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of Zoonotic Diseases in the South Caucasus

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LEPL NATIONAL CENTRE FOR DISEASE CONTROL AND PUBLIC HEALTH

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Introduction

Zoonotic diseases, which are infectious diseases transmitted to humans from animals, are an important cause of human morbidity and mortality; Around 75% of recently emerging human infectious diseases are zoonoses. Individuals working in veterinary medicine and animal husbandry are at higher risk of acquiring zoonotic diseases due to their contact with animal hosts capable of carrying and disseminating a wide range of pathogens. Thus, this higher-risk population might also serve as a biological sentinel for the presence of emerging zoonotic pathogens. They may also spread these pathogens to community members, their families, and uninfected animals. Regional mapping of transmission risk for zoonotic disease presents an important tool to answer many human and animal health-related questions and is crucial for addressing areas of increased risk to humans and livestock.

The South Caucasus (Armenia, Azerbaijan, and Georgia) exhibits high natural and social diversity, contributing to the persistent circulation of many zoonotic pathogens and the emergence of zoonotic diseases. Over the years, scientists from all three countries have developed a number of national atlases demonstrating territorial division, landscape, natural resources, and human population. Previous national atlases in these countries have not included information on the spatial distribution of zoonotic pathogens and diseases in animals and humans. To that end, we present a cartographic atlas of the nature and distribution of zoonotic diseases in the South Caucasus. This is the first presentation of the spatial distribution of seven zoonotic diseases (anthrax, brucellosis, Crimean-Congo hemorrhagic fever, leptospirosis, plague, tick-borne encephalitis, and tularemia) that originate and persist in the natural environment independent of humans. Our specific objective is to identify areas where the geographic and anthropogenic environment supports the circulation of zoonotic pathogens and influences their reservoirs in the region.

The goal of the Atlas is to identify and illustrate geographic, ecological, and social factors that drive the emergence, re-emergence, and persistence of pathogens in nature that are communicable to people and livestock. The information presented can be used to direct prevention and control efforts throughout the South Caucasus by identifying priority areas for targeted surveillance, livestock vaccination, and public health education campaigns. Such efforts reduce human transmission risk, contribute to the development of epidemiological assessment of disease burden, and improve programmatic planning and management in the region. To add to a broader understanding of the distribution of zoonotic diseases in the region, we performed descriptive and analytical studies to identify reservoirs, vectors and risk factors for zoonotic infections.

In an accessible way, we present the historical and current distribution of seven zoonotic diseases in Armenia, Azerbaijan and Georgia, as well as their epidemiological traits, regional and country population morbidity, and natural foci.

The global movement of people, goods, and animals, as facilitated by trade and tourism, accelerates the spread of infectious diseases. Livestock movement caused by migration, trade, and livestock markets is critical in the dissemination of zoonotic and vector-borne diseases. Efficient, robust surveillance systems are essential for early detection and response. Historical infection data, collected from 1950 to 2020, can help inform health networks in their early detection efforts and outbreak responses.

Effective surveillance systems rely on accurate reporting and response capability at local and national levels. Early identification of zoonotic disease emergence is crucial for containing cases and outbreaks of this disease. To develop the Atlas, we acquired historical information on the location, source, and impacted populations of different outbreaks and, by extension, identified other similar regions where their circulation may have gone undetected. The Atlas specifically acknowledges the broad range of determinants that impact patterns of infectious disease transmission.

The Atlas aims to support the modernization of national surveillance and to identify areas at risk for various zoonotic pathogens in the South Caucasus. Zoonotic pathogens, their arthropod vectors, and vertebrate reservoirs are an integral part of the natural environment, but various ecological and social factors also influence the distribution of these pathogens. Medical geography tools analyze spatially referenced data on distributions of animal hosts, arthropod vectors, and infectious agents, and their spatial concordance with environmental and social parameters.

Zoonotic diseases are maintained and spread through the environment via a variety of host and vector species. The key determinant of human spillover is whether or not they share an environment with a species capable of transmitting the disease. There are maps depicting 14 tick species, 16 small mammal species, and nine ungulate species that are medically relevant in the South Caucasus included in the Atlas.

Species' distribution ranges were compiled using models of the species occurrence probability. The sets of publicly aviable maps, as well as geographic data on climate, land use, soil, and biogeography were used to correct the obtained models according to known historical data on the species occurrence and species habitat preferences. The dataset used for the modeling includes data from the Collection of the Institute of Zoology of Ilia State University, Georgian National Museum, the Collection of Zoological Institute of Russian Academy of Science, Zoological Museum of Moscow State University, records from the National Centres for Diseases Control databases in all three countries, published scientific data, and data collected by the authors from 1983 to 2022 years. For the South Caucasus countries, 6,085 records of 15 species of rodents were collected in 1,676 locations from 1855 through 2022, 709 records of hare in 391 locations were collected from 1878 through 2021, and 1,390 records of nine species of ungulates were collected from 1876 through 2022. Moreover, 55,733 records from 1,004 locations in three countries were collected for the tick database from 1947 through 2021. Also, the most accurate predictions for each species distributions, derived from expert elicitation and statistical measures, are presented in this Atlas. The maps do not illustrate the complete distribution range for target species, but rather the distribution ranges of the key populations of these species. The maps obtained this way aligned well with the anticipated 50-60% likelihood of the species' population presence in this area as per the species' relative likelihood of occurrence models.

The Atlas includes a series of maps presenting data on the landscape, climate, vegetation, fauna, demographic patterns, social factors affecting the interface between animals and people, data on the detection and identification of zoonotic agents in natural habitats, and incidence of human disease morbidity across South Caucasus. The Atlas illustrates the regional heterogeneity in distribution of the infections concerning the mosaic of physical and cultural landscapes typical in the Southern Caucasus. Finally, we identify areas where zoonotic diseases may occur in the future based on a high risk of spillover to humans, thus providing guidance on targeted surveillance efforts.

The Atlas can be of use to geographers, environmental workers, epidemiologists, and public health specialists.

Political Map of the South Caucasus

Physical Map of the South Caucasus

Climate Types of Georgia

Georgia is situated in the northern margin of the subtropical zone, and is affected by subtropical, temperate and high latitude circulation processes.

The Caucasus Mountain range, which runs across the north of Georgia, forms a natural border and protects the country from the direct impact of arctic cold air masses. As a result, these masses arrive in Georgia either from the west or the east. Coming from the west, the lower layer of an air mass will be warmed, and its humidity and instability increased, while passing over the Black Sea, so that it enters Georgia saturated with moisture. This process causes a temperature drop and heavy precipitation in west Georgia. Such a synoptic situation is known as a Western Circulation Process. During this process air masses cross the mountain range of Likhi (Surami) — which runs perpendicular to the Caucasus, and is one of the main climate barriers in Georgia — and affect the weather patterns in eastern Georgia, causing strong westerly winds.

When air masses come from the East (this is known as Eastern Circulation Process), relatively cold air masses from the North Polar Basin and Siberia spread from the Caspian Sea. This mainly affects the weather conditions in the eastern regions of East Georgia. Usually, its strength is not enough to reach the Likhi Ridge and it dissipates on the plain of Shida Kartli. This process does not bring considerable weather changes in west Georgia.

The only circulation process that worsens weather conditions throughout Georgia is the "Double Access Invasion." This is when cold air masses invade Georgia simultaneously from the east and west. A sharp drop in air temperature and heavy precipitation characterize this process. After cold air masses from the north enter the south Caucasus, an anticyclonic situation develops there with weak winds, and dry and moderately cloudy weather throughout the whole territory of Georgia.

Once air masses have intruded into the southern Caucasus, stationary atmospheric fronts formed south of the southern Caucasus affect the weather patterns in Georgia. During this process, tropical air masses may invade the country, and this can cause an increase in summer air temperature as high as 40–41°C. Such a synoptic situation is called an "Undulatory Invasion from the South." The local circulation processes together with orography of the territory determine the character of climatic elements in Georgia and will be described below.

Georgia receives a considerable quantity of solar radiation due to its location in the northern margin of the subtropical zone. However, in the narrow gorges of the mountainous zone, in small depressions and on slopes of north–eastern and north–western orientation, sunshine is significantly reduced. Analysis of the data of long–term observation confirms that the annual duration of sunshine is more than 2000 hours in most of Georgia.

The special peculiarity of thermal field of underlying surface ground temperatures in the territory of Georgia is mainly stipulated by vertical zonality. The average temperature of the winter months, namely of January, is quite high in the Kolkheti Lowland, a condition caused by physical–geographical peculiarities and also by the frequency of easterly foehn winds. In most areas of western Georgia, the average temperature in January is above 0°C but becomes negative above 550–600 meters elevation. The warmest January is typically in Batumi, where the average air temperature reaches 7.0°C. Air temperature gradually decreases to the east, away from the sea; as well as with altitude. It is especially cold in this month in the high zone of the Caucasus (in Kazbegi high mountain –14.7°C and in Mamisoni –11.6°C), as well as in the Javakheti Upland (Efremovka –10.6°C and Paravnistskali –8.2°C), where along with the elevation of the site, the landforms contribute to the decrease in temperature.

The complicated orographic structure of the country and its interaction with air masses spread across the territory results in large contrasts in the distribution of precipitation in Georgia. It is natural that from the west and north–west of Europe air masses rich in moisture spread into Georgia from the Black Sea. In the colder portion of the year air masses spreading from the Caspian Sea also contain an adequate moisture supply, though in the warm portion of the year their moisture content significantly decreases. The air masses coming from the Caspian Sea do not provide precipitation in western Georgia. Warm and dry weather is related to air masses spreading in from the south.

A large amount of precipitation falling in Georgia is related to invasions of the air masses from the west. The air masses intruded from the east provide 10–15% of the annual precipitation, and only in the eastern part of the country. The two–way (simultaneously from the west and east) intrusion of air masses into the territory of the country provides abundant precipitation. The wave disturbances and convection processes developed in the south of Georgia are related to a considerable amount of precipitation.

The average annual amount of precipitation falling in the country's territory is 1250 mm, though, despite the lack of great distances, the annual amount of precipitation falling in Georgia varies greatly. The Achara coastline is the richest in precipitation. The annual amount of precipitation exceeds 4500 mm on Mt. Mtirala near the city of Batumi. In the north, along the seashore, the amount of precipitation gradually decreases to 1400–1500 mm.

Compared to the western part of the country, much less precipitation falls in eastern Georgia. Abundant precipitation is characteristic only of the mountainous and especially the high mountainous zones of the southern slopes of the Greater Caucasus Range, where 1200–1800 mm of precipitation occur during the year. In the agricultural areas such as Shida Kartli and Kvemo Kartli, Samtskhe–Javakheti, Shiraki and Eldari, the annual amount of precipitation does not exceed 400–600 mm.

Spatial distribution of precipitation in the territory of the country during warm and cold spells is not significantly different from the annual distribution.

The monthly patterns of precipitation in the eastern and western parts of Georgia are substantially different. The maximum amount of precipitation in eastern Georgia is observed in the months of May and June. A weak secondary maximum is observed in September and October. The main minimum is in January and the secondary in August. The maximum amount of precipitation in western Georgia in most cases is observed in October; the rest is distributed between November, December and January. The annual minimum is in April and May in the coastal zone and nearby regions, and in July and August in internal regions.

Present climate change is expressed in Georgia mainly by the frequency of droughts, strong winds and heavy rain, followed by flooding and landslides. The increase in temperature is mostly observable in winter and summer.

Winter, Svaneti © Roman Tolordava

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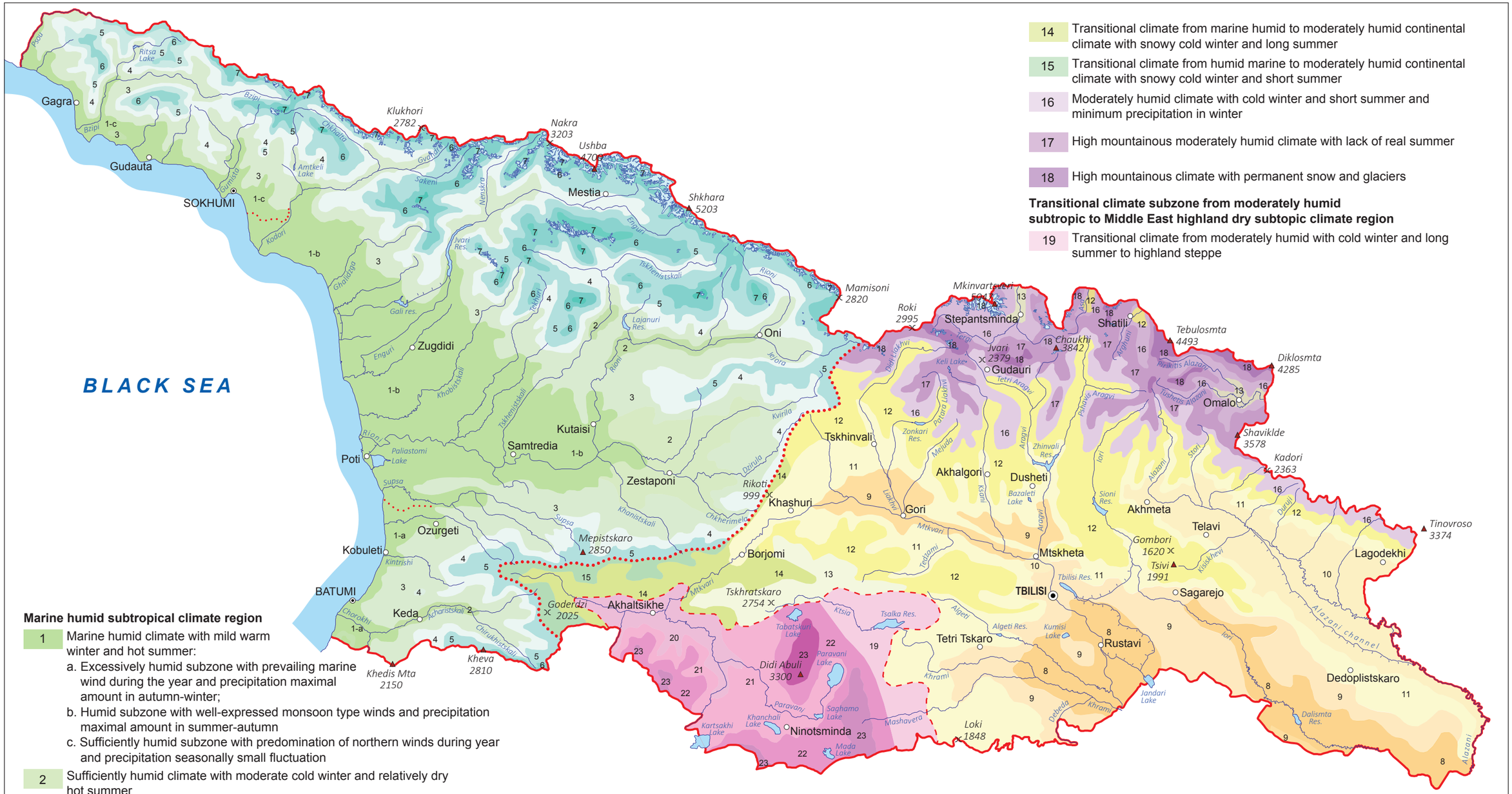
Climate Types of Georgia



Marine humid subtropical climate region

1 Marine humid climate with mild warm winter and hot summer:
- a. Excessively humid subzone with prevailing marine wind during the year and precipitation maximal amount in autumn-winter;
- b. Humid subzone with well-expressed monsoon type winds and precipitation maximal amount in summer-autumn
- c. Sufficiently humid subzone with predomination of northern winds during year and precipitation seasonally small fluctuation

2 Sufficiently humid climate with moderate cold winter and relatively dry hot summer

3 Humid climate with moderate cold winter and long warm summer

4 Humid climate with cold winter and long cool summer

5 Humid climate with cold winter and short summer

6 High mountainous humid climate with lack of real summer

7 High mountainous humid climate with year-round abundant snow and glaciers

Moderately humid subtropical climate region

8 Moderately warm steppe with hot summer and minimum precipitation twice a year

9 Transitional climate from a moderate warm steppe to a moderate humid one, with hot summer and minimum precipitation twice a year

10 Moderate humid climate with moderately cold Winter and hot summer and minimum precipitation twice a year

11 Moderate humid climate with moderately cold Winter and long warm summer and minimum precipitation twice a year

12 Moderate humid climate with cold Winter and long cold summer, minimum precipitation twice a year

13 Moderate humid climate with cold winter and long cool summer and minimum precipitation in winter

14 Transitional climate from marine humid to moderately humid continental climate with snowy cold winter and long summer

15 Transitional climate from humid marine to moderately humid continental climate with snowy cold winter and short summer

16 Moderately humid climate with cold winter and short summer and minimum precipitation in winter

17 High mountainous moderately humid climate with lack of real summer

18 High mountainous climate with permanent snow and glaciers

Transitional climate subzone from moderately humid subtropic to Middle East highland dry subtopic climate region

19 Transitional climate from moderately humid with cold winter and long summer to highland steppe

20 Highland steppe climate with less snowy, cold winter and long, warm summer

21 Highland steppe climate with less snowy, cold winter and long cool summer

22 Highland steppe climate with short summer and cold, less snowy winter

23 Highland moderately dry climate with lack of real summer

Climate region's border · Climate subzone's border · Subregion border

0 15 km
0 15 mi

Climate Types of Azerbaijan

The diversity of the climate of Azerbaijan was determined by the geographical location of the area, the complexity of the relief, the proximity of the Caspian Sea, the abundance of solar radiation, being under the influence of air masses of various origins and other factors. The Greater Caucasus Mountains, located in the north of the republic and stretching from northwest to southeast, protect most of the country from the direct influence of cold air masses coming from the north.

On formation of climate over the territory of Azerbaijan is influenced by arctic, continental and marine air masses of temperate latitudes, warm air masses of tropical latitudes, an anticyclone over Central Asia, as well as local atmospheric processes.

Azerbaijan experiences 8 out of 11 climate types. Most of the country is located in the subtropical zone.

The number of hours of sunshine varies between 1900-2800 hours. The annual amount of total solar radiation varies from 120 kcal/cm^2 to 160 kcal/cm^2. The annual volume of radiation balance is 40-50 kcal/cm^2 on the plains and foothills, 15-25 kcal/cm^2 in the highlands.

The average annual air temperature is 14-15°C in the lowlands, –13°C in the mountains. The absolute maximum (+46°C) and minimum (-33°C) air temperature values were observed on the Araz plain of the Nakhchivan Autonomous Republic, which is characterized by a sharply continental climate.

On the territory of Azerbaijan, the least precipitation falls in south-eastern Gobustan and on the southern coast of the Absheron Peninsula (200-300 mm per year, and in the Baku region less than 200 mm). The greatest amount of precipitation falls in the south of the Lankaran lowland and the slopes of the Talysh Mountains – 1200-1700 mm. In general, the amount of precipitation gradually increases from the coast of the Caspian Sea to the west, from the plains to the mountains.

The maximum amount of average annual relative humidity (75-80%) is observed in coastal areas, the minimum (55-65%) – in the territory of the Nakhchivan Autonomous Republic and in the highlands of the Greater and Lesser Caucasus.

The average annual absolute humidity is 4-5 mb in the highlands, 14-15 mb in the lowlands and the Caspian coastal zone. The value of absolute humidity in the Nakhchivan Autonomous Republic is 1-5 mb lower than in other regions of the republic (at the corresponding altitude).

The strongest winds in the Republic of Azerbaijan are the northern winds, which blow in all seasons of tthe year and are known as “khazri”. Its speed exceeds 10 m/sec, sometimes reaching 40-42 m/sec. These winds occur approximately 100 days a year. The strong winds also include the southern wind “gilavar”, which is characteristic of the Absheron Peninsula. It sometimes reaches speeds of 20-24 m/sec. Hot winds are observed in flat and foothill areas. When they occur, the air temperature sometimes rises to 40-42°C, and the relative air humidity drops to 10-30%. There are local winds that blow in different seasons of the year – “silyan”, “gara el”, “ag el”, etc.).

The temperature change in the country for the period 1880-2010 years ranged from 0,2 to 1,50°C in different regions, and the last 40 years are considered the warmest period. The greatest increase in temperature is observed on the Kura-Araz Plain (0.4-0.9°C), in the Ganja-Gazakh zone (0.6-1.10°C), the southern slope of the Greater Caucasus (0.5-0.80°C), in the northeastern (0.6-1.5°C) and northern (0.4-0.6°C) slopes of the Lesser Caucasus. If sum up Azerbaijan as a whole, the increase in temperature over the last hundred years is 0.7°C, which is close to the increase in the temperature of the Earth as a whole.

Gachresh Forest in February (Greater Caucasus) © Elina Karimova

Autumn. Chukhuryurd village, Shamakha district © Elina Karimova

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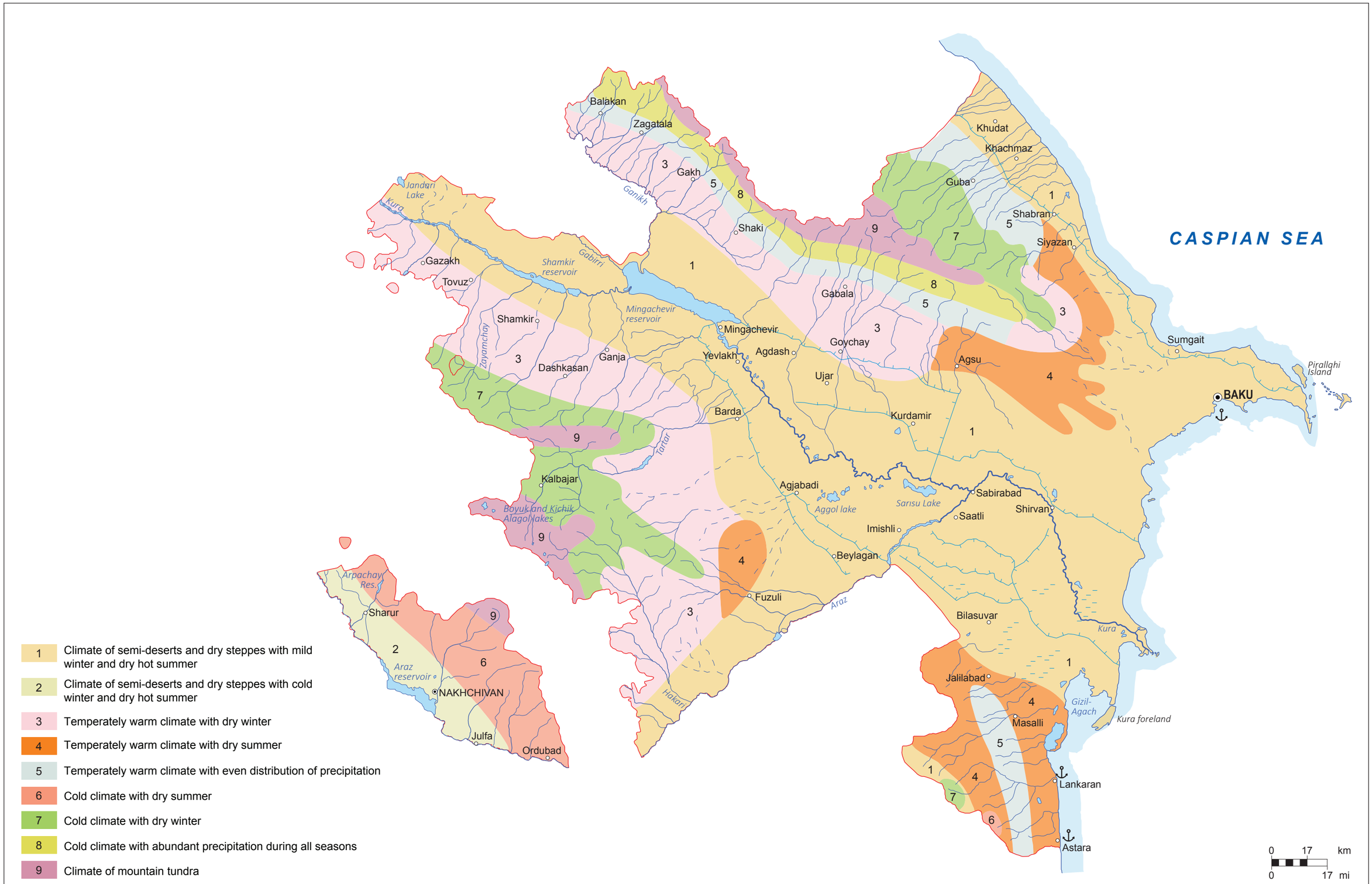
Climate Types of Azerbaijan



Climate Types of Armenia

Armenia is a country of climatic contradictions. Significant differences in climate are observed even in the smallest areas, mainly due to the complex terrain. Almost all climatic variations can be observed in the country – from dry subtropical to cold mountainous.

The average annual air temperature ranges from –8°C in high mountainous areas (2500 m and above) to 12-14°C in low valley regions.

Summer is mild with an average temperature of 16.7°C in July, and in the Ararat Valley it is in the range of 24-26°C.

Winter is quite cold. January is the coldest month of winter, with an average temperature of –6.7°C. In the northeastern and southeastern regions of the Republic, winter is mild.

The climate in Armenia is quite dry. The average annual precipitation is 592 mm. The highest precipitation is observed in high mountainous regions – 800-1000 mm annually. The most arid regions are Ararat Valley and Meghri region. Annual precipitation here amounts to 200-250 mm. The average precipitation in the Ararat Valley during the summer does not exceed 32-36 mm.

The climate of Armenia is also characterized by the intensity and abundance of solar radiation, which is 1.46 kcal/cm^2 and 2500 hours, respectively.

The average annual wind velocity in the territory of Armenia is unevenly distributed: 1.0 m/sec (Meghri) up to 8.0 m/sec (Sisian). In summer, the velocity of the mountainous winds can reach 20.0 m/sec or more.

In recent decades, there has been a significant increase in temperature growth rates in Armenia relative to the annual mean for 1961-1990 (5.5°C), whereby in 1929-1996 the average annual temperature increased by 0.4°C, in 1929-2007 by 0.85°C, in 1929-2012 by 1.03°C and in 1929-2016 by 1.23°C. The decreasing trends of precipitation are maintained. Precipitation during the period of 1935-2016 relative to the annual mean (592 mm) decreased by almost 9%.

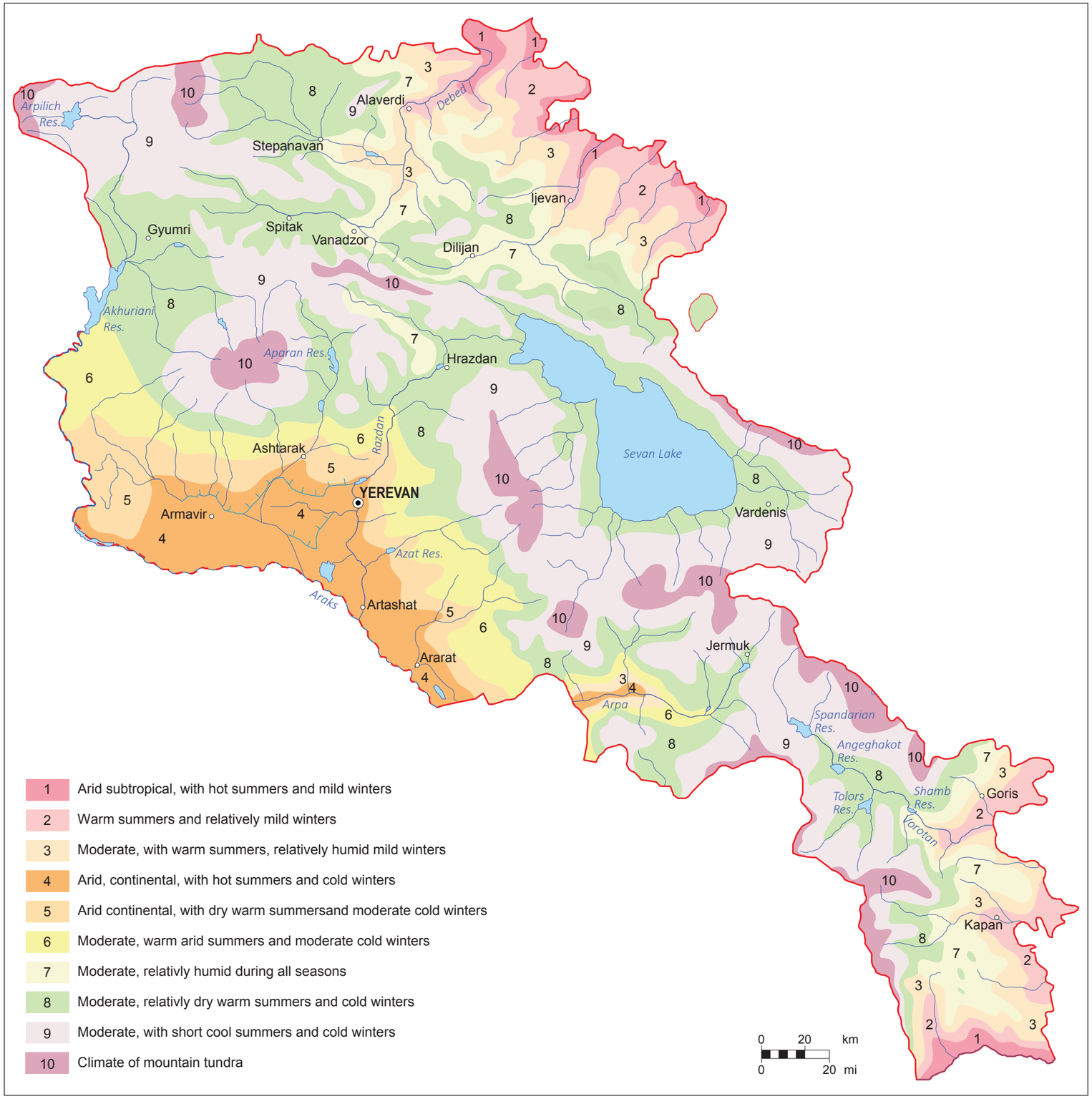
The territory of Armenia is characterized by high frequency and magnitude of hazardous hydrometeorological phenomena, which trigger the occurrence of emergency situations and inflict significant losses to the population and the economy.

Reference:

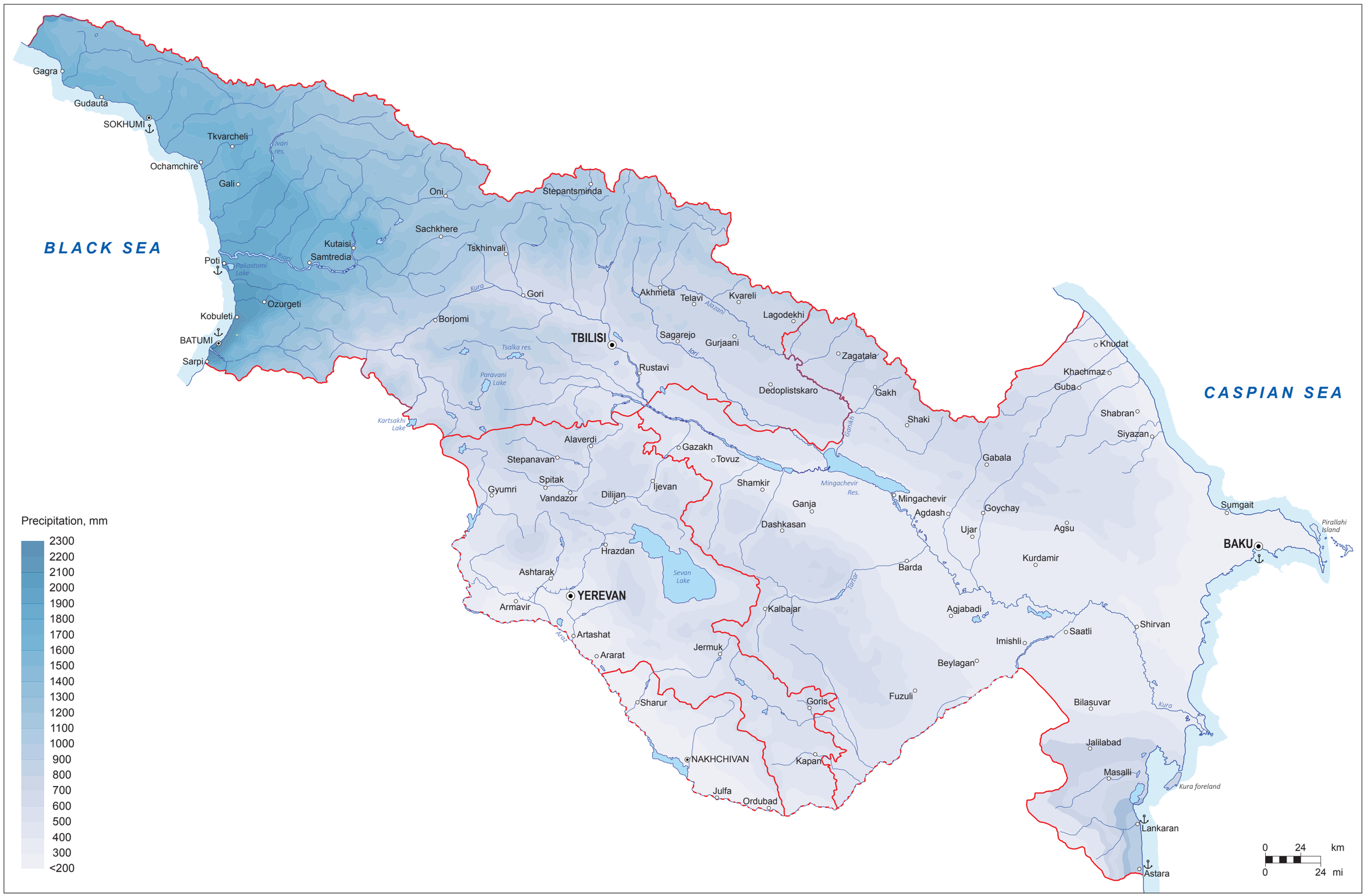
Fourth National Communication on Climate Change Under the United Nations Framework Convention on Climate Change. (2020) Yerevan, UNDP Armenia, 213 p.

