the mountains it drops to – 12°C. Invasions of Arctic air sometimes cause the temperature to drop sharply: the record low is – 46 °C. Winter is particularly inclement on the elevated, windswept plateaus. Autumn, long, mild, and sunny, is the most pleasant season. The ranges of the Lesser Caucasus prevent humid air masses from reaching the inner regions of Armenia. Evening breezes blowing down the mountains provide a welcome refreshing and cooling effect. Springs are short, while autumns are long. Autumns are known for their vibrant and colourful foliage. On the mountain slopes, at elevations from 4,600 to 6,600 feet, yearly rainfall approaches 800 millimetres, while the sheltered inland hollows and plains receive only 200 to 400 millimetres of rainfall a year. The climate changes with elevation, ranging from the dry subtropical and dry continental types found in the plain and in the foothills up to a height of 3,000 to 4,600 feet, to the cold type above the 6,600-foot mark. Lake Sevan, nestled up in the Armenian highlands, is the second largest lake in the world relative to its altitude, at 1,900 metres above sea level.

Soils

More than 15 soil types occur in Armenia, including light brown alluvial soils found in the Aras River plain and the Ararat Plain, poor in humus but still intensively cultivated; rich brown soils, found at higher elevations in the hill country; and chernozem (black earth) soils, which cover much of the higher steppe region. Much of Armenia's soil-formed partly by residues of volcanic lava – is rich in nitrogen, potash, and phosphates. The labor required to clear the surface stones and debris from the soil, however, has made farming in Armenia difficult.

Forests of Armenia

Armenia is considered a country where forests are scarce. Forests and forest lands cover about 11.2 % of the country area: to put it other way, 460 thousand hectares, of which 334.1 are forest-covered areas. This number incorporates about 50 thousand hectares of artificial (planted) forests. For correlation, let us indicate that the forest area of neighboring Georgia corresponds to more than 40% of the country area. Anyway, even this limited share of forests allotted us is rich in characteristic species composition. In the glacial era, hydrophilic and water-loving species of forests were ultimately eliminated, and lush subtropical forests gave place to broad-leaved forests with predominance of beech, oak and other species. Presently, the main species composing forests in Armenia are beech, oak, hornbeam and pine. There are also many rare species that grow in limited areas and are considered the oldest flora representatives. These are the taxus, the common ivy, the wild jasmine, the oriental platan, the Caucasian elm, the clematis and other. There is a commonplace saying that "forests are our planet's lungs" and the main suppliers of oxygen; hence, conservation of forests and their biodiversity represents one of environmental problems that are of paramount importance for all countries of the world.

The forests in the Republic of Armenia, regardless their ownership category, are classified into protected, special and commercial types according to their designated use. Average indicator of land productivity in Armenia is 3.6 bonitet (soil productivity indicator in the forests expressed by growth, height, integrity, composition, type of the trees (seed, vegitative). Forest land productivity is also defined by average height of trees at certain age. The forest lands in Armenia are unevenly distributed, 62 % of the forests are located in the northeast, 36% in the southeast and only 2% in the central part of Armenia. The forest lands of Armenia are characterized by rich natural resources and biodiversity. In these lands 274 types of native trees and shrubs can be found out of which 25 are endemic and 31relict species.

The main forest species are beech, oak, eastern hornbeam, pine. These 4 species occupy 89.1% of forest lands and constitute 97.2 % of forest resources. Subordinate (secondary) or accompanied species in the forests of Armenia are represented by maple, lime, birch, elm, ash-tree and other species. As compared with main forest composing species their productivity is 36 % less. The "open forests" are mainly represented by thin juniper forests with 0.3-0.4 of integrity, i.e. free surfaces are prevailing. The prevalence of forests in the mountain zones of Armenia are as follows: Sub mountain forests (lowland forest zone) – located on 550-1100 m elevations and represented by low-productive oak forest communities, Middle forest zone – located on 1100-1700 m elevations, bare-floor beech forests occur in north mountain slopes and oak forests in south mountain slopes, Upland forest zone – located on 1700-2400m (2500m) elevations, consists of oak and beech low integrity and low-productive forests with low indicators of natural reproduction.

Plant and animal life

The broken relief of Armenia, together with the fact that its highland lies at the junction of various biogeographic regions, has produced a great variety of landscapes. Though a small country, Armenia boasts more plant species (in excess of 3,000) than the vast Russian Plain. There are five altitudinal vegetation zones: semidesert, steppe, forest, alpine meadow, and high-elevation tundra. The semidesert landscape, ascending to an elevation of 4,300 to 4,600 feet, consists of a slightly rolling plain covered with scanty vegetation, mostly sagebrush. The vegetation includes drought-resisting plants such as juniper, sloe, dog rose, and honeysuckle. The boar, wildcat, jackal, adder, gurza (a venomous snake), scorpion, and, more rarely, the leopard inhabit this region. Steppes predominate in Armenia. They start at elevations of 4,300 to 4,600 feet, and in the northeast they ascend to 6,200 to 6,600 feet. In the central region they reach 6,600 to 7,200 feet and in the south are found as high as 7,900 to 8,200 feet. In the lower elevations the steppes are covered with drought-resistant grasses, while the mountain slopes are overgrown with thorny bushes and juniper.

Figure 3. Sarigyugh plantain

The forest zone lies in the southeast of Armenia, at elevations of 6,200 to 6,600 feet, where the humidity is considerable, and also in the northeast, at elevations of 7,200 to 7,900 feet. Occupying nearly one-tenth of Armenia, the northeastern forests are largely beech. Oak forests predominate in the southeastern regions, where the climate is drier, and in the lower part of the forest zone hackberry, pistachio, honeysuckle, and dogwood grow. The animal kingdom is represented by the Syrian bear, wildcat, lynx, and squirrel. Birds-woodcock, robin, warbler, titmouse, and woodpecker – are numerous. The alpine zone lies above 6,600 feet, with stunted grass providing good summer pastures. The fauna is rich; the abundant birdlife includes the mountain turkey, horned lark, and bearded vulture, while the mountains also harbour the bezoar goat and the mountain sheep, or mouflon. Finally, the alpine tundra, with its scant cushion plants, covers only limited mountain areas and solitary peaks.

Ijevan Branch of Yerevan State University [3]

The Ijevan branch of YSU is located on the banks of the Aghstev River and is located in the city of Ijevan, Tavush region. Green spaces are located near the central building of the university. More than 20 species of trees and shrubs grow in the green areas of the IB YSU.

Figure 4. Ijevan Branch of Yerevan State University

Dilijan National Park [4]

Dilijan National Park (Armenian: Դիլիջան ազգային պարկ, romanized: Dilijan National park) is one of the four national parks of Armenia. Occupying an area of 240 km^2, it is located in the north-eastern Tavush Province of Armenia [1]. It is known for its forest landscapes, rich biodiversity, medicinal mineral water springs, natural and cultural monuments, and extensive network of hiking trails.

Dilijan National Park was established in 2002 on the basis of the state nature reserve, which in its turn was established in 1958 on the basis of the former Dilijan and Kuybishev forest enterprises. The territory of the newly established national park has stayed unchanged. The national park stretches over the slopes of the Pambak, Areguni, Miapor, Ijevan (Kaeni) and Halab mountain ranges at the altitude of 1070–2300 m above sea level. The mountain meadows above this altitudes do not belong to the national park. The River Aghstev and its main tributaries – the Rivers Hovajur, Shtoghanajur, Bldan, Haghartsin and Getik run through the national park. There are Parz Lich (Clear Lake), Goshi Lich (Gosh Lake) and Tzrkalich (Leech Lake) as well as other minor lakes. The flora of Dilijan National Park includes 902 species of vascular plants, namely Lycopodium (1 species), Horse-tails (1), Ferns (12), Gymnosperms (7) and Angiosperms (881) [2]. About 40 rare species of plants occur in this territory. 29 species of the flora are registered in the Red Book of Endangered Species of Armenia and 4 in the Red Data Book of the USSR.

Figure 5. Dilijan National Park

The vegetation of the national park is of mesophilous Caucasian type mainly represented by forest associations. It mainly consists of deciduous species such as oak (Quercus iberica, Q. macranthera), oriental beech (Fagus orientalis), common and oriental hornbeam (Carpinus betulus, C. orientalis), which form homogeneous oak, beech and hornbeam forests as well as mixed forests with different combinations of the species mentioned. Georgian oak (Q. iberica) forests occur on the southern slopes of the middle forest zone and oriental beech forests on the northern slopes. In the upper zone forest consists of Q. macranthera.

Figure 6. Goshavank Monastery

Hornbeam occurs mainly in mixed forests. Oriental hornbeam reaches up to 1500 m above sea level, while common hornbeam spreading all over the forest zone up to 2000 m. Different species of lime (Tilia), maple (Acer) and ash (Fraxinus) grow in the middle forest zone and especially the upper limit of higher forest zone. Coniferous forests (pine – Pinus, juniper – Juniperus and yew – Taxus) occupy a limited territory in the national park and occur in patches. Pine often makes dense forests in the basin of the River Hovajur on the slopes of the Areguni and Pambak ranges in the vicinity of serpentine Dilijan highway. There are many pine trees in Dilijan and on nearby slopes. The forests in the national park are rich in fruit trees and bushes such as oriental apple – Malus orientalis, walnut – Juglans regia, cornel – Cornus mas, plum – Prunus spp., blackthorn – Prunus spinosa, pear – Pyrus communis subsp. caucasica, gooseberry – Grossularia reclinata (Ribes reclinatum), medlar – Mespilus germanica, common hazelnut – Corylus avellana (see also Hazelnut Reservation), various species of Blackcurrant – Ribes spp., and hawthorn – Crataegus spp. Many species occurring in the national park are well known as medicinal plants (Saint John's wort – Hypericum spp., mint – Mentha, thyme – Thymus, ziziphora – Ziziphora, etc.), edible plants (sorrel – Rumex, falcaria – Falcaria, cow parsnip – Heracleum, etc.), forage (clover – Trifolium, sainfoin – Onobrychis, sea-holly – Eryngi

Ijevan Subtropical Arboretum [5]

Ijevan Dendropark also known as Ijevan Subtropical Arboretum is an arboretum located in Ijevan, Tavush Province, Armenia. Located 630-650 m above sea level, on the right bank of Aghstev river, it was founded in 1962 by Mushegh Aghinyan, Griror Adamyants and Lyudvig Sayadyan.

Figure 7. Ijevan Dendropark

The plant collection includes over 625 species and varieties. The arboretum consists of two zones: the Ijevo arboretum 8.5 hectares and the pitoma zone 6.0 ha. In the arboretum were tested 1000 species of trees and shrubs from introduced from the areas of many countries in the world. In the arboretum there are 640 species of trees and shrubs.

1.2. Kazakhstan [6-9]

Kazakhstan

The English word Kazakh, meaning a member of the Kazakh people, derives from Russian: казах. The native name is Kazakh: қазақ, romanized: qazaq. It might originate from the Turkic word verb qaz-, 'to wander', reflecting the Kazakhs' nomadic culture. The term 'Cossack' is of the same origin. In Turko-Persian sources, the term Özbek-Qazaq first appeared during the mid-16th century, in the Tarikh-i-Rashidi by Mirza Muhammad Haidar Dughlat, a Chagatayid prince of Kashmir, which locates Kazakh in the eastern part of Desht-i Qipchaq. According to Vasily Bartold, the Kazakhs likely began using that name during the 15th Century.

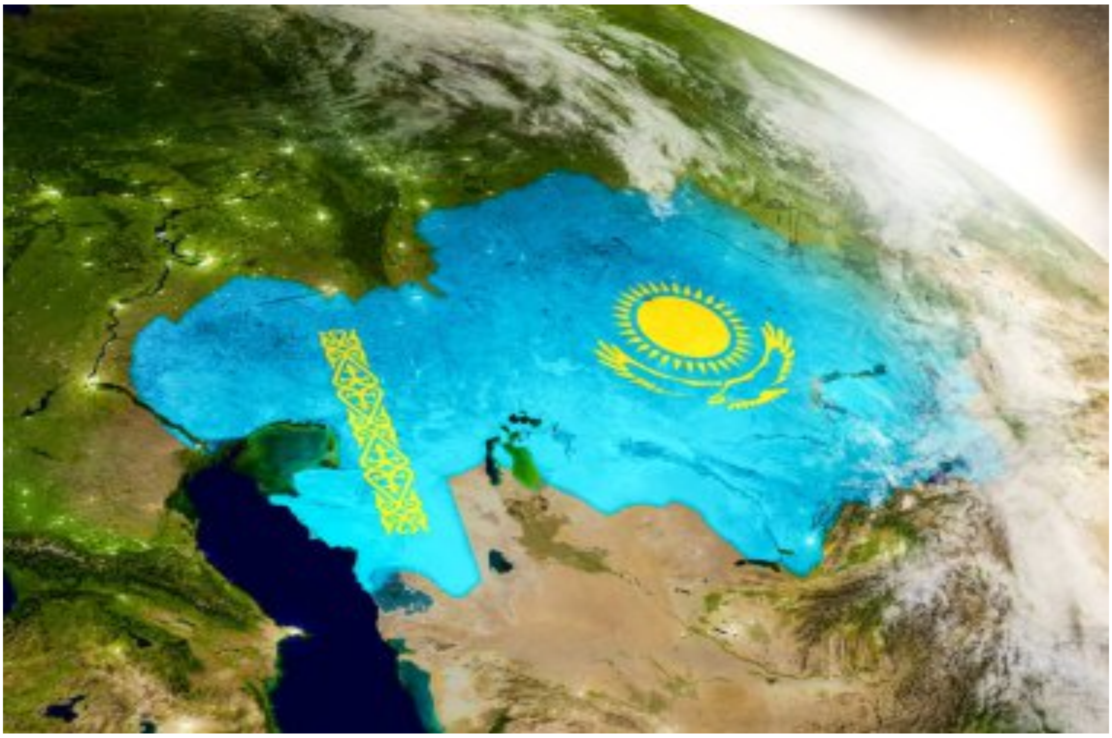

Figure 8. Flag of Kazakhstan on planet surface from space

Kazakhstan, officially the Republic of Kazakhstan, is a landlocked country mostly in Central Asia, with a part in Eastern Europe. It borders Russia to the north and west, China to the east, Kyrgyzstan to the southeast, Uzbekistan to the south, and Turkmenistan to the southwest, with a coastline along the Caspian Sea. *Its capital is Astana,* while the largest city and leading cultural and commercial hub is Almaty. Kazakhstan is the world's ninth-largest country by land area and the largest landlocked country. It has a population of 20 million and one of the lowest population densities in the world, at fewer than 6 people per square kilometre (16 people/sq mi). Ethnic Kazakhs constitute a majority, while ethnic Russians form a significant minority. *Officially secular, Kazakhstan is a Muslim-majority country, although ethnic Russians in the country form a sizeable Christian community.*

Kazakhstan has been inhabited since the Paleolithic era. In antiquity, various nomadic Iranian peoples such as the Saka, Massagetae, and Scythians dominated the territory, with the Achaemenid Persian Empire expanding towards the southern region. Turkic nomads entered the region from as early as the sixth century. In the 13th century, the area was subjugated by the Mongol Empire under Genghis Khan. Following the disintegration of the Golden Horde in the 15th century, the Kazakh Khanate was established over an area roughly corresponding with modern Kazakhstan. By the 18th century, the Kazakh Khanate had fragmented into three jüz (tribal divisions), which were gradually absorbed and conquered by the Russian Empire; by the mid-19th century, all of Kazakhstan was nominally under Russian rule. Following the 1917 Russian Revolution and subsequent Russian Civil War, the territory was reorganized several times. In 1936, its modern borders were established with the formation of the Kazakh Soviet Socialist Republic within the Soviet Union. Kazakhstan was the last Soviet republic to declare independence during the dissolution of the Soviet Union from 1988 to 1991.

Geography

As it extends across both sides of the Ural River, considered the dividing line separating Europe and Asia. With an area of 2,700,000 square km – equivalent in size to Western Europe – Kazakhstan is the ninth-largest country and largest landlocked country in the world. While it was part of the Russian Empire, Kazakhstan lost some of its territory to China's Xinjiang province, and some to Uzbekistan's Karakalpakstan autonomous republic during Soviet years.It shares borders of 6,846 km with Russia, 2,203 km with Uzbekistan, 1,533 km with China, 1,051 km with Kyrgyzstan, and 379 km with Turkmenistan. Major cities include Astana, Almaty, Qarağandy, Şymkent, Atyrau, and Öskemen. It lies between latitudes 40° and 56° N, and longitudes 46° and 88° E. While located primarily in Asia, a small portion of Kazakhstan is also located west of the Urals in Eastern Europe.Kazakhstan's terrain extends west to east from the Caspian Sea to the Altay Mountains and north to south from the plains of Western Siberia to the oases and deserts of Central Asia. The Kazakh Steppe (plain), with an area of around 804,500 square km, occupies one-third of the country and is the world's largest dry steppe region.

Topography

There is considerable topographical variation within Kazakhstan. The highest point is the top of the mountain Khan Tengri, on the Kyrgyz border in the Tian Shan range, with an elevation of 7,010 m above sea level; the lowest point is the bottom of the Karagiye depression at 132 m below sea level, in the Mangystau province east of the Caspian Sea. Most of the country lies at between 200–300 m above sea level, but Kazakhstan's Caspian shore includes some of the lowest elevations on Earth. The peak Khan Tengri in the Tian Shan Mountains (and on the border with Kyrgyzstan and China) is Kazakhstan highest elevation at 6,995 m (7,010 m with ice cap). Many of the peaks of the Altay and Tien Shan ranges are covered with snow, year-round, and their runoff is the source for most of Kazakhstan's freshwater rivers, streams, and lakes. Kazakhstan's Almaty region is also home to the Mynzhylky mountain plateau. Some 9.4% of Kazakhstan's land is mixed prairie and forest or treeless prairie, primarily in the north or in the basin of the Ural River in the west. More than three-quarters of the country, including the entire west and most of the south, is either semidesert (33.2%) or desert (44%). The terrain in these regions is bare, eroded, broken uplands (Upland and lowland), with sand dunes in the Qizilqum ("The Red Sands"; in the Russian form, Kyzylkum), Moyunqum (in the Russian form, Muyunkum) and Barsuki deserts, which occupy south-central Kazakhstan.

Languages

Kazakhstan is officially a bilingual country. Kazakh (part of the Kipchak sub-branch of the Turkic languages) is spoken natively by 64.4% of the population and has the status of "state language". Russian is spoken by most Kazakhs, has equal status to Kazakh as an "official language", and is used routinely in business, government, and inter-ethnic communication.The government announced in January 2015 that the Latin alphabet will replace Cyrillic as the writing system for the Kazakh language by 2025. Other minority languages spoken in Kazakhstan include Uzbek, Ukrainian, Uyghur, Kyrgyz, Tatar, and German. English, as well as Turkish, have gained popularity among younger people since the collapse of the Soviet Union. Education across Kazakhstan is conducted in either Kazakh, Russian, or both.

Demographics

The US Census Bureau International Database lists the population of Kazakhstan as 18.9 million (May 2019), while United Nations sources such as the 2022 revision of the World Population Prospects give an estimate of 19,196,465. Official estimates put the population of Kazakhstan at 20 million as of November 2023. In 2013, Kazakhstan's population rose to 17,280,000 with a 1.7% growth rate over the past year according to the Kazakhstan

Statistics Agency. The 2009 population estimate is 6.8% higher than the population reported in the last census from January 1999. The decline in population that began after 1989 has been arrested and possibly reversed. Men and women make up 48.3 and 51.7% of the population, respectively.

Ethnic groups

As of 2024, ethnic Kazakhs are 71% of the population and ethnic Russians are 14.9 percent.Other groups include Tatars (1.1%), Ukrainians (1.9%), Uzbeks (3.3%), Germans (1.1%), Uyghurs (1.5%), Azerbaijanis, Dungans, Turks, Koreans, Armeniansб Poles, and Lithuanians. In 1989, ethnic Russians were 37.8% of the population and Kazakhs held a majority in only 7 of the 20 regions of the country. Before 1991 there were about one million Germans in Kazakhstan, mostly descendants of the Volga Germans deported to Kazakhstan during World War II. After the dissolution of the Soviet Union, most of them emigrated to Germany. Most members of the smaller Pontian Greek minority have emigrated to Greece. In the late 1930s thousands of Koreans in the Soviet Union were deported to Central Asia.These people are now known as Koryo-saram. The 1990s were marked by the emigration of many of the country's Russians, Ukrainians and Volga Germans, a process that began in the 1970s. This has made indigenous Kazakhs the largest ethnic group. Additional factors in the increase in the Kazakhstani population are higher birthrates and immigration of ethnic Kazakhs from China, Mongolia, and Russia.

Climate

Kazakhstan has an "extreme" continental and cold steppe climate, and sits solidly inside the Eurasian steppe, featuring the Kazakh steppe, with hot summers and very cold winters. Indeed, Astana is the second coldest capital city in the world after Ulaanbaatar. Precipitation varies between arid and semi-arid conditions, the winter being particularly dry.

In summer the temperatures average more than 30 °C and in winter average – 9 °C. Aktau and the Caspian Sea shore on the country's west having a distinct cold desert climate and cold semi-arid climate, while Petropavl features a climate typical to the rest of the country; an extreme variation of the humid continental climate known for its uneven rainfall distribution and drastic temperature ranges between seasons. Despite the nation's relatively low precipitation rates and mostly arid geography, spring floods brought on by occasional heavy rainfall and snowmelt are not unusual in the northern and central.

Agriculture

Agriculture accounts for approximately 5% of Kazakhstan's GDP. Grain, potatoes, grapes, vegetables, melons and livestock are the most important agricultural commodities. Agricultural land occupies more than 846,000 square km (327,000 sq mi). The available agricultural land consists of 205,000 square km (79,000 sq mi) of arable land and 611,000 square km (236,000 sq mi) of pasture and hay land. Over 80% of the country's total area is classified as agricultural land, including almost 70% occupied by pasture. Its arable land has the second highest availability per inhabitant (1.5 ha). Chief livestock products are dairy products, leather, meat, and wool. The country's major crops include wheat, barley, cotton, and rice. Wheat exports, a major source of hard currency, rank among the leading commodities in Kazakhstan's export trade. Some Kazakh wine is produced in the mountains to the east of Almaty.

Forests in Kazakhstan

Kazakhstan is a country with a low percentage of forest cover. According to the Forestry and Wildlife Committee of the Ministry of Ecology, Geology and Natural Resources, in January 2022, forests covered 5 % of the country's territory and their area is 13.6 million ha. Kazakhstan's forests play an important role in land, wildlife, and watershed management, wind erosion and sand control, and recreation. Area-wise, about 70% of all wooded lands is located in the south and southeast – mostly saxaul scrub forests that are important for fuelwood production, stabilize the vegetation, and provide shade for animal grazing.

Figure 9. Summer green mountain landscape in Kazakhstan Almaty, nature, forest and sky

The high mountain forests of the southeast and east (20% of the area) have exceptionally high biodiversity, and recreational values, as well as nut and fruit production. The forests play a key role in watershed protection. Birch and pine stands of the northern forest-steppe fragmented amidst highly productive farmland serve as a major source of fuelwood and are important for wildlife and recreation. The west and center of the country are extremely arid and fundamentally devoid of forests.