River Dzoraget, Stepanavan, Armenia © Tigran Hayrapetyan

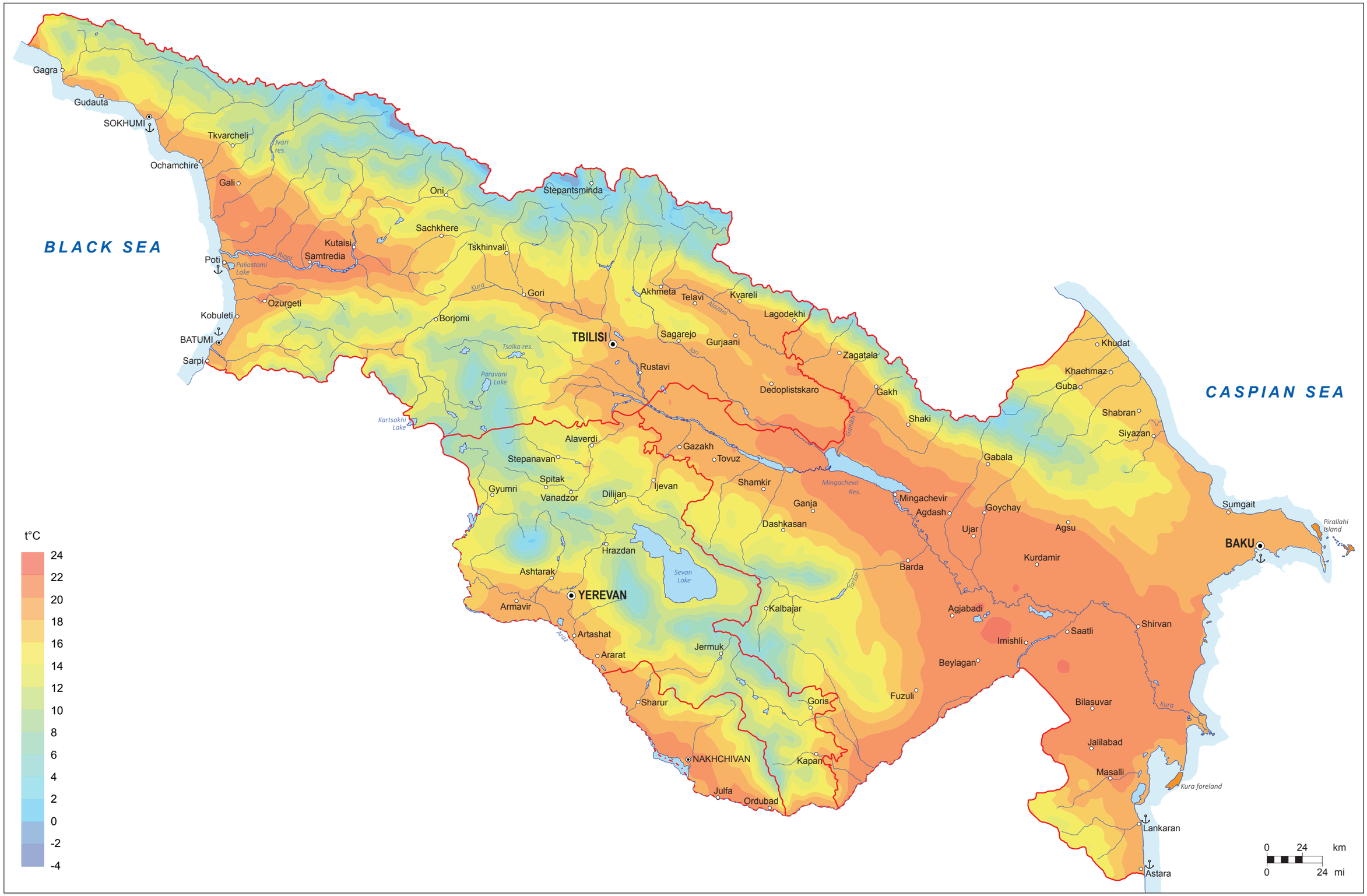
Climate Types of Armenia



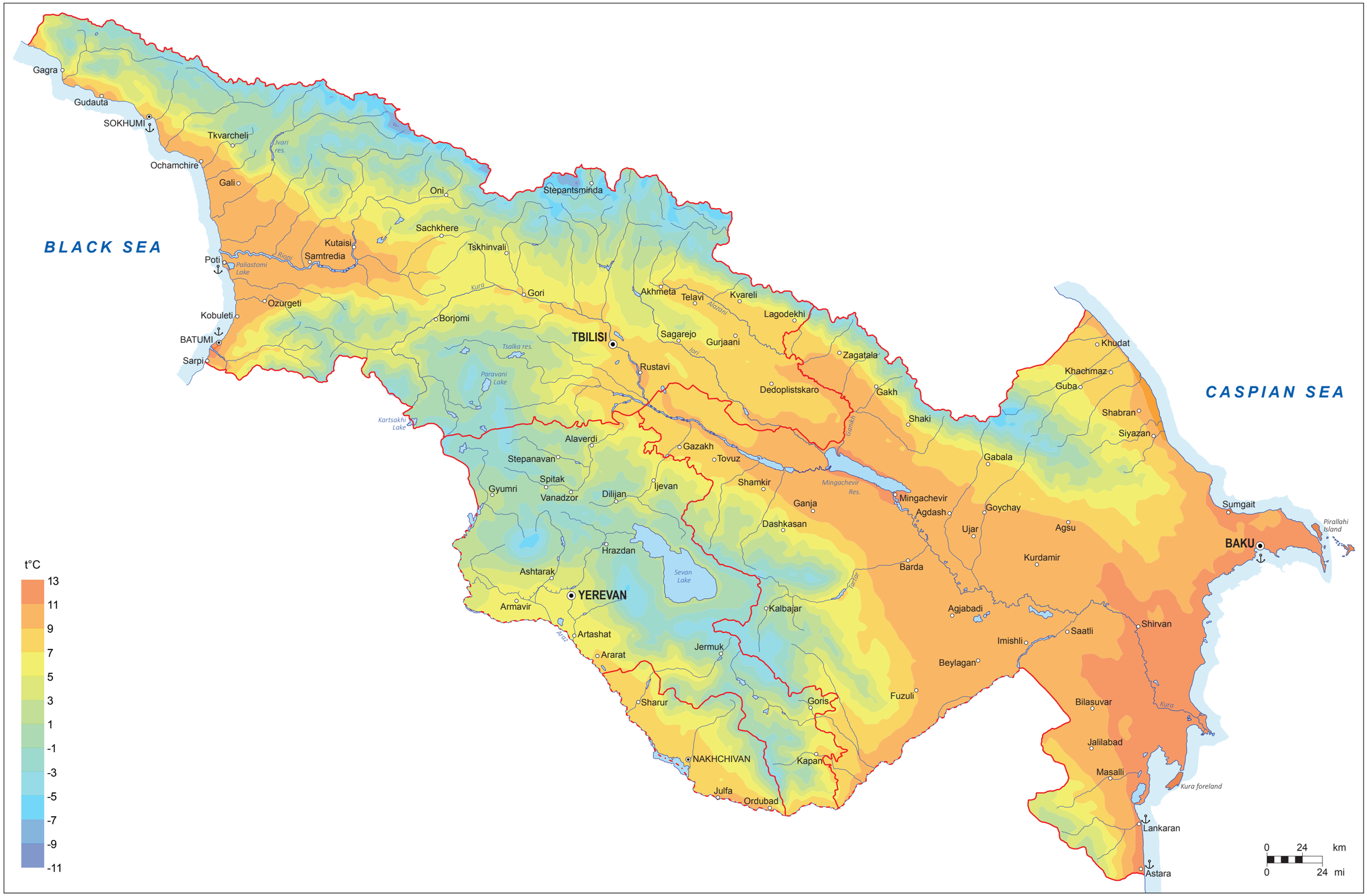
Precipitation of the South Caucasus



Maximum Air Temperature of the South Caucasus



Minimum Air Temperature of the South Caucasus

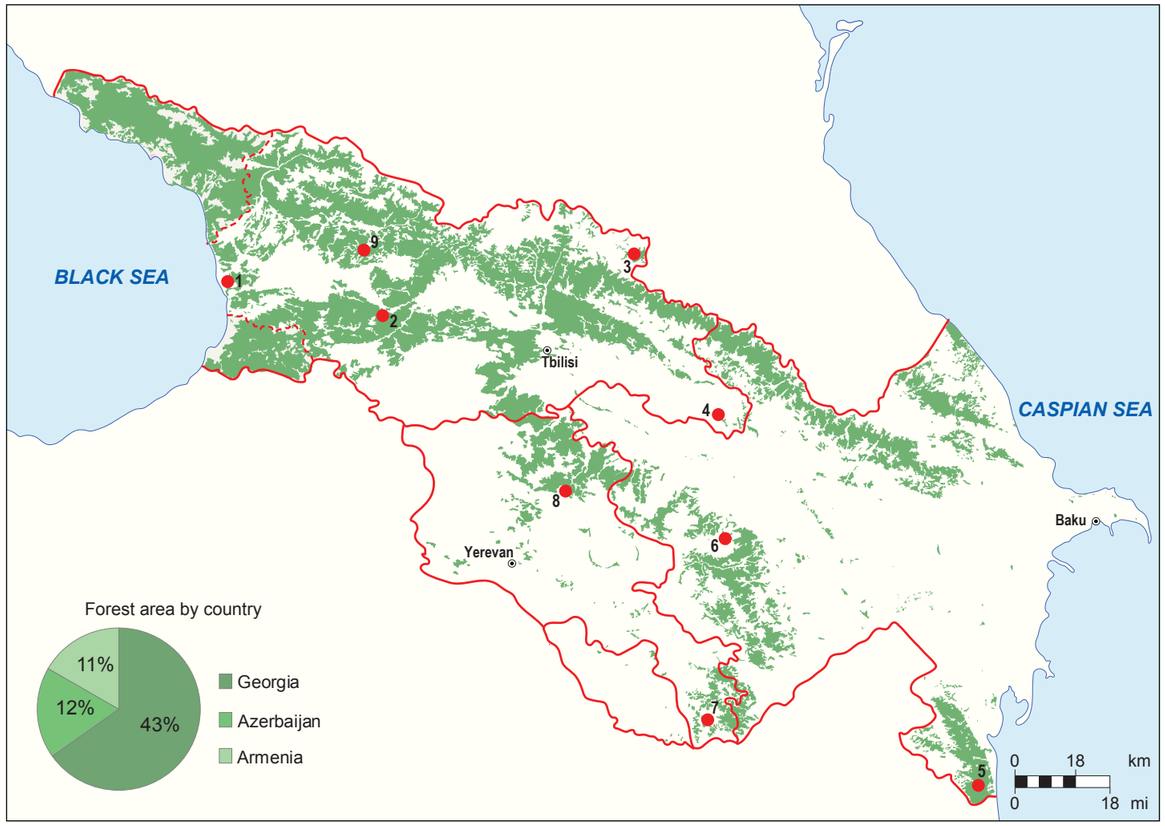


Water Resources of the South Caucasus

Forests of the South Caucasus

About 17% of the total land area of the Caucasus is covered by forests, primarily found between altitudes of 500-2000 m and growing on steep slopes. Most forests are broadleaf forests but a number of different types are found, including birch forests, oak forests, fir forests, alder forests and wing nuts forests. In Georgia the total area covered by forests is 40% while forest areas in the Northern Caucasus amount to 11.4%, in Azerbaijan to 14-15% and in Armenia to 10% only. In the Southern Caucasus most forests are found in the Greater and Lesser Caucasus, while in the Northern Caucasus most forestland is found in North Ossetia. In the Turkish and Iranian part of the Caucasus dense forest cover occurs along the Black and Caspian Seas only.

Source:
https://www.grida.no/resources/7908



1. Colchic rainforests and wetlands, Georgia. *http://georgiavoyage.ge/en/colchic-forests-granted-world-heritage-status/*

3. Tusheti, Georgia. *https://georgia4you.ge/where-to-go-in-georgia/TUSHETI*

5. Hirkan National Park, Azerbaijan. *https://gsaz.az/en/articles/view/82/HIRKAN-MILLI-PARKI*

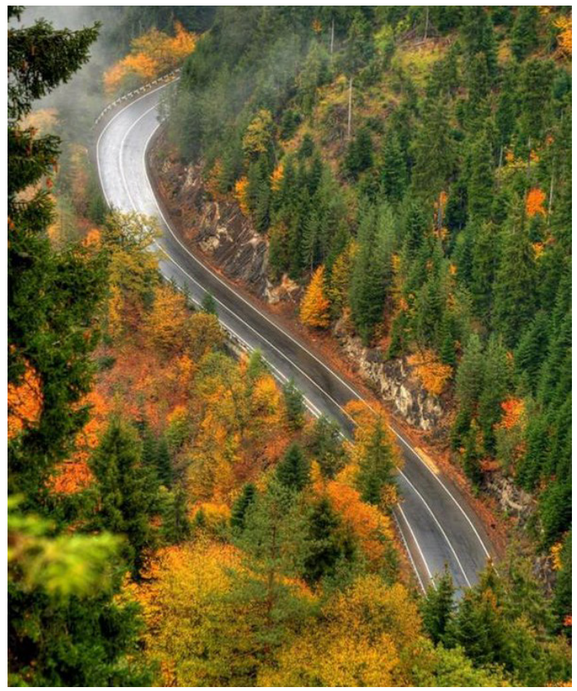
7. Arevik National Park, Armenia. *https://heroesofadventure.com/listing/arevik-national-park-armenia/*

8. Dilijan National Park, Armenia. *https://upload.wikimedia.org/wikipedia/commons/2/22/%22Dilijan%22_national_park.jpg*

2. Borjomi-Kharagauli National Park, Georgia. *https://upload.wikimedia.org/wikipedia/commons/3/32/Borjomi_mountains.jpg*

4. Arid-open forest (Pistacia mutica) © Shamil Shetekauri

6. Goygol National Park, Azerbaijan. *https://upload.wikimedia.org/wikipedia/commons/a/a7/Geygol.jpg*



9. Racha, Georgia. *https://www.facebook.com/221195488223048/photos/a.355738878102041/355738868102042/?type=3&locale=ms_MY*

Landscapes of the South Caucasus

The South Caucasus is characterized by a wide variety of landscapes, which is mainly explained by the complexity of its orography and climatic contrasts, as well as the peculiarities of the history of the formation of different parts of the Caucasus and the influence of neighboring territories. In the South Caucasus, both lowland and mountain landscapes are widely represented.

The flat landscapes of the South Caucasus belong to the subtropical zone. Natural landscapes characteristic of the territory of the South Caucasus are: deserts, semi-deserts, dry steppes.

Desert landscapes are common in Armenia in the form of small islands in the Goravan desert and in the Armavir region (near the Araz River).

Semi-desert and dry-steppe landscapes cover large areas in Azerbaijan. They were formed directly under the influence of an arid climate and occupy a relatively low part of the foothills and intermountain plains.

Semi-desert complex is distributed on the plains of the Kura-Araz and Caspian lowlands, the Araz plain in the Nakhchivan Autonomous Republic of Azerbaijan, and in the lowlands of Jeyranchol-Ajinour and Gobustan. In Azerbaijan, semi-desert landscapes occupy 1/3 of the country's territory. The most common plant formations are wormwood, wormwood-ephemeral, wormwood-saltwort, ephemeral plants and various combinations. Semi-desert landscapes of the plains have been developed since ancient times. They are used not only as pastures, but also through the use of water from transit rivers (Kura and Araz), various areas of irrigation farming have been developed on them. Therefore, natural plants were completely destroyed in irrigated areas and replaced by various cultivated plants.

The high level of groundwater as a result of intensive irrigation has caused salinization in large areas of some plains of the Kura-Araz Lowland and the Araz plain, and in some very wet places - waterlogging.

A significant part of the territory of **dry steppes** is tilled and developed for agricultural crops under irrigation. **Moderately dry steppes** alternate with dry steppes.

Dry steppe landscape is located above the semi-desert landscapes; it forms the second landscape level of the lowland landscapes. The dry-steppe landscape was formed directly in the zone of contact between the Kura-Araz lowland and the foothills of the Greater and Lesser Caucasus.

The areas of distribution of dry-steppe landscapes are located in the zone of transition of the slopes of the foothills of the Lesser Caucasus into the Karabakh, Mil and Ganja-Gazakh plains, as well as on the plateaus and ridges of the Jeyranchol and Ajinour lowlands, on the elevated parts of the Araz plain. In the southeast of the Greater Caucasus, dry steppe landscapes occupy relatively large areas on the ridges and hills of Gobustan.

Dry steppe landscapes developed on light chestnut, chestnut, and partly dark chestnut soils. The vegetation is dominated by bluestem, wormwood, fescue, thickets of Christ's-thorn and other xerophytic shrubs.

Favorable relief conditions, the presence of water sources for irrigation and high heat reserves allow the dry steppes to be widely used in agriculture. The dry steppe landscapes of the plains are the main areas of irrigated agriculture, especially grain farming. All subtypes and types of this landscape are also widely used as pastures, especially winter pastures (Ajinour-Jeyranchol). Moderately **wet steppes** are distributed mainly at medium altitudes of volcanic plateaus.

In the Colchis and Lankaran lowlands, landscapes of **humid subtropics** are widespread, formerly lowland forests, in the place of which there are now plantations of various subtropical crops and rice fields (in the Lankaran lowland). Alder swampy forests and swamp subtropical landscapes have been preserved. Large areas of swamps have been drained and developed for subtropical agriculture.

Mountain landscapes form three regions: the Greater Caucasus with the dominance of mountain-forest, mountain-meadow and glacial-nival landscapes; Lesser Caucasus with mountain forest and mountain meadow landscapes; The Armenian highlands are dominated by mountain-steppe and mountain-meadow volcanic landscapes. The Talysh Mountains, with their landscapes of humid subtropics, are part of the Hyrcanian region, which belongs mainly to northern Iran.

The distribution of landscapes in the mountains is subject to the laws of altitudinal zonation. **Subtropical forest landscapes** are common in the lower tier of the southern slope of the Greater Caucasus, the northern slope of the Lesser Caucasus and the Talysh Mountains. In the Western regions of the Caucasus of Georgia and in the Talysh Mountains of Azerbaijan, low-mountain landscapes of humid subtropics with red and yellow earth soils, deciduous forests of diverse floristic composition, evergreen shrubs in the undergrowth and lianas are developed. In the eastern part of the South Caucasus (the mountain frame of the Kura Depression), subtropical forests are xerophytic in nature and grow on mountain brown soils. **Mountain forest landscapes** are dominant in the mountains of the Greater and Lesser Caucasus. The lower part of the mountain forest belt in the South Caucasus, above the subtropical forest landscapes, forms oak forests with hornbeam, above - beech forests with hornbeam, occupying the middle mountains of the Talysh Mountains. Above them, in the western parts of the Greater and Lesser Caucasus, dark coniferous forests (from Caucasian spruce and fir) are common; in the Eastern Caucasus there are pine forests. **Mountain forests** of the Caucasus are dominated by mountain forest brown soils. Mountain forests serve as a source of valuable timber and play an important soil and water conservation role. **Mountain-steppe landscapes** with mountain black soils are common on lava plateaus and plains of the Armenian Highlands. The highlands of the Greater and Lesser Caucasus and the Armenian Highlands are occupied by mountain-meadow landscapes (in the most continental regions, meadow-steppe). High-mountain meadows of the subalpine zone on typical mountain-meadow soils are used for haymaking and periodic grazing; low-grass meadows and carpets of the alpine belt on mountain-meadow peaty soils serve as summer pastures. The upper, subnival part of the mountain meadow belt has fragmentary soil and plant cover. On the highest ridges of the Greater Caucasus, and partly in the Armenian Highlands (Aragats, Zangezur ridge), **a glacio-nival landscape** is widespread.

Alpine, subalpine meadows, Batabat lake, Nakhchivan (Azerbaijan). © Elina Karimova

Yeranos Mountains. The province of Ararat (Armenia). © Tatevik Safaryan

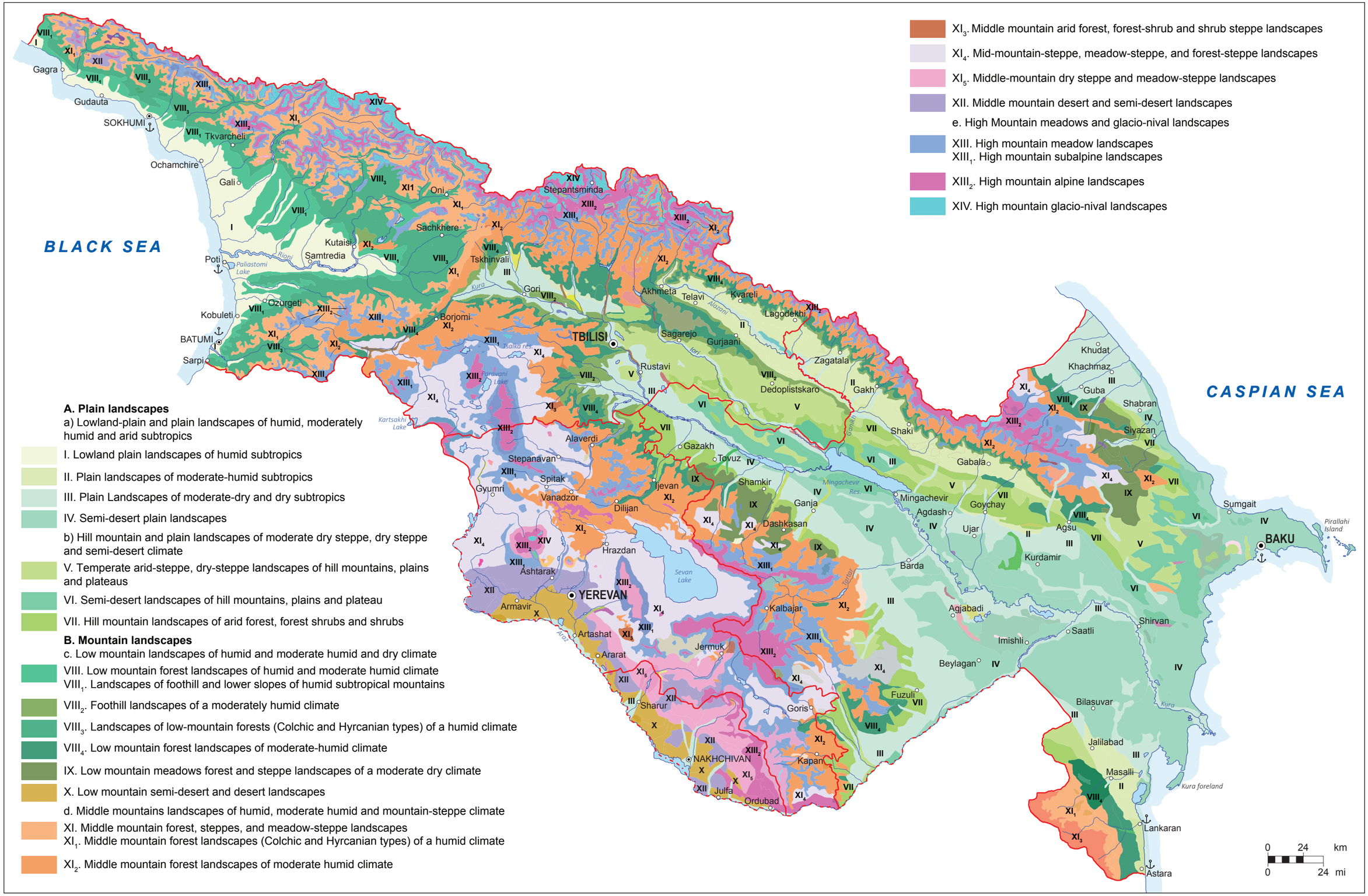
Kolkheti National Park. © Roman Tolordava

Mt. Ushba (Georgia). © Roman Tolordava

Mud volcano Deveboynu, Gobustan (Azerbaijan). © Elina Karimova

Geghama mountains in Ghegharkunik province (Armenia). © Tatevik Safaryan

Landscapes of the South Caucasus



A. Plain landscapes

a) Lowland-plain and plain landscapes of humid, moderately humid and arid subtropics

I. Lowland plain landscapes of humid subtropics

II. Plain landscapes of moderate-humid subtropics

III. Plain Landscapes of moderate-dry and dry subtropics

IV. Semi-desert plain landscapes

b) Hill mountain and plain landscapes of moderate dry steppe, dry steppe and semi-desert climate

V. Temperate arid-steppe, dry-steppe landscapes of hill mountains, plains and plateaus

VI. Semi-desert landscapes of hill mountains, plains and plateau

VII. Hill mountain landscapes of arid forest, forest shrubs and shrubs

B. Mountain landscapes

c. Low mountain landscapes of humid and moderate humid and dry climate

VIII. Low mountain forest landscapes of humid and moderate humid climate
$VIII_1$. Landscapes of foothill and lower slopes of humid subtropical mountains

$VIII_2$. Foothill landscapes of a moderately humid climate

$VIII_3$. Landscapes of low-mountain forests (Colchic and Hyrcanian types) of a humid climate

$VIII_4$. Low mountain forest landscapes of moderate-humid climate

IX. Low mountain meadows forest and steppe landscapes of a moderate dry climate

X. Low mountain semi-desert and desert landscapes

d. Middle mountains landscapes of humid, moderate humid and mountain-steppe climate

XI. Middle mountain forest, steppes, and meadow-steppe landscapes
XI_1. Middle mountain forest landscapes (Colchic and Hyrcanian types) of a humid climate

XI_2. Middle mountain forest landscapes of moderate humid climate

XI_3. Middle mountain arid forest, forest-shrub and shrub steppe landscapes

XI_4. Mid-mountain-steppe, meadow-steppe, and forest-steppe landscapes

XI_5. Middle-mountain dry steppe and meadow-steppe landscapes

XII. Middle mountain desert and semi-desert landscapes

e. High Mountain meadows and glacio-nival landscapes

XIII. High mountain meadow landscapes
$XIII_1$. High mountain subalpine landscapes

$XIII_2$. High mountain alpine landscapes

XIV. High mountain glacio-nival landscapes

Soil Types of Georgia

Georgia is characterized by a wide range of soil cover, due to the diversity of soil forming factors. Complex geological structure and heterogeneity of bed rocks, the relief peculiarity and contrasting climate conditions, specificity of vegetation cover and biodiversity, all influence the mosaics of the soil cover of Georgia and its peculiar geographical distribution. The genetic types characteristic of humid subtropical lowland areas and arid regions are widespread in the foothills, mountain-forest and mountain-meadow zones.

The diversity of soil cover of Georgia is especially noticeable in the lowlands and regions with plain relief; in the mountains such differences are less evident. Each physical-geographical region in Georgia has a complex of characteristic soil types.

The Caucasus region is characterized by the common structure of the vertical zonality of soil cover. However, according to local climatic and other conditions, the soil types' spectrum is different within regions. In the southern slopes of the Caucasus, the Brown Forest Soils prevail. Further above, the Mountain-Meadow subalpine and alpine soils are represented, reaching a high mountainous nival zone in the form of primitive soils.

In the southern highland, the Mountain Chernozems dominate. At the higher massifs, ranges and slopes, the Mountain Meadow soils are widespread. Lesser Caucasus outer slopes are characterized by Brown Forest, Mountain-Forest Cinnamonic and Mountain Meadow soils.

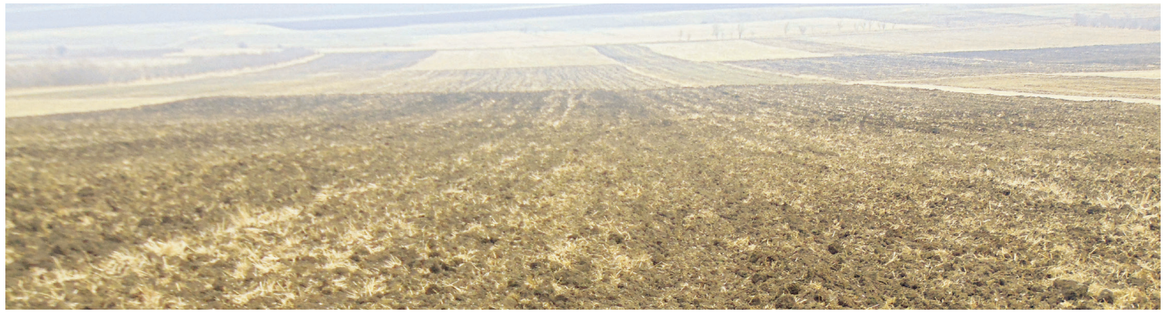
In the Kolkheti Lowland hydromorphic soils are common, such as Marsh Soils, Alluvial Soils and Subtropical Podzols. In the upraised parts of the lowland, Red Soils and Yellow Soils can be found.

The Mtkvari Lowland is characterized by dry subtropical soils – Grey and Meadow Grey Cinnamonic Soils, as well as Salt Soils.

In Georgia, three soil-geographical regions – Western Georgia, Eastern Georgia and Southern Georgia – can be distinguished, with corresponding subregions, zones and areas.

Within the soil region of Western Georgia, three soil-geographical subregions can be distinguished: the Caucasus, the Intermountain lowlands, and the Transverse ranges of the southern highlands. Within the soil region of Eastern Georgia there are three sub-regions: the Caucasus, the Intermountain lowlands and uplands, and the Transverse ranges of southern highlands. And within the soil region of Southern Georgia the tsubregions of the Akhaltsikhe intermountain depression and the volcanic uplands of Southern Georgia can be distinguished.

Meadow Cinnamon - Gleyic-Vertic Kastanozems. Shida Kartli arable lands. © Davit Sartania



Black Calcareous - Calcic Vertisols. Sartichala. © Besik Kalandadze

Zinnamonic - Haplic Kastanozems. Arable lands in Uplistsikhe. © Besik Kalandadze

Each soil-geographical subregion includes the corresponding soil zones and areas.

In the areas of the country which are subject to strong industrial impacts, the soils are strongly modified and so called "anthropogenic soils" are formed, occupying 0.1% of the area (>80 km^2) of Georgia. They have lost their natural construction and the upper part of the profile experiences anthropogenic impact.

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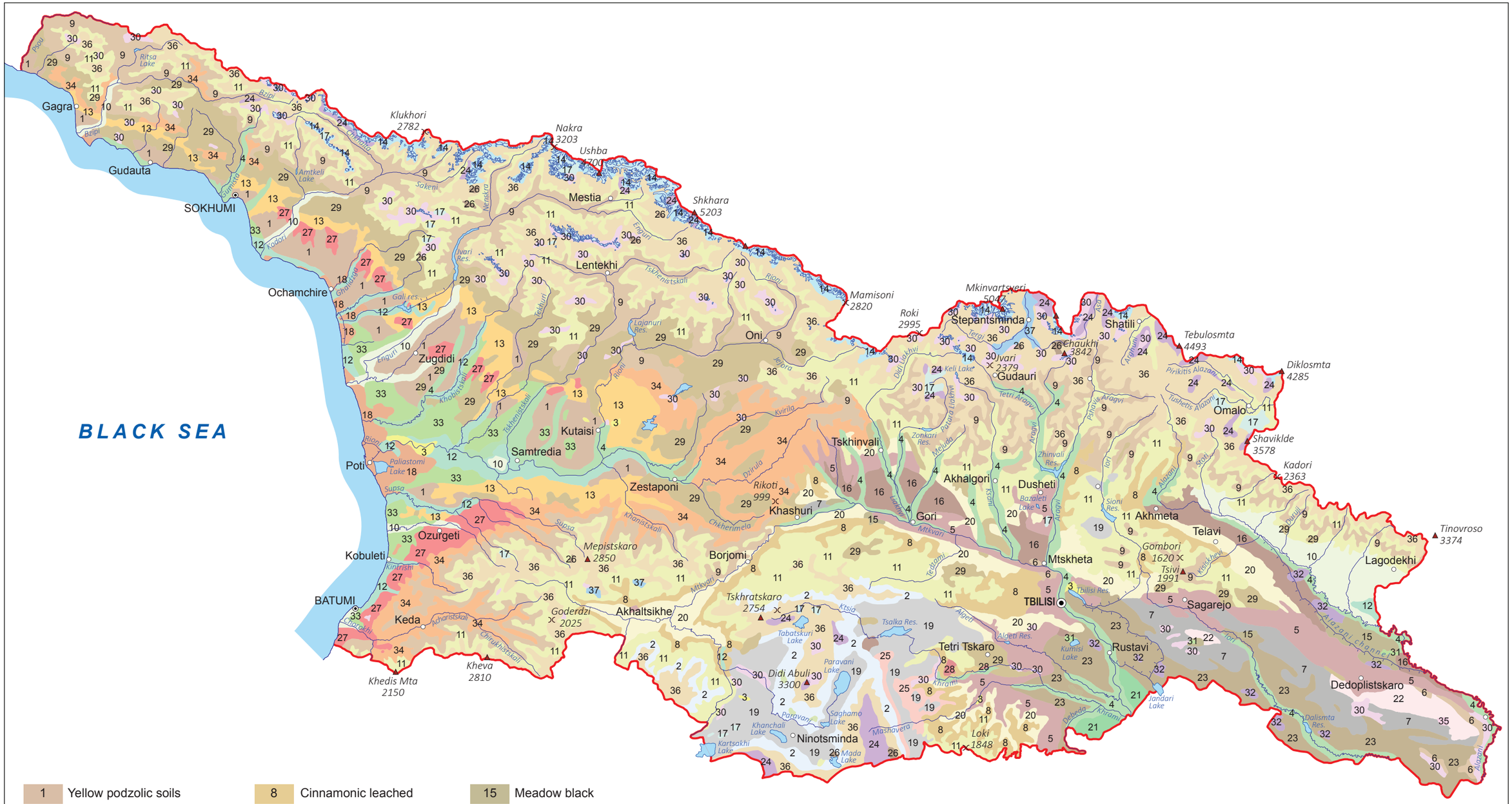
Soil Types of Georgia



1	Yellow podzolic soils	8	Cinnamonic leached	15	Meadow black						
2	Andosols	9	Dystric cambisols	16	Meadow cinnamonic	22	Black	28	Brown forest black	34	Yellow brown forest
3	Anthropogenic soils	10	Alluvial acid	17	Mountain meadow peat	23	Grey cinnamonic	29	Rendzic leptosols	35	Raw humus sulphate
4	Alluvial calcareous	11	Eutric cambisols	18	Gleysols	24	Primitive mountain meadow	30	Strongly eroded soils and bare rocks	36	Mountain meadow
5	Cinnamonic calcareous	12	Alluvial saturated	19	Chernozems	25	Leached chernozems	31	Solonchak	37	Mountain forest meadow
6	Cinnamonic light	13	Yellow soils	20	Chernozems	26	Mountain meadow chernozem like	32	Solonetz		
7	Black calcareous	14	Glaciers	21	Meadow grey cinnamonic	27	Red soils	33	Yellow podzolic gley soils		

Soil Types of Azerbaijan

Soil types widespread in the country are subject to a rule of horizontal zonation on the plains and the subject to a rule of vertical zonation in mountainous areas. The height of the area, climate, soil-forming rocks, age form sharply different soil types, subtypes and the diversity of their chemical, physicochemical properties, as well as changes in mineralogical composition.

There are 25 types and 60 subtypes of soils in the country. According to geographical distribution, as well as geomorphological features, the soils of the Azerbaijan Republic are divided into mountainous and flat.

Mountain areas are characterized by erosion, denudation, and primitive soil-forming processes. The soils of the lowlands and plains were formed on sedimentary rocks. These soils have a thick soil profile and are subjected to salinization and waterlogging. In lowlands and plains, changes in the structural and morphological characteristics of soils are greatly influenced by irrigation.

On the plains of Azerbaijan (except for the Lankaran Plain) gray, gray-brown, gray-meadow soils are distributed. In the depressions of the plains, saline soils are distributed – solonchaks and solonetzes (local name is "shor").

Chestnut soils are distributed in the foothills and low-mountain steppes up to an altitude of 800 m.

Mountain forest soils are distributed in mountainous areas at an altitude of 700-2200 m. Brown mountain forest soils and brown mountain forest soils are distinguished. In the Lankaran region, due to heavy rainfall, brown mountain forest soils occupy vast areas. But in Nakhchivan this type of soil is absent due to the arid climate.

In conditions of a humid subtropical climate, yellow soils (zheltozems) are developed under Hyrcanian-type forests of chestnut-leaved oak in the Talysh Mountains and Lankaran Plain. Due to the high iron content, the soil turns red and yellow.

In the territories from 1500-1600 m to an altitude of 2600-3000 m in the Greater and Lesser Caucasus, mountain meadow soils are distributed. These soils are formed under high alpine and subalpine meadows. The type of mountain-meadow soils includes mountain-meadow, peaty (alpine), mountain-meadow turf (subalpine) and mountain-meadow chernozem-like (meadow-forest) soils, which successively replace each other, starting with the highest located and youngest in age mountain meadow peaty soils.

Since the climate on the high mountain peaks is cold, there are no conditions for soil formation.

On the Shollar Plain, in the Ganykh-Agrichay Valley and along the bed of the Kura River, where groundwater comes close to the surface, alluvial-meadow soils are distributed.

Saline land (Solonchak) and takyr, Chalkhangala, Nakhchivan © Elina Karimova

Solonetz, Southeast Shirvan © Mirnuh Ismayilov

Ferric Luvisols (Candy Cane Mountains), Duzdag, Nakhchivan © Nazim Bababayli

Mountain-gray brown soil, Jalilabad © Elina Karimova

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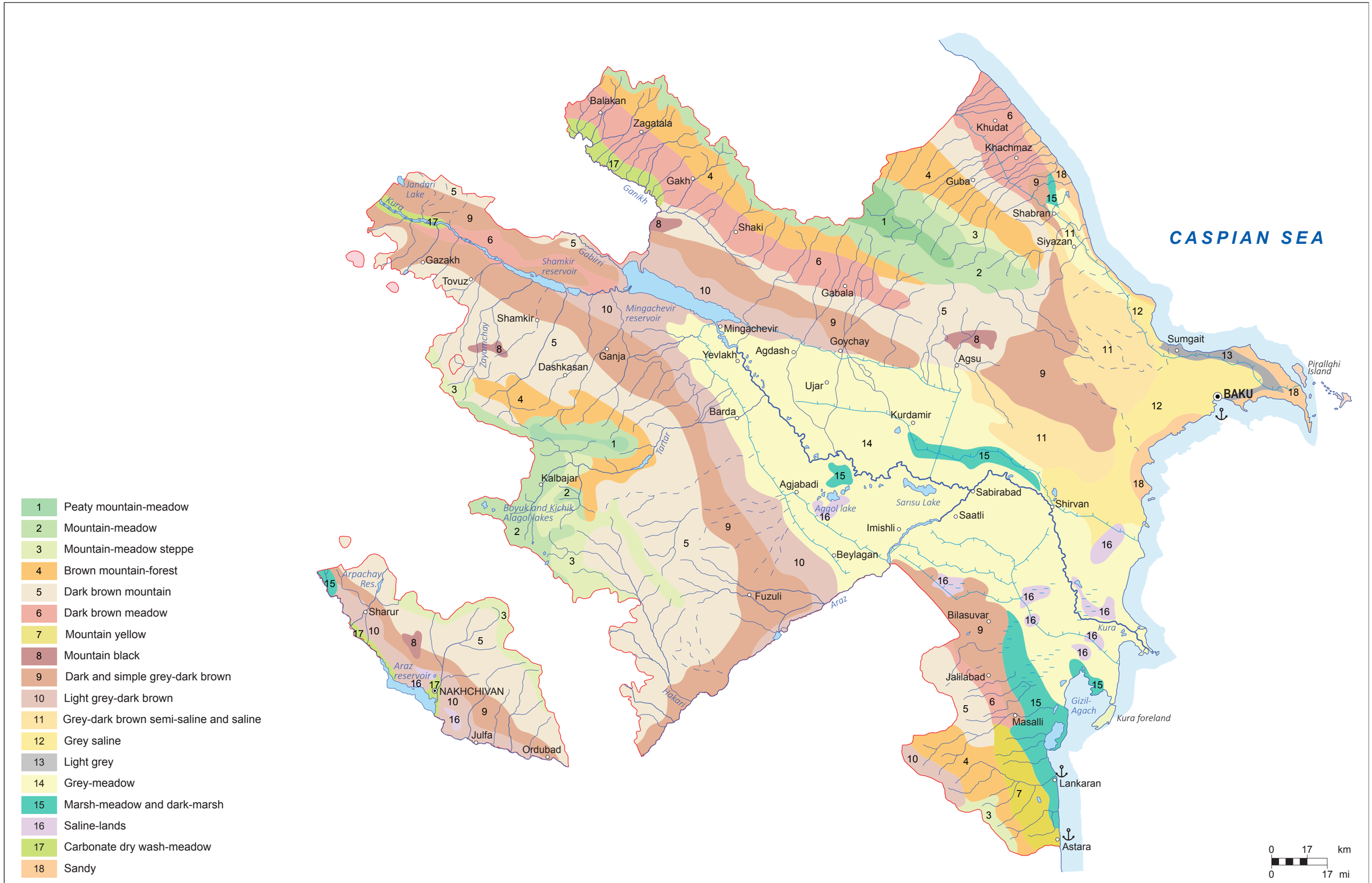
Soil Types of Azerbaijan



1 Peaty mountain-meadow
2 Mountain-meadow
3 Mountain-meadow steppe
4 Brown mountain-forest
5 Dark brown mountain
6 Dark brown meadow
7 Mountain yellow
8 Mountain black
9 Dark and simple grey-dark brown
10 Light grey-dark brown
11 Grey-dark brown semi-saline and saline
12 Grey saline
13 Light grey
14 Grey-meadow
15 Marsh-meadow and dark-marsh
16 Saline-lands
17 Carbonate dry wash-meadow
18 Sandy

Soil Types of Armenia

The formation of soils, flora and fauna of Armenia is closely connected with the history of the emergence and formation of the Armenian Highlands.