Volume-wise, over 80% of the nation's timber stock is in the north and northeast, half of it in the fir and pine forests of the East Kazakhstan Oblast where the bulk of the country's commercial-scale harvesting is concentrated.All forests in the Republic of Kazakhstan are protected. All forests have been established under long-term management plans and they perform important water-protective, field-and soil conservation, sanitation, health, and other useful functions. About 10% of all forests in Kazakhstan were created, by the forestry authorities during Soviet times, for protection against wind erosion and sand drifts. In this regard, the forest fund category "field and forest conservation" dominates and makes 9.8 million ha or 79% of the total wooded area. Coverage by protected areas of important sites for mountain biodiversity is 20% in 2020. 100% of Kazakhstan's forests are publicly owned. 79.2% of the lands of the forest fund are administered by the regional authorities (Akimats of administrative regions), 20.1% are in the conduct of the national forestry committee and 0.7% are owned by other national agencies. The State Forest fund lands include land covered with forest and land which is not forested but designed for the needs of the forestry sector. Overall, forests managed by state forest agencies account for 22.

Plant and animal life

The flora of Kazakhstan includes 68 species of tree species, 266 species of shrubs, 433 species of semi-shrubs and semi-grasses, 2,598 species of perennial grasses, and 849 species of annual grasses. About 500 species are endemics. This means that they can be found only in Kazakhstan, and only in limited areas. For example, here grows a tree-bush Haloxylon, specific to the Central Asian deserts, the wood of which is so dense that it sinks in water; an amazing creation of nature – Greig tulip (lat. Túlipa gréigii), petals which reach 12-15 cm, the famous blue Tien Shan firs, the wild Sivers apple tree (Málus sievérsii), which is considered the progenitor of all modern apple varieties. The landscape of Kazakhstan is mostly steppes, semi-deserts, and deserts. But some northern regions of Kazakhstan belong to the forest-steppe zone to a greater extent, and Kazakhstan's Altai is generally covered with real taiga forests. Forests, including Haloxylon forests, occupy only about 4.2% of the territory of Kazakhstan. These are birch and aspen forests of the northern regions, island forests of the northwest and the right bank of the Irtysh, pine forests of the Kazakh shallow ground, mixed and coniferous forests of Altai, and Saur, Jungar Alatau, and the Tien Shan

Coniferous forests include pine, spruce, including the famous Tien Shan fir, fir, larch, and cedar. The deciduous species, birch, aspen, poplar, and willow are widespread. Many shrubs: rose hips, meadowsweet, yellow acacia, and in the deserts there are Tamarix, juniper, sand acacia, and, of course, Haloxylon. It may seem that there is little vegetation in the Kazakh steppes, but in fact, this is absolutely not the case. There grows feather grass, sheep fescue, Anabasis salsa, ferula, wormwood – plants perfectly adapted to life in the harsh dry climate. Plants with a strong root system, with leaves covered with thick skin take root here. Steppe shrubs, such as Haloxylon and turanga, sometimes form real forests with their own life in them. In spring, the steppe blooms into a veritable carpet of color. Rare species of Schrenk tulips bloom in the steppe, in a variety of colors, from pure white to dark purple, through all shades of red and yellow. The very beginning of summer is when the red steppe poppy blooms. Most of Kazakhstan's rare plants grow in specially protected areas: nature parks and nature reserves, where they are constantly monitored by specialists. For example, in the canyon of the Charyn River, in its lower reaches, grows a rare Sogdian (or as it is also called Turkistan) ash-tree. There is a real relict ash grove with an area of almost 500 ha, and it stretches along the river for more than 25 km. The Sogdian ash grew here back in the Tertiary period, which is more than 25 million years ago. It is one of the few plants that managed to survive the ice age and remain in its original form.

The animal world

The animal world of Kazakhstan is no less diverse than the plant world. Many animals that live here are included in the Red Book: for example, the irbis (or snow leopard), saiga antelope, gazelle, steppe bustard. There are such rare animals as the Ustyurt mouflon or urial, honey badger of the family of the Mustelidae, Brandt's (long-needle) hedgehog, and wild cats: manul, caracal, sand cat (Felis margarita), and the famous Asian cheetah. The desert and semi-desert areas of Central Kazakhstan are inhabited by small saiga and gazelle antelopes, and in the west by the Ustyurt mouflon. These are unpretentious animals that are content with scarce steppe vegetation. Among predatory animals, wolf, corsac, and desert lynx caracal live here. There are a lot of rodents and small animals, such as gophers, jerboas, sand mice.In the desert areas, you can find a lot of species of lizards and snakes, including those listed in the Red Book: round-headed lizard, saw-scaled viper (sand Aepha), cobra. Under the rocks hide dangerous insects: Central Asian scorpion and caracourt spider (Mediterranean widow). In Northern Kazakhstan, in the forest-steppe zone, live elk, roe deer, squirrel rabbit, common vole mouse, water vole, forest birch mouse, black grouse, white grouse. There are also large predators: Eurasian wolf, brown bear, lynx. Numerous lakes in Northern Kazakhstan are home to a large number of waterfowl – swan, goose, duck, gull. The grass-covered steppes are inhabited by rodents: bobak marmot, steppe mottled vole, narrow-backed vole, and gophers. Among birds – bustard, little bustard, Eurasian Curlew, Gyrfalcon, Steppe Trickey, skylark, Steppe Eagle, Steppe, and Meadow Harrier. From the beginning of summer, herds of saigas and gazelles come here from the south to fatten, escaping the southern heat, and leave for wintering in the desert areas closer to the middle of autumn.

The Kazakh National Agrarian Research University [10]

NJSC "Kazakh National Agrarian Research University" (KazNARU) is an innovative university, a leader in agricultural education and science in Kazakhstan, training specialists in the agricultural industries.

KazNARU is located in the very center of the southern capital – Almaty. The university grounds are impressive with their green attire. Many types of coniferous trees grow here – Scots pine, Tien Shan spruce, Norway spruce, prickly spruce (blue form) oriental thuja, Cossack juniper and Virginia juniper, deciduous trees – pedunculate oak, sumac, horse chestnut, honey locust, silver birch, willow crying and many others. The entire territory was landscaped with the work of scientists from the Department of Forest Resources, Game Management and Fisheries. The first pine trees were planted by students of the first graduating class of the Faculty of Forestry back in 1953.

Figure 10. Kazakh National Agrarian Research University

Kazakh Agro Technical University [11, 12]

Planting plantations on the territory of the Kazakh Agro Technical University (KATU) located in the Saryarkinsky district cover the following types of green areas: boulevards, squares, street plantings. They are located on three sections: the first is between the streets of Moldagulova, Shakarim and the avenue Zhenis, the second one between the streets of Shakarim, Esenberlin and Zhenis avenue, and the third is between Moldagulova, Beibitshilik, Shakarima, Esenberlin streets. On the green areas KATU are 23 species of trees and shrubs. Total count of plants is 3463, of which conifers: spruce and spruce pine are 110 pieces, deciduous – 3353 pieces.

Figure 11. Saken Seifullin Kazakh Agrotechnical University

Arboretum "Forest Nursery" [13, 14]

Not far from the city of Issyk, in the arboretum "Forest Nursery" is the largest collection of world flora in republic Kazakhstan. It occupies 378 ha and is located in the village of Baltabay, 53 km east of Almaty. It was created in 1959 at the Academy of Sciences of Kazakhstan with the aim of preserving and studying the world fund of tree and shrub plant forms. It was a concentration (according to inventory 2014) of more than 1300 species, forms and varieties of trees and shrubs, representing 58 families and 153 species, introduced from different countries of Eurasia, the Mediterranean, North America, China, Korea and Japan.

Figure 12. Bush in the Forest Nursery

Plants continue to be imported for the purpose of acclimatization in the desert-steppe zone, which occupies most of Kazakhstan. Pets of the arboretum are grown for landscaping and decorating cities, creating forest belts and restoring forests throughout the republic.

"Buiratau" State National Nature Park [15, 16]

The "Buiratau" State National Nature Park was established on March 11, 2011 by the Forestry and Hunting Committee of the Ministry of Agriculture of the Republic of Kazakhstan

The national park Buiratau (translated from the Kazakh – "Curly Mountains") is located in the transition zone between the sub-zones of moderately arid and dry steppes, which determines the uniqueness of the territory in the combination of steppe ecosystems with forest ecosystems (birch spruce, black alder).

The park was established in the reserve lands and lands of the state forest fund of Temirtau and Erementau forestry institutions and is located in the Erementau district of Akmola region and Osakarovsky district of Karaganda region. It consists of two branches – "Ereimentau" (60 814 hectares) and "Belodymovsky" (28 154) ha). The total area of the national park is 88 968 ha. A guard zone with an area of 88,064 ha is created around the park. The central office is located in the village Molodezhnyi, Karaganda region.

Figure 13. The Buiratau State National Nature Park

The main types of the relief of the national natural park "Buiratau" are the low mountains (hilltops), the low hills high (ridged), low (hilly and hilly-ridge), and various types of intermountain and inter-mountain plains – inclined, wavy, ruffled, flat. The characteristic elements of the relief are valleys of temporary watercourses, river valleys of small rivers and lake basins. In accordance with soil-geographical zoning the territory of the park is located within the subzone of moderately dry steppes with predominance of zoned dark chestnut soils.

Chapter 2.
Procedure for determining diversity indexes

2.1. The weighted average category of plants

Studies of green plantations in the investigated object were carried out in accordance with the accepted method, trees were assessed on a four-point scale – "good", "satisfactory", "unsatisfactory" and "emergency" [17].

I – good trees of the state (signs of weakening);

II – trees of a satisfactory condition (weakened);

III – trees of unsatisfactory condition (strongly weakened, shrinking trees).

IV – emergency state tree. plants recommended for removal (felling)

The analysis of the ecological state of woody and shrubby vegetation is made using the following categories, biodiversity indices and and environmental quality indices.

The weighted average category of plants:

$$K = \frac{(n_1 \times 1.0 + \ n_2 \times 2.0 + n_3 \times 3.0)}{N},$$

where n_1, n_2, and n_3 are the corresponding numbers of trees of I, II, III categories, and N is the total number of trees [17].

2.2. The Shannon diversity Index

The concept of entropy has many interpretations in various fields of human knowledge. The system interacts with the outside world as a whole. An open system can exchange energy, material and, which is not less important, information with environment. The system consumes information from the environment and provides information to environment for act and interact with environment. Shannon [18] was the first who related concepts of entropy and information. He has suggested that entropy is the amount of information attributable to one basic message source, generating statistically independent reports. Get any amount of information entropy is equal to the lost. Information entropy for independent random event x with N possible states is calculated by the following equation:

$$H = -\sum_{i=1}^{N} p_i \log_2 p_i,$$

where P_i is the probability of frequency of occurrence of an event.

The entropy of Shenon or the Shannon diversity Index (the Shannon Index) has become a popular index of diversity in environmental literature after the 1955 article by Robert Helmer MacArthur, who used the Shenon equations to assess the degree of structuring of biocenoses [19]. Margalef postulated theoretical concept that meets a variety of entropy for a random selection of species from the community [20, 21]. When calculating the diversity of biocenoses, the value expressing the amount of information per element (individual, unit of biomass, etc.) is denoted by:

$$H = -\sum_{i=1}^{S} \frac{n_i}{N} log_2 \frac{n_i}{N}.$$

The information of the whole biocenosis or its part in a unit of space (volume, area), equal to the product of H by the number of elements, is denoted by where N is the total number of elements in the biocenosis; n_i is the number of elements in this group; S is the number of groups. The number of elements can be understood as the number of individuals, their biomass and any other characteristics of the groups. Thus, according to MacArthur "*The variety in the Shannon index is treated as the amount of information per species that is enclosed in distributions by species, individuals, or energy over trophic connections*".

2.3. Simpson's diversity indices

The term 'Simpson's Diversity Index' can actually refer to any one of 3 closely related indices [22]:

$$D = \frac{\sum n\,(n-1)}{N(N-1)},$$

where:

n = the total number of organisms of a particular species;
N = the total number of organisms of all species.

The value of D ranges between 0 and 1.

Gini–Simpson index of Diversity 1 – D The value of this index also ranges between 0 and 1, but now, the greater the value, the greater the sample diversity. This makes more sense.

Simpson's Reciprocal Index 1 / D. This measure is also known in ecology as the probability of interspecific encounter [23] and the Gini–Simpson index [24]. It can be expressed as a transformation of true diversity of order 2: The most popular of such indices have been the inverse Simpson index (1/D) and the Gini–Simpson index (1 – D).

2.4. Geo-Ecological Evolving Organized (GEVORG) (G) and Armenian index of environmental quality (AREQ) (A)

To determine the values of the GEVORG index and armenian index of environmental quality (AREQ), the following computational algorithm is used [25-31]:

Determines the total number of *trees of each* categories – *n.*

Estimates the total *the total number of trees* (*N*) – $N=\sum n$.

Computes log_2N, $nlog_2n$ and $\sum nlog_2n$.

Determines geoecological evolving organized syntropy (I) and entropy (H):

$$I = \sum nlog_2n / N \text{ and } H = log_2N - I.$$

Then GEVORG index is determined:

$$G = H / I.$$

Further, the total number of emergency trees is estimated (M) – $M=\sum m$.

Computes log_2M.

Finally, armenian index of environmental quality was obtained:

$$A = G + 0.1\ log_2M.$$

Using the Geo-Ecological Evolving Organized index (GEVORG) and armenian index of environmental quality (AREQ) comprehensive assessment of the quality of surface waters was carried out [25-31] and a structural analysis of the state of biological systems at the level of proteins, ribonucleic acid, cells [32, 33] and a structural analysis of the state of oil [34-36] and trees [37, 38].

Table 1. Classes of water quality depending on the value of the GEVORG and AREQ

GEVORG Value	AREQ Value	Rating of Quality	Guality classes
<0.7	<1.1	Excellent water quality	1
0.7-1.0	1,1-1,4	Good water quality	2
1.0-1.4	1.4-1.8	Fair water quality	3
1.4-1.7	1.8-2.1	Marginal water quality	4
>1.7	> 2.1	Poor water quality	5

The values of the GEVORG and AREQ indexes indicate what and to what extent prevails in the structure of the system (see table 1): chaos or order. So, if GEVORG < 1(AREQ < 1,4), then order prevails in the structure of the system, otherwise, when GEVORG >1 (AREQ < 1,4), the organization of the system is in equilibrium.

Chapter 3.
Analysis of Environmental Status of Wood and Shrub Vegetation by the Armenian Index of Environmental [37]

This chapter assesses the ecological state of wood and vegetation using the Geo-Ecological Evolving Organized (GEVORG) indices (G) and the Armenian environmental quality (AREQ) index (A), on the territory of the Kazakh Agrotechnical University (KATU), located in the Saryarka region, Kazakh National Agrarian Research University" (KazNARU) and the Ijevan branch Yerevan State University, Ijevan Arboretum and in the vicinity of the Goshavank Monastery of Dilijan National Parkof Tavush Region of Armenia.

Based on detailed surveys of green plantations in 2015-2016 in the territory of the main building of KATU for accounting, assessment and status, biometric measurements, interpolation and statistical processing field material developed scientific approaches to the creation and reconstruction of green spaces. Landscaping plantations on the territory of the university were surveyed, covering the following types of green areas: boulevards, squares, street plantings. Table 2 presents data on the distribution of KATU woody vegetation by categories. With the help of these data, the calculation of the indices diversiti (see table 3).

Table 2. Distribution of woody vegetation KATU by category

Number, pcs. / Name of the plant	Status category code			Total	Emergency
	I	II	III		
Ulmus pumila	949	767	148	1883	79
Acer negundo	152	171	113	436	63
Populus balsamifera	124	39	8	171	286
Malus baccata	86	80	6	172	17
Caragana arborescens	90	7	1	97	6
Betula pendula	35	28	–	63	5
Salix fragilis	40	16	–	56	4
Pinus sylvestris	6	45	7	58	2
Syringa vulgaris	26	3	1	30	2
Sorbus aucuparia	24	2	–	26	1

Table 3. Values of diversity indices of plants on the territory of the KATU

Name of the plant	H	D	1-D	1/D	G	A	К
Ulmus pumila	1.42	0.4258	0.5742	2.3485	0.1502	0.7802	1.55
Acer negundo	1.61	0.3379	0.6620	2.9593	0.2242	0.8218	1.91
Populus balsamifera	1.03	0.5776	0.4224	1.7314	0.162	0.9775	1.32
Malus baccata	1.18	0.4644	0.5366	2.1531	0.1891	0.5976	1.46
Caragana arborescens	0.45	0.8470	0.1530	1.1805	0.073	0.3313	1.07
Betula pendula	0.994	0.4966	0.5033	2.0134	0.1995	0.4315	1.44
Salix fragilis	0.834	0.5844	0.4166	1.711	0.1738	0.3738	1.28
Pinus sylvestris	0.994	0.6207	0.3793	1.6111	0.2046	0.3046	2.01
Syringa vulgaris	0.675	0.754	0.264	1.3262	0.1596	0.2596	1.17
Sorbus aucuparia	0.391	0.8523	0.1477	1.173	0.0907	0.0907	1.08

For example, for *Malus baccata*, the number of trees in categories I, II and III is 86, 80 and 6, respectively. The total number of trees is

$$N = 172;$$
$$\sum n\log_2 n = 552.3 + 505.5 + 15.5 = 1073.3;$$
$$I = 1073.3 / 172 = 6.24;$$
$$H = \log_2 172 - 6.24 = 7.42 - 6.24 = 1.18;$$
$$G = 1.18 / 6.24 = 0.1891.$$

The total number of emergency trees is (see Table 2):

$$M = \Sigma m = 17;$$
$$\log_2 M = \log_2 17 = 4.085;$$
$$A = 0.1891 + 0.4085 = 0.5976.$$

From the data given in Table 1 it can be seen that the populus balsamifera, ulmus pumila, acer negundo and malus baccata. ta are mainly recommended for removal (cutting down). Factors of destabilization of the state and disruption of useful functions of green plantations of the city of Astana are natural and anthropogenic factors. The natural factors are that the city is territorially located in the steppe zone, in the subzone of dry fescue-feather grass steppes with sharply continental climate, characterized by a significant moisture deficit, severe low-snow and prolonged winters, strong winds and abrupt temperature changes within 24 hours [10, 11].

Anthropogenic factors that adversely affect the green plantings of the city of Astana include the following: dustiness and gassing of the atmosphere, high density of communal structures, etc. One of the main reasons is salinization of soils. For plantings it is necessary to carry out preventive measures for their care, consisting in the following: application of mineral fertilizers, pruning of shrinking branches.

From the data given in Table 4 it can be seen that the Acer pseudoplatanus, Populus pyramidalis and malus ta are mainly recommended for removal (cutting down).

Table 4. Distribution of woody vegetation of the Ijevan subtropical arboretum by category

Number, pcs. / Name of the plant	Status category code			Total	Emergency
	I	II	III		
Cedrus deodara	50	20	10	80	0
Cédrus atlántica	40	20	0	60	0
Cryptomeria japonica	10	10	5	25	0
Cupressus arizonica	10	5	5	25	5
Acer pseudoplatanus	10	10	10	50	20
Populus pyramidalis	5	10	15	40	10
Pinus pallasiana	7	5	2	16	2
Pinus Weiwutow	18	4	0	22	0
Malus	100	50	20	180	10

Table 5. Values of diversity indices of plants on the territory of the Ijevan subtropical arboretum

Name of the plant	H	D	D-1	1/D	G	A	K
Cedrus deodara	1.3	0.4164	0.5838	2.403	0.2586	0.4906	1.5
Cédrus atlántica)	0.91	0.5480	0.4519	1.8247	0.1823	0.2823	1.33
Cryptomeria japonica)	1.52	0.333	0.666	3	0.4875	0.7195	1.8
Cupressus arizonica	1.92	0.25	0.75	4	0.7063	0.9383	2.6
Acer pseudoplatanus	1.92	0.265	0.735	3.773	0.5163	0.9483	2.0
Populus pyramidalis	1.91	0.263	0.263	3.8052	0.5598	0.7918	2.1
Pinus pallasiana	1.8	0.275	0.725	3.636	0.8170	0.9170	1.93
Pinus Weiwutow	0.6868	0.6883	0.3118	1.4528	0.1821	0.3405	1.18
Malus	1.567	0.3979	0.6021	2.513	0.2647	0.6967	1.5

Assessment of the values of plant diversity indices in the territory of Ijevan *subtropical arboretum* (see table 5).

From the values of the indices of diversity for plants on the territory of the Ijevan Dendrological Park, it can be seen that A, G. H and K have high values for cryptomeria japonica, cupressus arizonica, acer pseudoplatanus, populus pyramidalis and pinus pallasiana indicating that they are in a bad state.

Further, a correlation matrix was computed, using all the indices values, in order to establish the indices relationships and similar behaviours (Table 6).

Table 6. Correlations between diversity indices

	H	D	K	G	A
H	1	-0.97379	0.85474	0.80741	0.8588
D	-0.97379	1	-0.80741	-0.77274	-0.82176
K	0.85474	-0.80741	1	0.79766	0.6655
G	0.80741	-0.77274	0.79766	1	0.65936
A	0.8588	-0.82176	0.6655	0.65936	1

Analysis of obtained data indicates that A has liner dependence on H, G, K, and an inverse dependence on D. The correlation coefficients have large values, as expected, indicating strong associations between diversity indices and statistically all the relationships can be designated as highly significant.

According to the tasks and purpose of the work, a test site of 100m x 100m (1 ha) was selected in the vicinity of Goshavank, and the species and quantity composition of trees in that area was studied and calculated, which is presented in table 7. 12 oak, 8 Fraxinus, 20 Carpinus, 4 Tilia, 11 Fagus, 19 Pine and 2 Peach trees were recorded within the scope of vegetation monitoring of one hectare area around Goshavank using the test site method.

Table 7. Distribution of woody vegetation of the in the vicinity of Goshavank by category

Number, pcs. / Name of the plant	Status category code			Total
	I	II	III	
Oak (Quercus iberica)	4	2	6	12
Fraxinus	3	3	2	8
Carpinus betulus	9	4	7	20
Tilia cordata	1	–	3	4
Fagus orientalis	2	3	6	11
Koch pine	4	3	12	19
Peach	–	–	2	2

Also, 2 pear trees of the 3rd class were found, the data of which we did not include in the calculation of plant diversity indices.

Table 8. Values of diversity indices of plants on the territory of the vicinity of Goshavank

Name of the plant	K	D	H	G
Oak (Quercus iberica)	2	0.333	1.146	0.539
Fraxinus	1.875	0.25	1.81	1.52
Carpinus betulus	1.9	0.331	1.51	0.537
Tilia cordata	2.2	0.5	0.812	0.383
Fagus orientalis	2.364	0.345	1.44	0.712
Koch pine	2.421	0.438	1.32	0.45

From the values of tree diversity indicators in the Goshavank area, it can be seen that D, H and K have high values for Fagus orientalis, Fraxinus and pine, which are in poor condition.

Subsequently, to confirm the relationships and similar behavior of the indices, correlation dependences were calculated using the values of all diversity indices (Table 9).