Both the climate and the development of soils, flora and fauna of the Republic of Armenia were greatly influenced by the proximity of the Black and Caspian seas, as well as the Iranian and Asia Minor highlands.

Due to the diversity of bioclimatic conditions in the Republic of Armenia, its soils, flora and fauna are also diverse.

The soils of Armenia were formed under conditions of complex mountainous terrain, diversity of parent rocks and climate. Human influence was also of great importance. These factors determined the diversity of the soil cover of the republic.

As the altitude of the area changes, the entire complex of soil formation also changes. For example, on the Ararat Plain at altitudes of 800-1300 m, desert and semi-desert soils characteristic of this territory are common: gray soils, saline soils. This type of soil was formed due to the sharply continental climate and sparse vegetation. Therefore, the humus content in the soils here does not exceed 1-2%. But intense human activity has dramatically changed the natural properties of these soils. They can only be used for artificial irrigation, so the local irrigation system has an ancient history (for example, the Arzni-Shamiram canal, built during the reign of the Urartian kings). Currently, thanks to the use of fertilizers and other agricultural means, these lands have turned into irrigated lands, which are used mainly for the cultivation of grapes, fruits, industrial and vegetable and melon crops.

Mountain chestnut soils in the northeast of the republic are distributed up to an altitude of 800 m, and in the south – up to 1300-1700 m. They were formed in a hot and relatively dry climate. These soils are richer in humus (4-5%) and are suitable for growing various crops: grains, tobacco, vegetables, fruits, as well as some types of subtropical crops (figs, almonds, olives).

Mountain chernozems are distributed at altitudes of 1300-2400 m (volcanic plateaus and highlands), occupy 25% of the territory and are characterized by a high humus content (4-11%). Chernozems were formed in a warm, relatively humid climate under the cover of steppe and meadow-steppe vegetation. The thickness of the soil layer reaches 75 cm. Sugar beets, potatoes, and some types of fruit varieties are cultivated on these soils.

Brown and gray forest soils are common on the slopes of the Lesser Caucasus mountains, in the northeastern and southeastern regions, at altitudes of 900-2400 m. They are found in islands on the slopes of Mount Aragats, the Areguni, Tsakhkunyats ridges and the Vayk region. These soils were formed in a moderately warm, relatively humid climate.

Meadow soils are common at altitudes of 2100-2500 m and have a relatively high humus content (8-15%). The lower border is used for haymaking, and the upper border is used for pasture, so these soils are important for the development of livestock farming in the Republic of Armenia.

Mountain meadow soils were formed in a cold mountain climate under the cover of subalpine and alpine vegetation. In the southern regions of the republic, the lower limit of these soils begins at an altitude of 2400 m, and in the northern regions – from 1800-2000 m. The upper limit reaches 4000 m and meets high-mountain rock formations.

Reference:
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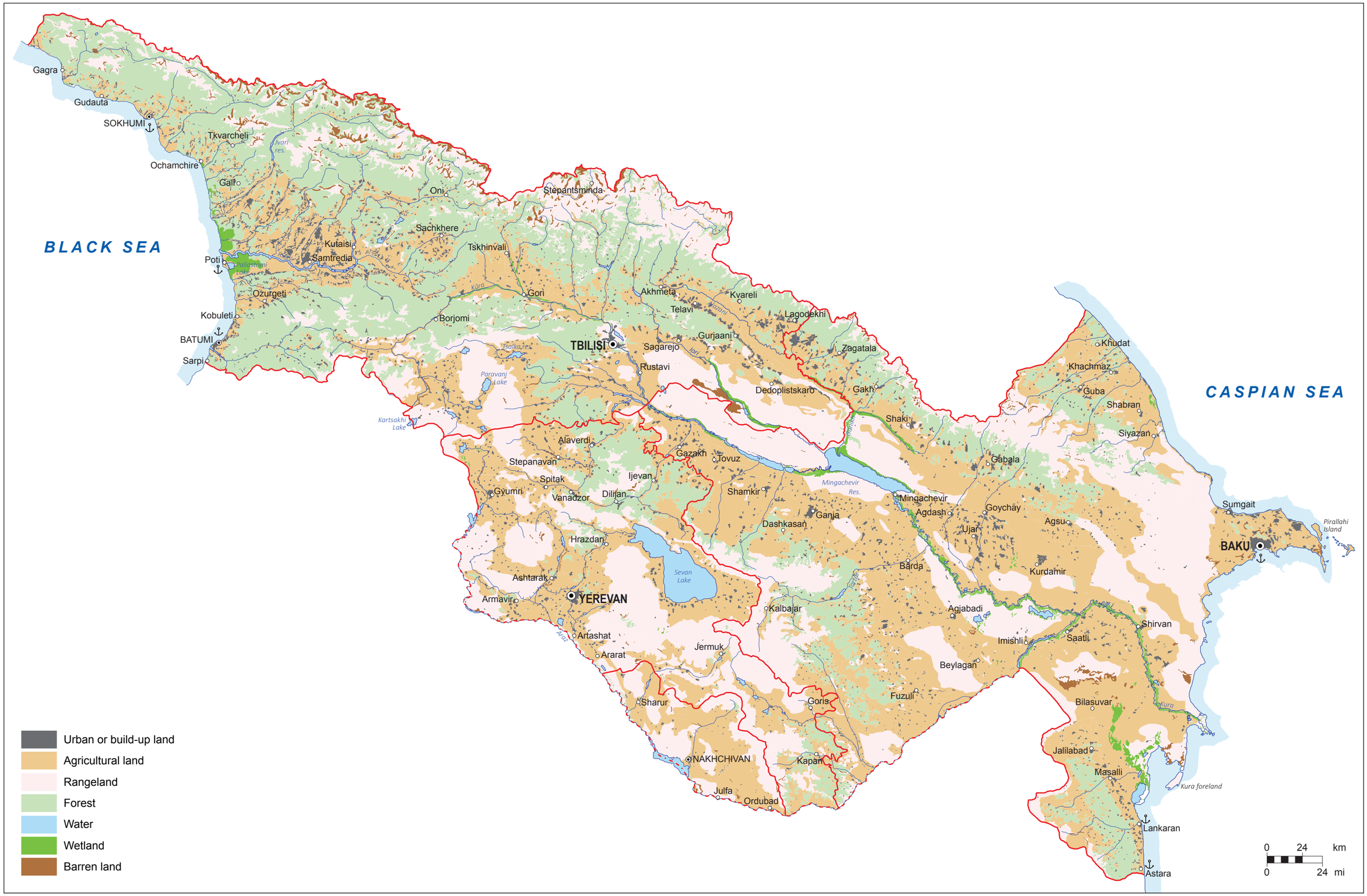
Soil Types of Armenia

Land Use of the South Caucasus



Ticks

Ticks (Ixodidae) are parasitic arthropods belonging to the subclass Acari. They are ectoparasites of mammals, birds, reptiles, amphibians, and sometimes humans. Ticks are of significant medical and veterinary importance due to their ability to transmit pathogens that cause diseases, including tularemia, Crimean-Congo hemorrhagic fever, and tick-borne encephalitis. These diseases can affect both humans and animals, leading to serious health consequences if not treated promptly.

Ticks transmit vector-borne pathogens because they consume their hosts' blood. Ticks' feeding habits, frequency, and preference for vertebrate hosts can influence their vectorial capacity to acquire, maintain, and transmit the pathogens.

Certain diseases can be more effectively spread by specific tick species than others. The abundance of ticks in a specific area affects the likelihood of disease transmission, and higher densities can increase transmission rates. Temperature, humidity, and other environmental conditions affect tick survival and the development of pathogens within them, influencing disease transmission rates. Ticks are found in diverse habitats, including forests, grasslands, and urban environments. They are especially abundant in areas where their hosts (animals they feed on) are prevalent. Ticks have a complex life cycle that typically includes four stages: egg, larva, nymph, and adult.

Controlling ticks involves various strategies, including habitat modification, acaricides (tick-killing chemicals), and personal protective measures such as protective clothing and repellents. Knowledge of tick biology and environmental factors affecting tick distribution is crucial for predicting tick-borne disease cases and outbreaks, designing interventions, and prevention of vector-borne diseases.

Maps of tick distribution identify points where ticks were collected. The ranges indicate the predicted likelihood of a species' presence within the South Caucasus. These maps are compiled using the results of the probability of occurrence modeling for each of the 14 tick species. The modelling is based on the tick database containing 55,733 records from 1004 locations in three countries collected for from 1947 through 2021.

ACARI: *Ixodida*

1. *Dermacentor marginatus* Sulzer, 1776

Common name: Ornate cow tick/Ornate dog tick
Distribution in the Caucasus area: Georgia, Azerbaijan (p. 36)
Hosts: *D. marginatus* is a three-host tick species. Larger mammals - deer, horses and cattle, but more importantly sheep. It is also found on domestic dogs and hares but will seldom attach to humans. The immatures occur predominantly on small mammals, particularly rodents (shrews, moles, and hedgehogs). *Dermacentor marginatus* developmental stages have seldom been reported from bats or birds.
Ecology: The seasonal activity of adult *D. marginatus* is higher in spring and a lower in autumn. Larvae and nymphs living in the burrows and nests of small mammals. *D. marginatus* prefers meadows and pastures. In Georgia, the habitats of *D. marginatus* can be characterized by xerophilic plant communities, it can occur from 20 meters up to 1000 meters above sea level. In Central Europe, adult questing starts in late August and can last until May/June of the next year, including the winter months during days of mild weather. Larvae and nymphs are active during the summer In Georgia, this species has been found from 20 meters up to 1300 meters above sea level.
Significance in medical and veterinary aspects: *D. marginatus* is associated with various viral pathogens and is a vector of following viruses: tick-borne encephalitis virus, Crimean-Congo haemorrhagic fever virus, Omsk haemorrhagic fever virus, *Rickettsia sibirica*, *R. slovaca* (TIBOLA or DEBONEL in humans), *R. conorii*, *R. raoultii*, *R. massiliae*, *Babesia caballi* and *Theileria equi*, West Nile virus, *Coxiella burnetii*, *Ehrlichia canis* and *Borrelia afzelii*. Tularemia caused by *Francisella tularensis* and veterinary pathogens *Babesia caballi* and *Theileria equi*. (Estrada-Peña et al., 2018).

https://www.gbif.org/species/2183411

2. *Haemaphysalis punctata* Canestrini and Fanzago, 1878

Common name: Red sheep tick
Distribution in the Caucasus area: Georgia, Armenia (new record 2023,) Azerbaijan (new record 2023) (p. 36)
Hosts: *H. punctata* is a three-host tick. Adults mainly feed on wild and domestic animals: cattle, sheep, goats, dogs, red foxes, mustelids, lagomorphs and hedgehogs. The immature stages feed on small mammals, hares, hedgehogs, birds and lizards. Humans are bitten frequently. Migrating birds may play a role in the introduction of this species to new areas.
Ecology: The species can be found in different climatic zones and wide variety of habitats from cold to mild and humid biotopes. In general, this species inhabits in lowland semi-deserts, steppes and open forests. H. punctata also occupied in pastures, forest margins, forest steppes, brush areas, limestone pastures, artificial conifer forests, and oak forests.
This species is generally associated with open grazed grassland, trails, along forest edges, primary growth areas with overgrown shrubs, forest-steppe, oak grazing woods, and salt marshes/forested dune areas grazed by livestock.

Significance in medical and veterinary aspects: *H. punctata* is known as vector of the tick-borne encephalitis and Crimean-Congo haemorrhagic fever viruses. The species has been associated with Bhanja, Palma, Tribec, and louping-ill virus. The pathogens associated with *H. punctata* are: *Rickettsia sibirica*, *R. helvetica*, *R. massiliae*, *R. hoogstraalii*, *R. monacensis*, *Anaplasma bovis*, *A. central*, *A. phagocytophilum*, *Babesia bigemina*, *B. major*, *B. motasi*, *Coxiella burnetii* and *Francisella tularensis* (Estrada-Peña et al., 2018).

https://www.gbif.org/species/2183078

3. *Haemaphysalis concinna* Koch, 1844

Common name: Relict tick

Distribution in the Caucasus area: Georgia (p. 36)

Hosts: The lifecycle of the tick is three-hosted, which can be completed within three years. Immature stages prefer small to medium-sized mammals, especially rodents and hedgehogs, and ground-feeding birds, while adults feed on artiodactyls and carnivores (dog, horse, cow, sheep, goat, hedgehog, hare, squirrel, thrush, and Robert's snow vole).

Ecology: The species is active throughout the year, with peak activity in late spring or summer, and most adults are found from April to November. The larvae are active from the end of May until November and the nymphs from the middle of April until October. The species is thermophilic and prefers humid habitats. It can occur in a variety of different forest habitats, including deciduous forests, mixed-forests, mixed hornbeam-oak forests with bush-undergrowth, river basins, and in shoreline vegetation. In Georgia, this species has been found from 20 meters up to 500 meters above sea level, distributed in humid forest zone (Kolkheti forest) and secondary pastures.

Significance in medical and veterinary aspects: *H. concinna* is known as vector of the tick-borne encephalitis virus, Crimean-Congo haemorrhagic fever virus, Omsk haemorrhagic fever virus and Tamdy virus. The species is the vector of following Rickettsia: *R. heilongjiangensis*, *R. sibirica*, *R. Helvetica*. It is also a vector of *Anaplasma phagocytophilum*, *A. bovis*, *Coxiella burnetii*, *Francisella tularensis*. *H. concinna* is able to acquire infection with Borreli agarinii and *B. burgdorferi*, however, it is unclear whether the species is a competent vector (Estrada-Peña et al., 2018).

https://www.gbif.org/species/2183101

4. *Haemaphysalis (Allocerea) inermis* Birula, 1895

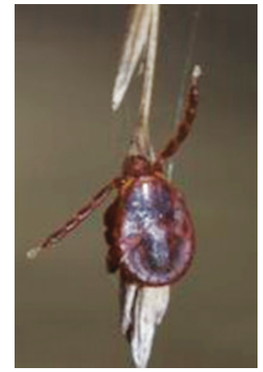
Common name: Winter tick

Distribution in the Caucasus area: Georgia (p. 36)

Hosts: *H. inermis* is three-host tick with a peculiar life cycle in that immature forms feed on a host and fall off within a few hours. Adults of *H. inermis* feed on domestic and wild ungulates; immature stages of this species feed on small mammals, very rarely in lizards and birds. The ticks can parasitize mammals including cattle, horses, sheep, deer, dogs, foxes and hedgehogs; human infestation has also been reported.

Ecology: *H. inermis* is generally found in temperate broadleaf and mixed forests, secondary meadows and pastures, xerophilic bush plantations and steppes. Adults are active from October until May, larvals are active during spring and summer, and nymphs are present from late spring to early autumn. The immature forms feed on a host and fall off within a few hours. In Georgia, this species has been found from 400 meters up to 500 meters above sea level, adult ticks were collected in April and May and from September to December.

Significance in medical and veterinary aspects: *H. inermis* is a putative vector of tick-borne encephalitis (*Rickettsia aeschlimannii*, *R. helvetica*). The role of *H. inermis* as a vector is largely unknown (Estrada-Peña et al., 2018).



https://www.gbif.org/species/2183316

5. *Haemaphysalis parva* (Neumann, 1897)

Common name: Mediterranean ear tick

Distribution in the Caucasus area: Georgia, Armenia, Azerbaijan (p. 37)

Hosts: *H. parva* is a three-host tick. Ticks infest large, medium, and small wild and domestic animals. The adults feed on large and medium mammals, mostly domestic, and immatures feed on medium and small wild mammals such as hedgehogs, hares, rodents, carnivores, some ground-feeding birds, and reptiles. Both adults and immatures infest humans.

Ecology: *H. parva* adults are active in autumn, winter and spring. Their peak activity occurs in October and November, immatures in June and July. *H. parva* prefers various types of mountain forest and steppe habitat. The species is mostly observed in areas surrounding grazing livestock. In Georgia, this species has been found from 300 meters up to 1000 meters above sea level.

Significance in medical and veterinary aspects: *H. parva* can transmit *Babesia ovis*, *Coxiella burnetii*, *Franciesella tularensis*, *Rickettsia hoogstraali*, and *Rickettsia goldwasserii* (Estrada-Peña et al., 2018).

https://www.gbif.org/species/2183048

6. *Haemaphysalis sulcata* Canestrini and Fanzago, 1878

Common name: Near East lizard tick; Middle East lizard-goat-sheep haemaphysaline

Distribution in the Caucasus area: Georgia, Armenia, Azerbaijan (p. 37)

Hosts: *H. sulcata* is three-host tick. Adults mostly feed on domestic and wild ungulates such as sheep,

goat, horse, cow, donkey, buffalo and small mammals. Immatures have a special preference for reptiles, and are found on tortoise, lizards, and snakes. Rarely, the species is found on ground-nesting birds.

Ecology: *H. sulcata* mostly distributed in steppe regions with a semi-desert. It is widespread in wormwood foothills, mountain steppe, dry steppe and semi-desert habitats. Adult infestations peak from March to May and October to November. Immatures are active in the hot months; larvae between April and August, nymphs between April and October. In Georgia, this species has been found from 300 meters up to 500 meters above sea level.

Significance in medical and veterinary aspects: *H. sulcata* is known to transmit *Brucella abortus*, *B. melitensis*, *Anaplasma ovis*, *Coxiella brunette*, and *Rickettsia hoogstraalii* (Estrada-Peña et al., 2018).

https://www.gbif.org/species/2183325

7. *Hyalomma aegyptium* Linnaeus, 1758

Common name: Bont leg tick

Distribution in the Caucasus area: Georgia, Armenia, Azerbaijan (p. 37)

Hosts: *H. aegyptium* is a three-host tick, tortoises (mainly genus Testudo) are the dominant hosts for all of the developmental stages, but it has a wide variety of other hosts including cattle, deer, wild pigs, horses, donkeys, camels, dogs, hedgehogs, hares, fox, rodents, birds, and lizards. The species were registered only from the tortoises in Georgia. In some regions, humans can be infested with adults ticks and nymphs.

Ecology: *H. aegyptium* mostly distributed in steppe regions with a semi-desert character, widespread mostly in mountain steppe, dry steppe, and semi-desert habitats. The species' development dependents on the temperature. The number of adult male individuals are very high in April. The density and infestation with adults is very intense during mid-June. Oviposition is most successful between 20 and 35 degrees Celsius and there is a high number of nymphs in August. According to the literature, infestation continues throughout the summer. Under laboratory conditions, the whole life cycle is completed in 60 days.

Significance in medical and veterinary aspects: The species is known as vector of *Hemolivia mauritanica*, *Hepatozoon kisrae*, *Rickettsia aeschlimannii*, *Coxiella burnetii* and *Borrelia turcica* (Estrada-Peña et al., 2018).

https://www.gbif.org/occurrence/4096784790

8. *Hyalomma marginatum* Koch, 1844

Common name: Mediterranean hyalomma

Distribution in the Caucasus area: Georgia, Armenia, Azerbaijan (p. 37)

Hosts: *Hyalomma marginatum* adults feed on a wide variety of mammals, wild and domestic ungulates, particularly bovines. The larvae and nymphs are specific to small mammals (insectivores) and ground-dwelling birds. This tick is reported as biting humans.

Ecology: *Hyalomma marginatum* has one generation per year. The species is adapted to dry, semi-desert, and steppe climates. *Hyalomma marginatum* nymphs begin their activity during the summer months in Georgia; the most active period of adult ticks starts in March and continues to November. In high altitudes, tick development is shorter and lasts for three months. The optimal temperature and humidity ranges for species development are 22–27 degrees Celsius and 75–100%, respectively.

Significance in medical and veterinary aspects: *Hyalomma marginatum* is the primary vector for humans of the Crimean-Congo hemorrhagic fever virus (Estrada-Peña et al., 2018). In Georgia, the species is known as the vector of the following diseases of horses and domestic ungulates: Piroplasmosis, brucellosis, theileriosis, and gonderiosis (Japaridze, 1960).

https://www.gbif.org/species/4548126

9. *Ixodes crenulatus* Say, 1821 Synonym of Amblyomma cajennense Fabricius, 1787

Common name: Cayenne tick

Distribution in the Caucasus area: Georgia, Armenia, Azerbaijan (p. 38)

Hosts: *Ixodes crenulatus* is three-host tick species, the main hosts are foxes, badgers, hamsters, hedgehogs, moles, rats, jackals, several families of *Rodentia*, *Carnivora* (*Canidae, Felidae*, and *Mustelidae*), Erinaceomorpha (Erinaceidae) and Lagomorpha (Leporidae and Ochotonidae) (Estrada-Peña et al., 2018). In some cases, dogs and cats can host I. crenulatus (Galuzo, 1950).

Ecology: Japaridze (1960) found the life cycle lasted 101 to 114 days at 18 to 20 degrees Celsius, the egg-laying phase ended in 17 to 31 days, the embryonic development took 23 to 37 days, and the larval development took 55 to 62 days.

Significance in medical and veterinary aspects: This species carries the Russian tick-borne encephalitis virus (Estrada-Peña et al., 2018).

https://www.gbif.org/species/2184178

10. *Ixodes ricinus* (Linnaeus, 1758)

Common name: Castor bean tick

Distribution in the Caucasus area: Georgia, Armenia, Azerbaijan (p. 38)

Hosts: According to Petney et al. (2012), *Ixodes ricinus* is the most widespread tick species in Europe as well as the most important vector of many tick-borne diseases. *I. ricinus* is a three-host tick (Nicholson et al., 2009). Its life cycle lasts from 2 to 3 years, but in some areas where the climatic conditions allow, it is active throughout the year and the life cycle is shorter (Dantas-Torres and Otranto 2013). The life cycle of *I. ricinus* takes 155 days to complete in a laboratory (Pomerantsev, 1950). Adults prefer larger mammals like cattle and deer, whereas larvae and nymphs typically feed on small mammals, birds, and reptiles (Nicholson et al., 2009; Medlock et al., 2013).

Ecology: *Ixodes ricinus* is frequently found in mixed woods and deciduous and coniferous woodlands. It is less able to survive extreme temperatures and desiccation since it is climate-sensitive and dependent on a wet micro-environment. *I. ricinus* is therefore restricted to environments with moderate to high rainfall and vegetation that maintains a high humidity level because it needs a relative humidity level of at least 80% to thrive during its off-host period (Medlock et al. 2013).

Significance in medical and veterinary aspects: *Ixodes ricinus* is the major vector of Borrelia burgdor-

feri s.l. in its sylvatic cycles and in terms of transmission to humans in Europe. *I. ricinus* has also been suggested as the major vector of the relapsing fever spirochete, Borrelia miyamotoi, in Western Europe. *Rickettsia slovaca* and *R. helvetica* have been reported from *I. ricinus*. *Rickettsia monacensis* and *Anaplasma phagocytophilum* have also been associated with *I. ricinus*. *Bartonella henselae* has been recovered from *I. ricinus* in Central Europe. Francisella tularensis has also been recovered from *I. ricinus* (Estrada-Peña et al., 2018).

Babesia divergens, which is a pathogen of cattle, is transmitted by *I. ricinus* This species can cause disease in immunocompromised humans. Babesia venatorum (Babesia sp. EU1), a recently discovered member of this genus, is associated with I. ricinus and is thought to use deer as hosts (Estrada-Peña et al., 2018).

Mammals are the primary hosts of the tick-borne encephalitis (TBE) virus complex. Ixodes ricinus is one of the tick species that are known as a vector of this virus.

Isolated the Eyach virus from *I. ricinus* near the Eyach River in Baden. Tribec virus was first isolated from *I. ricinus* in Slovakia in 1963 (Gresíkova et al. 1965). Both of these viruses have been implicated as causes of human disease Lipovnik, Erve, and Uukuniemi viruses have also been isolated from *I. ricinus* ticks (Estrada-Peña et al., 2018).

https://www.gbif.org/species/2182588

11. *Ixodes redikorzevi* Olenev, 1927

Common name: Redikorzev's russet tick

Distribution in the Caucasus area: Georgia, Armenia, Azerbaijan (p. 38)

Hosts: *I. redikorzevi* is a species of tick that mostly parasitizes rodents, shrews, and small carnivores. It also occasionally feeds on reptiles and dendrophile birds that feed on the ground (Filippova 1977). The species can be found in significant numbers on dendrophilic birds (Tiflova, 1974). If the mammalian and avian hosts are absent it can parasitize lizards (Orlova et al. 2022).

I. redikorzevi's hosts: *Spermophilus pygmaeus*, *Sicista subtilis*, *Mus musculus*, *Apodemus agrarius*, *Apodemus ponticus*, *Sylvaemus uralensis*, *Sylvaemus witherbyi*, *Rattus rattus*, *Microtus arvalis*, *Microtus socialis*, *Chionomys spp.*, *Cricetulus migratorius*, *Cricetus cricetus*, *Mesocricetus raddei*, *Dryomys nitedula*, *Crocidura suaveolens*, *Crocidura leucodon*, *Sorex volnuchini*, and *Sorex satunini*.

Ecology: *Ixodes redikorzevi* inhabits mountain deciduous forests and the nearby steppes, Black Sea shore, and Kolkhic lowland (Djaparidze, 1960). The forest zone is the primary habitat for all stages of *I. redikorzevi*, as reported by Olenev (1931). According to Pomerantzev's 1950 study, adults were active in October, December, April, and May, while the larvae and nymphs were found in April, June, and August.

Significance in medical and veterinary aspects: It is commonly recognized that I. redikorzevi contributes to the spread of Francisella tularensis and Coxiella burnetii (Djaparidze, 1960).

Comment: It is currently undecided whether I. redikorzevi is a synonym of *I. acuminatus* or not. Kolonin (2009) considers this species a synonym of *I. acuminatus*, but Guglielmone et al. (2010) regard it as a provisionally distinct species(?).Guglielmone et al. (2014) note that this question can be solved by comparing specimens of both species. Moreover, Pomerantsev (1950) described two subspecies: *I. redikorzevi redikorzevi* and *I. redikorzevi emberizae*. Later an additional subspecies, *I. redikorzevi* theodori was described, although Filippova comments (1977) that the authors had limited material during descriptions. It is necessary to compare more specimens from additional locations of its large range.

https://doi.org/10.5281/zenodo.11196115

12. *Rhipicephalus annulatus* Say, 1821

Synonymy: Rhipicephalus annulatus formerly belonged to the genus Boophilus (as *B. annulatus*), from 2001 list it under this name.

Common name: Cattle tick

Distribution in the Caucasus area: Georgia (p. 38)

Hosts: *R. annulatus* is a one-host tick, all stages feeding on the same animal. The whole life cycle can take less than 2 months, and two generations per year can occur under favorable conditions. The short life cycle can lead to massive infestations on animals, resulting in huge economic losses (Spickler and Rovid 2007).

Cattle are the main hosts and the source of infestation of *R. annulatus*, but sheep, goats, wild ungulates, humans, and dogs are also occasionally infested. The preferred feeding sites are legs, belly, neck, and pectoral area (Walker et al. 2003).

Ecology: *R. annulatus* is represented in Black Sea shore and Kolkhic lowland, and humid steppe areas that have hot and dry summers. The species is distributed in subalpine and alpine forests and semi deserted in the eastern Georgia. During the summer, this species can survive for more than 3 to 4 months without feeding (Emmanuel et al. 2011). In Georgia, the ticks are active from March to October.

Significance in medical and veterinary aspects: *Rhipicephalus annulatus* is known for its role in transmitting babesiosis (*Babesia bigemina* and *B. bovis*) and anaplasmosis (*Anaplasma marginale*) to cattle (Japharidze, 1960; Walker et al. 2003).

https://www.gbif.org/species/2183769

13. *Rhipicephalus rossicus* Yakimov & Kol-Yakimova, 1911

Common name: Brown tick

Distribution in the Caucasus area: Georgia, Armenia, Azerbaijan (p. 39)

Hosts: *R. rossicus* is a three-host tick with a natural life cycle of 2 to 3 years (Emchuk 1967; Walker et al. 2000). All stages feed on a variety of hosts: nine families of birds and 17 families of mammals have been reported as hosts (Mihalca et al. 2015). Amphibians and reptiles are exceptionally rare hosts (Filippova 1997; Akimov and Nebogatkin 2013). This tick has been reported on humans several times (Mihalca et al. 2015).

Ecology: *R. rossicus* is one of the widespread tick species in the Eurasian steppe. The typical habitats of *R. rossicus* include mostly dry forests and xeric shrublands from steppe regions (Guglielmone et al. 2014; Mihalca et al. 2015). Habitat preference is attributed mainly to host abundance and availability rather than to abiotic factors (Shatas and Bystrova 1954). The tick has been found at various altitudes, ranging from 0 meters to 1500 meters above sea level. (Mihalca et al. 2015). In Georgia *R. rossicus* has a similar vertical distribution range (Djaparidze, 1960). Larvae and nymphs are active from as early as March to as late as November. Adults are active all year. All stages reach peak activity between April and July (Pomerantzev et al. 1940; Emchuk 1960; Dumitrache et al. 2014; Mihalca et al. 2015). The host-seeking behavior is unknown, but it is probably similar to other Rhipicephalus ticks which actively move and 'hunt' their host.

Significance in medical and veterinary aspects: *R. rossicus* is the vector for *Francisella tularensis*, Crimean-Congo hemorrhagic fever virus, and West Nile virus (for a complete review, see Mihalca et al. 2015). Other pathogens that have been detected in *R. rossicus* are *Theileria equi*, *Babesia bigemina*, and *Coxiella burnetii*, but there is no experimental evidence for its vectral ability (Mihalca et al. 2015).

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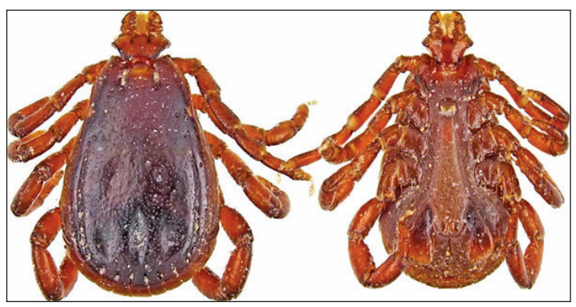

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14. *Rhipicephalus sanguineus* Latreille, 1806

Common name: Brown dog tick

Distribution in the Caucasus area: Georgia (p. 39)

Hosts: Domestic dogs are the primary host of *R. sanguineus*, although it has occasionally been reported from other hosts, particularly carnivores but also hares, cattle, and horses (Walker et al. 2000). Humans have rarely been recorded as a hosts (Walker et al. 2000).

Ecology: *R. sanguineus* usually occurs indoors, where infestations in dog kennels have been reported year round (Dantas-Torres, 2008). The life cycle of R. sanguineus can be completed outdoors in tropical and subtropical countries (Walker et al. 2000). Engorgement, oviposition, and hatching can all take place indoors; sufficiently warmer winter temperatures may lead to its ability to survive in the wild (Gothe & Hamel 1973). The parasitoid Ixodiphagus (Hunterellus) hookeri is known to sporatically infest *R. sanguineus* (Hoogstraal 1956, Munaf 1976).