Table 9. Correlations between diversity indices

	H	D	K	G
H	–	-0.85213	-0.38168	0.78631
D	-0.85213	–	0.64258	-0.77498
K	-0.38168	0.64258	–	-0.48829
G	0.78631	-0.77498	-0.48829	–

More than 20 green spaces located near the central building of the Ijevan branch of Yerevan State University are in good condition.

TheKazNARU university grounds are impressive with their green attire, which is in good condition. Many types of coniferous trees grow here – Scots pine, Tien Shan spruce, Norway spruce, prickly spruce (blue form) oriental thuja, Cossack juniper and Virginia juniper, deciduous trees – pedunculate oak, sumac, horse chestnut, honey locust, silver birch, willow crying and many others.

Conclusions

1. Thus, studies have shown that the current state of green plantations on the territory of the KATU does not meet the current standards and requirements. The existing level of gardening of the investigated object is uneven.

2. It is shown that for the plants in the Ijevan subtropical arboretum the values of diversity indices: A, G. H and K have high values for the cryptomeria japonica, cupressus arizonica, acer pseudoplatanus, populus pyramidalis and pinus pallasiana, indicating that they are in poor condition.

3. It is established, that the Armenian index of environmental quality has liner dependence on Shannon diversity and GEVORG indices, weighted average category of plants, and an inverse dependence on Simpson's diversity indices. The correlation coefficients have large values, as expected, indicating strong associations between diversity indices and statistically all the relationships can be designated as highly significant.

4. Analysis of the data obtained in the vicinity of the Goshavank monastery shows that G has a direct relationship with H, as well as an inverse relationship with K and D. The correlation coefficients have sufficient values. as expected, this shows a strong correlation of diversity measures, and statistically all relationships can be qualified as highly significant.

Chapter 4.
Features of the genetic dynamics of some tree species in the arboretum "Forest Nursery" of Kazakhstan and Ijevan subtropical arboretum of Armenia [14, 38]

This chapter will discuss the authors' research done in the "Forest Nursery" of Kazakhstan and the Ijevan Subtropical Arboretum of Armenia.

Thus, the purpose of this chapter is to first study the ecological and genetic variability of introduced conifers in the "Forest Nursery" of Kazakhstan in the conditions of the foothill desert-steppe zone and determine interest in the variability of genetic and environmental factors, as well as the relative stability of the manifestation of a quantitative trait in ontogenesis, characterizing the adaptation features of the species to new conditions. To do this, we measured the annual height increases of one morphological address of pitch pine, Crimean pine, Scots pine, blue spruce and fir spruce.

Secondly, based on the data on the average annual increase in tree height, calculate the Geo-Ecological Evolving Organized Index (GEVORG) for pitch pine, Crimean pine, Scots pine, blue spruce and fir trees. of the "Forest Nursery", and for the trees Cedrus deodara, Cédrus atlántica, Cryptomeria japonica, Cupressus arizonica, Acer pseudoplatanus, Populus pyramidalis and Pinus Weiwutow of the Ijevan subtropical arboretum.

Afforestation should be performed not only by representatives of the local flora, which in some areas of the Republic of Kazakhstan is not very diverse, but to use the types and forms of trees, growing in the temperate zones of the world. The study of this wealth and an introduction to the culture of the most valuable species is a very important job. Such work is the responsibility of the botanical gardens and arboreta. This applies in particular to the Arboretum located in the conditions that differ significantly from the natural habitats of introduced species[39]. This kind of arboretum is JSC "Forest Nursery" of the Ministry of Kazakhstan which is located in the south-east of the country. The main features of the local climate should be considered relatively high air temperatures from spring to late fall, especially in the summer months, the atmospheric dryness, coinciding with a period of high temperatures, dry winds domination, and therefore intensive evaporation and, therefore, a clear shortage of moisture [10].

Plantings of the arboretum are unique in that, they are created by large enough biogroups collectively resemble the likeness of forest environment; allowing to count per unit area (per hectare), important inventory indices of their growth and productivity. For sparsely state it is extremely important to obtain marketable timber for needs of construction, paper, wood chemistry and others purposes regardless of "vagaries" of the international market.

Introducents of Arboretum reached the age of about 60 years, it is enough to demonstrate its ability to adapt to harsh environments, and yet it is not enough to complete the process of acclimatization. It was during this period of transition it is necessary to examine the results of acclimatization of introduced tree species in order to better understand the process and learn how to manage them.

Procedure for determining

To do this, in nine trunks of pitch pine, nine trunks of Crimea pine, nine trees of Scotch pine, seven trees of blue spruce and the same number of fir spruce were measured annual increments in height of one morphological address, since its increment of 2014 and further sequentially down the shaft until unless it was preserved lateral branches of the first order in whorls or clearly distinguishable traces of them. The phenotypic variability of quantitative traits genetically diverse populations is a complex result of the interaction of genotype and environment [40-44], competing plants relationship, the degree of stability of individual physiological processes and their relative autonomy from changes in external conditions [45, 46].

The most important feature of genetic variation of wood species is the ability of its adaptation in ontogenesis to changing environmental conditions.

This property is due to genetic formulas overriding attributes ensure survival, especially when changing the combination of factors that are in the limit [47, 48]

If the wood species have a variety of systems that determine drought resistance, cold resistance, heat resistance, immunity, the adaptation to the new conditions will be successful due to their ability to genotypic dynamics in ontogenesis, unless the level override genetic formulas will not be exceeded change the limiting factors of the new environment.

Evaluation of phenotypic variability of annual increment in height (hereinafter – increments) for the small number of plants in biogroups (Table 10) should be performed using analysis of variance, which allows to establish the significance of differences in growth rates between individual trees and makes it possible to determine the heritability coefficient in a broad sense [49].

Also, it is possible to compare the variances increments of one morphological address (comparison increments, grew up in the same year in different trees), which with increased environmental assessment base is the proportion of phenotypic variance increments than random variance in the preparation of its analysis in increments of groups of trees.

Phenotypic variance of increments in both constructions of dispersion systems is the same. If the assessment of the environmental variance increments of one morphological address will be different from random, which is usually taken as an ecological, but including proportion of variance determined by the interaction genotype-environment competitive genotypic and environmental noise, there is a need to assess a large number of parts of the phenotypic variability of the test number of years, in general, and for periods of growth.

Table 10. Comparative characteristics of coniferous species, annual increments of which were analyzed with the help of analysis of variance of ACF (autocorrelation function) and SA (spectral analysis) by the period of growth

All kinds of trees, age of biogroups	Number of trees, in biogroupe, pieces	The number of measurements trunks, pieces	Inventory indices		Average annual increment in height / for number of years			The duration of the growing season, the days
			Average height, m	Average height increase, cm	All measured increments, cm	The first period of increment, cm	the second period of increment, cm	
Pitch pine 52 years	7	9	18,3	41,67	54,10 32 years	57,75 16 years	50,45 16 years	83
Scotch pine 55 years	22	9	16,52	39,34	59,54 28 years	72,14 14 years	46,94 14 years	67
Crimea pine 49 years	8	9	15,0	41,66	56,03 28 years	56,07 14 years	55,99 14 years	66
Blue spruce 49 years	17	7	10,2	28,34	42,53 26 years	37,31 13 years	47,75 13 years	43
Fir spruce 49 years	9	7	13,81	38,36	49,22 30 years	50,30 15 years	48,14 15 years	55

Average separation of the phenotypic variance of quantitative trait / σ^2ph / on genotypic / σ^2g / and environmental / σ^2e / part is not enough if there is evidence of the dispersion increments of one morphological address and the use of normalized autocorrelation function and the spectral density of a stationary random function to assess the level of plant competition with an unknown degree of relationship [50, 51].

Therefore the distinction of phenotypic variance has a different scheme [52]:

$$\sigma^2 ph = \sigma^2 g + \sigma^2 gcom + \sigma^2 e + \sigma^2 ecom \quad (1).$$

On the right side of the equation it is allocated share of genotype variance due to competitive (σ^2gcom) and dispersion, depending on the competition, determined by the environmental conditions (σ^2ecom).

To the right-hand side of the equation it is necessary to include the variance determined by the interaction of genotype environment, genotypic dispersion of adaptability, dispersion, estimating the accumulation of individual developmental differences, such as differences in the length of the growing season, which is in a new environment conditions varies in each species, in accordance with its inherent features and is controlled by the limiting factors of environment. But the evaluation of all components of phenotypic variance of quantitative traits in woody species always causes difficulties for a number of objective reasons: at first, the traditional methods of studying genotypic population structure based on known models of genetics of quantitative traits, have limiting conditions determining the validity of the method for obtaining estimates to quantify genetic parameters reflecting the structure of the population. Failure to meet compliance requirements limiting conditions of used statistical method to the character of the target population will make sure of distortion in the evaluation results [53]; secondly, distortion of the phenotypic variance components estimates are possible because of the ambiguity and the integrity of the phenomena, when a number of effects practically do not divide and together affect the final expression trait in plants.

This circumstance fully applies to introducents when it is impossible to estimate ecological consequence of the place of origin of the introduced offspring, influence of generality of the new environment on the offspring of different origin and contrast among parents on the environment of the new dwelling descendants, ontogenetic accumulation of differences due to the fluctuation of limiting factors and changing conditions of competition in the ontogeny of introducents of human origin; thirdly, there is no information about the ecological and genetic structure of populations of the original homeland of exotic species (USA, Canada, Europe, the north of the Republic of Kazakhstan); fourth, unknown nature of genotypic dynamics of quantitative traits at home conifer introductions.

Analysis of components of phenotypic variance of increments for each group of trees under Lash's scheme with the calculation of the coefficients of heritability in a broad sense showed that the phenotypic variance of increments is almost equal of random, which is in univariate variance analysis approximately assesses the environmental share in total dispersion of variance. Therefore, heritability coefficients in a broad sense estimating variability share which are defined with hereditary factors are equal to zero except for the first period of growth in pitch pine and the last 15 years of life of fir spruce (Table 12). Due to the significant change in the average growth in height on the periods of growth of scotch pine, a few smaller differences in average growth for the period of pitch pine and blue spruce and stable average growth for the period of Crimea pine and fir spruce was necessary to assess the significance of differences increments by the periods of growth and interaction-period gains.

For this reason, two-factor dispersion systems with repeated data were made up in which periods of growth are factor A, growth rates of trees in the group are factor B as well as AB evaluates the interaction of factors. An example of such complex is presented in Table 3 and the results of two-factor dispersion analysis with repeated data for each variety of introduces are shown in Table 14.

Table 12. The average value of the annual increments in the height of introducents for the time corresponding to the total number of measurements, by periods of growth and estimation of heritability coefficient in a broad sense

Types of trees	Average growth			Heritability coefficient		
	For years of studying, duration of periods	For the first period, duration of periods	For the second period, duration of periods	For years of studying, duration of periods	For the first period, duration of periods	For the second period, duration of periods
Pitch pine	54,10 32	57,75 16	50,45 16	0,081 32	0,157 16	0,030 16
Scotch pine	59,54 28	72,14 14	46,94 14	0,002 28	0,055 14	0,036 14
Crimea pine	56,03 28	56,07 14	55,99 14	0,031 28	-0,007 14	0,079 14
Blue spruce	42,53 26	37,31 13	47,75 13	0,059 26	0,026 13	0,092 13
Fir spruce	49,22 30	50,30 15	48,14 15	0,063 30	-0,016 15	0,214 15

Results of the analysis indicate about different character of increments variability increase in periods of growth of introducents and the interaction of factors: Pitch pine and Scotch pine have significant differences in increments by the periods of growth at the level of 01significance, there are no significant differences in trees increments, the interaction of factors period – increments of Pitch pine is insignificantly and it is essential in Scotch pine with probability of 95%.There are no differences in increments in the Crimea pine neither in the factors A, B nor on their interaction. There are significant differences in both factors with the probability of 99% and 95% in Blue spruce, there is no interaction between factors, and on the contrary there are no differences of increments by factors, but their interaction is significantly at level 01.

Table 13. Initial data for two-factor dispersion analysis of annual increments in the height of the group of trees of the Crime pine by the periods of growth

B	Tree 1	Tree 2	Tree 3	Tree 4	Tree 5	Tree 6	Tree 7	Tree 8	Tree 9
A	x	x	x	x	x	x	x	x	x
Crimea pine, the second period, 14 years 1	70	30	40	40	35	80	60	70	25
	40	10	40	20	45	100	70	55	65
	35	90	45	100	70	40	90	60	50
	40	40	55	40	35	80	55	55	35
	30	30	40	55	60	43	50	45	75
	30	75	50	45	55	42	110	60	45
	55	60	55	55	55	35	65	65	45
	65	60	45	58	50	55	55	70	40
	65	60	60	77	55	70	60	65	45
	65	75	60	60	50	85	65	70	35
	55	75	60	60	50	55	80	70	50
	80	70	60	80	40	85	35	80	55
	60	60	50	60	50	65	60	50	30
	80	50	60	60	40	100	25	30	25
Crimea pine, the first period, 14 years 2	65	65	55	75	50	35	55	50	105
	50	75	75	75	60	65	50	55	30
	75	40	75	40	90	60	25	55	45
	80	80	55	45	80	55	60	35	35
	55	60	45	45	70	95	85	30	35
	70	40	80	45	80	60	70	80	60
	55	80	65	43	70	90	85	65	105
	55	70	65	57	40	100	65	65	65
	40	80	60	45	70	20	55	50	70
	40	70	40	45	50	53	55	30	50
	40	60	25	40	15	65	62	50	30
	50	70	85	90	25	60	65	40	60
	25	40	40	40	45	50	60	45	25
	25	50	15	40	45	55	60	45	40

Table 14. Results of two-factor dispersion analysis with repeated data of annual increment in height for five species of introducents increasing of genotypic variance increments to phenotypic variance by trees group

Dispersion	S	f	S^2	$F_{фак.}$	F_{01}/F_{05}
Pitch pine					
by factor A	3835,42	1	3835,42	16,93	6,75/–
by factor B	8175,24	8	1021,90	2,37	–/3,44
by interaction AB	3454,61	8	431,83	1,91	–/1,97
random (Z)	61182,81	270	226,60		
absolute	76648,08		266,14		
Scotch pine					
by factor A	40002,48	1	40002,48	102,75	6,75/–
by factor B	4721,34	8	590,17	0,76	–/3,44
by interaction AB	6219,91	8	777,49	2,00	–/1,98
random (Z)	91098,78	234	389,31		
absolute	142042,52				
Crimea pine					
by factor A	0,40	1	0,40	0,01	–/3,88
by factor B	5214,89	8	651,86	1,86	–/3,44
by interaction AB	2805,60	8	350,70	1,08	–/1,98
random (Z)	76242,86	234	325,82		
absolute	84263,75				
Blue spruce					
by factor A	4958,79	1	4958,79	25,90	6,80/–
by factor B	3711,82	6	618,64	4,85	–/4,28
by interaction AB	764,90	6	127,48	0,67	–/2,15
random (Z)	32165,84	168	191,46		
absolute	41601,36				
Fir spruce					
by factor A	245,38	1	245,38	1,30	–/3,89
by factor B	4015,31	6	669,22	1,09	–/4,28
by interaction AB	3699,12	6	616,52	3,26	2,9/–
random (Z)	37022,66	196	188,89		
absolute	44982,48				

Thus, it becomes evident the need to analyze the variability of increments by groups of trees for the entire period studied and its parts, and the presence or absence of the interaction of factors determines the need for a more detailed analysis of the ratio of the variances increments of one morphological addresses, by tree-groups and periods of growth (Table 15).

Table15. Changing of the size and nature of the phenotypic, environmental and genotypic variances of increments of one morphological address, groups of trees, periods of growth and the ratio of the increments dispersions

Types of trees	The periods of growth, the difference in variances, $\Delta \sigma^2$	Dispersions of annual increments in height							
		One morphological address				By groups of trees			
		σ^2_{ph}	σ^2_e	σ^2_g	$\Delta g = \Delta\sigma_g^2 / \Delta\sigma^2_{ph}$	σ^2_{ph}	σ^2_e	σ^2_g	$\Delta g = \Delta\sigma_g^2 / \Delta\sigma^2_{ph}$
Pitch pine	1	320.0	214.2	105.8		319.71	269.34	50.37	
	2	189.0	131.8	57.2		189.47	183.86	5.61	
	$\Delta \sigma^2$	131.0	82.4	48.6	0.37	130.24	85.48	44.76	0.344
Scotch pine	1	488.0	453.1	34.9		486.46	459.60	26.86	
	2	328.0	279.8	48.2		320.83	309.47	11.46	
	$\Delta \sigma^2$	160.0	173.3	–/13.3/	–/0.083/	165.53	150.13	15.4	0.093
Crimea pine	1	355.0	315.1	39.9		355.84	358.29	–/2.45/	
	2	318.0	314.6	3.4		317.28	292.3	24.98	
	$\Delta \sigma^2$	37.0	0.5	36.5	0.986	38.56	27.43	–/22.53/	–/0.58/
Blue spruce	1	184.0	152.9	31.1		182.43	177.67	4.76	
	2	223.0	219.6	3.4		217.53	197.57	19.96	
	$\Delta \sigma^2$	–/39,0/	–/66.7/	27.7	0.71	–/35.1/	–/19.9/	–/15.2/	–/0.433/
Fir spruce	1	172.0	175.4	–/3.4/		168.89	171.52	–/2.63/	
	2	258.0	269.8	–/11.8/		257.54	202.29	55.25	
	$\Delta \sigma^2$	–/86,0/	–/94.4/	–/8.4/	–/0.098/	–/88.65/	–/30.77/	–/52.62/	–/0.594/

Increment of phenotypic, environmental and genotypic variances of increments, as well as the ratio of the increment of genotypic varies to phenotypic changes by type of introducents and by periods of growth. Dispersions signs and their increments indicate in what period this or that dispersion is more. In Pitch pine all dispersions are more in the first period of growth and the ratio of the increment of genotypic variance to phenotypic increments are equal to a group of trees and a morphological address. In Scots pine there are inverse values of relationship of increment values of the phenotypic variance or increments of one morphological phenotypic address and the group of trees. There are the same values σ^2e of increments of one morphological address by the periods of growth and reverse of the ratio in Crimea pine.

In Blue spruce σ^2ph, σ^2e increments of one morphological address is more in the second period and σ^2g – on the contrary. In the group of trees of spruce barbed all dispersion increments are more in the second period. Therefore, increment ratio $\Delta\sigma_g^2 к \Delta\sigma^2_{ph}$ of the group of trees is opposite to a similar ratio for the increments of morphological address. Fir spruce shows a special relationship not only increment dispersions, all dispersions are more in the second period, but excess of environmental variance increments of one morphological address of phenotypic variance and a similar excess of increments of a group of trees in the first period for a second σ^2ph is more than σ^2e. Genotypic variance of increments of one morphological address and increments the group of trees of Fir spruce is more in the second period of growth.

Change of the value and the "sign" of relations of increment of genotypic proportion of variance of increments of one morphological address and a group of trees to the increment of phenotypic leads to the conclusion that there are possible differences in the nature of the override genetic formulas of exotic species in ontogeny. Receiving a zero score of level genotype due to the variability of growth in groups of trees and distinct increment dispersions can be concluded that all types of new environmental conditions due to the small number of boats rated trees or small number biogroups after multistage artificial selection have no genotypic diversity trait under study and all phenotypic variance increments determined by the environmental conditions change or genotypically determined differences "smeared" other shares phenotypic variability: competitive genotypic, competitive environment, interaction of genotype-environment accumulated developmental noise, because the set change effects of the increase period gains, factor groups of trees, the interaction of these factors and the change in the average growth for the period Blue spruce, Pitch pine and especially Scots pine.

During the first period, pines have a higher average growth than in the second. Average growth of blue spruce in the first years is less and in future it will be more. Crimea pine and fir spruce differ with stability of average increment in life periods (Table 1). So there is reason to assume the existence of the reasons determining the differences observed average increments and dispersions by periods of growth.

After the analysis of variance, increments of one morphological address, in which the random variance is indeed environmental and ecological competitive part of the phenotypic variance, it was possible to highlight the proportion of genotypic variance, but again not for all types and periods (Table 16).

Table 16. Estimates of heritability coefficient in a broad sense, calculated by the variance of annual increments of one morphological address

Types of trees	Heritability coefficient		
	For the years of studying / years	For the first Period / years	For the second period / years
Pitch pine	0,352 / 32	0,331 / 16	0,303 / 16
Scotch pine	0,352 / 28	0,07 / 14	0,147 / 14
Crimea pine	0,06 / 28	0,112 / 14	0,01 / 14
Blue spruce	0,19 / 26	0,169 / 13	0,015 / 13
Fir spruce	-0,035 / 30	-0,02 / 15	-0,046 / 15

Ecological and phenotypic variance of increments of Pitch pine as by periods and for all the years of study remains at the same level.

In the first period, the phenotypic variance of Scotch pine increments is almost equal to environmental, a small proportion of genotypic variance appeared in the second period of growth, and in general during 28 years, about a third of the phenotypic variance accounted for genotypic share. Crimea pine showed little genotype variability due to increments only in the first period of life. Blue spruce has several large hereditary variability of growth for 26 years and in the first period of life. Fir spruce in all cases has an exceeding environmental variance of increment over the phenotype that determined the negative marks of zero heritability coefficient values in the broadest sense and indicates the presence of noise, overstating the environmental variance.

Analysis of variance increments of one morphological address gives only a glimpse of the features of species of introducents to adapt. Therefore, for a more detailed study of relations of phenotypic and environmental variances calculated for increments of one morphological address for group of trees and periods of life, it was done comparative analysis of the obtained dispersions (Tables 15 and 17).

Pitch pine and Scotch pine have exceeded of phenotypic, environmental and genotypic variance of increments during the first period of life of both groups of trees, and in the analysis of variance increments of one morphological address.

Table 17. Phenotypic and environmental dispersions of annual increments of introducents for studied years and periods of growth

Types of trees	Dispersions of annual increments in height					
	by groups of trees			One morphological address		
	pheno-typic, en-viron-mental for study-ing years	pheno-typic, en-viron-mental the first period	pheno-typic, en-viron-mental the sec-ond pe-riod	pheno-typic, en-viron-mental for study-ing years	pheno-typic, en-viron-mental the first period	pheno-typic, en-viron-mental the sec-ond pe-riod
Pitch pine	267,07 245,42	319,71 269,34	189,47 183,86	267,0 173,0	320,0 214,2	189,0 131,8
Scotch pine	559,12 558,16	486,46 459,60	320,93 309,47	566,0 366,46	488,0 453,1	328,0 279,8
Crimea pine	335,56 325,15	355,84 358,29	317,28 292,3	335,0 314,86	355,0 315,1	318,0 314,6
Blue spruce	227,4 213,69	182,43 177,67	217,53 197,57	230,0 186,87	184,0 152,9	223,0 219,6
Fir spruce	212,65 199,16	168,89 171,52	257,54 202,29	215,0 222,63	172,0 175,4	258,0 269,8

The ratio of the difference of genotypic variance of increments $\Delta\sigma_g^2$ (Table 5) to the difference of the phenotypic variance by the periods of life $\Delta\sigma^2_{ph}$ makes up respectively, for the group of trees and one morphological address 34 and 37% for Pitch pine, 9.3%, 8.3% – for Scotch pine, but $\Delta\sigma_g^2$ increments of one morphological address is reverse to $\Delta\sigma_g^2$ increments by groups of trees.