Significance in medical and veterinary aspects: Thogoto virus was detected in *R. sanguineus* in southern Europe. *Rickettsia conorii ssp.* and *Rickettsia massiliae* can be transmitted to humans by *R. sanguineus*. The causative agent of Rocky Mountain spotted fever (*R. rickettsii*), can be transmitted to humans by *R. sanguineus*. *Rickettsia rhipicephali* and Candidatus *R. kulagini* are also transmitted by *R. sanguineus*. The cause of canine monocytic ehrlichiosis (*R. rickettsii*) is transmitted by *R. sanguineus*. Babesia canis vogeli, which is cosmopolit *B. gibsoni*, which occurs in Asia and North America, and Hepatozoon canis are pathogens that are transmitted by *R. sanguineus* and cause significant diseases in dogs (Trevor et al., 2012).

https://www.gbif.org/species/2183597

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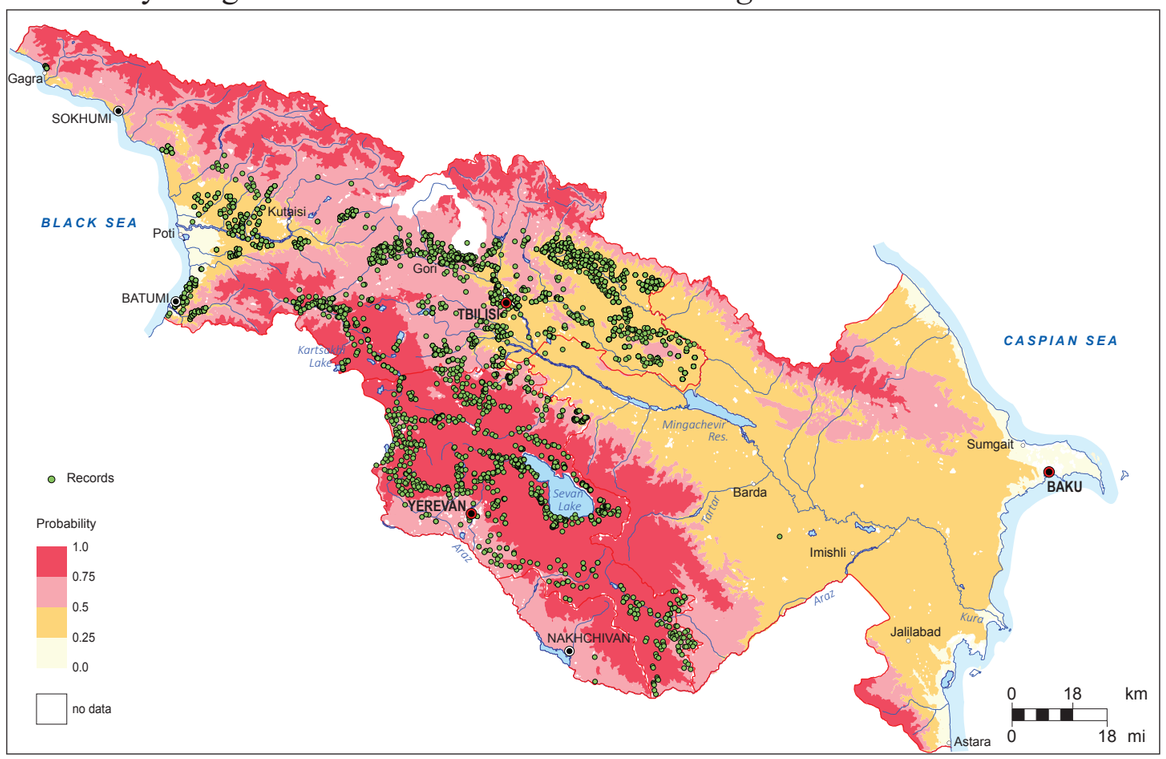
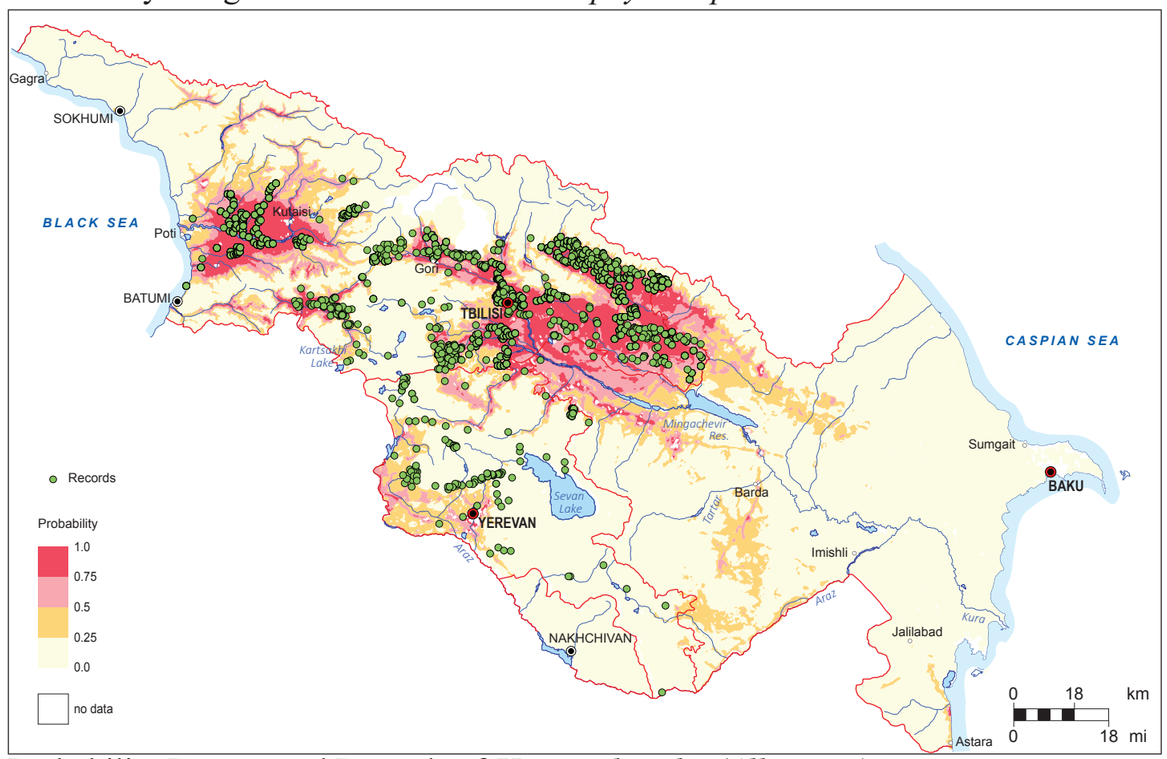
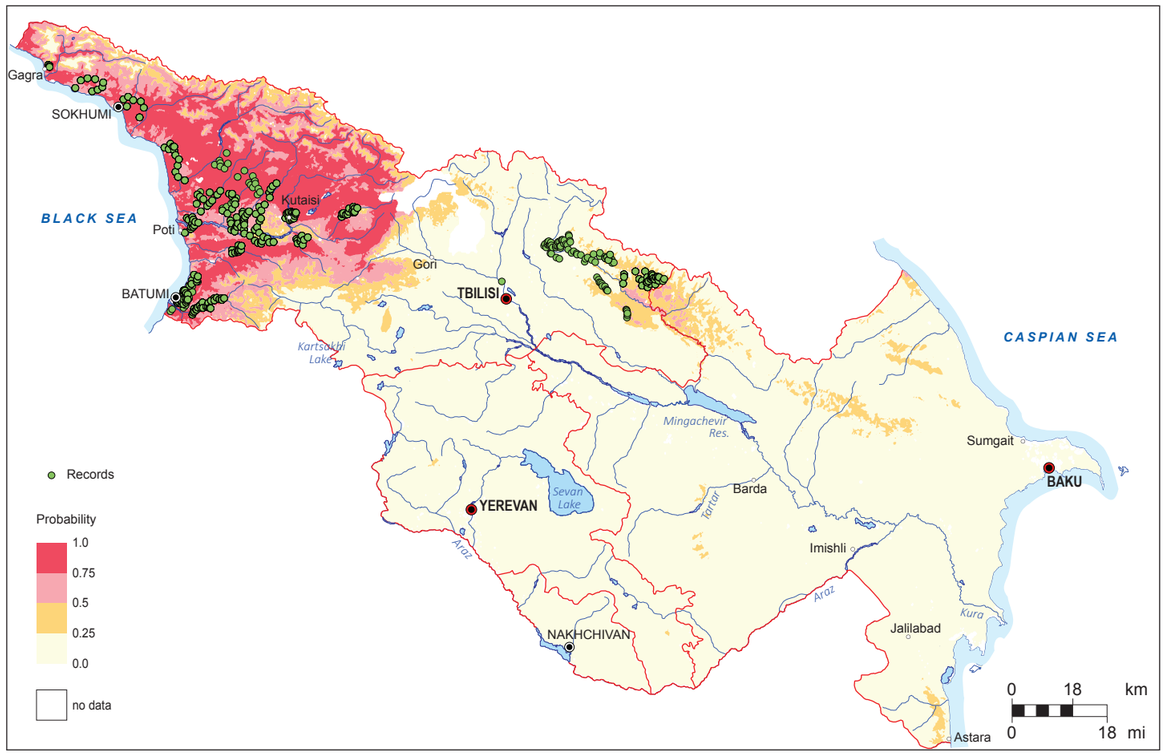
Probability Ranges and Records of *Dermacentor marginatus* in the South Caucasus



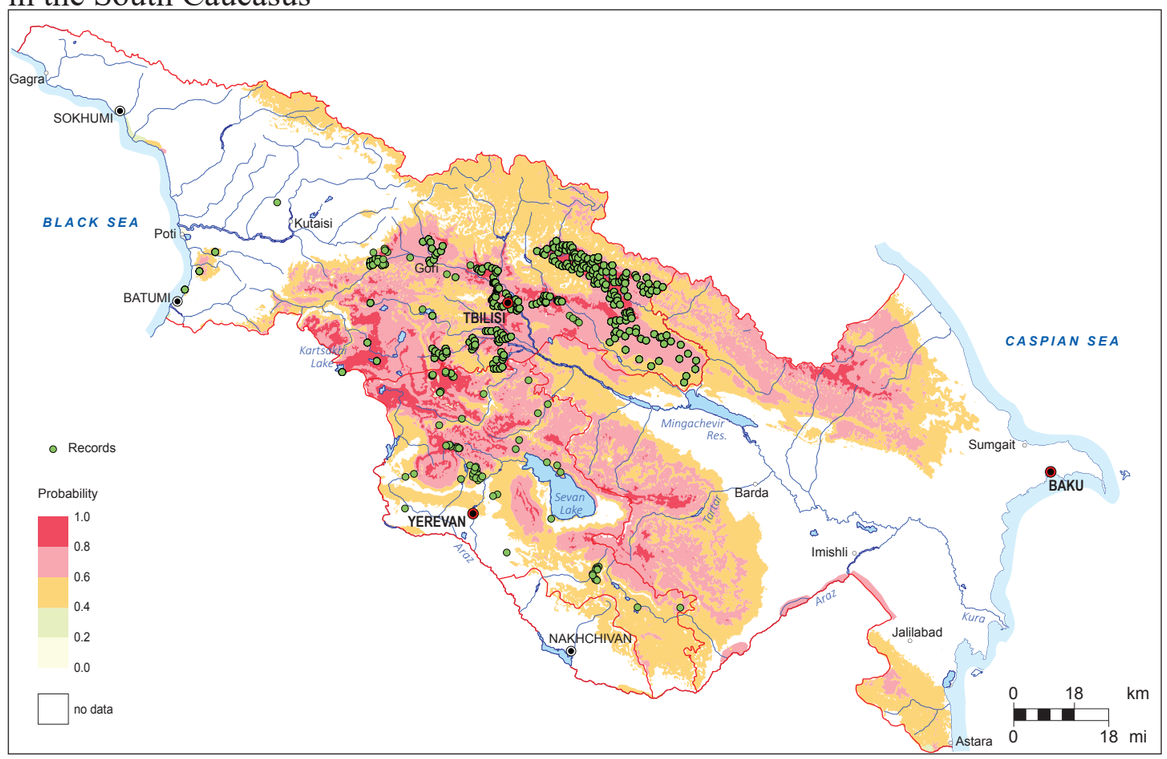
Probability Ranges and Records of *Haemaphysalis punctata* in the South Caucasus



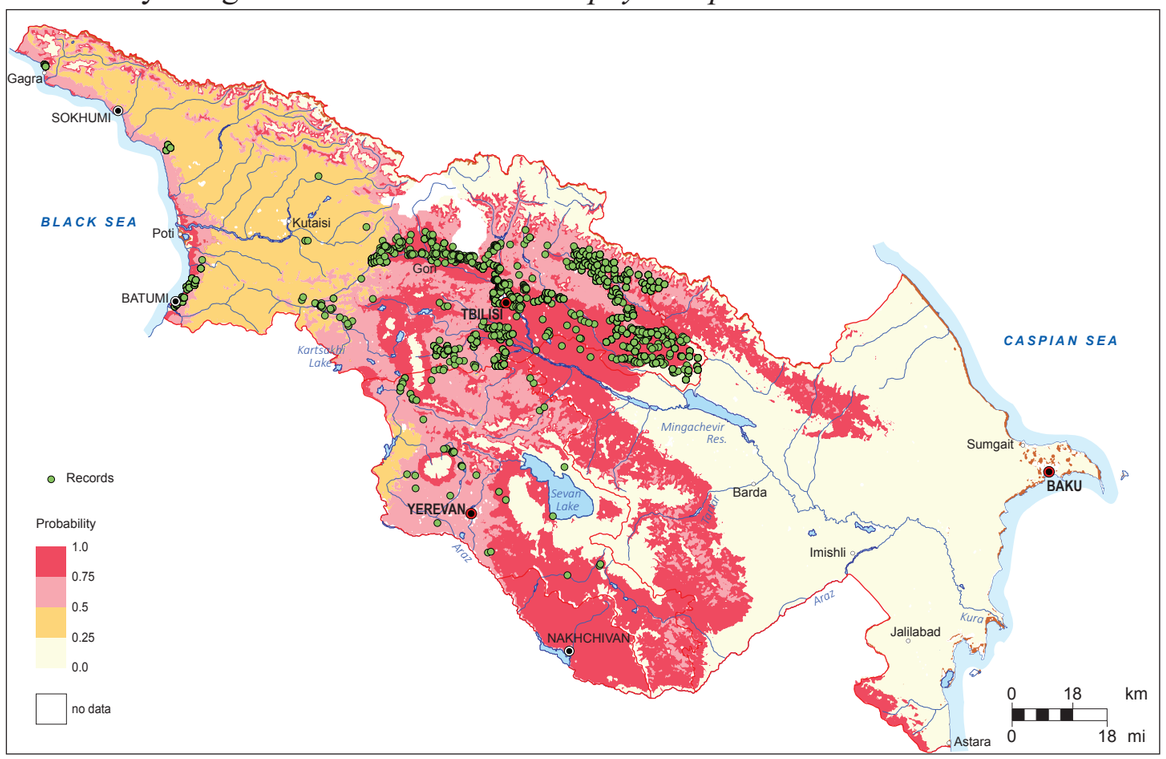
Probability Ranges and Records of *Haemaphysalis concina* in the South Caucasus



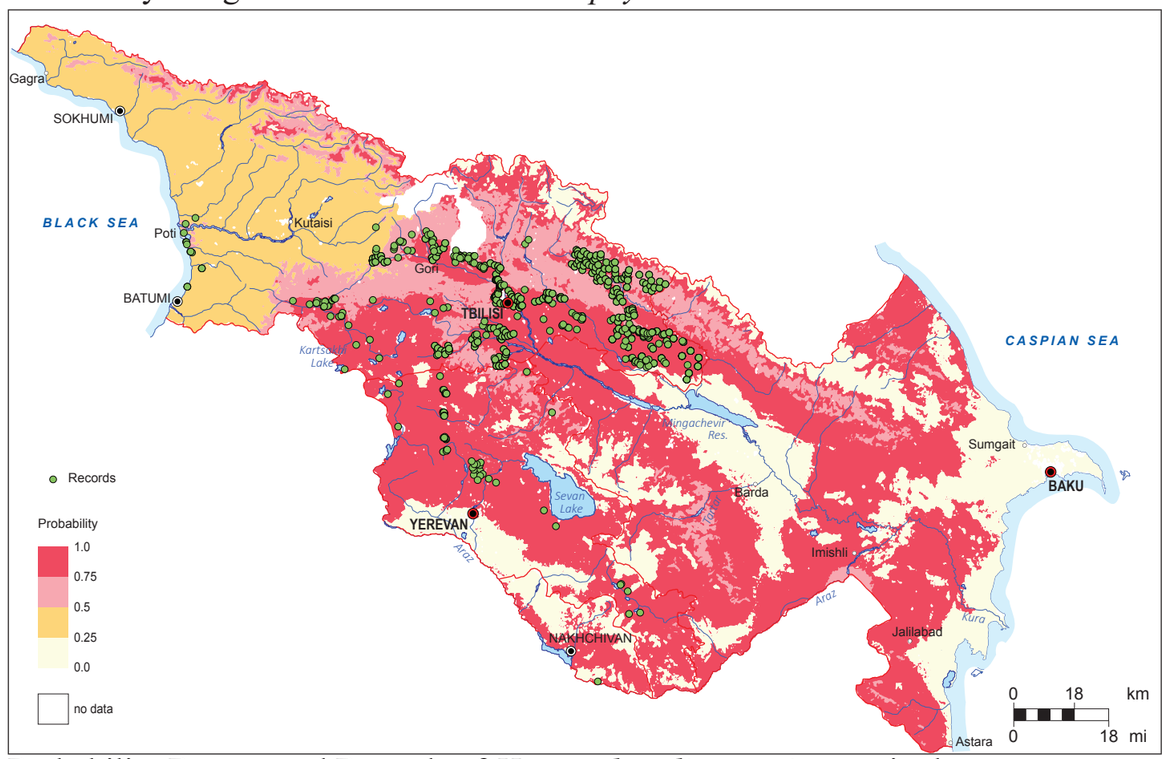
Probability Ranges and Records of *Haemaphysalis (Allocerea) inermis* in the South Caucasus



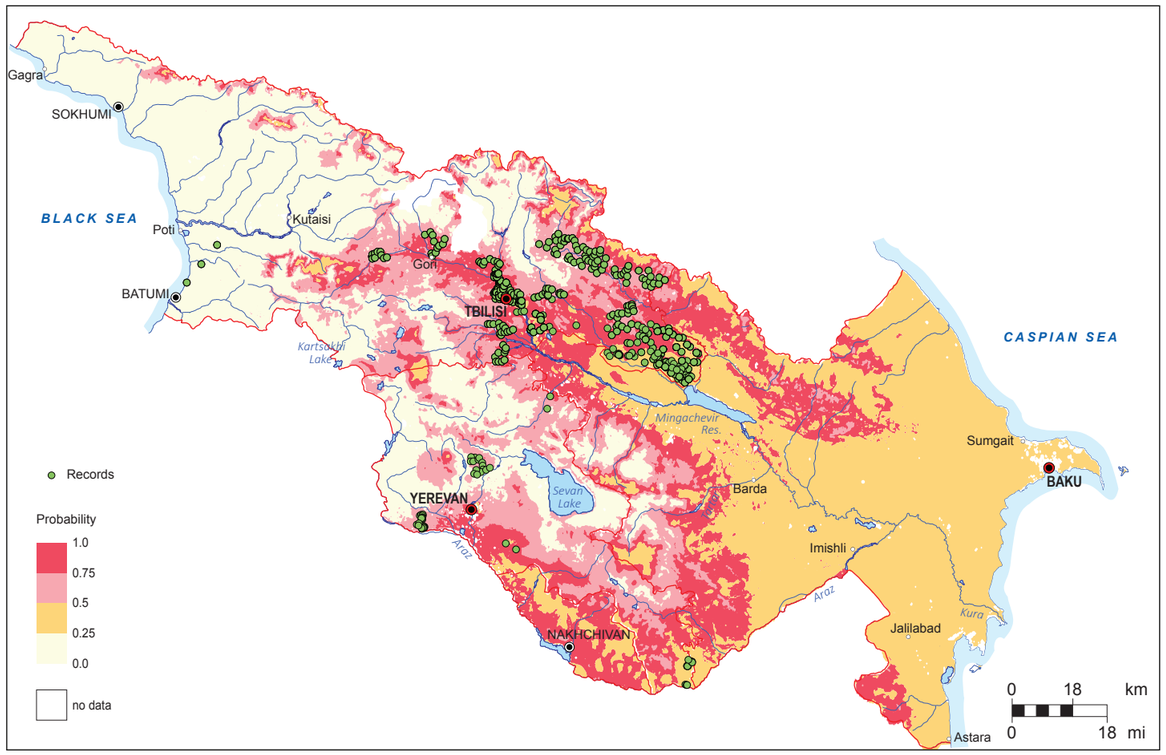
Probability Ranges and Records of *Haemaphysalis parva* in the South Caucasus



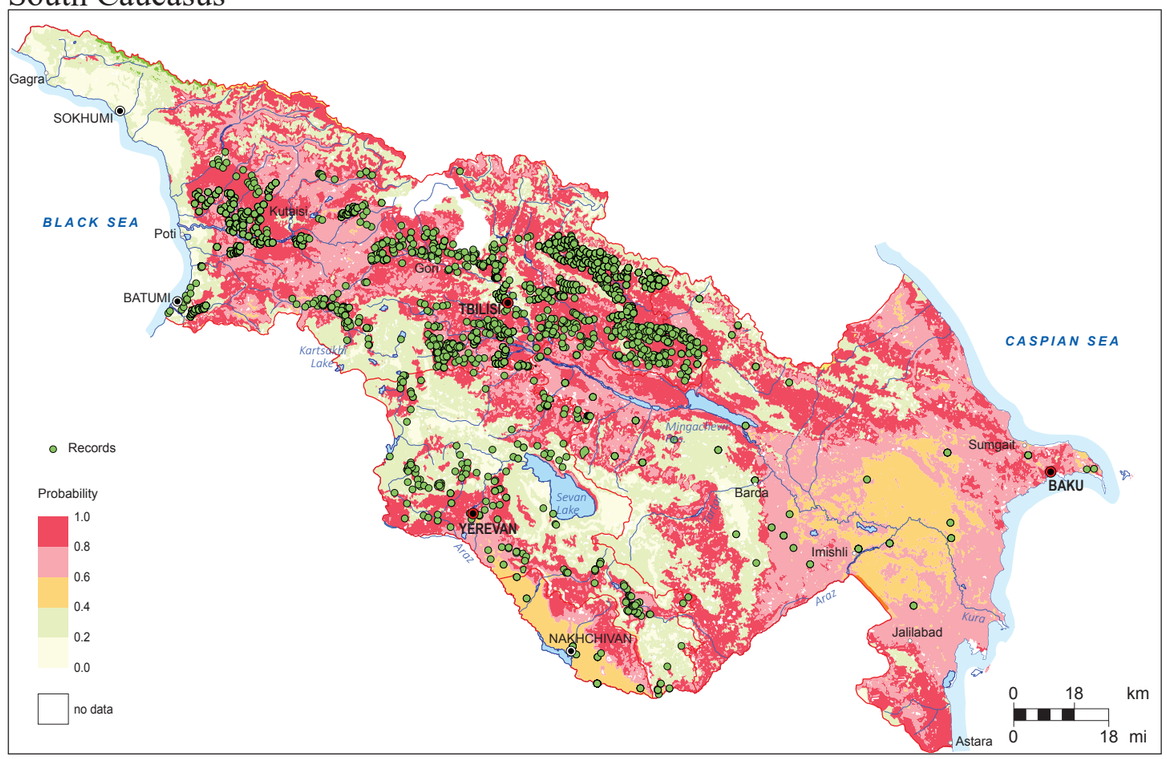
Probability Ranges and Records of *Haemaphysalis sulcata* in the South Caucasus



Probability Ranges and Records of *Hyalomma aegyptium* in the South Caucasus



Probability Ranges and Records of *Haemaphysalis marginatum* in the South Caucasus



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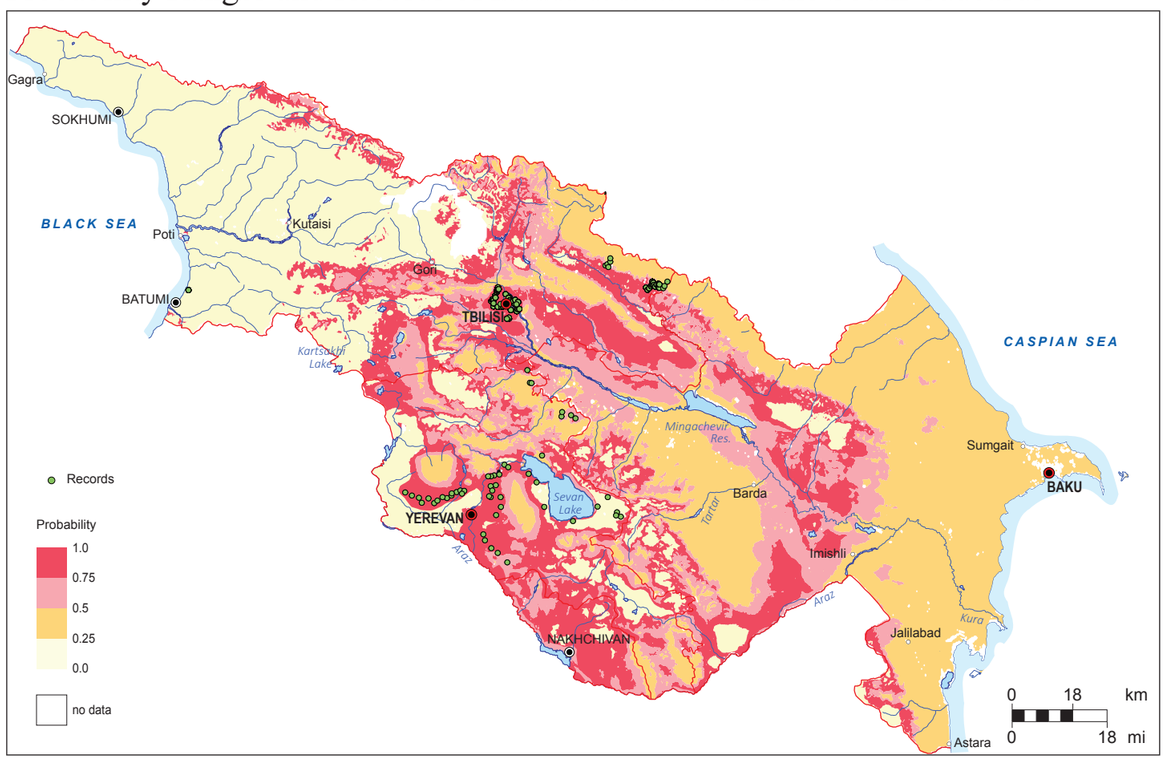
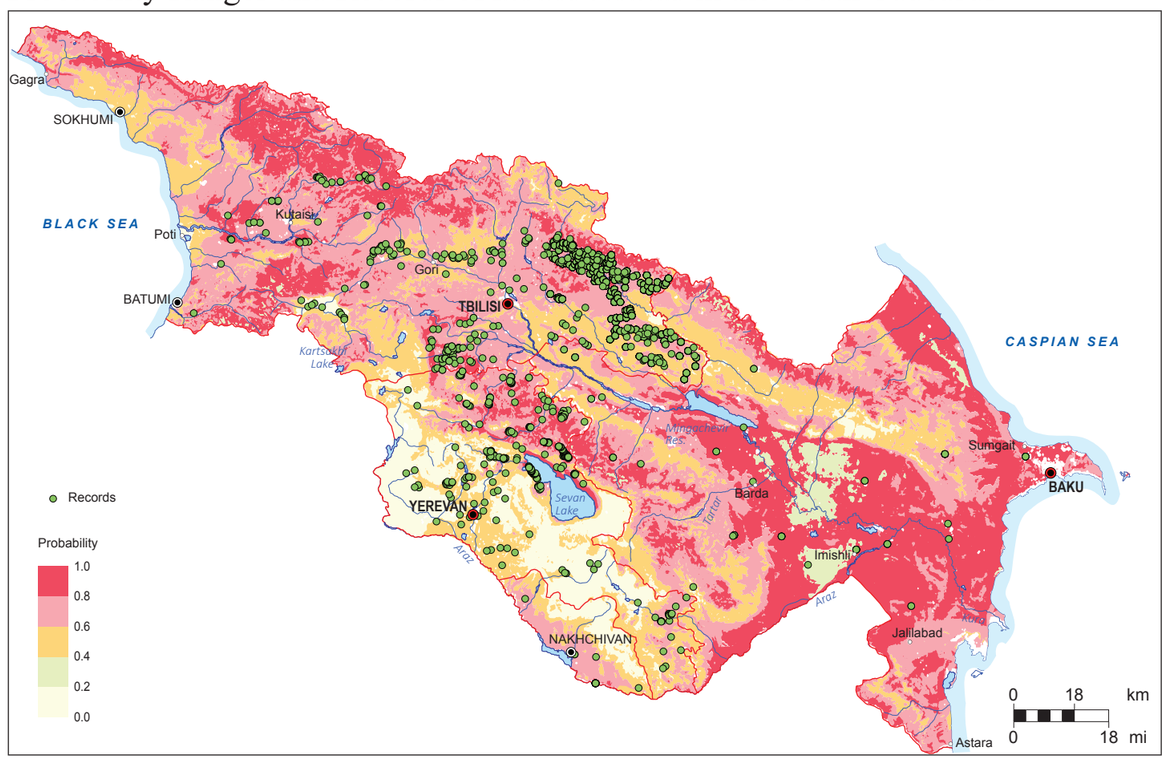


Probability Ranges and Records of *Ixodes ricinus* in the South Caucasus



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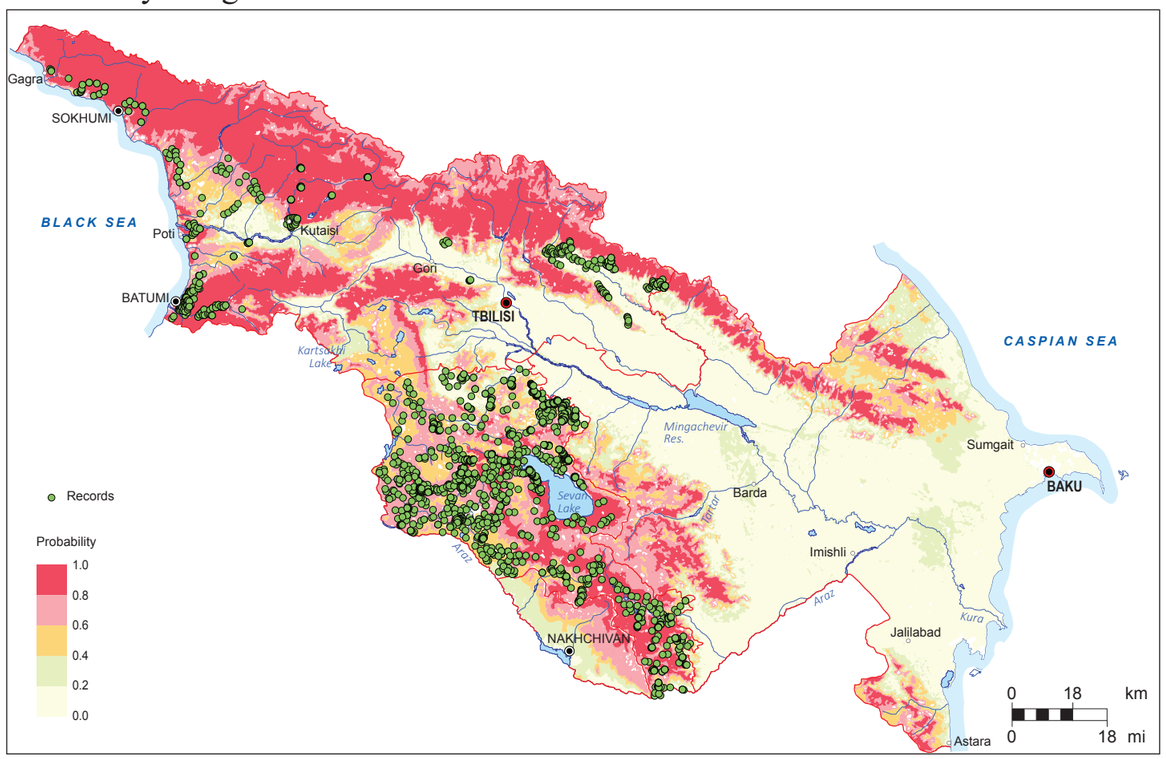

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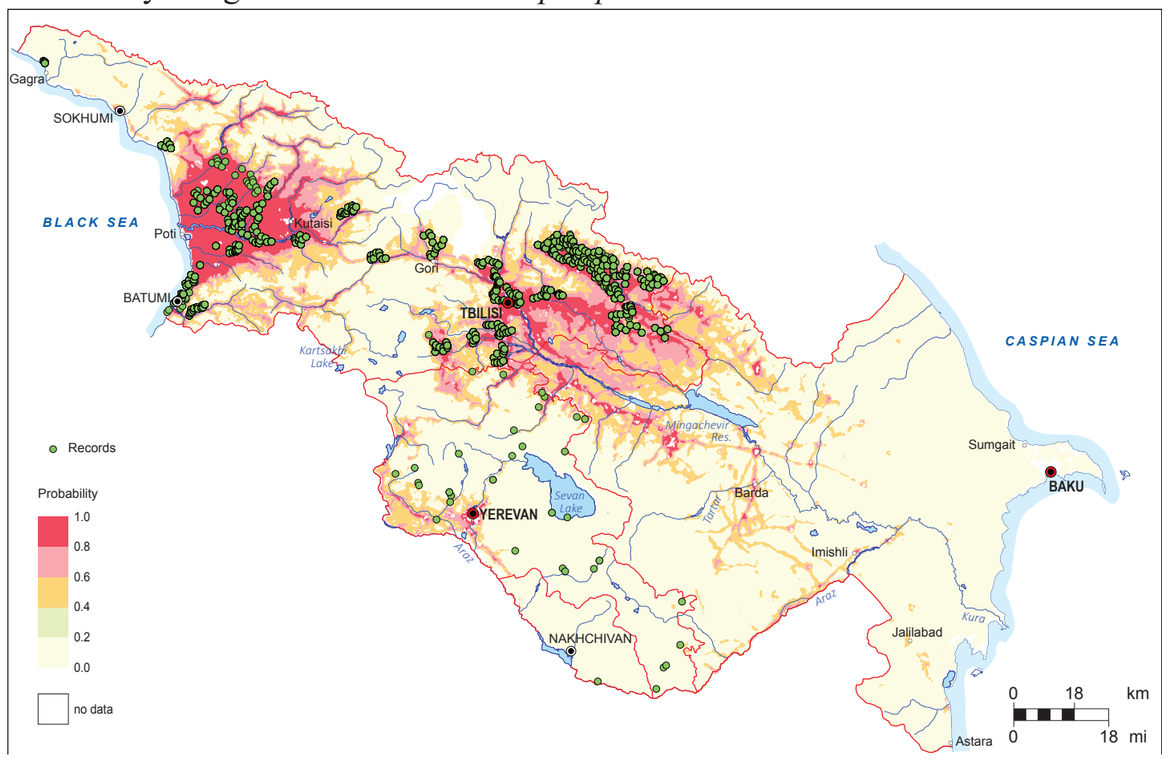
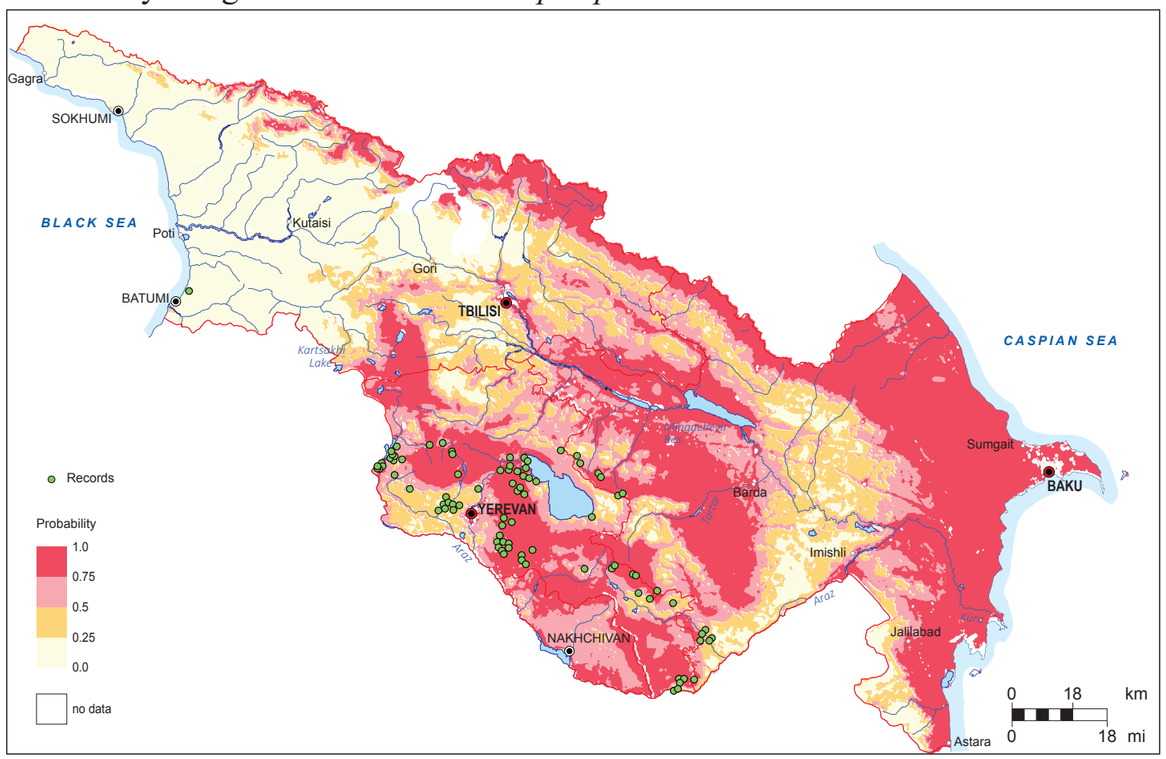
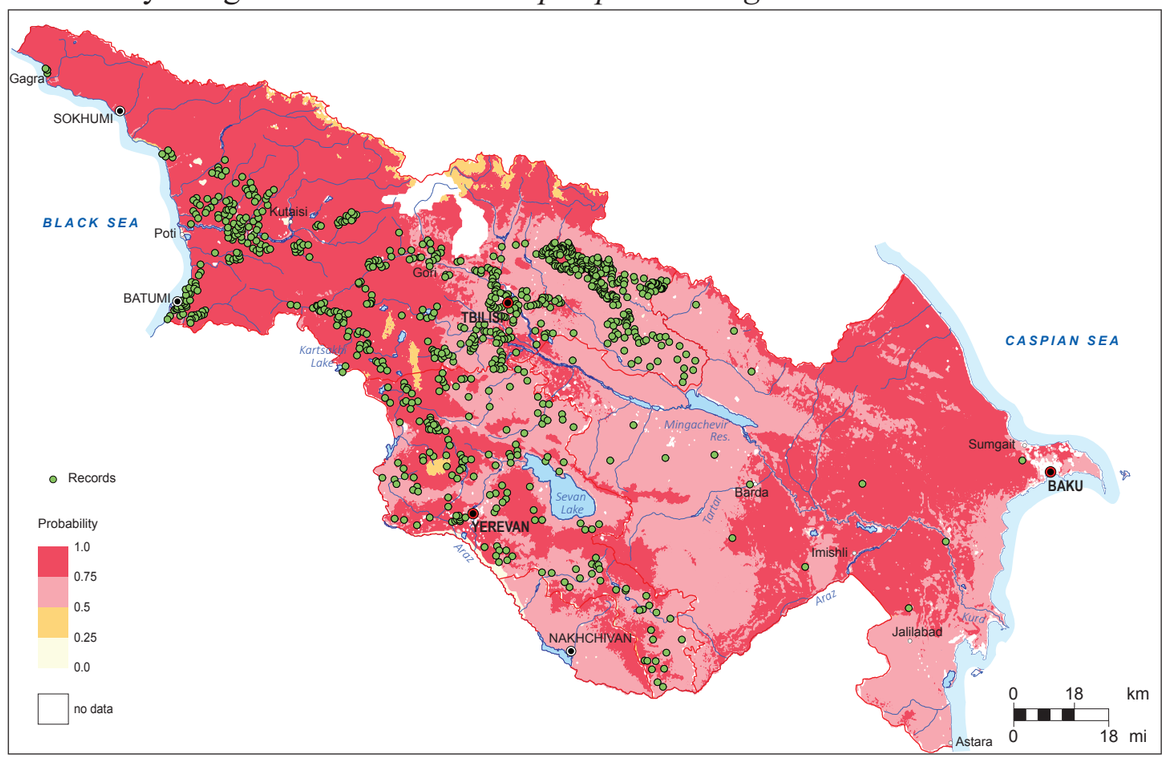


Probability Ranges and Records of *Rhipicephalus rossicus* in the South Caucasus



Probability Ranges and Records of *Rhipicephalus sanguineus* in the South Caucasus



Ungulates

Ungulates are one of the most extensive orders of mammals and thrive in diverse habitats where food resources are available. While most of them are herbivorous, consuming grasses, leaves, fruit, flowers, twigs, water plants, roots, and nuts, the Suidae family is an exception with its omnivorous diet that includes insect larvae, grubs, eggs, and occasionally small mammals.