The coefficients of heritability in a broad sense are given in Table 6. The Crimea pine shows other relations. Environmental variance increments of one morphological address virtually unchanged for periods of growth σ^2e28 σ^2e1-14 ~ σ^2e2-14 (314.86 ~ 315.1 ~ 314.6, Table 7), so in the result, the ratio of the genotypic difference of increments to the phenotypic differences makes up 0.986 0,986, $\Delta\sigma_g^2$ decreased in the second period by 98%.

As a group of trees of Crimean pine, environmental dispersion of increments was more phenotypic in the first period and the calculation of the heritability coefficient becomes meaningless. During the second period of evaluation H2 = 0,079 is very low because of the small difference between σ2ph and σe2 (Table 7). Increment $\Delta\sigma_g^2$ = –/22,53/ by a group of trees in the growth is reverse $\Delta\sigma_g^2$ = 36,5 to the increments of one morphological address, so $\Delta\sigma_g^2$ increased in the second period to 58% by the increments of group of trees. It turns out that variation genotypic variance of Scots pine for the same period, but specified by the increments of a group of trees and a morphological address has different direction. Similar situation with a change in the genotypic variance increments of Crimean pine, only increment $\Delta\sigma_g^2$ is opposite to Scotch pine.

Blue spruce for the first period of life has phenotypic and environmental variance is less than a second as in the growth of a group of trees and in the growth of morphological address. Genotypic proportion of phenotypic variance was greater in the structure of the average squares of the same morphological address in the first period, and the group of trees – in the second. The ratio of genotypic differences in the phenotypic variance on a group of trees and one morphological address makes up 43.3% and 71.0%, respectively, but with the reverse increments $\Delta\sigma_g^2$ like in Scotch pine and Crimean pine. Fir spruce in the growth of morphological address showed excess of environmental dispersion of phenotypic for the first and second period of life, and in the growth of groups of trees – for the first time.

During the second period, a group of trees of Fir spruce has a rating of genotypic diversity increments H2 = 0,214 (Table 2), and genotypic variance increment ratio of growth to the increment of the phenotypic group of trees and a morphological addresses are respectively, 59.4% and 9.8%. Pitch pine has almost the same percentage changes of relationship of variance of increments of morphological address and increments of group of trees by the periods of growth, Scots pine showed opposite direction of increments similar in magnitude. In Crimean pine $\Delta\sigma_g^2$ has not only a different direction, but differ significantly in size. Blue spruce having exceeded the phenotypic and environmental variances increments of one morphological address and increments of a group of trees for the second group of the first period of growth show different meaning $\Delta\sigma_g^2$ by value has a different direction of increments with which it differs from Fir spruce.

Thus, the value of the mean squares varies considerably by the increments of morphological address and increments of group of trees, species of introducents and the periods of their lives, which leads to the conclusion about the presence in the environmental, genotypic and phenotypic variances of some noise, which has different value and are developed in a greater degree or in the analysis of groups of trees, or increments of one morphological address, i.e., change the cause of its symptoms. Therefore, the scheme of separation of dispersions of increments on genotypic and environmental is insufficient and it is necessary to use other methods of determining the components of phenotypic variation of annual increments in the height of the introduced species.

Based on the data in Table 13, the average annual increase in height of the Krimovaya pine was calculated. Table 18 presents the average annual height increase of Krimovaya pine and the calculation of the Geo-Ecological Index of Organized Development (GEVORG) for Crimean pine trees of the Forest Nursery by growth periods. Average annual growth (n) of Crimean pine trees.

It is shown that for trees of the "Forest Nursery" of the value GEVORG index depends on the growth period. For the trees under study, the value of the GEVORG index is obtained from 0.582 to 0.753. In the Pitch pine, the GEVORG index is smaller in the first growth period (G= 0.680), than in the second growth period of (G = 0.700). In the Scots pine index GEVORG in the first growth period, it is the smallest (G = 0.625) and in the second growth period it is (G= 0.692).

Table 18. Geo-Ecological Evolving Organized (GEVORG) index for of trees of the Crime pine by the periods of growth

Year	For the first growth period		For the second growth period	
	n	$n\log_2 n$	n	$n\log_2 n$
1	50.0	282.03	59.4	349.87
2	49.4	277.80	59.4	349.87
3	64.4	590.84	56.1	325.76
4	59.4	349.87	58.3	341.75
5	47.6	265.67	57.8	338.07
6	56.9	331.54	65.0	391.22
7	54.4	313.53	73.1	452.37
8	55.3	320.00	64.7	388.99
9	52.0	296.25	55.6	322.12
10	62.8	374.87	48.1	268.64
11	61.7	366.68	43.0	233.2
12	65.0	391.22	60.5	357.96
13	53.9	309.85	41.1	220.23
14	52.2	297.71	41.7	224.25

N	785.0	783.8
∑nlog2n	4767.86	4564.30
I	6.075	5.823
H	3.536	3.786
GEVORG	0.582	0.650

Index GEVORG in the Crimea pine in the first growth period, it is the smallest (G = 0.582) and in the second growth period it is (G= 0.650). In the Blue spruce in the first period of growth, the GEVORG index is greater than (G = 0.753), and in the second period it is (G = 0.710). Fir spruce shows an equal relationship in the first and second period.

It is shown that for trees of the "Forest Nursery" of the value GEVORG index depends on the growth period. For the trees under study, the value of the GEVORG index is obtained from 0.582 to 0.753. In the Pitch pine, the GEVORG index is smaller in the first growth period (G= 0.680), than in the second growth period of (G = 0.700). In the Scots pine index GEVORG in the first growth period, it is the smallest (G = 0.625) and in the second growth period it is (G= 0.692). Index GEVORG in the Crimea pine in the first growth period, it is the smallest (G = 0.582) and in the second growth period it is (G= 0.650). In the Blue spruce in the first period of growth, the GEVORG index is greater than (G = 0.753), and in the second period it is (G = 0.710). Fir spruce shows an equal relationship in the first and second period.

It turned out that for the trees of the Ijevan subtropical arboretum, the Geo-Ecological Evolving Organized index has high values (0.8507-0.9560) for Cedrus deodara, Cédrus atlántica, Cryptomeria japonica, Cupressus arizonica, Acer pseudoplatanus, Populus pyramidalis, and Pinus Weiwutow, and is largely independent of the increment period.

Chapter 5.
Assessment of the state of woody and shrubs plants of the state national natural park "Buiratau" and Ijevan subtropical arboretum by Geo-ecological Evolving Organising Index [54, 55]

Chapter 5 assessed the ecological state of wood and vegetation using the Geo-Ecological Evolving Organized (GEVORG) (G) indices in the territory of the State National Park "Buiratau" of Kazakhstan and Ijevan *subtropical arboretum*.

Below is the research data on the territory of the State National Park "Buiratau" of Kazakhstan in the period from 2020 to 2022. route-reconnaissance method [56]. In areas with the presence of spiky steppe forests and shrub thickets, transects measuring 400x200 m were laid. On the sites, the species composition of woody plants, life form, ecological group, life state of the plant, placement in the layer of vegetation cover, as well as phytoprotective conditions were taken into account. Determination of species composition was carried out according to "Flora of Kazakhstan", TT. 1-9 [57], the names of taxa were given according to the system of S.K. Cherepanov [58]. The life form of plants was identified based on the classification of I.G. Serebryakov [59], ecological groups according to the classification of A.V. Kuminova [60]. Life status was assessed on a 5-point scale.

An assessment of the species composition made it possible to determine that 50 species from 25 genera and 14 families grow on the territory of the Buiratau State National Park (Table 19).

The maximum number of species is in the family Rosaceae: 10 genera (40%) and 16 species (32%). The remaining families include 1-2 genera and from 1 to 5 species. In general, the proportion of tree species in the national park is not large. The composition of tree species includes 50 species, which is only 8.2% of the total number of vascular plants in the study area.

Analysis of the ratio of life forms showed the following types: trees, shrubs and subshrubs (Table 20). In SNNP "Buiratau" the maximum number of species belongs to shrubs – 31 taxa or 62.0%. These are species such as three-stamen willow, common raspberry, stone and golden currant, meadowsweet, Cossack juniper, Kuril bush tea and others. The second position is occupied by trees – 13 taxa or 26.0%; Among them are silver and Kyrgyz birch, sticky alder, aspen, black poplar, ash-leaved maple, blood-red hawthorn and others. In last place are semi-shrubs.

Table 19. Taxonomic composition of trees and shrubs of SNNP "Buiratau" and Geo-ecological evolving organised (GEVORG) index

Families grow	Number of genera		Number of species from	
	n	*n*log₂*n*	*n*	*n*log₂*n*
Pinaceae	1	0	1	0
Cupressaceae	1	0	1	0
Ephedraceae	1	0	1	0
Betulaceae	2	2	5	11.6
Salicaceae	2	2	13	48.1
Aceraceae	1	0	1	0
Ulmaceae	1	0	2	2
Grossularia-ceae	1	0	3	4.75
Rosaceae	10	33.2	16	64
Rhamnaceae	1	0	1	0
Elaeagnaceae	1	0	1	0
Caprifoliaceae	1	0	2	2
Viburnaceae	1	0	1	0
Solanaceae	1	0	2	2

N	25	50
$\sum n\log_2 n$	37.2	134.45
I	1.448	2,689
H	4.192	2.950
GEVORG	0.345	1.097

Table 20. The composition of life forms of trees and shrubs SNNP "Buiratau" and values of I, H, G

Life forms	*n*	$n\log_2 n$
Trees	13	48.8
Srubs	31	153.5
Semishrubs	6	15.5

N	50
$\sum n\log_2 n$	217.1
I	4.347
H	1.258
G	0,299

A study of the distribution of ecological groups showed the presence of the following: hygrophytes, hygromesophytes, mesophytes, xeromesophytes, mesoxerophytes and xerophytes (Table 21).

Table 21. The composition of ecological groups of trees and shrubs SNNP "Buiratau" and values of I, H, G

Ecological groups	*n*	$n\log_2 n$
Hygrophytes	4	8
Hygromesophytes mesophytes	3	4.75
Mesophytes	33	166.36
Xeromesophytes	2	2
Mesoxerophytes	1	0
Xerophytes	7	19.64

N	50
$\sum n\log_2 n$	200.25
I	4.015
H	1.625
G	0.405

The maximum number of taxa falls on the group of mesophytes – 33 species or 66.0% of the total number of species of all tree and shrub plants. These are aspen, willows, meadowsweet, zoster, steppe almond and others. In second place are xerophytes – 7 species or 14.0%. Among them: Cossack juniper, meadowsweet, European oleaster, ephedra bispica and others. In third place are hygrophytes, 4 species or 8.0%. The remaining ecological groups are represented by a small number of species.

Plants were ranked according to their life status based on a 5-point scale. It was revealed that all species had vitality from 3 to 5 points. Plants in a vital state of 1 to 2 points were not recorded. The largest number of species was noted with a vitality of 4 points – 34 taxa or 68.0%. In second place are species rated by vitality at 5 points – 12 taxa or 24.0%. The last position is occupied by species with vitality 3 points – 4 taxa or 8.0% (Table 22).

An analysis of growth in the layers of plant communities showed that most of the species occupy the upper tree layer – 35 species or 70.0%, the middle shrub layer is formed by 11 species or 22.0%, and 4 species or 8.0% occupy the lower layer (Table 23).

Table 22. The vital state Plants and values of I, H, G

Points	*n*	*n*log₂*n*
1	0	0
2	0	0
3	4	8
4	34	172.9
5	12	43

N	50
$\sum n\log_2 n$	223.9
I	4.478
H	1.162
G	0,252

Table 23. The layer Plants and values of I, H, G

Layer	*n*	$n\log_2 n$
Upper tree layer	35	179.4
Middle shrub layer	11	38
Lower layer	4	8

N	50
$\sum n\log_2 n$	215.4
I	4.308
H	1.333
G	0,309

It is shown that Specially Protected Areas are important reserves for the conservation of biological diversity. Studies of natural communities have made it possible to determine that 50 species from 25 genera and 14 families grow on the territory of the Buiratau State National Park. The largest family, including 10 genera and 16 species, is Rosaceae.

According to life forms, trees and shrubs were divided into 3 groups: trees (13 taxa), shrubs (31) and subshrubs (6). 6 ecological groups have been identified: hygrophytes, hygromesophytes, mesophytes, xeromesophytes, mesoxerophytes, xerophytes. The maximum number of species includes the group of mesophytes. Plants had a vital state from 3 to 5 points, occupying tiers from 1st to 3rd. 6 species of woody and shrub plants have been identified that need protection on the territory of the State National Park “Buiratau”.

For the systems under study, the value of the index of geoecological evolving organization was obtained from 0.252 to 1.092.

Next, we conducted a study in the Ijevan Subtropical Arboretum of the Republic of Armenia.

Analysis of the ratio of life forms showed the following types: trees, shrubs and subshrubs (Table 24).

Table 24. The composition of life forms of trees and shrubs Ijevan Subtropical Arboretum and values of I, H, G

Life forms	n	$n\log_2 n$
Trees	400	3455,5
Srubs	200	1527,9
Semishrubs	25	116
N	625	
$\sum n\log_2 n$	5099,4	
I	8,159	
H	1.123	
G	0,138	

In the Ijevan Subtropical Arboretum, the maximum number of species belongs to trees – 400 taxa or 64.0%. The second place is occupied by shrubs – 200 taxa or 32.0%; in last place are subshrubs. For the systems under study, the value of the geoecological evolution index was obtaine 0.138.

List of references

1. URL: https://www.britannica.com/place/Armenia

2. URL: https://en.wikipedia.org/wiki/Armenia

3. URL: http://ijevan.ysu.am/en/

4. URL: https://en.wikipedia.org/wiki/Dilijan_National_Park

5. Sayadyan M.L. Colection of plant species: Ijecan subtropical arboretum.Vanadzor: SIM Press. 2010, 204 p.

6. URL: https://en.wikipedia.org/wiki/Kazakhstan

7. URL: https://welcome.kz/en/kazakhstan/flora-fauna/

8. URL: https://www.britannica.com/topic/Kazakh-language

9. Askarova M.A., Arslan M., Mussagaliyeva A.N. Environmental Security of Geosystems of Kazakhstan. State and Evaluation. Oxidation Communications. 37(3). 882 (2014).

10. URL: https://en.wikipedia.org/wiki/Kazakh_National_Agrarian_University

11. Zhakupova A.A., Atasoy E., Galay E. An Evaluation of Recreational Potential of BSNNP in Order to Increase the Touristic Image of the Pavlodar Region. Oxidation Communications. 37 (3). 871 (2014).

12. URL: https://kazatu.edu.kz/en

13. Medvedev A.N. Forest Nurseries in Kazakhstan. Kazgosagru,Almaty, 1997. 176 p. (in Russian)

14. Sarsekova D.N., Simonyan G.S. Features of genetic dynamics of some species of the pine family in the semi-desert zone of Kazakhstan. Oxid Commun, 42 (4), 527 (2019).

15. URL: https://en.wikipedia.org/wiki/Buiratau_National_Park

16. Minakov A.L., Ismailova F.M., Sagaliev N.G., Ishmuratova M.Yu., Turlybekova G.K. Fauna and flora of the State National Park "Buiratau". Monograph, Karaganda: 2019, 140 p. (in Russian)

17. Pavlov N.V., Smolyanov A.S., Weiss A.A. Mathematical methods in forestry. Krasnoyarsk: SibSTU, 2005. 192 p. (in Russian)

18. Shannon C.E. A mathematical theory of communication. The Bell System Technical Journal, 27, 379 (1948).

19. McArthur R.M. Fluctuation of Animal Populations and Measure of Community Stabiliry. Ecology, 36 (3), 533 (1955).

20. Margalef R. Information Theory in Ecology. Gen Syst, 3, 36 (1958).

21. Margalef R. La teoria de la information en ecologia. Mem. Real. acad. cienc. y artes Barcelona, 32, 373 (1957).

22. Simpson E.H. Measurement of diversity. Nature, 163, 688 (1949).

23. Hill M.O. Diversity and evenness: a unifying notation and its bconsequences. Ecology, 54, 427 (1973).

24. Jost L. Entropy and diversity. Oikos, 113, 363 (2006).

25. Simonyan A.G., Pirumyan G.P., Simonyan G.S. Analysis of Environmental Status of the Kechut Artificial Reservoir and River Arpa with Armenian Index of Water Qualiti. Austrian Journal of Technical and Natural Sciences, 7-8, 37 (2016).

26. Simonyan A.G., Simonyan G.S., Pirumyan G.P. Analysis of environmental status of the rivers Aghstev and Getik with armenian index of water quality. European journal of Natural History. №4, 22 (2016).

27. Piroumyan G., Pirumyan E., Simonyan G., Simonyan A. Method of Determining the Level of Water Pollution. RA Patent, No 3063A, 2016.

28. Simonyan G.S., Simonyan A.G., Pirumyan G.P. Systemic-entropy approach for estimating the water quality of a river. Oxidation Communications, 41 (2). 307 (2018).

29. Pirumyan G., Simonyan G., Margaryan L. Geoecological Evaluational Integrating Index of Natural Waters and other Systems. CopyPrint LTD. Yerevan. 2019, 244 p.

30. Simonyan G. (July 29th 2020). Systemic-Entropic Approach for Assessing Water Quality of Rivers, Reservoirs, and Lakes, In Book Inland Waters – Dynamics and Ecology, Edited by Adam Devlin, Jiayi Pan and Mohammad Manjur Shah, Intech Open, DOI: 10.5772/intechopen.87463, 2, 19 (2021). DOI: 10.5772/intechopen.93220.

31. Simonyan G.S., Simonyan A.G., Margaryan L.A. A new approach to assessment of water quality of the Hrazdan river // Oxidation Communications, 43 (4), 861 (2020).

32. Simonyan G.S. Entropic-systems approach to assessing the structure of COVID-19 // Oxidation Communications. 43 (4), 641 (2020).

33. Simonyan G.S., Simonyan A.G. Entropic-systems Approach for Assessing the Structure of Proteins of SARS-CoV-2 // Oxidation Communications, 45 (4), 682 (2022).

34. Simonyan G.S., Pirumyan G.P. New judgment on the genesis of oil. CopyPrint LTD, Yerevan, 2021. 248 p. (in Russian)

35. Simonyan G.S. Entropy approach to naphthide systems. Progress Petrochem Science. 4 (1), 338, PPS. 000576. (2021). DOI: 10.31031/PPS.2021.04.000576

36. Simonyan G.S. Evaluation of the influence of nitrogen on the stability of naptic systems with the help of geo-ecological evolving organized index. Oxidation Communications, 42(3), 329 (2019).

37. Simonyan G.S., Simonyan A.G., Sayadyan M.L., Sarsekova D.N., Pirumyan G.P. Analysis of Environmental Status of Wood and Shrub Vegetation by the Armenian Index of Environmental Quality. Oxid Commun, 41 (4), 533 (2018).

38. Simonyan G.S., Sarsekov D.N. Analysis of the Ecological State of the Trees bym Geo-ecological Evolving Organising Index. Oxidation Communications, 44, 696 (2021).

39. Medvedev A.N. Forest nurseries in Kazakhstan. Almaty: Kazgosagru, 1997, 176 p. (in Russian)

40. Turbin N.V. Heterosis and genetic balan. Heterosis Minsk, Publishing House of AS BSSR, 3, (1961).

41. Rokitskiy P.F. Introduction to statistical genetics. Minsk: Higher. school., 1978. 448 p. (in Russian)

42. Leper P.R., Nikoro Z.S. Genetic and mathematical foundations of assessment of breeding qualities of animals. Novosibirsk, Publishing House “Science”, Siberian branch, 1966, 142 p. (in Russian)

43. Dyakov A.B., Dragavtsev V.A. Plant competitiveness in connection with the selection. Report I. Reliability of assessment of geneticists on phenotypes. Genetics.5,11, (1975).

44. Dyakov A.B., Dragavtsev V.A., Behter A.G. Plant competitiveness in connection with the selection. II. The new principle of the analysis of the dispersion of productivity. In the collection “The theory of selection in plant populations”. Novosibirsk, Publishing House “Science”, SO AS, 1976, 237-251 p. (in Russian)

45. Shmalgauzen I.I. The body as a whole in the individual and historical development. Publishing House of AS of the USSR, 1942, 211p (in Russian)..

46. Shmalgauzen I.I. The problem of stability of organic forms (ontogeny) in their historical development. Journal of general biology. 1, 3 (1945).

47. Dragavtsev V.A., Utemisheva N.B. On the problem of variability of developmental genetics and statistical parameters in plant populations. Genetics, 11.128 (1975).

48. Dragavtsev V.A., Tsilke R.A., Reiter B.G. and oth. Genetics signs of productivity of spring wheat in Western Siberia. Novosibirsk, “Science”, 1984, 228 p. (in Russian)

49. Lush A.L. Heritability of quantitative characters in farm animals. Hereditas, supp. V. 356 (1949).

50. Saharov V.I., Markovin A.P. Analytical selection of tree species principles. Collection of reports, SRW and OKR, ser. 25, № 22, 1988. p. 24. Report about SRW (final in 7 books), Almaty, 1987, 542 p. (in Russian)

51. Saharov V.I. Application methods for studying stationary random processes in plant systems to assess their response to changing environmental conditions. Botanical research in Kazakhstan. Almaty, Science, 1988, p. 19. (in Russian)

52. Dragavtsev V.A. The genetics of quantitative traits in plant breeding solving problems. Abstract of diss. On competition uch. Degree of Doctor of Biological Sciences. M., 1983, 36 p. (in Russian)

53. Medvedev A.N., Saharov V.I., Markovin A.P. Direction and selection methods for plantation and ecological production. Forest Journal Arkhangelsk 5, 19 (1998).

54. Alibekova F.A., Ismaiilova F.M., Sarsekova D.N., Satybaldiyeva G.K. Assessment of the state of woody and shrubs plants of the state national natural park "Buiratau" The scientific heritage. 89, 7 (2022). (in Russian)

55. Simonyan G.S., Sarsekova D.N. and all. Assessment of the state of woody and shrubs plants of the state national natural park "Buiratau" and Ijevan subtropical arboretum by Geo-ecological Evolving Organising Index. Oxidation Communications, 47 (2024). (in press)

56. Shcherbakov A.V., Mayorov A.V. Field study of flora and herbarization of plants. M.: Moscow State University Publishing House, 2006. 84 p. (in Russian)

57. Flora of Kazakhstan. T. 9. Alma-Ata: Science, 1966. 425 p. (in Russian)

58. Cherepanov S.K. Vascular plants of Russia and neighboring states (within the former USSR). St. Petersburg: Peace and Family, 1995, 990 p. (in Russian)

59. Serebryakov L.G. Ecological morphology of plants. Life forms of angiosperms and conifers. M.: Higher School, 1982.380 p. (in Russian)

60. Kuminova A.V. Vegetation cover of Altai. Novosibirsk, 1960. 449 p. (in Russian)