In the South Caucasus, Ungulates are represented by three families: Bovidae, Cervidae, and Suidae. The Bovidae family includes four genera — *Gazella*, *Capra*, *Ovis*, and *Rupicapra* — comprising six species: *Gazella subgutturosa*, *Capra aegagrus*, *C. caucasica*, *C. cylindricornis*, *Ovis ammon*, and *Rupicapra rupicapra*. The Cervidae family is represented by two genera, *Cervus* and *Capreolus*, and encompasses two species: *Cervus elaphus* and *Capreolus capreolus*. The Suidae family in this region is represented by a single species, *Sus scrofa*.

The distribution range maps of all nine ungulate species were created using models of the species occurrence probability based on 1,390 records' points reported from 1876 through 2022 for the South Caucasus countries. In 1990, after the collapse of the USSR all three South Caucasus countries became independent. In the provided maps, records are divided into two categories: 1) historical records reported before 1990, and 2) recent records made after that.

Ungulates could serve as reservoirs for zoonotic and vector-borne infections. They play a certain role as reservoirs for pathogenic agents such as anthrax and brucellosis. Additionally, ungulates spread tick-borne diseases by serving as hosts for ticks, which feed on their blood and transmit agents of these diseases, e.g. tick-borne encephalitis (Grassi, L. et al., 2023).

1. *Sus scrofa* – Wild boar

In the South Caucasus, the Suidae family is represented by the single wild-living species wild boar (*Sus scrofa*), which is distributed across all three countries Georgia, Armenia and Azerbaijan (p. 44). Currently, Sus scrofa does not have conservation status in Georgia, Armenia, or Azerbaijan.

The species has a wide distribution throughout the region, ranging from coastal areas to elevations up to 2600 meters above sea level, and ascending alpine meadows. This species typically resides in forested areas with good shelter but is also found in grassy semi-arid areas, shrublands, swamplands, and visits agricultural lands within suitable habitats. Wild boars are omnivorous. They predominantly eat crops, fruits, nuts, roots, and green plants. They also consume bird eggs, carrion, small rodents, insects, and worms.

The contact between populations of wild boar and herds of domestic pigs creates opportunities for pathogen transmission.

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2. *Capreolus capreolus* – Roe Deer

The roe deer - *Capreolus capreolus* - is found across all three countries in the region - Georgia, Armenia and Azerbaijan (p. 45). This species forms widespread and permanent populations in the mountain forest belt and forests on the plains. The roe deer occurs on elevations from sea level up to 2000 meters. However, there are records at higher altitudes. They prefer tall-grass meadows interspersed with shrubs, deciduous, mixed, and coniferous woods with plenty of large clearings, swamped forests, and forest edges covered with tall grasses and bushes providing good shelter and feeding conditions. The diet of the roe deer includes grasses, leaves, and young shoots in summer, and bark, shoots with buds, and leaves of bushes in winter. The presence of winter-feeding areas is important for this species. The species has different conservation status in different countries of the South Caucasus. In the red list of Azerbaijan, the conservation status considering the criteria of International Union for Conservation of Nature (IUCNc is listed as Vulnerable (VU), In Georgia and Armenia, roe deer do not have conservation status.

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Roe deer could be found in the areas that are used for cattle grazing and domestic pig herding under the forest canopy.

3. *Cervus elaphus* – Red Deer

The red deer - *Cervus elaphus* - was distributed in all three countries - Georgia, Armenia and Azerbaijan (p. 46), from 0 to 2300 meters above sea level. However, there are records at higher altitudes. Today, there are three separate populations in Georgia (eastern Greater Caucasus, Meskheti Ridge, and riparian forest along the Mtkvari (Kura) River at the border with Azerbaijan), three separate populations in Azerbaijan (eastern Greater Caucasus in the westernmost part of the country, the easternmost end of the Greater Caucasus, and on slopes of the Lesser Caucasus) and two known points of the occurrences of this species in Armenia (at the border with Iran and in the northern forested region).

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All populations are situated within protected areas (Lagodekhi State Reserve, Borjom-Kharagauli National Park, Gardabani Managed Reserve, Tusheti National Park in Georgia; Zagatala State Nature Reserve, Ilisu State Reserve, Shakhdagh National Park, Goygol National Park in Azerbaijan; Dilijan National Park and Arevik National Park in Armenia). Sometimes, single individuals or small groups of deer are seen outside the protected areas. The red deer has different conservation status in different countries of the South Caucasus. In the red lists of Armenia and Georgia, the conservation status considering the criteria of IUCN is Critically Endangered (CR), In Azerbaijan, conservation status is Vulnerable (VU).

The red deer inhabit different types of forests, primarily without large areas covered with thick undergrowth under the forest canopy and with many forest edges overgrown with bushes that keep green leaves and buds. The diet of the red deer includes grasses and leaves in summer, and shoots and bark of trees and bushes in winter.

Because the red deer occurs generally in protected areas with limited activity of livestock farming and it seldom goes to summer pastures of sheep, therefore we assume this species does not play an important role in the transmission of diseases.

4. *Gazella subgutturosa – Goitered gazelle*

The Goitered Gazelle - *Gazella subgutturosa* - is found in Azerbaijan and Georgia (p. 46) within the arid part of the Kura-Arax intermountain lowland. Five stable populations are situated within protected areas and in their vicinities in Azerbaijan (Shirvan Strict Nature Reserve and Shirvan National Park, Absheron National Park, Agh-Gol National Park, Ilisu State Reserve, and Korchay State Nature Reserve), and smaller populations in Gobustan, and on Khara Zira island.

All known populations in the South Caucasus occupy arid and semi-arid ecosystems from sea level up to 500 meters. This species prefers habitats with sandy and gravel soils. They inhabit hill slopes and plains with grasses, and sparse shrubs as well as areas with very sparse vegetation. In some places, the gazelle occurs at the edge of cultivated land, but it does not inhabit areas used for cultivation or livestock grazing. They are adapted to arid environments; their diet primarily consists of a variety of grasses, including galofits. The species has different conservation status in Azerbaijan and Georgia. According to the International Union for Conservation of Nature (IUCN) criteria, the Goitered Gazelle is classified as Vulnerable (VU) in the red list of Azerbaijan. In Georgia, the species has been on the red list as Regionally Extinct and a gazelle restoration project was initiated in 2013. Now, the population of

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the gazelle is established in the Eldari Steppe (Samukh) managed by the Vashlovani National Park administration.

The goitered gazelle occupies the same areas where the winter pastures of sheep are situated. Thus, outside the protected areas and in a few cases even in the protected areas (Vashlovani National Park), this species is in contact with domestic sheep and goats.

5. *Ovis gmelini* – Mouflon

The mouflon - *Ovis gmelini* - is distributed in the southern parts of Armenia and Azerbaijan (p. 46) from 1000 to 3000 meters above sea level.

Most of the observation points are situated within the low mountain semi-deserts, mountain steppes, and meadow steppes with dwarf-shrub vegetation (phrygana) and sparse bushes. A smaller number of records are within the middle-mountain juniper light forest, beech, hornbeam-oak, and pine forests, alternating with the secondary grasslands. The mouflons are fixed in sub-alpine meadows, high mountain steppes, and alpine meadows. This species prefers the arid mountain grasslands, interspersed with scrublands, along with subalpine and alpine meadows, and areas punctuated by rocky outcrops and canyons. The mouflon's diet consists of various plants - grass, leaves, twigs, bark, flowers, fruit, and roots. According to the criteria set by the International Union for Conservation of Nature (IUCN), the mouflon holds the conservation status of Endangered (EN) in Armenia and Azerbaijan. In both countries, the feeding areas of mouflon partly overlap with the pastures of domestic sheep, allowing for the potential exchange of pathogens via contaminated vegetation and soil.

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6. *Capra caucasica* – Western Caucasian Tur

The Western Caucasian tur - *Capra caucasica* - is found at the north-western edge of the South Caucasus, on the western part of the Greater Caucasus ridge, in Georgia (p. 47). This species has the smallest range of distribution among Caucasian ungulates and from the South Caucasus countries, the species is distributed only in Georgia. This species predominantly occupies subalpine and alpine meadow belts and rocky taluses, at elevations ranging from 1,600 up to areas permanently covered by snow at 2900 to 3500 meters above sea level. However, there are records at higher altitudes. In winter, turs retreat below the upper timberline in the forest. The species' diet includes grass, leaves, twigs, bark, flowers, fruit, and roots. They are endangered (EN) according to the IUCN Red List of Georgia.

The Western Caucasian tur avoids places involved in human activity. The feeding areas of the species and pastures of the domestic sheep are, for the most part, separated from each other.

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7. *Capra cylindricornis* – Eastern Caucasian Tur

The Eastern tur - *Capra cylindricornis* - is found in the central and eastern parts of the Greater Caucasus Range. The species occupies the southern slopes of the Greater Caucasus in Georgia and Azerbaijan (p. 47).

These turs inhabit subalpine and alpine meadows, subalpine crooked forest (the krummholz belt), rocks, and rocky taluses, from 1600 to 3500 meters above sea level. However, there are records at higher altitudes. During winter, turs retreat below the upper timberline deeper into the forest. The species' diet includes grass, leaves, twigs, bark, flowers, fruit, and roots. Considering the criterions of IUCN, the species is included in the red list of Georgia with the conservation status VU (Vulnerable).

Their feeding areas overlap with the pastures of domestic sheep, allowing for the potential exchange of pathogens via contaminated vegetation and soil.

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8. *Capra aegagrus* - Bezoar goat

The Bezoar goat - *Capra aegagrus* - is found throughout all three countries of the South Caucasus region – Georgia, Armenia and Azerbaijan (p. 48), in the north and south parts of the region, residing at elevations ranging from 900 to 3200 meters above sea level. However, there are records at higher altitudes.

In Georgia, this species mainly occurs in the upper-mountain pine forests with birch, and in surrounding sub-alpine tall-herb communities, crooked forest, rhododendron thickets, and sub-alpine meadows. In Azerbaijan and Armenia, most of the observation points are situated within the low mountain semi-deserts, mountain steppes, and meadow steppes with dwarf-shrub vegetation (phrygana) and sparse bushes. A smaller number of records are within the middle-mountain juniper light forest, beech, hornbeam-oak, and pine forests, alternating with the secondary grasslands. The Bezoar goat's diet is varied, consisting of grass, leaves, twigs, bark, flowers, fruit, and roots. Its conservation status varies across the South Caucasus: in Armenia and Azerbaijan, it is listed as Vulnerable (VU) according to the IUCN criteria, whereas in Georgia, it is categorized as Critically Endangered (CR).

In Azerbaijan and Armenia, the feeding areas of bezoar goats partly overlap with the pastures of domestic sheep and goats (*Capra hircus*), allowing for the potential exchange of pathogens via contaminated vegetation and soil.

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9. *Rupicapra rupicapra* – Chamois

The chamois - *Rupicapra rupicapra* - is present in Azerbaijan and Georgia (p. 49) on the southern slopes of the Main Caucasus ridge, occupying elevations from 500 to 2500 meters above sea level. In western Georgia, they are found on Svaneti Ridge, Egrisi Ridge, Lechkhumi Ridge, the northern end of Racha Ridge, and some other minor ridges of the Greater Caucasus mountain system. In eastern Georgia chamois is found on Mtiuleti Ridge, Pshav-Khevsureti Ridge, Atsunta

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Ridge, and on some minor ridges of the Greater Caucasus mountain system. On the Lesser Caucasus Chain, in western Georgia, it occupies Meskheti Ridge, the western part of the Trialeti Ridge, and Shavsheti Ridge. Diet varies with the seasons. In summer, the main feed is meadow herbs. In winter, the chamois can feed on young shoots of pine, lichens, and mosses. In western Georgia, it winters in forests with evergreen un-

derwood and eats leaves, shoots, and bark. According to the criteria set by the IUCN, the chamois holds the conservation status of Endangered (EN) in Georgia and Azerbaijan.

Outside the protected areas, the feeding areas of the chamois overlap with the pastures of domestic sheep and goats in mountain meadows in summer, and with cattle and pig herds under a canopy of the forest in winter.

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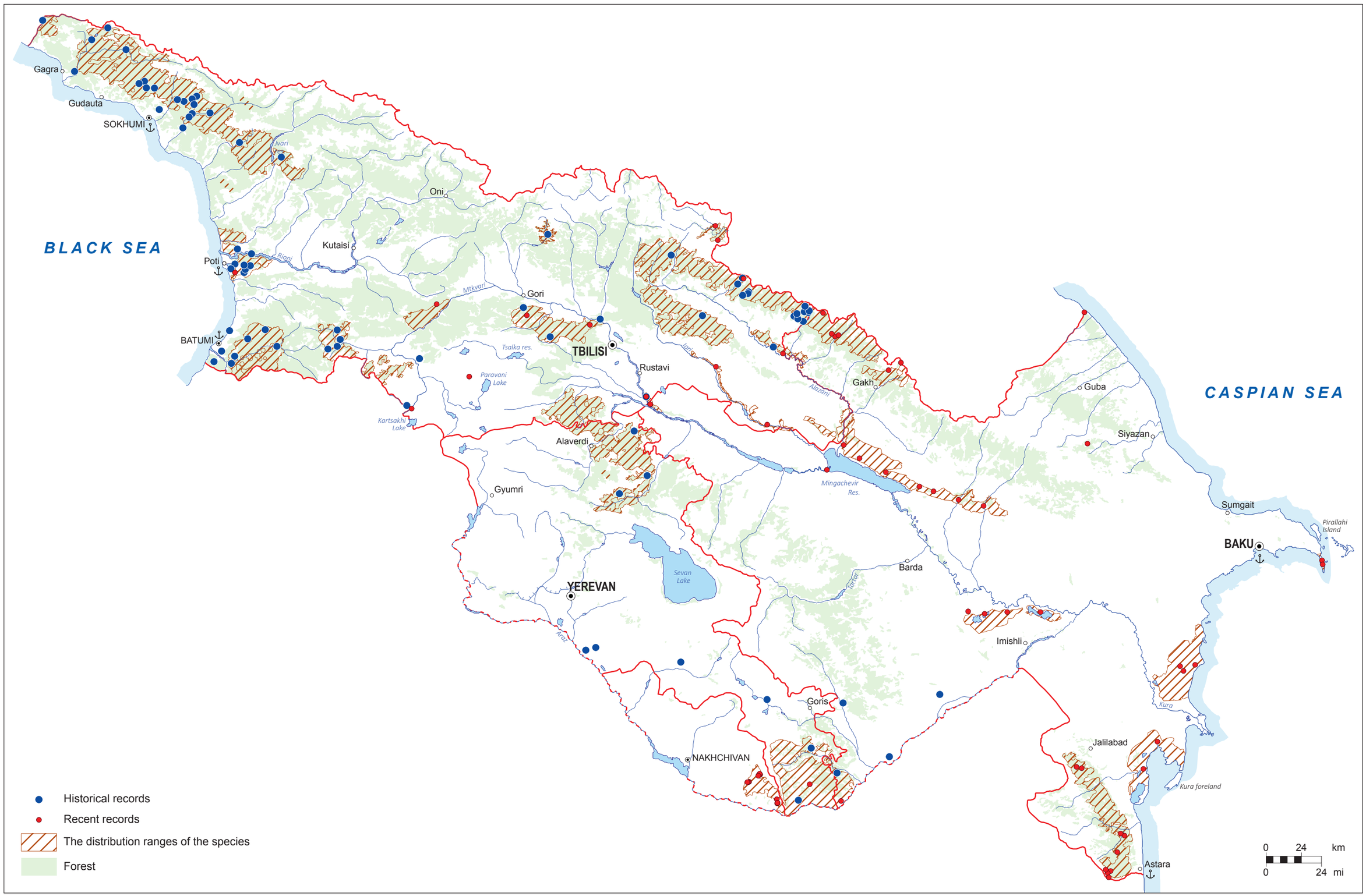
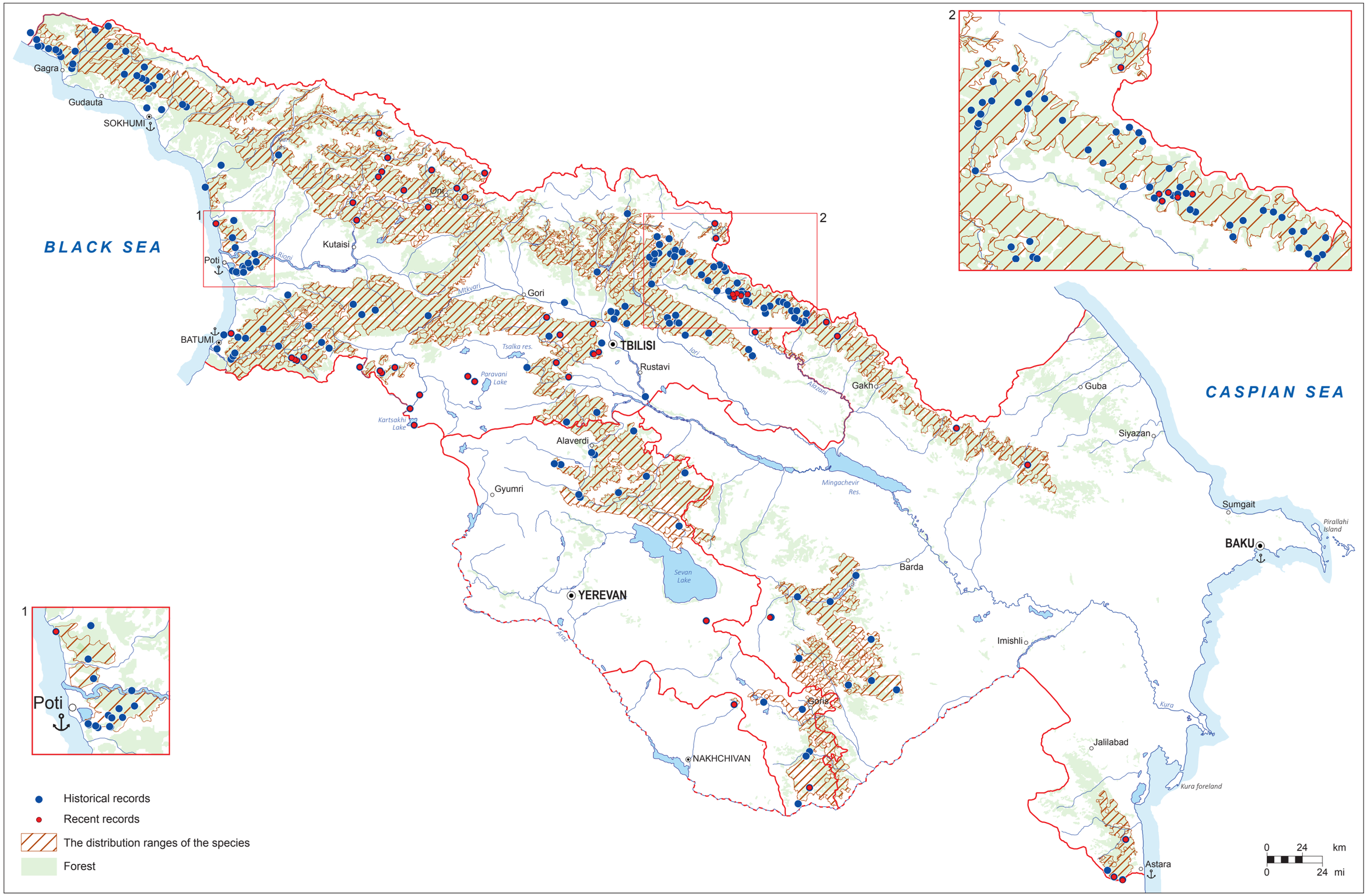
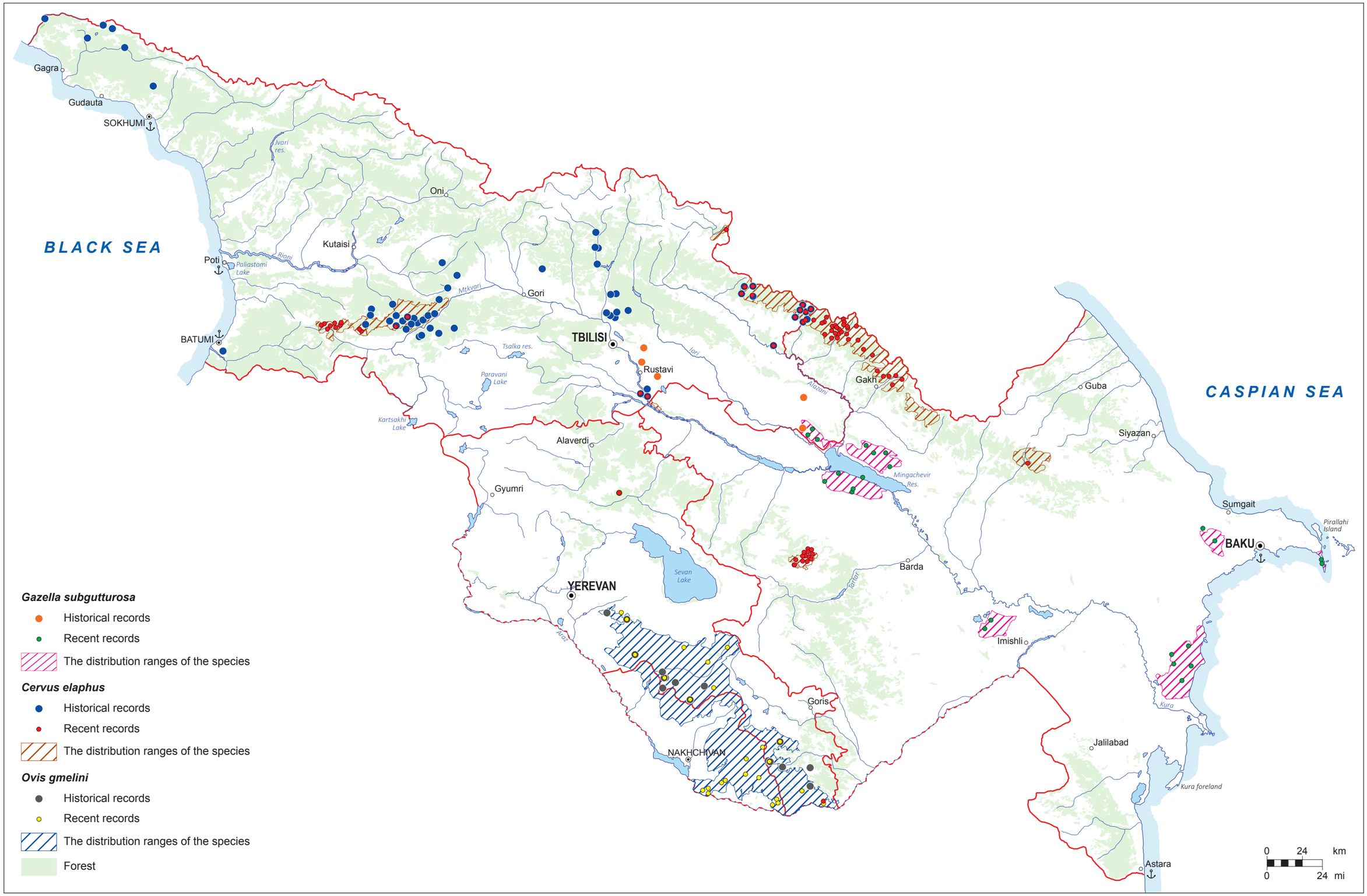
Distribution Ranges and Records of *Sus scrofa* in the South Caucasus



Distribution Ranges and Records of *Capreolus capreolus* in the South Caucasus



Distribution Ranges and Records of *Gazella subgutturosa*, *Cervus elaphus* & *Ovis gmelini* in the South Caucasus



Gazella subgutturosa

- Historical records
- Recent records
- The distribution ranges of the species

Cervus elaphus

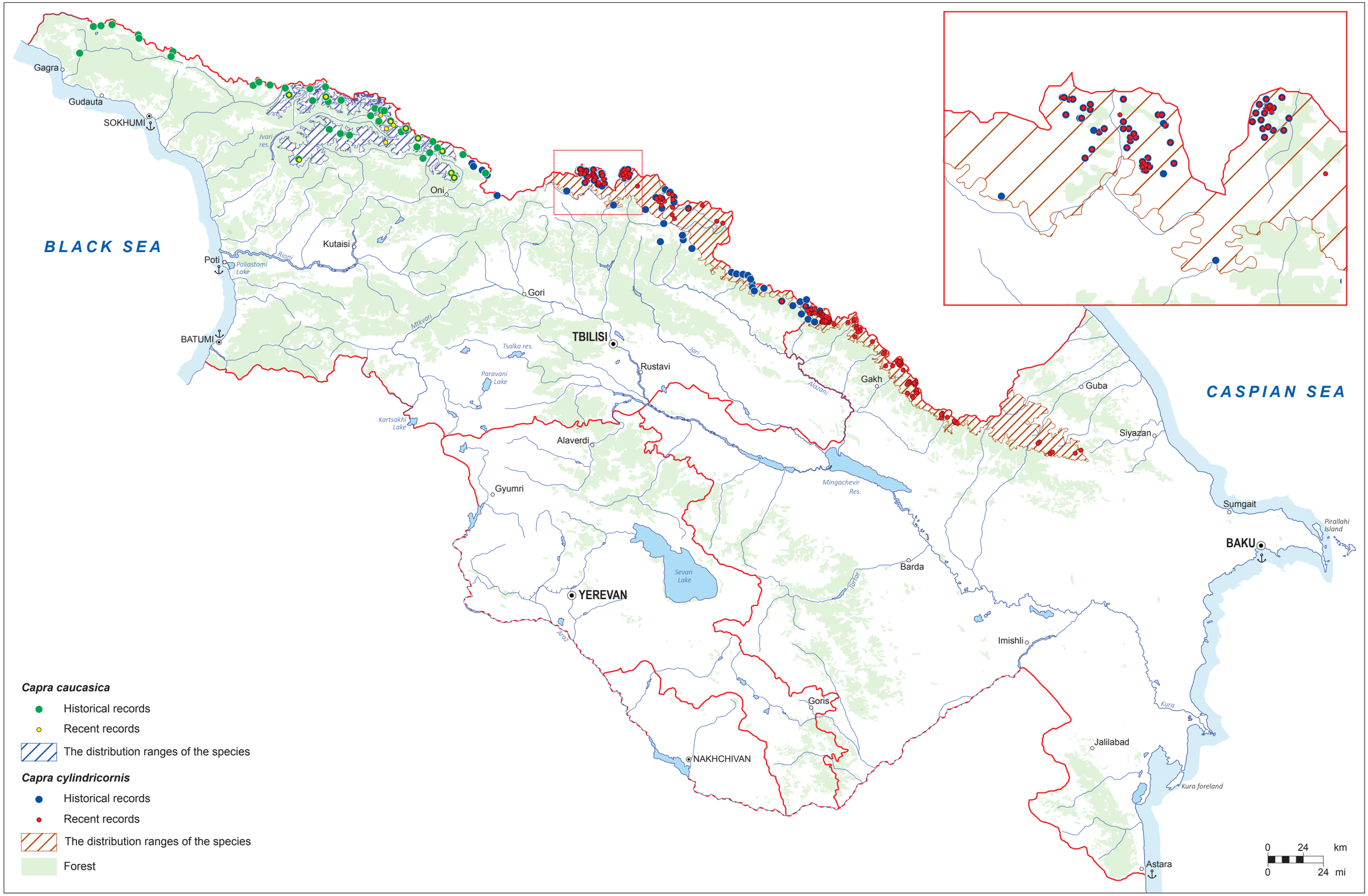
- Historical records
- Recent records
- The distribution ranges of the species

Ovis gmelini

- Historical records
- Recent records
- The distribution ranges of the species

Forest

Distribution Ranges and Records of *Capra caucasica & Capra cylindricornis* in the South Caucasus



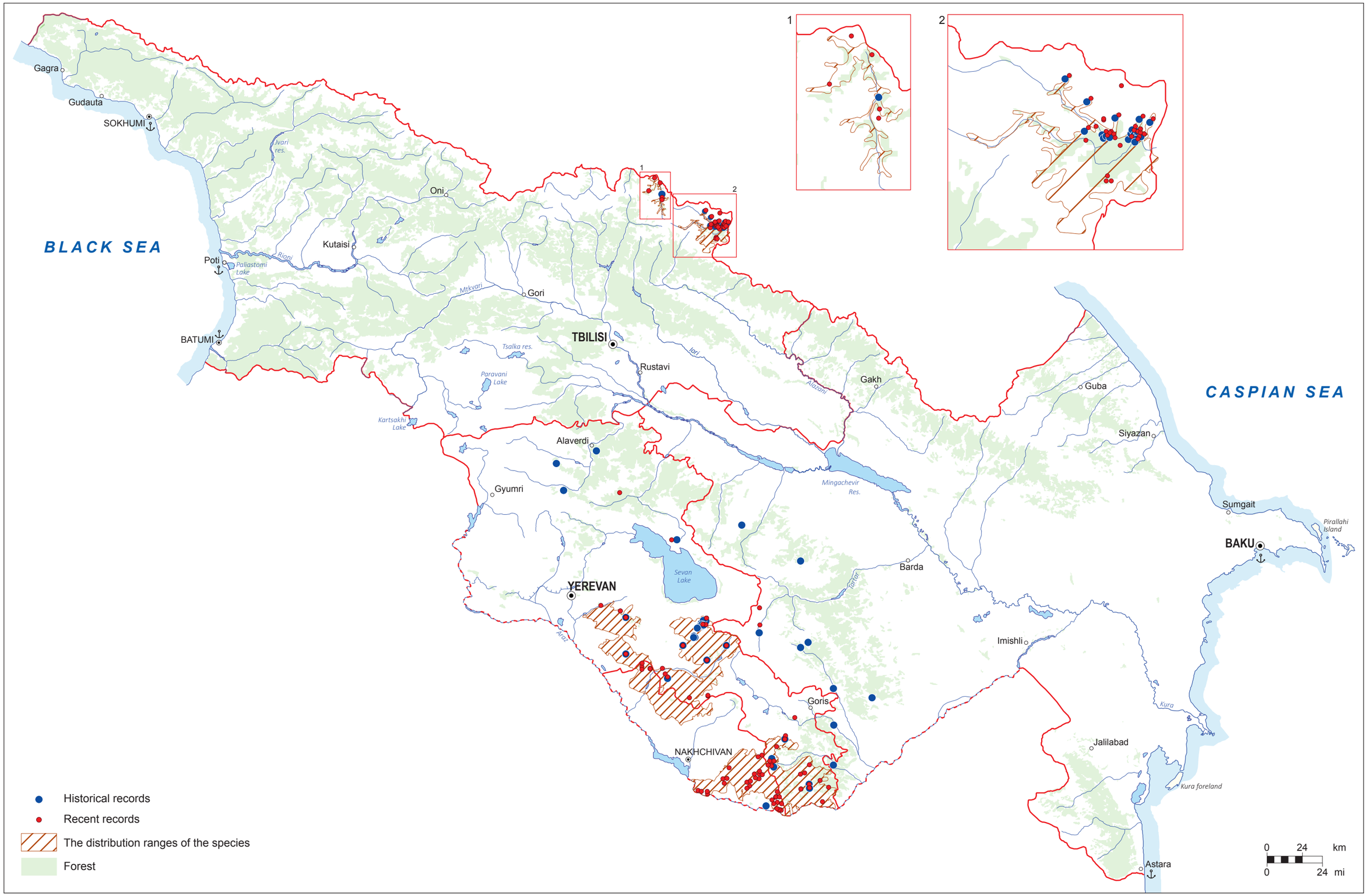
Capra caucasica

- Historical records
- Recent records
- The distribution ranges of the species

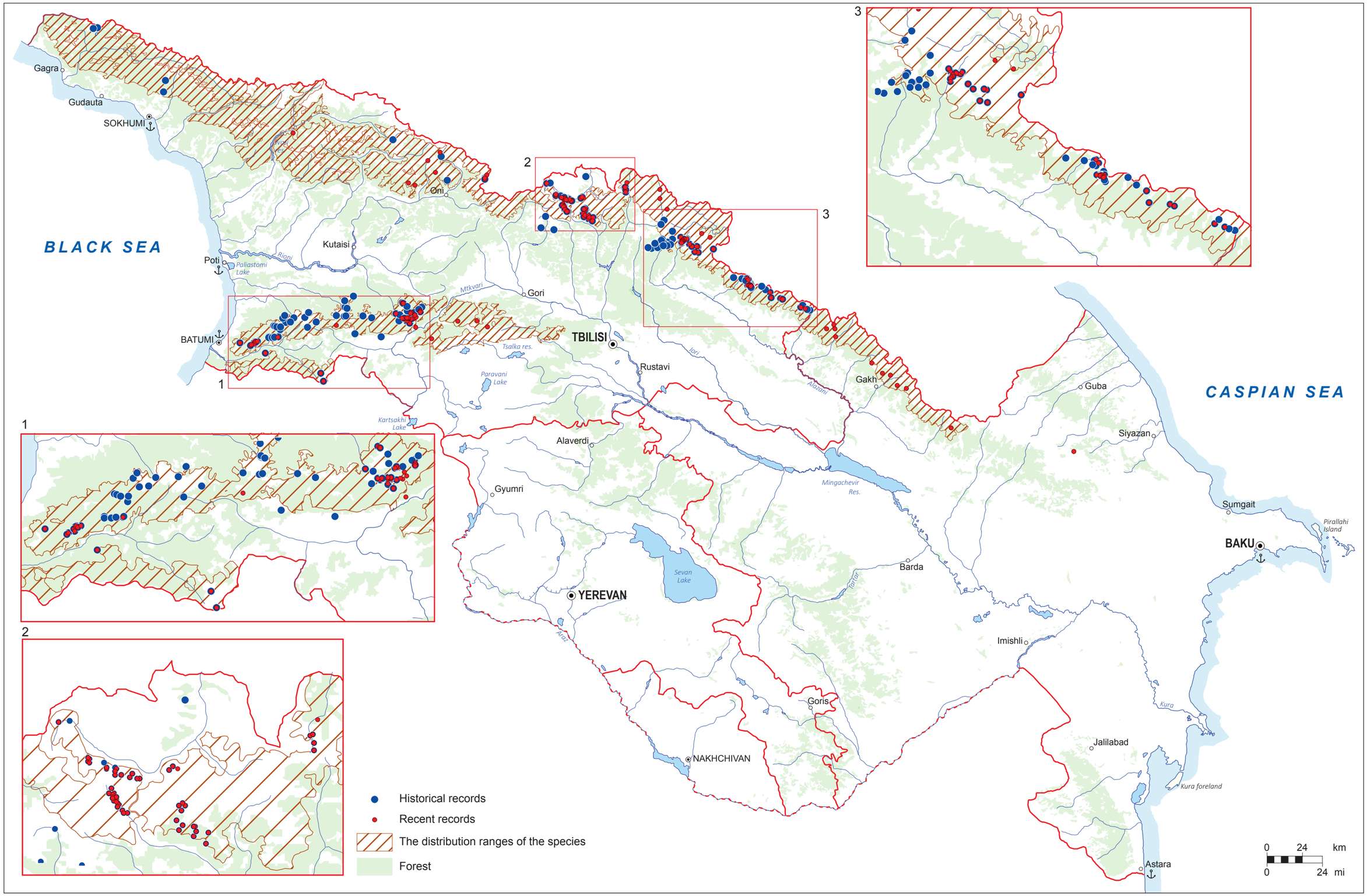
Capra cylindricornis

- Historical records
- Recent records
- The distribution ranges of the species
- Forest

Distribution Ranges and Records of *Capra aegagrus* in the South Caucasus



Distribution Ranges and Records of *Rupicapra rupicapra* in the South Caucasus



Rodents

RODENTS AND LOGOMORPHS

In the South Caucasus, rodents are represented by nine families, 24 genera, and 50 species. Order Lagomorpha is represented by one family, one genus, and one species in the South Caucasus.

Some rodents are known reservoirs for more than 20 transmissive human infections and zoonoses. Ectoparasites such as fleas and ticks feed on the blood of rodents and hares. Rodents can also transmit the pathogens through contaminated food, water, and soil.

The European hare (*Lepus europaeus*) and 15 rodent species are featured in this atlas. They are recognized reservoirs of the seven important zoonotic infectious diseases (anthrax, brucellosis, Crimean-Congo hemorrhagic fever, leptospirosis, plague, tick-borne encephalitis, and tularemia) that endure in the natural environment without human involvement. Among these 15 species of rodents, two species belong to the family of *Dipodidae* (jerboas - *Scarturus elater* and *Scarturus williamsi*), six species are member of family of *Cricetidae* (voles - *Arvicola amphibius*, *Microtus obscurus*, *Microtus rossiaemeridionalis*, *Microtus irani schidlovskii*, *Microtus socialis*, and Grey dwarf hamster - *Nothocricetulus migratorius*), and seven species are included in the *Muridae* family (jirds - *Meriones libycus* and *Meriones tristrami*, mice - *Apodemus uralensis*, *Apodemus witherbyi*, and *Mus musculus*, and rats - *Rattus norvegicus*, *Rattus rattus*).

The most recent publication focusing on rodent distribution in the South Caucasus dates back to 1976 (Shidlovskiy, 1976). More recent studies have led to the increase in rodent species found in the Caucasus and changes in their taxonomy. Though updated data on species distribution were collected across all three countries, most of the data remained unpublished and unanalyzed. Therefore, the Atlas represents updated maps of small mammals' distribution ranges.

Species range distribution maps were compiled using species presence probability models made using Maximum Entropy Modeling of Species Geographic Distributions (MaxEnt software), and the species' relative likelihood of occurrence modeling performed at Colorado State University. The dataset used for distribution range and niche modeling includes data from the Collection of the Institute of Zoology of the Ilia State University, the Georgian National Museum, the Collection of Zoological Institute of Russian Academy of Science, Zoological Museum of Moscow State University, records from the National Centres for Diseases Control databases in all three countries, published and unpublished scientific data collected since 1983 till 2022 years. For the South Caucasus countries, 6,085 records of 15 species of rodents were collected in 1,676 locations from 1855 through 2022, and 709 records of hare, in 391 locations were collected from 1878 through 2021. The models were adjusted considering species preferences according to the information obtained from the books, and authors' experience. The set of maps used for corrections comprises but is not limited to, the following maps: Caucasus Landscape map by Prof. N.L. Beruchashvili (1979, 1995), Caucasus Forest map, Landuse and Land Cover maps, and other geographic maps reflecting terrain relief, waters, settlements, protected areas, etc. The maps obtained this way aligned well with the anticipated 50-60% likelihood of the species' population presence in this area as per the species' probability of occurrence models.

The maps in this Atlas do not illustrate the complete distribution range of specific species or the extent of occurrence and the area of occupancy ranges based on IUCN criteria (IUCN, 2012). Instead, the polygons on the maps depict the distribution ranges of the key populations (most abundant and stable) of these species, hence - the areas where the process of the pathogen circulating in nature is most likelly.

Each map shows the locations of rodent species reports, though not all points fall within the range of polygons. This discrepancy arises from changes in species ranges over the data collection period (mid-19th century to early 21st century), possible identification errors, outdated taxonomy, and random encounters with animals in unsuitable habitats. Additionally, researcher biases and preferences in selecting observation sites could contribute to these deviations.

1. Little Jerboa - *Scarturus elater* (Lichtenstein, 1825)

In the South Caucasus, there are two isolated sites - Azerbaijanian and Ararat. The Azerbaijanian section starts from the shore of the Caspian Sea, reaches Lake Jandari in Georgia at the north, and reaches the Aker River valley along the Aras River at the south border of the study area. The Ararat site is located in the Ararat Valley in Armenia, in Nakhichevan, and the adjacent territories of Turkey and Iran. See Map of the distribution ranges of the main populations of the little jerboa (*Scarturus elater*), and williams' jerboa (*Scarturus williamsi*) (p. 55). There is an opinion that populations of this species exist separately withing these two sites. This species occur in desert steppes, saltwort, clayey and gravelly deserts, and semi-deserts; it avoids sandy deserts, although it enters them and settles in small clayey areas in sandy deserts (Shenbrot et al., 1995, Shenbrot et al., 2016). Prefers areas with clumps of wormwood, saltwort, forbs, and bushes with small areas devoid of vegetation. Little Jerboa can serve as an indicator of the degree of degradation of the steppe ecosystem. The altitudinal range is from -27 meters up to 2500 meters above sea level (Shenbrot et al. 2016). It is thought that this species plays a role in contributing to the persistence of the bacteria of a plague and leptospirosis in nature. *Scarturus elater* is protected by law in Armenia, included in the Red Book with category EN B1ab(ii, iii, iv) in accordance with IUCN categories.

Little jerboa (*Scarturus elater*), Georgia, 2017
© B. Eriashvili

2. Williams' Jerboa - *Scarturus williamsi* (Thomas, 1897)

The Williams' Jerboa occurs in southeast Azerbaijan and southwest Armenia and on the Iori Plateau in Georgia. See Map of the distribution ranges of the main populations of the little jerboa (*Scarturus elater*), and williams' jerboa (*Scarturus williamsi*) (p. 55). It inhabits deserts, semi-deserts, solonchaks, mountainous dry steppes, and stony banks of drying rivers. It is found in deserted areas in the place of degraded lowland forests. This species avoid territories with tall grasses, preferring sagebrush-grass areas; it also occurs in saltwort associations. Occassionally this species was reported in agricultural landscapes. The altitudinal range is known from -28 meters up to 2500 meters above sea leve. (Shenbrot et al. 1995). Hibernates from October to March, but may skip hibernating in warm winters. This species is believed to contribute to the persistence of plague bacteria in nature.

Williams' jerboa (*Scarturus williamsi*) via Intrnet
https://ar.pinterest.com/pin/350999364691127093/

3. Water Vole - *Arvicola amphibius* Linnaeus, 1758

This species was formerly known as Arvicola terrestris, but recent genetic studies resulted in separation of *A. terrestris* into multiple distinct species. According to the current classification, the genus Arvicola in the South Caucasus is represented by two species - Arvicola amphibius and *A. persicus*. The exact distribution boundaries of these species in the South Caucasus have not yet been accurately defined. Nevertheless, the biological characteristics of these species show little variation, enabling us to view them as a single reservoir of pathogens for highly dangerous infections from an epidemiological perspective. See Map of the distribution ranges of the main populations of the water vole (*Arvicola amphibius*) (p. 56). *A. amphibius* occurs on the slopes of the Greater Caucasus and in the Samur Lowland in Azerbaijan, and *A. persicus* inhabits the South Caucasus. The known altitudinal range is from –27 meters up to 3200 meters above sea level. (Kryštufek, Shenbrot 2022). In the Colchis Lowlandof western Georgia, the water vole is very rare, despite environmental conditions close to ideal for the existence of this species (Verestchagin 1959; Bukhnikashvili 2005).

The likely reason for this is strong competitive pressure from the brown rat (*Rattus norvegicus*). A. persicus swims well and leads a semi-aquatic lifestyle. To construct burrows, it prefers raised, steep banks overgrown with dense vegetation (grass, shrubs) of slowly flowing or stagnant bodies of water. Some of the burrow entrances are below the water level. Inhabits floodplain forests and swamps. Through irrigation canals, it penetrates in arid landscapes and agricultural lands. Not found far from bodies of water. *A. amphibius* has two ecotypes. Everything said above about the semi-aquatic *A. persicus* is also true for the semi-aquatic ecotype *A. amphibius*. This form is not characterized by significant fluctuations in population numbers. The fossorial ecotype builds burrows away from water, even when there are suitable sites near water. It inhabits meadows, gardens, and some crops. Sometimes this ecotype is found at a considerable distance from bodies of water. Population sizes of the fossorial ecotype fluctuate greatly. When their numbers increase, they damage crops. This species plays a certain role as a reservoir of the pathogen agents of a plague, tularemia, leptospirosis, brucellosis, and tick-borne encephalitis in the natural cycle.

Water Vole (*Arvicola amphibius*) via Internet [Pinterest WATER VOLE.jpg (2197×1463) (mirror.co.uk)]

MICROTUS ARVALIS GROUP

The group of grey voles is represented by two species, indistinguishable from each other by external morphological characteristics. Until recently, all grey voles living in the South Caucasus were classified as one species, *Microtus arvalis*. With the development of genetic methods, this species has been split into several species. These species have a similar biology and lifestyle. Altay grey vole – *Microtus obscurus* is widespread in the South Caucasus. The second species of East-European grey vole - Microtus rossiaemeridionalis - was previously recorded only in Armenia. In 2021, it was discovered in Georgia at the mouth of the Chorokhi River. The grey voles living in southern Armenia may belong to another twin species of the Caspian grey vole – Microtus mystacinus, but this has not yet been confirmed by genetic studies. Reports of East-European grey vole in the South Caucasus are not sufficient to build a range model and determine the boundaries of the range of this species. It was found in Georgia and closely located points in the south of Armenia. In old publications and all reports of the anti-plague service of the South Caucasus countries, these voles were identified as *M. arvalis*. Taking into account that the East-European grey vole is less susceptible to plague than *M. arvalis* and *M. obscurus*, we present here a separate map of the range of Altay grey vole considering the important role as the pathogen reservoir. See Map of the distribution ranges of the main populations of the altay grey Vole (*Microtus obscurus*), and records of the East-European grey vole (*Microtus rossiaemeridionalis*).

4. Altay Grey Vole - *Microtus obscurus* Eversman, 1841 (former - Common Grey Vole - *Microtus arvalis* Pallas, 1779)

In all countries of the South Caucasus, this grey vole prefer mesophilic landscapes (p. 57). *M. obscurus* lives in the mountain steppe, subalpine, and alpine meadows. There are especially many of them in secondary meadows. Some populations live in fairly dry ecosystems. The known altitudinal range spans from 500 meters up to 2400 meters above sea level. Numerous, sometimes dominant species in rodent communities, create large colonies during high numbers. When numbers increase, it damages crops. In the South Caucasus, this species supports the Transcaucasian mountain plague focus on the Armenian Highlands. This species plays a certain role as a reservoir of tularemia, leptospirosis, and brucellosis in the natural cycle.

Altay Grey Vole (*Microtus obscurus*) via Internet: Armenia, 2017, Photo by Artem, [https://inaturalist.ca/observations/5000033]

5. East-european Grey Vole - *Microtus rossiaemeridionalis* Ognev, 1924 (twin species to *Microtus obscurus*)

East-European grey vole - *Microtus rossiaemeridionalis* is a widespread species in Eurasia (p. 57). It is very similar species to the Altay grey vole - Microtus obscurus. In the South Caucasus, this species was known only from Armenia. In 2021, it was discovered in Georgia at the mouth of the Chorokhi River. It inhabits tall and dense herbaceous vegetation and shrubs. Wet places are preferred. It also lives in fields and densely overgrown gardens (Krištufek, Vohralik 2005). The altitudinal range is known from 0 meters up to 2500 meters above sea level.. This species plays a certain role as reservoir of a plague, tularemia, leptospirosis, and brucellosis in the natural cycle.

6. Schidlovski's vole - *Microtus irani schidlovskii* Pallas, 1773

Schidlovski's vole is found in the Armenian Highlands in Turkey, northern Armenia, and Southern Georgia adjacent to Armenia. See Map of the distribution ranges of the main populations of the social vole (*Microtus socialis*), and Schidlovski's vole (*Microtus irani schidlovskii*) (p. 58). This abundant species inhabits mountain steppes, subalpine meadows, natural biotopes, and agricultural landscapes, with altitudes ranging from 200 meters to 2500 m above sea level. The species' epidemiological role remains unstudied. In Armenia, Schidlovski's vole is legally protected and classified as EN B1ab (ii, iii, v) under the IUCN categories.

7. Social vole - *Microtus socialis* Pallas, 1773

The widespread species - Social vole is found in all countries of the South Caucasus. See Map of the distribution ranges of the main populations of the social vole (*Microtus socialis*), and Schidlovski's vole (*Microtus irani schidlovskii*) (p. 58). Inhabits semi-deserts, cereal and grass-wormwood steppes, light forests, pastures, arable lands, and perennial crops plantations. During population surges, it ventures into urban centers and sparsely populated floodplain forests. Its altitudinal range spans from -27 meters to 2500 meters above sea level. Abundant and at times dominant, these creatures form extensive colonies during peak numbers, posing a threat to crops. Their behavior includes minor migrations linked to grass burning and habitat disruption caused by agricultural activities. Furthermore, this species serves as a reservoir for plague, tularemia, and leptospirosis in the natural ecosystem.

Social vole (*Microtus socialis*), Georgia, 2018
© A. Kandaurov

8. Grey dwarf hamster - *Nothocricetulus migratorius* Pallas, 1773

The grey dwarf hamster can be found throughout the countries of the South Caucasus, ranging from plains to highlands. See Map of the distribution ranges of the main populations of the grey dwarf hamster (*Nothocricetulus migratorius*) (p. 59). In the forest mountain belt, it resides in treeless areas, screes, and rocks, avoiding the forest itself. Found in small numbers in steppes and semi-deserts on the plains, does not avoid agricultural lands. In the mountains, particularly in the subalpine zone and mountain steppes, it favors rocks, screes, and bushes on the slopes. It is rarely seen in heavily grazed summer pastures. In Armenia, permanent populations are established within large human settlements, specifically in multi-story buildings (Gromov, Erbaeva 1995; Vohralek 1999). The altitudinal range known for this species spans from -27 meters to 3000 meters above sea level. It is believed that the grey dwarf hamster plays a role in maintaining the prevalence of plague, tularemia, leptospirosis, and brucellosis in nature. In Georgia, this species is protected by the law and is listed in the Red List under the IUCN category VU A2a.

The Grey dwarf hamster (*Nothocricetulus migratorius*) via Internet Photo 335133982, Ledenkov S.V.

9. Libyan jird - *Meriones libycus* Lichtenstein, 1823

In Azerbaijan and Georgia, this jird lives in semi-deserts and degraded steppes on loess, loess-sand, and clay-

ey soils, less often on gravelly soils. See Map of the distribution ranges of the main populations of the Libyan jird (*Meriones libycus*), and Tristram's jird (*Meriones tristrami*) (p. 60). It occupies winter pastures, is found in shepherd's houses near sheep farms, and penetrates gardens and crops of forage grasses. Everywhere it prefers uneven terrain, such as basins, slopes of dry valleys, the foot of cliffs, slopes of embankments, etc. The altitudinal range is known from -27 meters up to 2000 meters above sea level. (Gromov, Erbaeva 1995; Granjon 2016). The Libyan jird is a colonial species with significant fluctuations in population size and size of their settlements. At high numbers, individual colonies merge, forming a continuous settlement over large areas. This species plays a main role as a reservoir of a plague within the Transcaucasian lowland natural focus of a plague, and it is thought that this species plays a role in contributing to the persistence of the bacteria of tularemia and anthrax in nature.

Libyan jird (*Meriones libycus*), Georgia, 2022.
© G. Sheklashvili

10. Tristram's Jird - *Meriones tristrami* Thomas, 1892

In the South Caucasus, it is found in all countries. In Armenia and Nakhichevan, it occupies a narrow strip of plain in the River Aras valley along the southwestern and southern border. In Azerbaijan, they live along the southern border, on the plain at the northern and northwestern foothills of the Lesser Caucasus ranges and the mountain steppes of the Talysh Mountains. The range of this species enters Georgia in its extreme northern part along the foothills on the right bank of the Kura River valley. See Map of the distribution ranges of the main populations of the Libyan jird (*Meriones libycus*), and Tristram's jird (*Meriones tristrami*) (p. 60). Tristram's jird mainly inhabits steppes and semi-deserts; it is not found in deserts and heavily deserted areas of pastures. It inhabits areas where livestock are not grazed, even in biotopes atypical for this species. It prefers various soil compositions (loess, alluvial, sandy), avoids rocky areas (Chabovsky, Popov 2002), and does not avoid the shores of reservoirs if the groundwater is deep. The worldwide altitudinal range is from 0 meters up to 2000 meters above sea level. (Chabovsky, Popov 2002; Sozen et al. 2021). The Tristram's Jird is a minor species in the Transcaucasian plain-foothill plague focus and in the "Priaraxinskiy" low mountain plague focus. It is thought that this species plays a role in contributing to the persistence of tularemia bacteria in nature. In Georgia, Tristram's jird is protected by law and is included in the Red List with category VU B2a under the IUCN categories.

Tristram's jird (*Meriones tristrami*), zoo, V. Motycka via Internet
Image - Meriones tristrami (Tristram's Jird) | BioLib.cz

11. Lesser Wood-Mouse - *Apodemus uralensis* Pallas, 1811

The lesser wood-mouse lives on the plains and in the mountains In all countries of the South Caucasus. See Map of the distribution ranges of the main populations of the lesser wood-mouse (*Apodemus uralensis*), and steppe field mouse (*Apodemus witherbyi*) (p. 61). This is mainly a forest species, preferring clearings, forest edges, forest areas with rocky outcrops, and the banks of rivers and streams. In subalpine meadows and mountain steppe, it is found near bushes, forested gorges, and river beds. Lesser wood-mouse found in small numbers in the lowland steppe. A common inhabitant of agricultural landscapes, in winter it sometimes inhabits residential and outbuildings. *A. uralensis* is a dominant species in rodent communities within most habitats except for steppes and semi-deserts, in some places reaching 80-100% of the total number of captured terrestrial small mammals. The altitudinal range is from 0 meters up to 3000 meters above sea level (Kryštufek et al. 2016). It is thought that this species plays a role in contributing to the persistence of the pathogen agents of tularemia, leptospirosis, brucellosis, Crimean-Congo hemorrhagic fever, and tick-borne encephalitis in nature.

Lesser wood-mouse (*Apodemus uralensis*) via Internet
https://elovilag.turaoldal.hu/allatok/allat.php?faj=kislabu_erdei-eger

12. Steppe field mouse - *Apodemus witherbyi* Tomas, 1902

The steppe field mouse is found in all South Caucasus countries, inhabiting open landscapes on the plains and mountains across a broad range of climatic conditions, from humid subtropics to steppes and semi-deserts. See Map of the distribution ranges of the main populations of the lesser wood-mouse (*Apodemus uralensis*), and steppe field mouse (*Apodemus witherbyi*) (p. 61). This species prefers areas covered with bushes and forest edges. This species does not go deep into the forest. In open landscapes it is often a dominant species. In some places it reaches 80-100% of the total number of captured terrestrial small mammals. In the mountains, in subalpine meadows and mountain steppes, it is more often found near human habitation. For the winter, it moves into residential and outbuildings, temporarily occupying an ecological niche of the house mouse Mus musculus that is absent high in the mountains. The altitudinal range is from 0 meters up to 2500 meters above sea level. It is thought that this species play a role in contributing to the persistence of the pathogen agents of a tularemia, leptospirosis, brucellosis, Crimean-Congo haemorrhagic fever, and tick-borne encephalitis in nature.

Steppe field mouse (*Apodemus witherbyi*) Georgia, 2021,
© G. Sheklashvili

MUS MUSCULUS GROUP

13. House Mice - *Mus musculus* Linnaeus, 1758 / Macedonian Mouse - *Mus macedonicus* Petrov et Ruzic, 1983

The cosmopolitan species *Mus musculus* lives in all countries of the South Caucasus, both on the plains and in the mountains. See Map of the distribution ranges of the main populations of the house mice (*Mus musculus*) (p. 62). Another species of the genus Mus, the Macedonian house mouse (*Mus macedonicus*) is so far known only in Georgia. Since the range of this species lies completely within the range of the house mouse and the lifestyle and interaction with humans are almost the same in both species, we consider them in this work as one group of closely related species . The map shows, as a species range, areas where house mice establish stable, permanent populations in natural and anthropogenic ecosystems outside human settlements. In the South Caucasus, there are two subspecies of the synanthropic house mouse - *M. musculus musculus* and *M. musculus domesticus*. The region is the zone of hybridization of these two subspecies (Mezhzherin, Kotenkova 1992, Orth et al. 1996). In the South Caucasus, house mice are represented by synanthropic and exanthropic forms. Synanthropic mice have inhabited almost all populated areas and detached farm buildings. In rural areas, these mice move into the surrounding anthropogenic and natural biotopes at short distances from housing in the summer. In the winter they return to buildings. In the subalpine zone, the house mouse is found only in residential premises (Bukhnikashvili et al. 2023; Rossikov 1887). Exanthropic house mice establish permanent populations in open landscapes away from populated areas. In cold winters, they sometimes partially infiltrate into residential and outbuildings. In natural ecosystems, their number often reaches 20% of the total number of captured terrestrial small mammals (Kandaurov, Sagdieva 1987). The known altitudinal range is from 0 meters up to 2600 meters above sea level. *Mus macedonicus* lives in steppes, semi-deserts, and agricultural lands. It is found in high numbers in arid light forests and shrubs. The known altitudinal range

House mouse (*Mus musculus*), Georgia, 2022,
© G. Sheklashvili

in Caucasus is up to 1300 m a.s.l. (Kryštufek, Vohralik 2016; Bukhnikashvili et al. 2023). It is thought that house mice play a role in contributing to the persistence of the pathogen agents of plague, tularemia, leptospirosis, brucellosis, and tick-borne encephalitis in nature. The house mouse is a minor species in the Transcaucasian plain-foothill plagues focus.

14. Brown rat - *Rattus norvegicus* Berkenhout, 1767

This cosmopolitan species, the brown rat lives in all South Caucasus countries, mainly in populated areas. See Map of the distribution ranges of the main populations of the brown rat (*Rattus norvegicus*) (p. 63). It is found in remote farms and other outbuildings. In populated areas, it mainly occupies basements and the lower floors of residential, commercial, and industrial buildings. In large cities, it forms numerous populations and colonizes underground communications and sewer systems. On plains with warm winters, it lives in forests and bushes, in open landscapes, and everywhere near water. Creates permanent exanthropic settlements, for example, in the swampy forests of the Colchis lowland. In natural ecosystems, it competes with local semi-aquatic mammal species and displaces them (Kucheruk 1991; Verestchagin 1959; Bukhnikashvili 2005). The altitudinal range is from 0 meters up to 2400 meters above sea level (Gromov, Erbaeva 1995), above 1400 meters above sea level found only in residential areas. Synanthropic rats destroy food supplies, damage property, damage communications, and other equipment, and create a constant threat of infecting people with dangerous infections. It is thought that Brown rats play a role in contributing to the persistence of the pathogen agents of plague, tularemia, leptospirosis, brucellosis, and tick-borne encephalitis in nature.

Brown rat (*Rattus norvegicus*), via Internet
https://live.staticflickr.com/65535/49118105483_fa6eb4128b.jpg

15. Black rat - *Rattus rattus* Linnaeus, 1778

This cosmopolitan species, the black rat lives in all the South Caucasus countries, mainly in populated areas. See Map of the distribution ranges of the main populations of the Black rat (*Rattus rattus*) (p. 64). It forms significant populations in densely populated areas along the Transcaucasian Railway stretching from the Black Sea shores to the ports of Azerbaijan on the Caspian Sea. In mountainous regions, it is only found in residential areas while in plains and foothills, it establishes permanent populations in both natural and

Black rat (*Rattus rattus*), Georgia, 2024, via Internet.
© Nikita Tiunov, *https://inaturalist.ca/observations/204426945*

man-made ecosystems as depicted on the map. The black rat resides in forests and shrubbery, often near water bodies. It tends to migrate deeper into the forest in the presence of the brown rat (*Rattus norvegicus*) (Gromov, Erbaeva 1995; Kryštufek et al. 2021). Synanthropic black rats within urban areas are typically located on upper floors and in building attics, with a belief that they do not migrate from urban settings to natural habitats. On ships, they outnumber the Brown rat. Their habitat extends from sea level up to 1650 meters above sea level (Kryštufek et al. 2021; Bukhnikashvili 2004). Above 250 meters above sea level, they are primarily found indoors (Gillespie, H. 2004.). It is suggested that this species may contribute to the spread and maintenance of disease-causing agents like plague, tularemia, and leptospirosis in nature.

16. European Hare - *Lepus europaeus* Pallas, 1778

European hare is a widespread species. It lives in all countries of the South Caucasus, both on the plains and in the mountains. **S**ee Map of the distribution ranges of the main populations of the European hare (*Lepus europaeus*) (p. 65). This species inhabits open landscapes, bushes, ravines, and forest edges. It goes deep into the forest along roads and through clearings. In tea plantations, it is found near water bodies. In the absence of bushes, it uses piles of boulders as shelter. It is observed in small quantities near populated areas. Quite significant vertical seasonal migrations of this species are known. The altitudinal range is from 0 meters up to 2500 meters above sea level. It is thought that this species plays a role in contributing to the persistence of the pathogen agents of a plague, tularemia, antraxis, Crimean-Congo hemorrhagic fever, and tick-borne encephalitis in nature. The hare is a hunting game species.

European Hare (*Lepus europaeus*), Georgia, 2006,Georgia, 2024,
© Nika Budaghashvili

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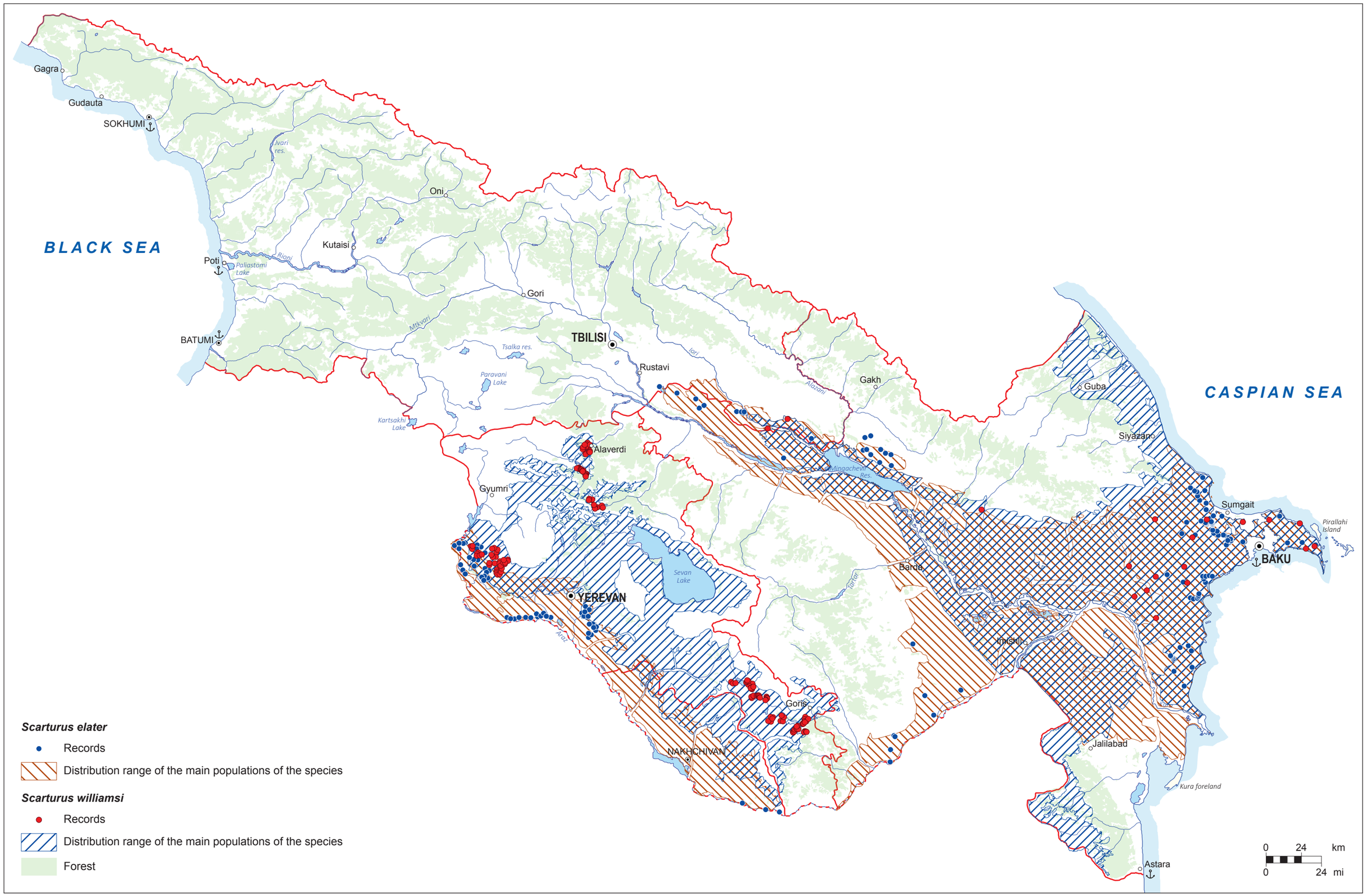
Distribution Ranges of the Main Populations of the *Scarturus elater* & *Scarturus williamsi* in the South Caucasus



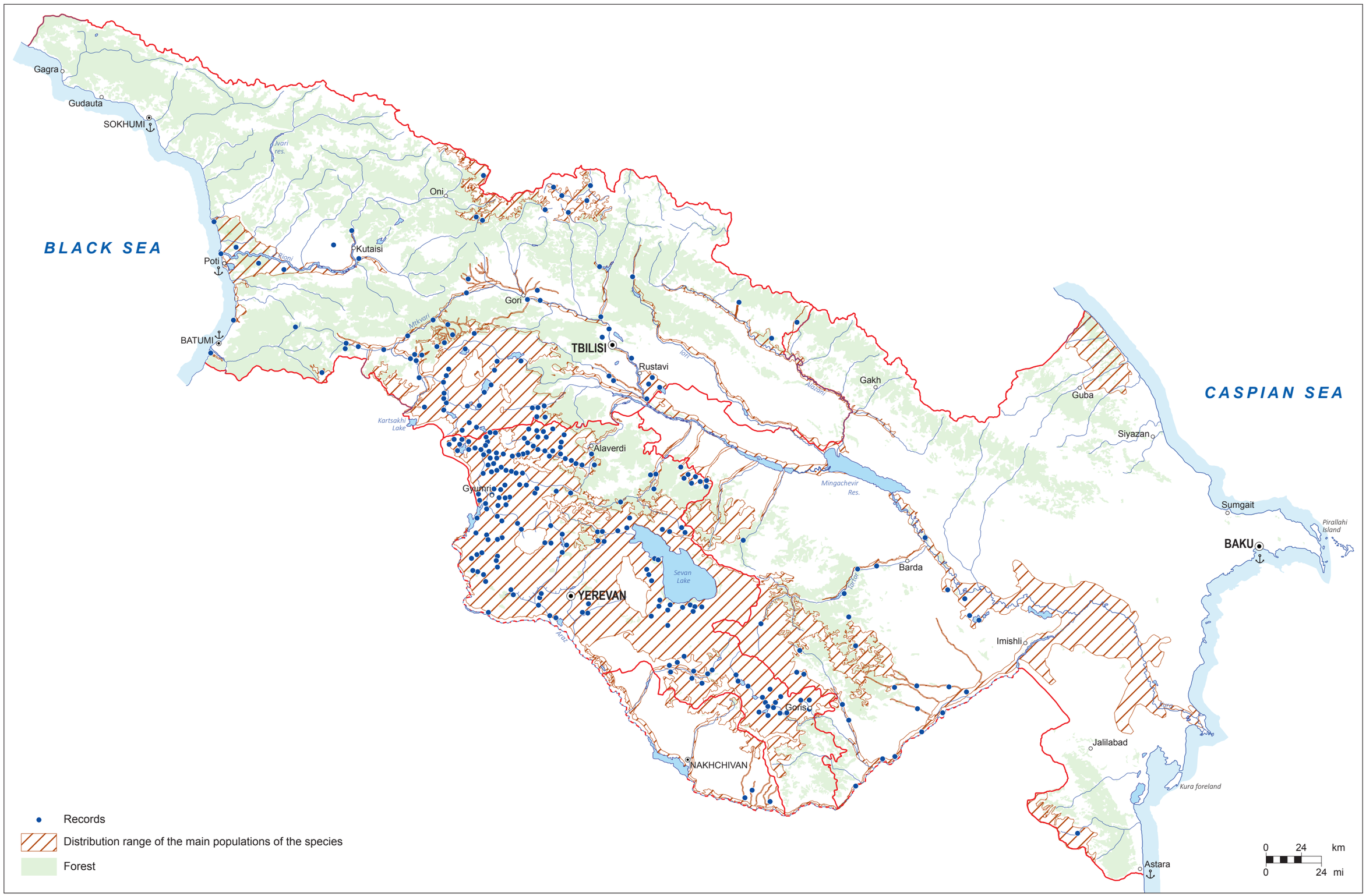
Scarturus elater

- Records
- Distribution range of the main populations of the species

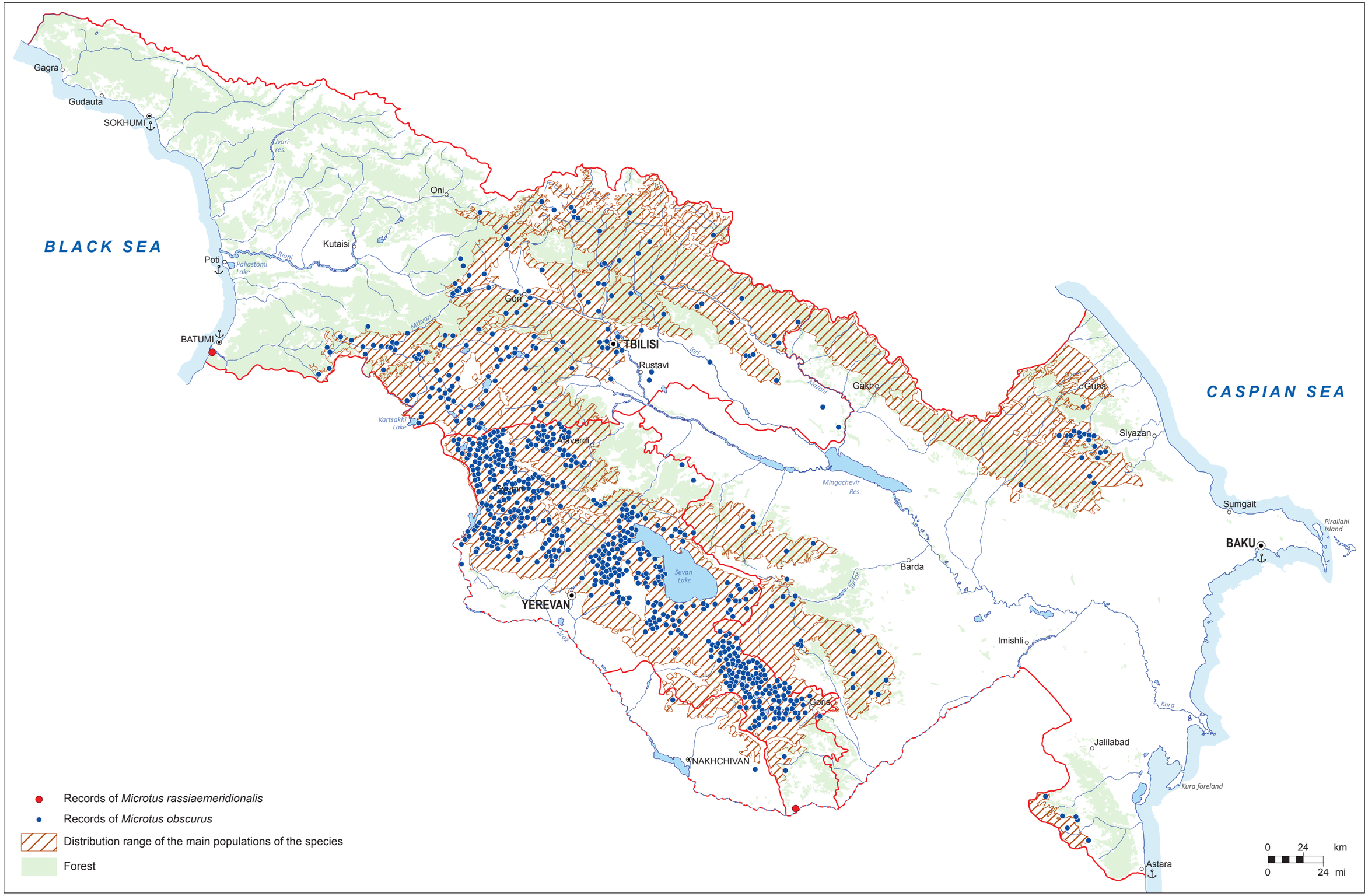
Scarturus williamsi

- Records
- Distribution range of the main populations of the species
- Forest

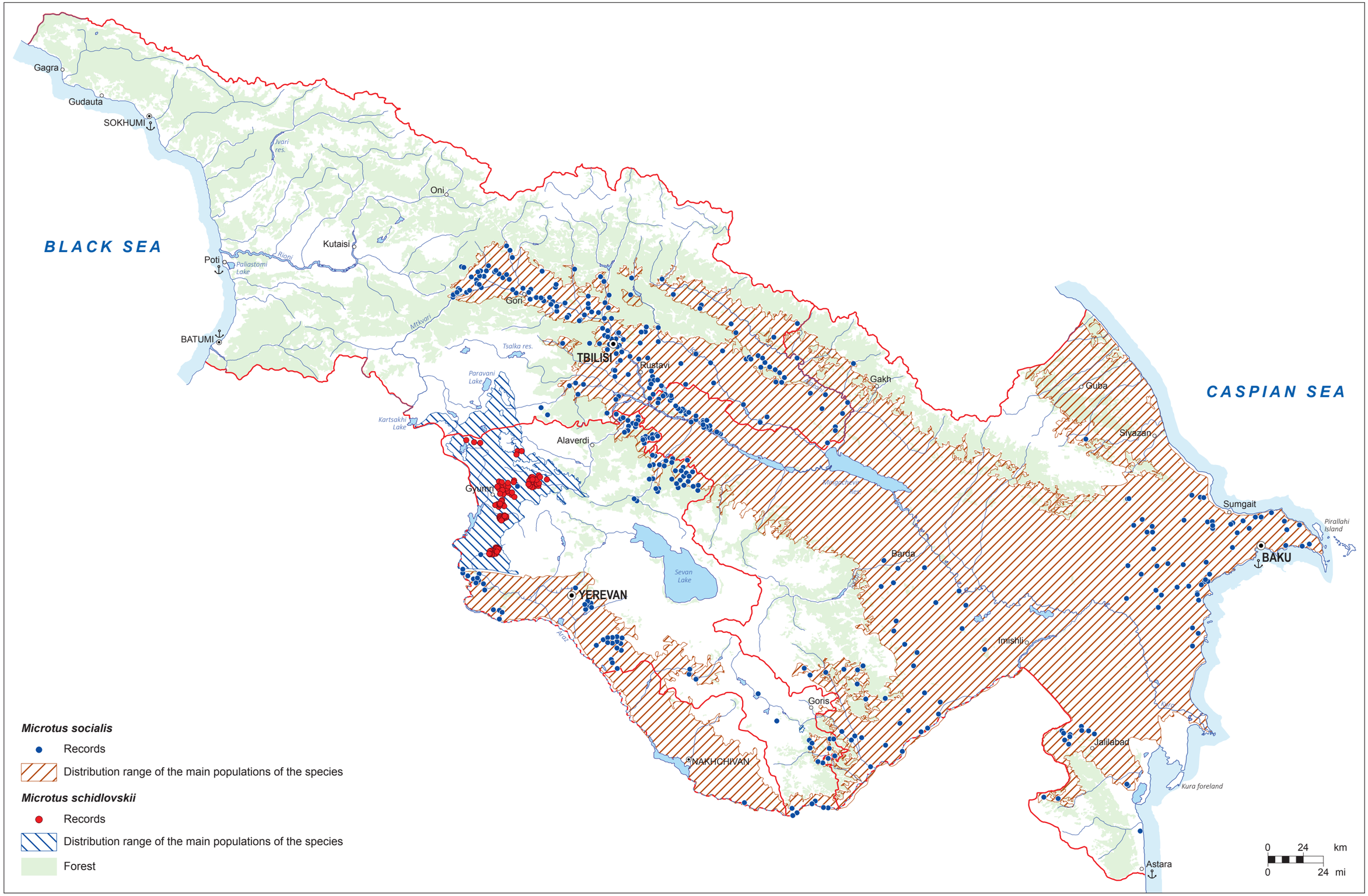
Distribution Ranges of the Main Populations of the *Arvicola amphibius* in the South Caucasus



Distribution Ranges of the Main Populations of the *Microtus obscurus* in the South Caucasus



Distribution Ranges of the Main Populations of the *Microtus socialis* & *Microtus schidlovskii* in the South Caucasus



Microtus socialis

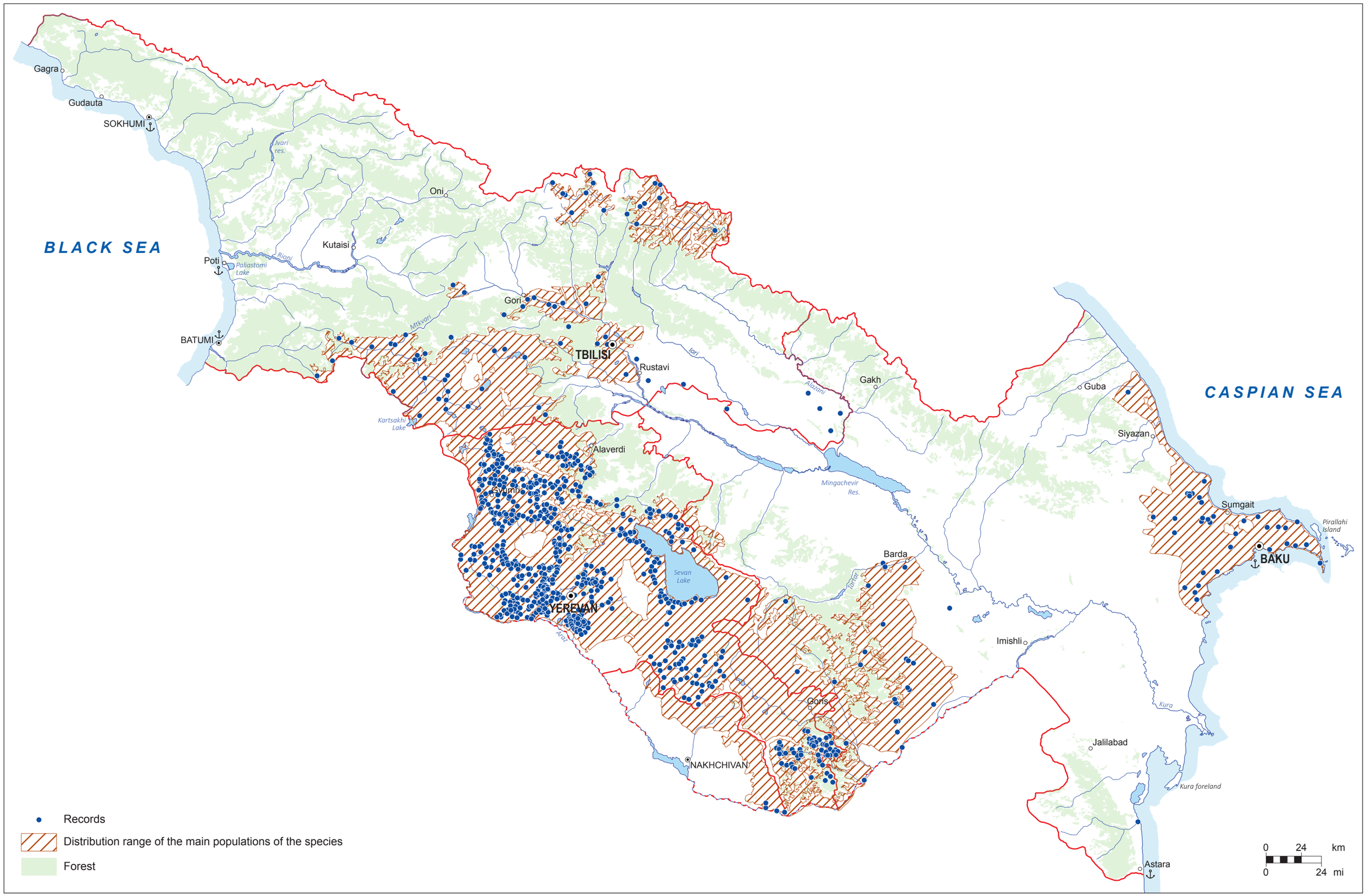
- Records
- Distribution range of the main populations of the species

Microtus schidlovskii

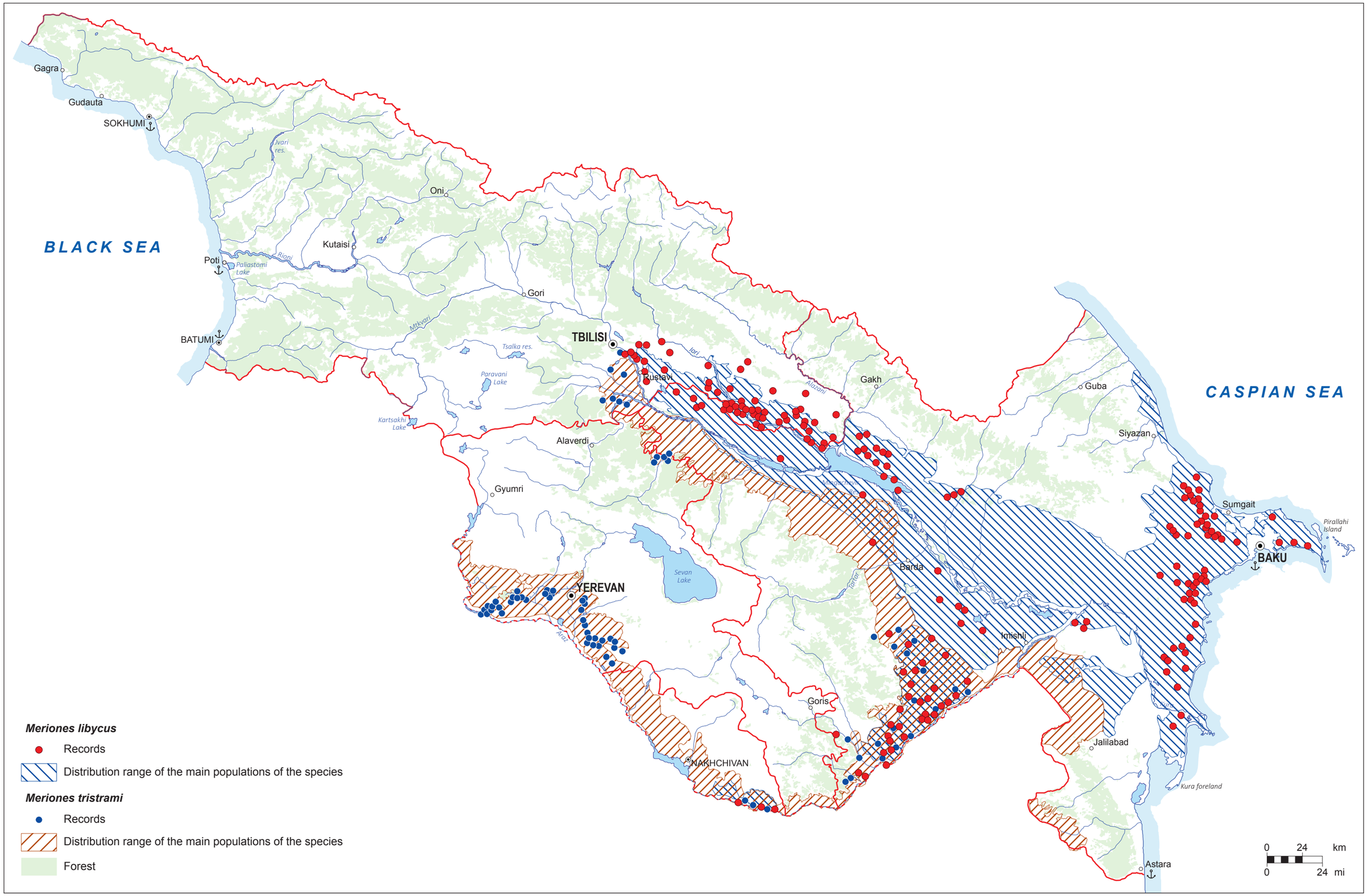
- Records
- Distribution range of the main populations of the species

Forest

Distribution Ranges of the Main Populations of the *Nothocricetulus migratorius* in the South Caucasus



Distribution Ranges of the Main Populations of the *Meriones tristrami* & *Meriones libycus* in the South Caucasus



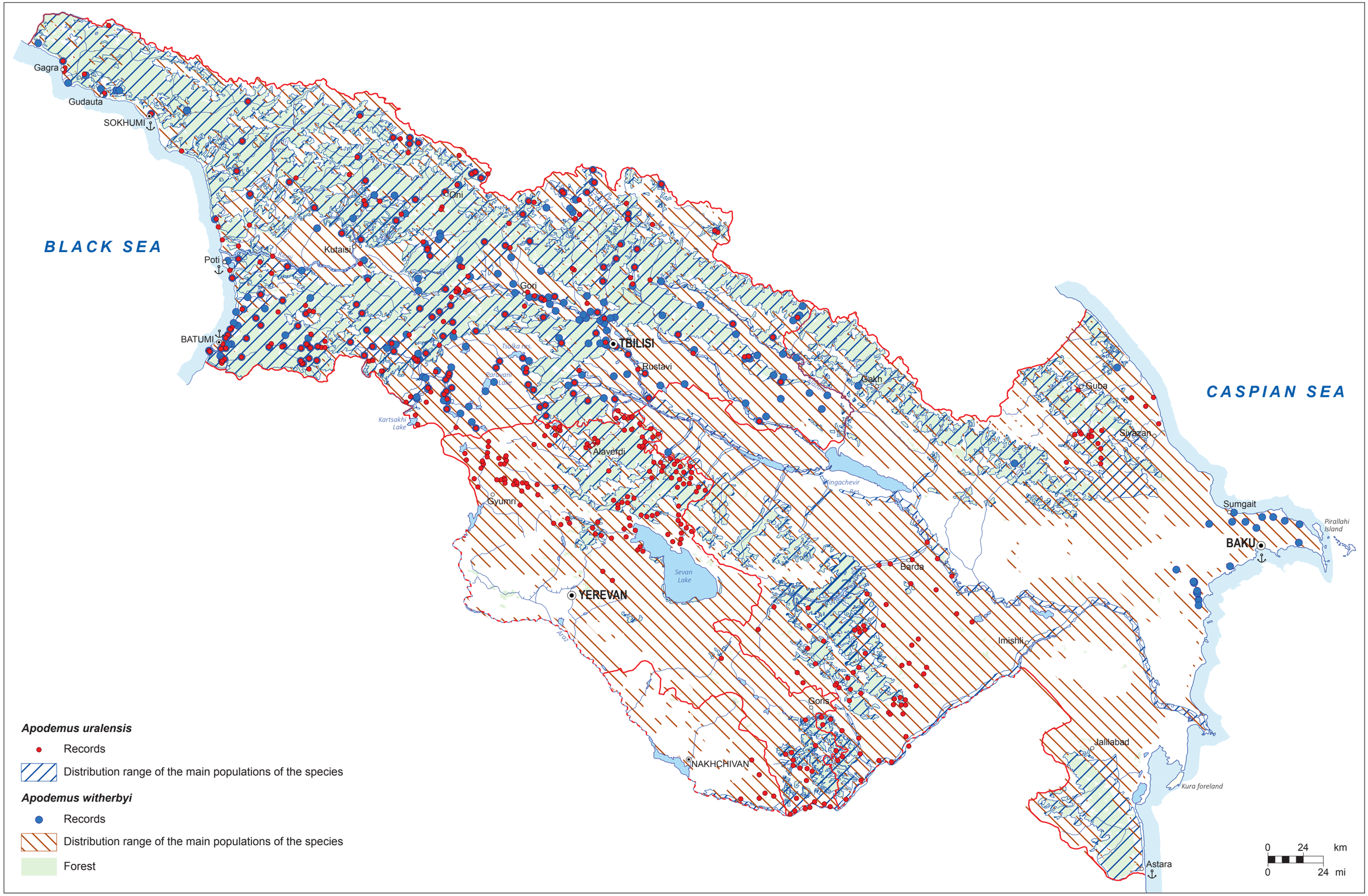
Meriones libycus

- Records
- Distribution range of the main populations of the species

Meriones tristrami

- Records
- Distribution range of the main populations of the species
- Forest

Distribution Ranges of the Main Populations of the *Apodemus uralensis* & *Apodemus witherbyi* in the South Caucasus



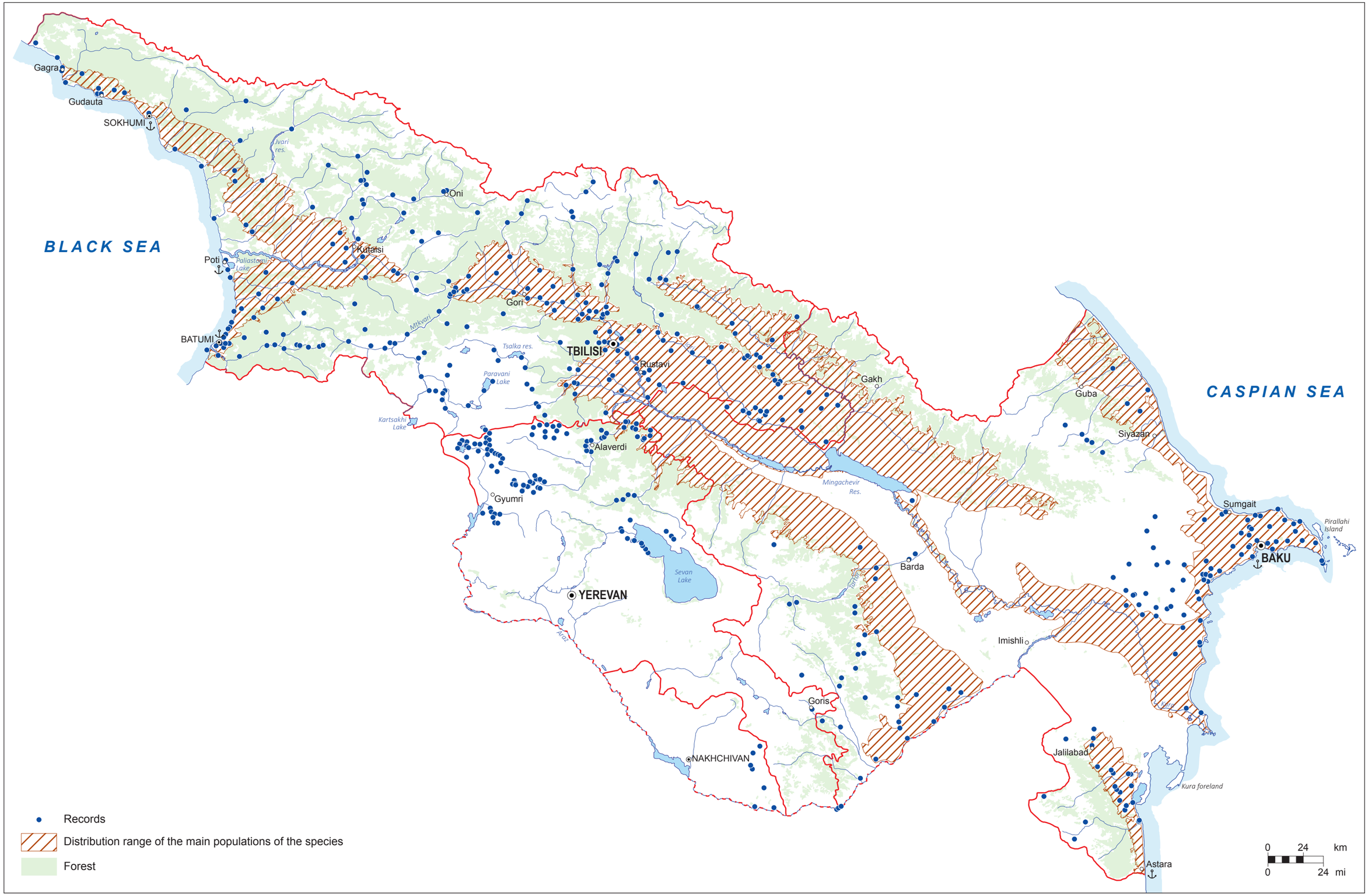
Apodemus uralensis

- Records
- Distribution range of the main populations of the species

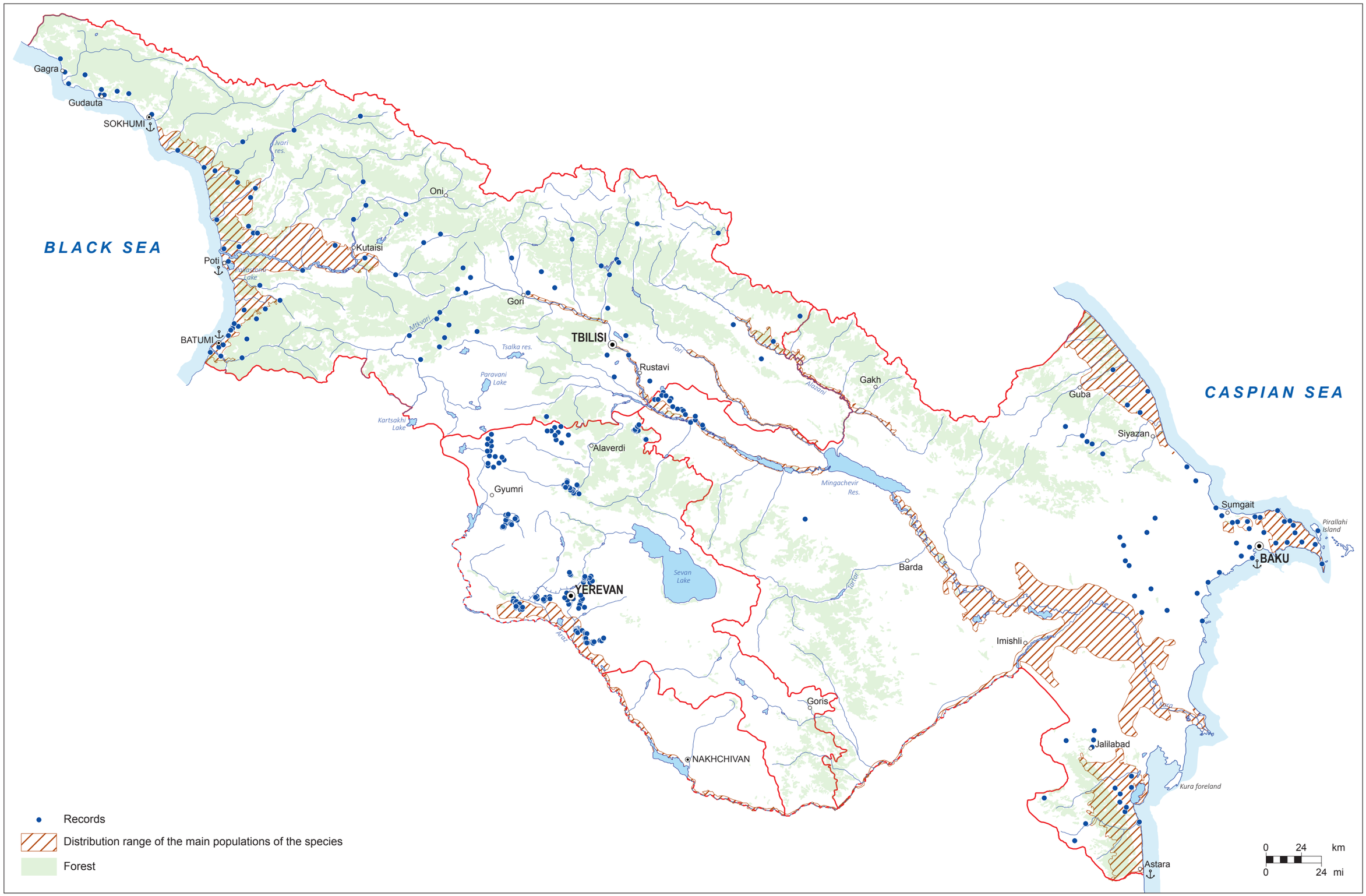
Apodemus witherbyi

- Records
- Distribution range of the main populations of the species
- Forest

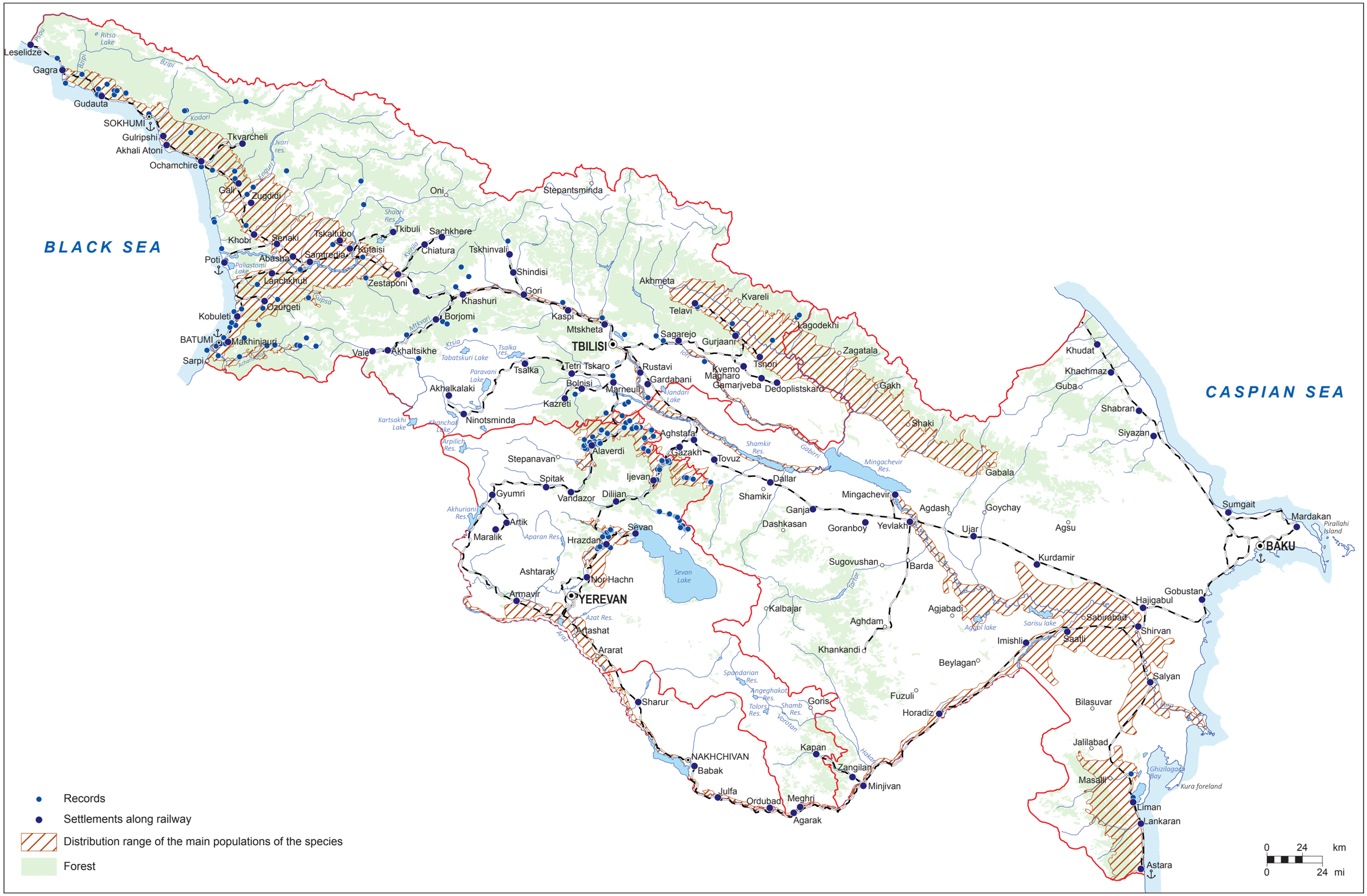
Distribution Ranges of the Main Populations of the *Mus musculus* Linnaeus in the South Caucasus



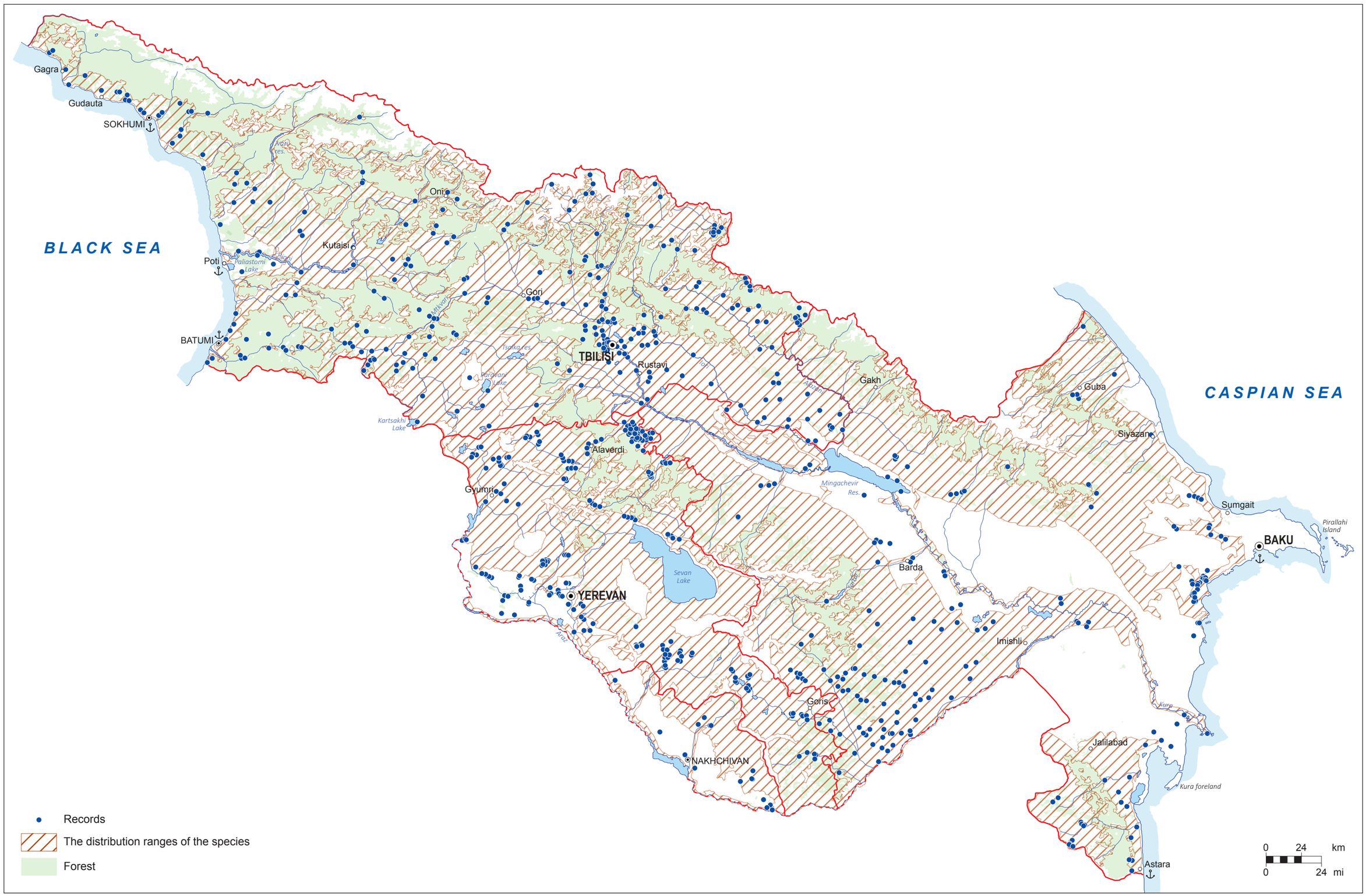
Distribution Ranges of the Main Populations of the *Rattus norvegicus* in the South Caucasus



Distribution Ranges of the Main Populations of the *Rattus rattus* in the South Caucasus



Distribution Ranges of the Main Populations of the *Lepus europaeus* in the South Caucasus



Anthrax

Anthrax is a zoonotic disease caused by the bacterium Bacillus anthracis. Anthrax bacteria form spores that can persist for decades in the soil. This disease affects domestic and wild animals worldwide, such as cattle, sheep, goats, antelopes, and deer. The animals become infected by consuming contaminated plants, water, and soil. Humans can contract anthrax via direct or indirect contact with infected animals or contaminated animal products. Anthrax can cause severe disease in both humans and animals. In general, anthrax is not considered a contagious disease in humans, although there are some records of human-to-human transmission. The extent to which human health and veterinary surveillance and control programs are integrated determines the control of anthrax in human populations. Routine surveillance and regular interagency reporting between veterinary and human health surveillance systems and close cooperation between these systems, are particularly important for conducting epidemiological studies and managing outbreaks. Bacillus anthracis spores are potential biohazard agents because they are easily spread and resistant to heat, light, and radiation.

Anthrax human positive case (cutaneous form, 2008)
© Nikoloz Tsertsvadze

The incidence of the natural disease in humans is dependent on the level of exposure to affected animals and, national incidence data for non-industrial cases reflects the size of the livestock population. The incidence of anthrax around the world decreased from 20,000 to 100,000 cases in 1958, to approximately 2,000 cases per year in the 1980s. The disease can be contracted at any time of the year, although the number of cases increases significantly in summer and autumn. Anthrax is most prevalent in the agriculturally active regions of sub-Saharan Africa, Central and South America, Central and Southwest Asia, the Caribbean, and Southern and Eastern Europe. Although outbreaks still occur in livestock and wild herbivores in Canada, the United States, and Western Europe, human anthrax in these areas are now rare. Outbreaks of human anthrax from the

Soil samples collection (from a burial site) for Anthrax laboratory investigation © Tengiz Chaligava

eastern Mediterranean region have occurred in Morocco, Sudan, Afghanistan, Iraq, Iran, and Pakistan.

In animals, anthrax occurs in a generalized form and it is contagious during the entire period of the disease. In humans, of the four forms of anthrax, cutaneous anthrax is the most common form, accounting for approximately 95% of cases. Anthrax is a notifiable disease in many countries. Inhalation, gastrointestinal and injection anthrax, are less common. Anthrax meningitis can be complicated by hematogenous spread from the four main clinical manifestations of anthrax, or can develop independently. The anthrax outbreaks of cutaneous and gastrointestinal anthrax are associated with handling infected animals, the slaughter and consumption of meat from these animals. The incubation period is 2 to 8 days; rarely it can last up to 14 days and depends on the clinical form.

For primary prevention, exposure to anthrax spores should be limited. If occupational exposure is anticipated, the use of appropriate personal protective equipment and biosecurity measures are recommended including special work clothing that covers all exposed skin, eye protection, and a mask or respirator. Work clothes should be washed on site. People should practice hand hygiene and avoid putting their fingers in their eyes, nose or mouth. Because inhalation anthrax is associated with large-scale processing of animal skins and wool, measures to improve ventilation in these occupational settings are recommended. Precautions should be taken to avoid vigorous shaking or beating of animal hides. Contact precautions should be taken to prevent human-to-human transmission of anthrax, and if there is a risk, isolation for 8 to 10 days is necessary. Post-exposure prophylaxis consisting of anthrax vaccine and antibiotic therapy, is recommended for secondary prevention, after known or suspected exposure to aerosolized spores of *Bacillus anthracis* (e.g., a bioterrorist attack), and vaccination is recommended only for routine use in certain groups. These include at-risk adults, military personnel, and some laboratory personnel.

There are several treatment options for patients with anthrax, including antibiotics and antitoxins. Patients with severe cases of anthrax require hospitalization to receive aggressive treatment such as continuous drainage of fluids and mechanical ventilation. Antibiotics are used for treatment of all forms of anthrax. Another possible treatment option for the toxins created by bacterial multiplication is an antitoxin, which targets the anthrax toxins in the human body. Antitoxin is used in combination with other treatment options.

Data on Anthrax had been collected from the mid 20th century from all three countries (1946-2019) from publications, annual reports, public health centers, former anti-plague stations, veterinary centers, and finished and/or ongoing scientific projects. Cases of anthrax are common in both humans and animals in all three countries of the South Caucasus (pp. 68-70). The majority of human cases are between 40 to 60 years old in Georgia, while in Armenia, most are 20 to 50, and 30 to 50 in Azerbaijan. More than 70% of human cases are male in all three countries. By clinical manifestation, all registered cases are cutaneous, except for two cases of gastorintestinal anthrax in Georgia. For animal cases, most cases are found in cattle, although all three countries have reported cases in sheep, goats, pigs and dogs.

Most cases in western Georgia have been reported in areas with humid climates with moderately cold winters and comparatively dry, hot summers, and in maritime humid climates with mild winters and hot summers. In eastern Georgia, cases have been reported in transitional climates from moderate warm steppes to moderate humid climates with hot summer and minimum precipitation twice a year. Southern Georgia cases mostly occur in highland steppe climates with less snowy cold winters and prolonged warm summers (pp. 74-76).

In Armenia, the majority of Anthrax cases have been reported across the territories with arid, continental, hot summers and cold winters, moderate, relatively dry, warm summers and cold winters, and arid subtropical, with hot summers and mild winter (pp. 80-81). In Azerbaijan, cases are registered in semi-desert and dry steppe climates with mild winters and dry, hot summers, and temperately warm climates with dry winters (pp. 77-79).

Anthrax human positive case (cutaneous form, 2009)
© Nikoloz Tsertsvadze

Anthrax is characterized by seasonality and the majority of cases are reported during the hot season of the year, when average maximum temperatures are between 9-13°C (pp. 85-87). In Georgia, most cases of anthrax are reported in areas where the annual sum of precipitation is 600 mm to 2,200 mm (pp. 82-84). In Armenia and Azerbaijan, cases are registered where the annual sum of precipitation is 600 mm to 700 mm (pp. 82-84).

Soil type is an important factor for Anthrax. In western Georgia, cases are registered in subtropical gley podzolic soils, raw humus calcareous soils, brown forest podsolic soils and yellow soils. The majority of anthrax cases in eastern Georgia are in meadow cinnamonic soils, grey cinnamonic soils and brown forest unsaturated soils (pp. 91-93). In Armenia, anthrax occurs across the territories with the mountain chestnut, fulvous forest, mountain black earth and gray-fulvous

Decontamination of soil (a cow slaughter site) contaminated at the surface with *Bacillus anthracis* spores © Tengiz Chaligava

(fulvous semi-desert) soil types (pp. 97-98). In Azerbaijan, cases are found in areas with grey-meadow, dark and simple grey-dark brown and dark brown meadow soil types (pp. 94-96).

Overall, Anthrax cases in humans and animals are mostly registered in agricultural territories within the South Caucasus (pp. 102-104).

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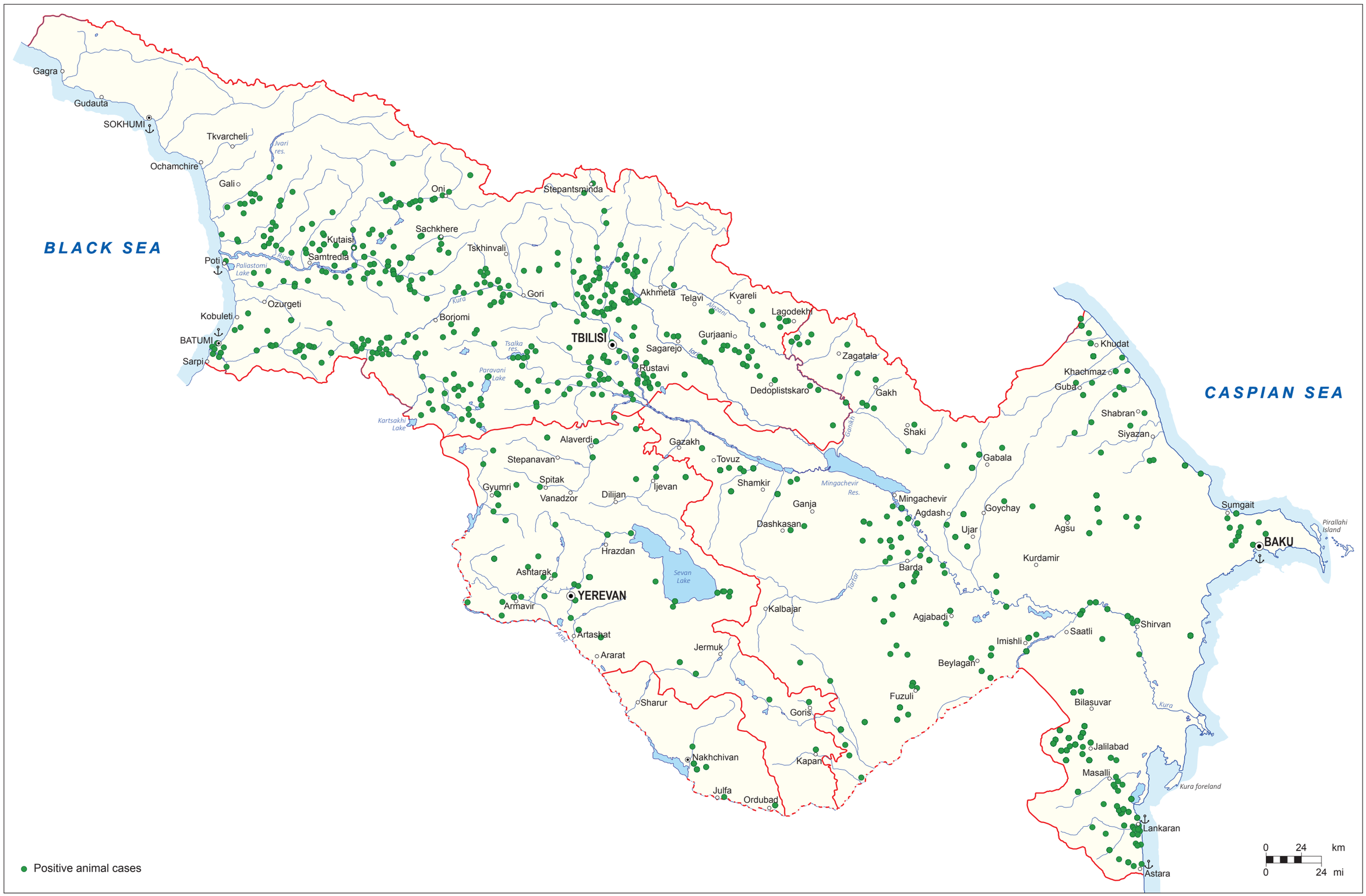
Distribution of Anthrax Human Cases in the South Caucasus, 1950-2019

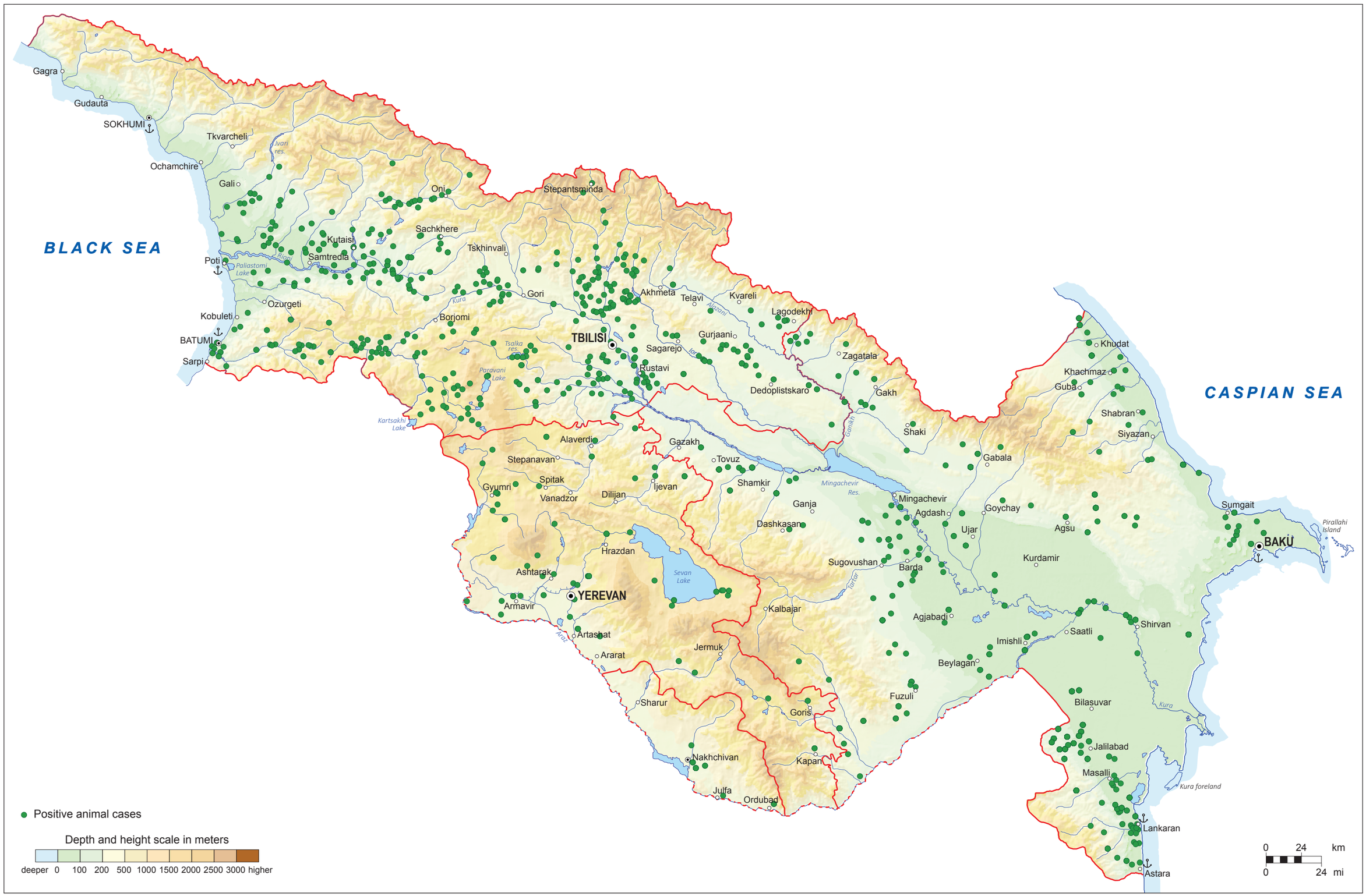
Distribution of Anthrax Animal Cases in the South Caucasus, 1950-2019



Distribution of Anthrax Positive Soil Samples in the South Caucasus, 1948-2019

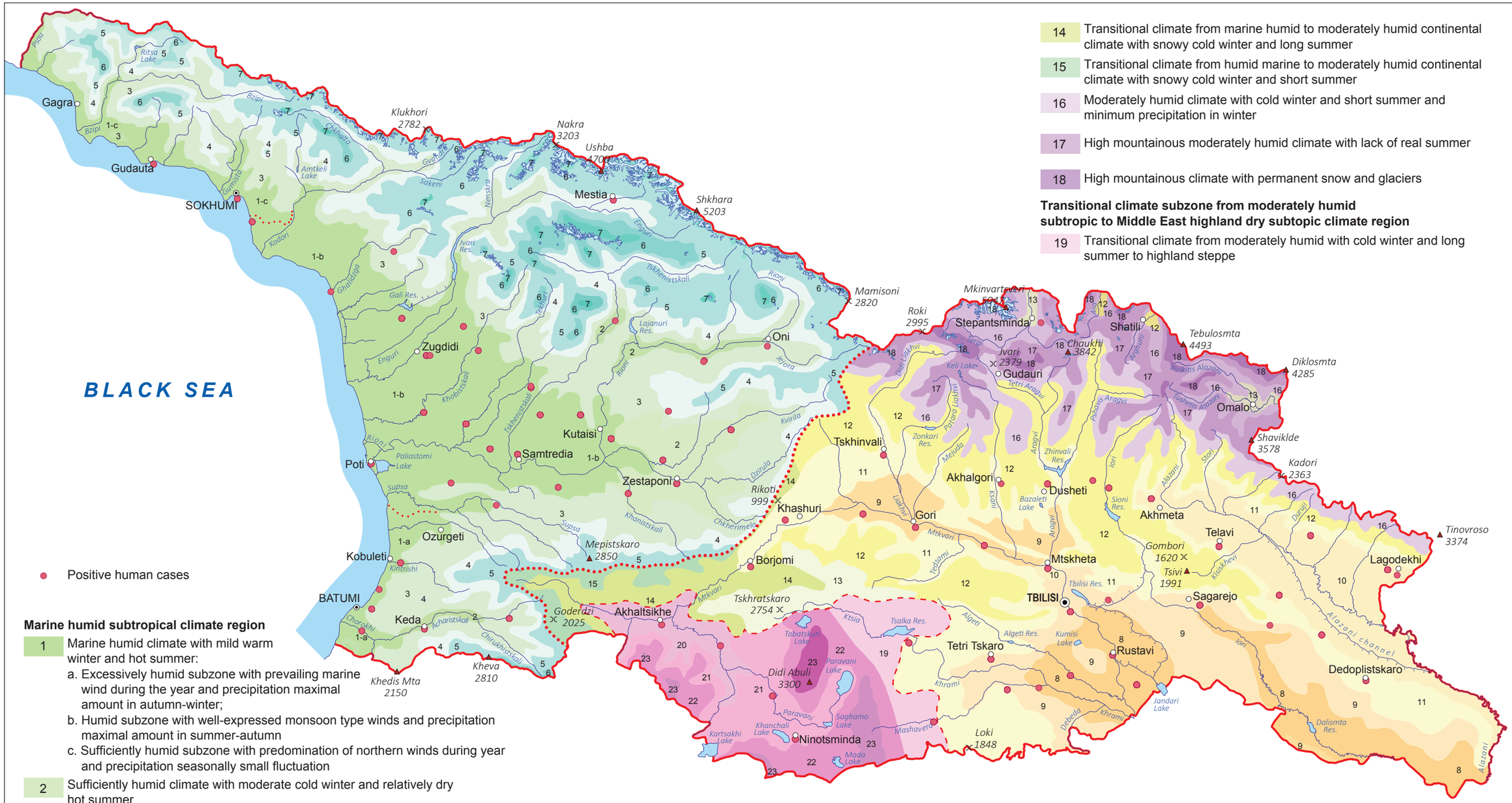
Distribution of Anthrax Human Cases by Elevation in the South Caucasus, 1950-2019

Distribution of Anthrax Animal Cases by Elevation in the South Caucasus, 1950-2019



Distribution of Anthrax Positive Soil Samples by Elevation in the South Caucasus, 1948-2019

Distribution of Anthrax Human Cases by Climate Types in Georgia, 1956-2019



- Positive human cases

Marine humid subtropical climate region

- 1 Marine humid climate with mild warm winter and hot summer:
  - a. Excessively humid subzone with prevailing marine wind during the year and precipitation maximal amount in autumn-winter;
  - b. Humid subzone with well-expressed monsoon type winds and precipitation maximal amount in summer-autumn
  - c. Sufficiently humid subzone with predomination of northern winds during year and precipitation seasonally small fluctuation
- 2 Sufficiently humid climate with moderate cold winter and relatively dry hot summer
- 3 Humid climate with moderate cold winter and long warm summer
- 4 Humid climate with cold winter and long cool summer
- 5 Humid climate with cold winter and short summer
- 6 High mountainous humid climate with lack of real summer
- 7 High mountainous humid climate with year-round abundant snow and glaciers

Moderately humid subtropical climate region

- 8 Moderately warm steppe with hot summer and minimum precipitation twice a year
- 9 Transitional climate from a moderate warm steppe to a moderate humid one, with hot summer and minimum precipitation twice a year
- 10 Moderate humid climate with moderately cold Winter and hot summer and minimum precipitation twice a year
- 11 Moderate humid climate with moderately cold Winter and long warm summer and minimum precipitation twice a year
- 12 Moderate humid climate with cold Winter and long cold summer, minimum precipitation twice a year
- 13 Moderate humid climate with cold winter and long cool summer and minimum precipitation in winter
- 14 Transitional climate from marine humid to moderately humid continental climate with snowy cold winter and long summer
- 15 Transitional climate from humid marine to moderately humid continental climate with snowy cold winter and short summer
- 16 Moderately humid climate with cold winter and short summer and minimum precipitation in winter
- 17 High mountainous moderately humid climate with lack of real summer
- 18 High mountainous climate with permanent snow and glaciers

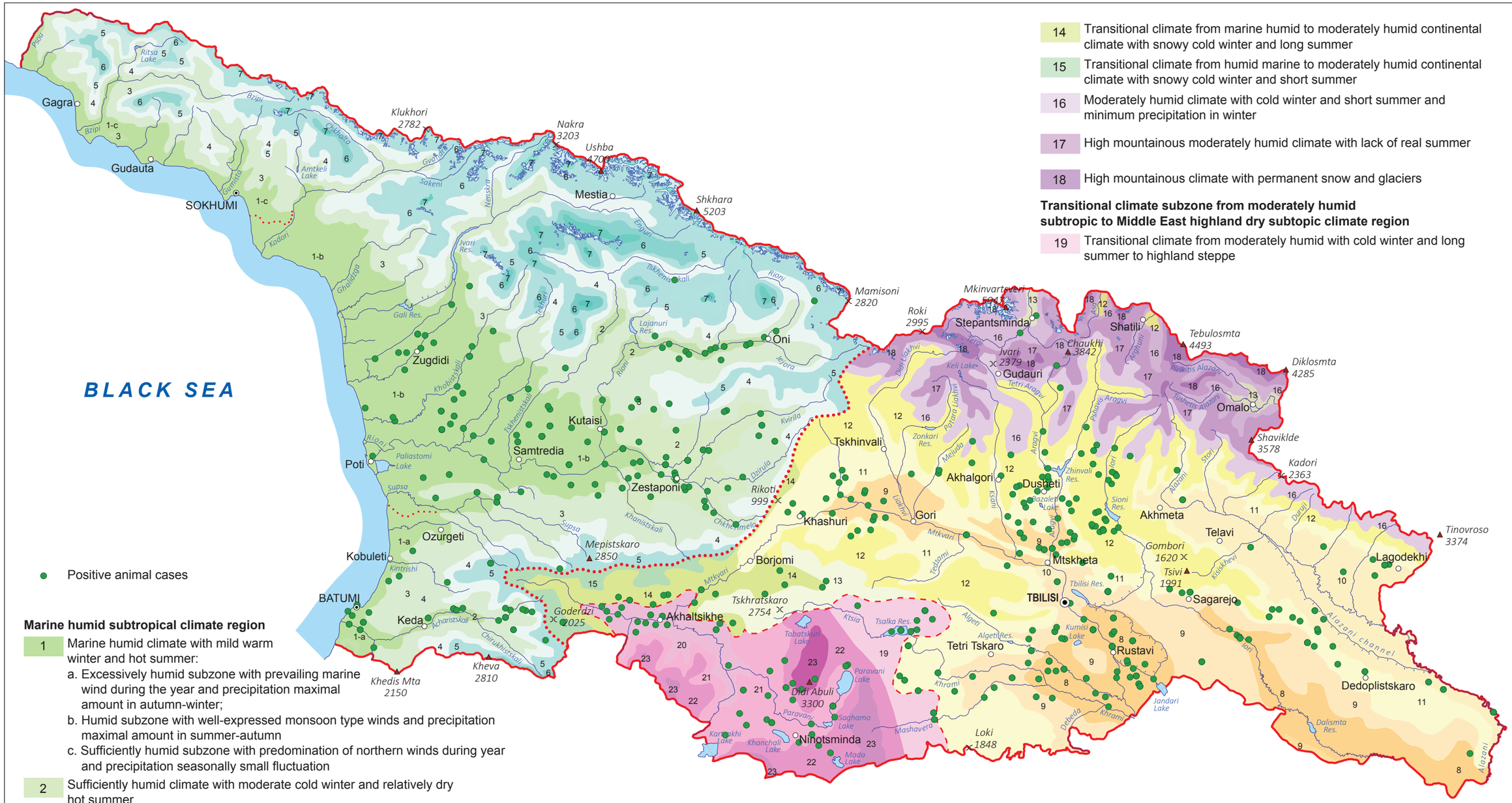
Transitional climate subzone from moderately humid subtropic to Middle East highland dry subtopic climate region

- 19 Transitional climate from moderately humid with cold winter and long summer to highland steppe
- 20 Highland steppe climate with less snowy, cold winter and long, warm summer
- 21 Highland steppe climate with less snowy, cold winter and long cool summer
- 22 Highland steppe climate with short summer and cold, less snowy winter
- 23 Highland moderately dry climate with lack of real summer

Climate region's border · Climate subzone's border · Subregion border

0 15 km
0 15 mi

Distribution of Anthrax Animal Cases by Climate Types in Georgia, 1951-2019



Marine humid subtropical climate region

1 Marine humid climate with mild warm winter and hot summer:
- a. Excessively humid subzone with prevailing marine wind during the year and precipitation maximal amount in autumn-winter;
- b. Humid subzone with well-expressed monsoon type winds and precipitation maximal amount in summer-autumn
- c. Sufficiently humid subzone with predomination of northern winds during year and precipitation seasonally small fluctuation

2 Sufficiently humid climate with moderate cold winter and relatively dry hot summer

3 Humid climate with moderate cold winter and long warm summer

4 Humid climate with cold winter and long cool summer

5 Humid climate with cold winter and short summer

6 High mountainous humid climate with lack of real summer

7 High mountainous humid climate with year-round abundant snow and glaciers

Moderately humid subtropical climate region

8 Moderately warm steppe with hot summer and minimum precipitation twice a year

9 Transitional climate from a moderate warm steppe to a moderate humid one, with hot summer and minimum precipitation twice a year

10 Moderate humid climate with moderately cold Winter and hot summer and minimum precipitation twice a year

11 Moderate humid climate with moderately cold Winter and long warm summer and minimum precipitation twice a year

12 Moderate humid climate with cold Winter and long cold summer, minimum precipitation twice a year

13 Moderate humid climate with cold winter and long cool summer and minimum precipitation in winter

14 Transitional climate from marine humid to moderately humid continental climate with snowy cold winter and long summer

15 Transitional climate from humid marine to moderately humid continental climate with snowy cold winter and short summer

16 Moderately humid climate with cold winter and short summer and minimum precipitation in winter

17 High mountainous moderately humid climate with lack of real summer

18 High mountainous climate with permanent snow and glaciers

Transitional climate subzone from moderately humid subtropic to Middle East highland dry subtopic climate region

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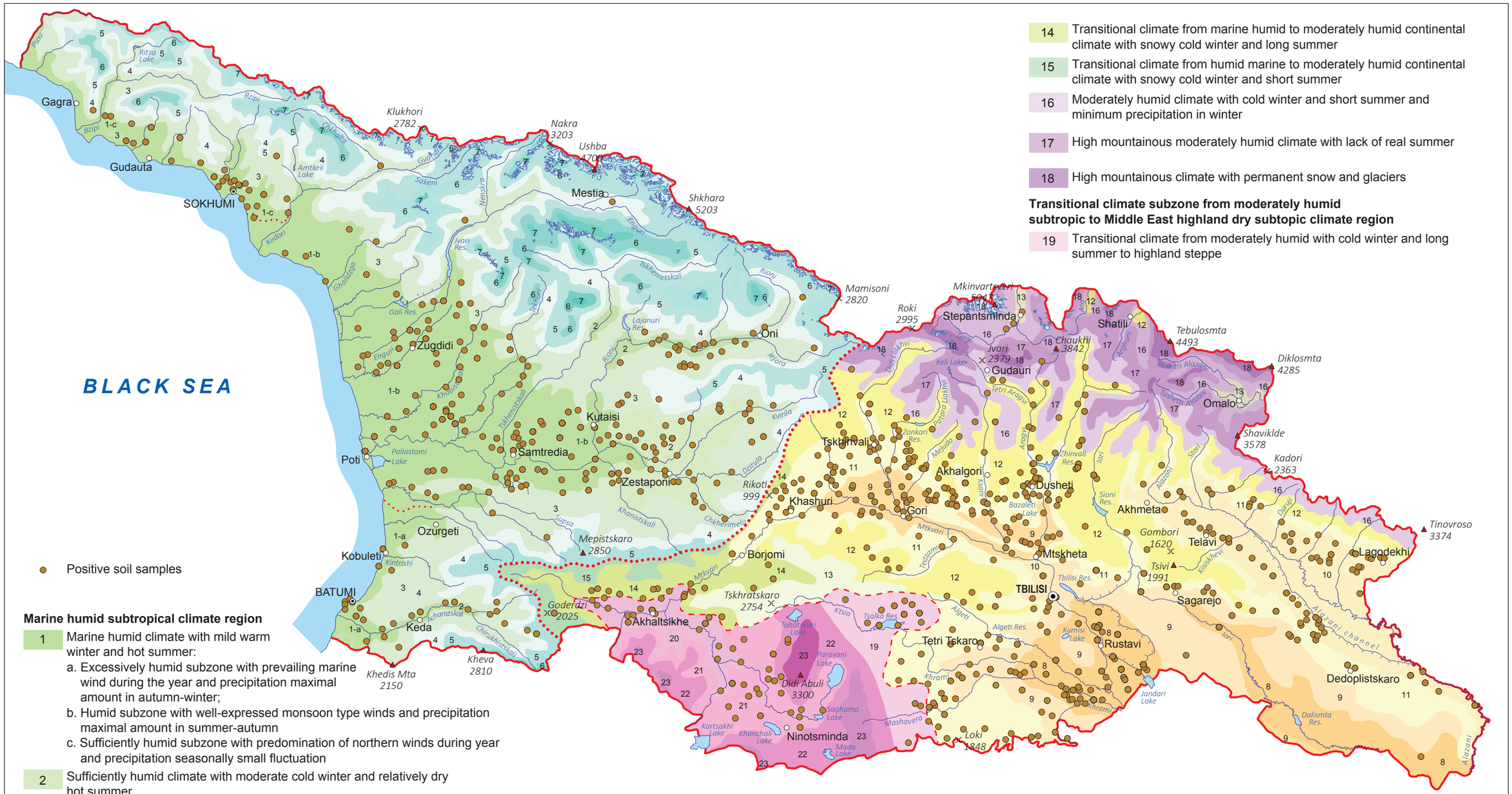
21 Highland steppe climate with less snowy, cold winter and long cool summer

22 Highland steppe climate with short summer and cold, less snowy winter

23 Highland moderately dry climate with lack of real summer

Distribution of Anthrax Positive Soil Samples by Climate Types in Georgia, 1948-2019



- Positive soil samples

Marine humid subtropical climate region

1 Marine humid climate with mild warm winter and hot summer:
- a. Excessively humid subzone with prevailing marine wind during the year and precipitation maximal amount in autumn-winter;
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Transitional climate subzone from moderately humid subtropic to Middle East highland dry subtopic climate region

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21 Highland steppe climate with less snowy, cold winter and long cool summer

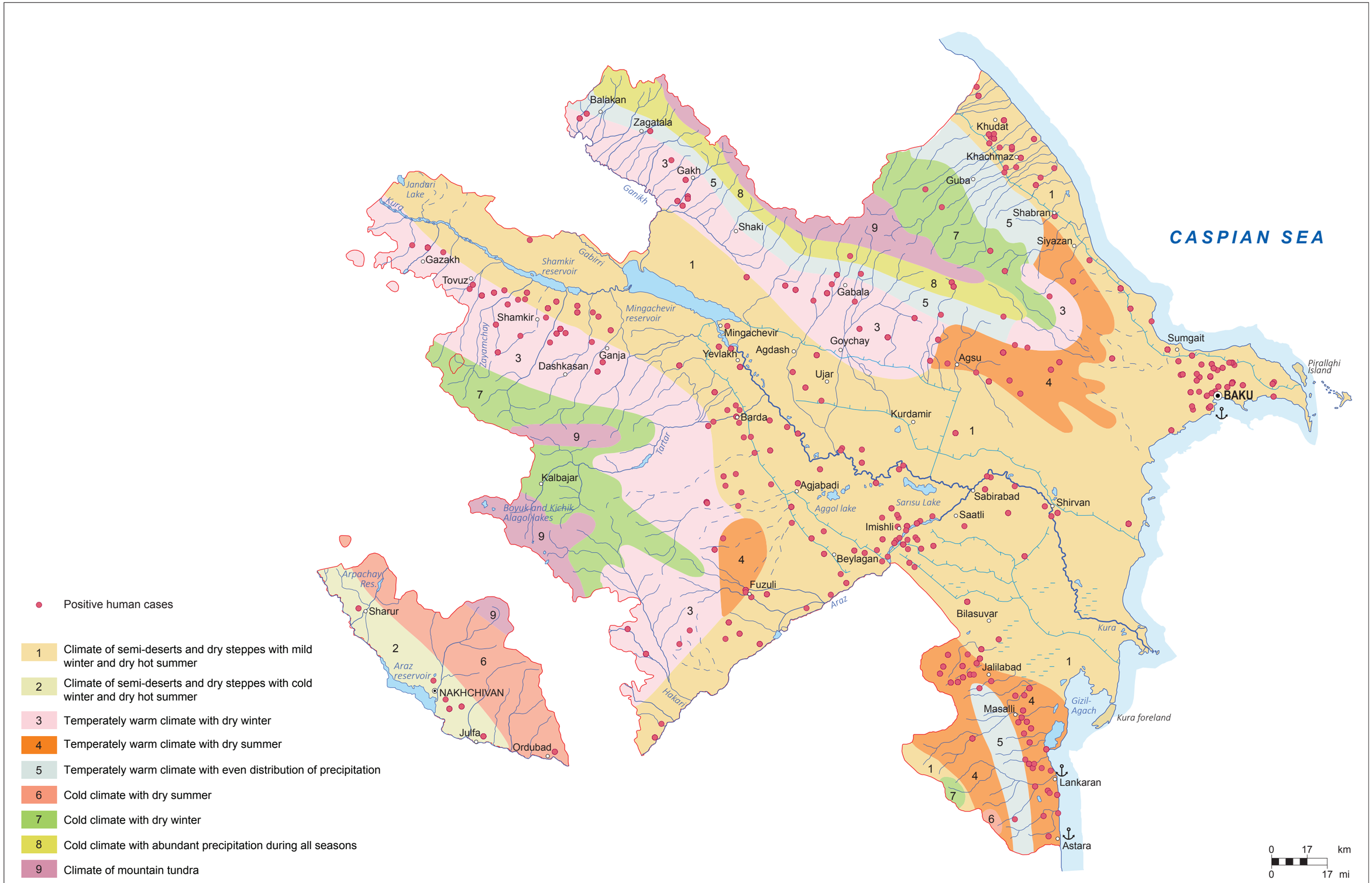
22 Highland steppe climate with short summer and cold, less snowy winter

23 Highland moderately dry climate with lack of real summer

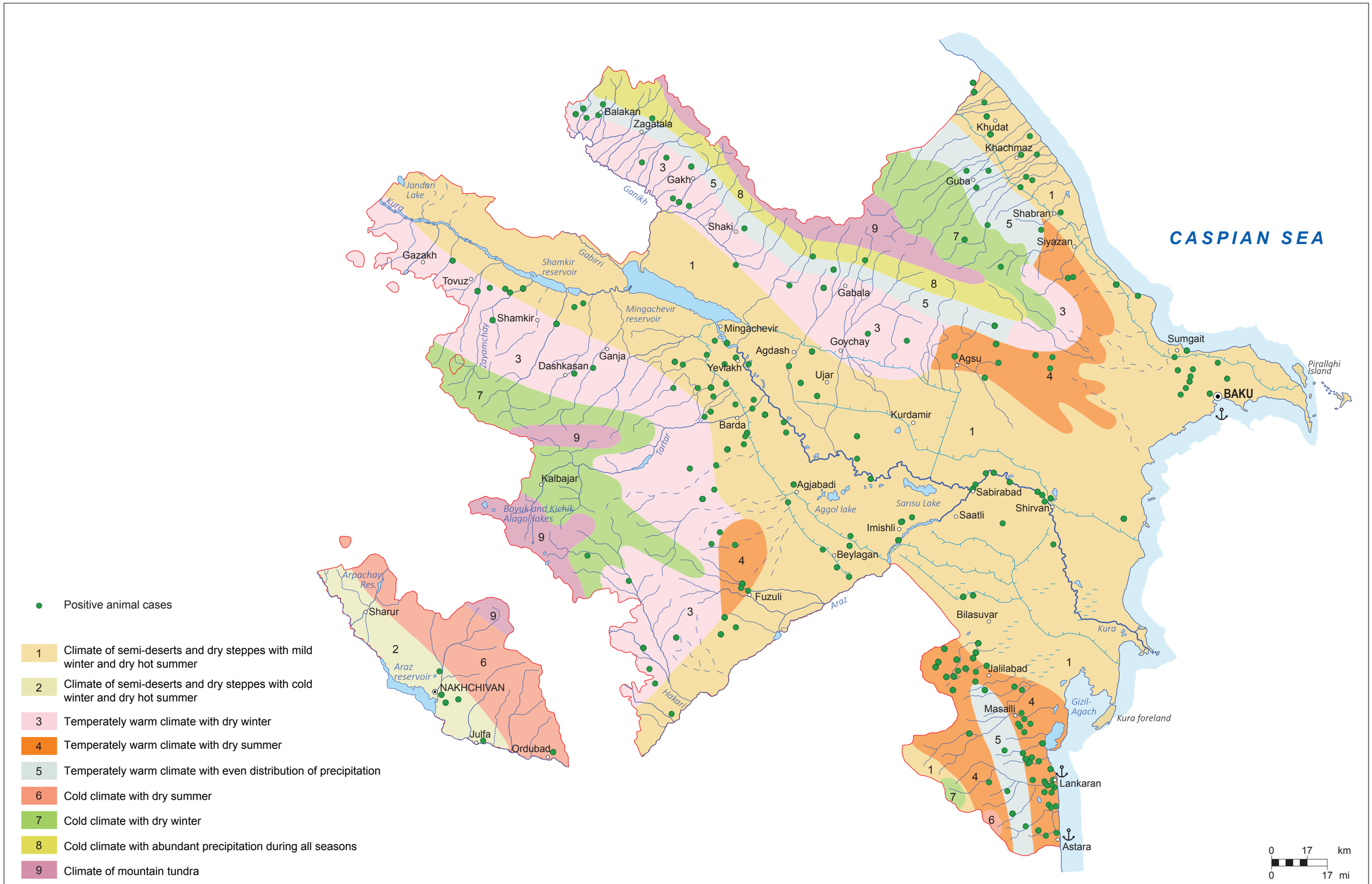
- Climate region's border
- Climate subzone's border
- Subregion border

0 15 km
0 15 mi

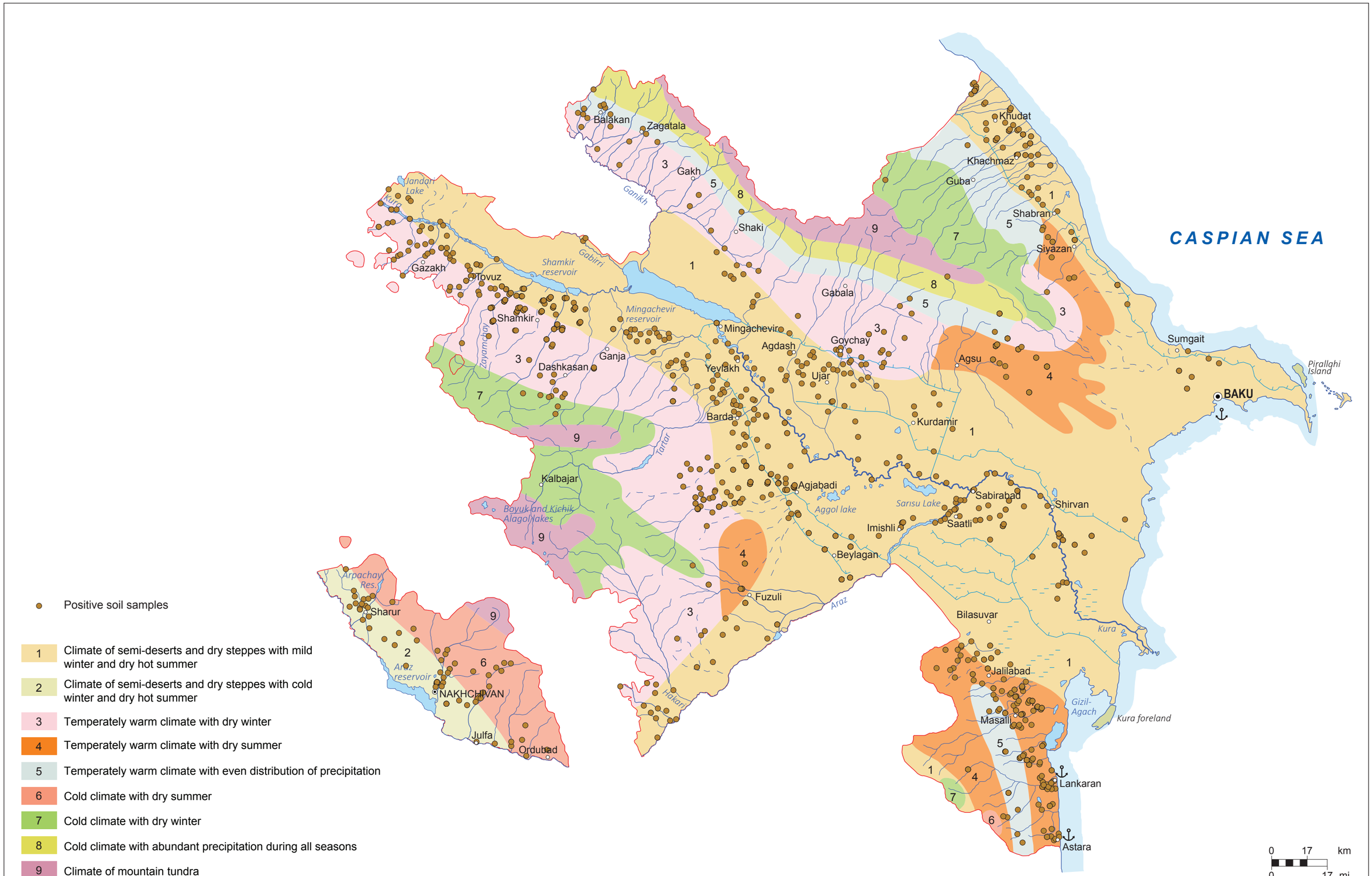
Distribution of Anthrax Human Cases by Climate Types in Azerbaijan, 1950-2019



Distribution of Anthrax Animal Cases by Climate Types in Azerbaijan, 1950-2019



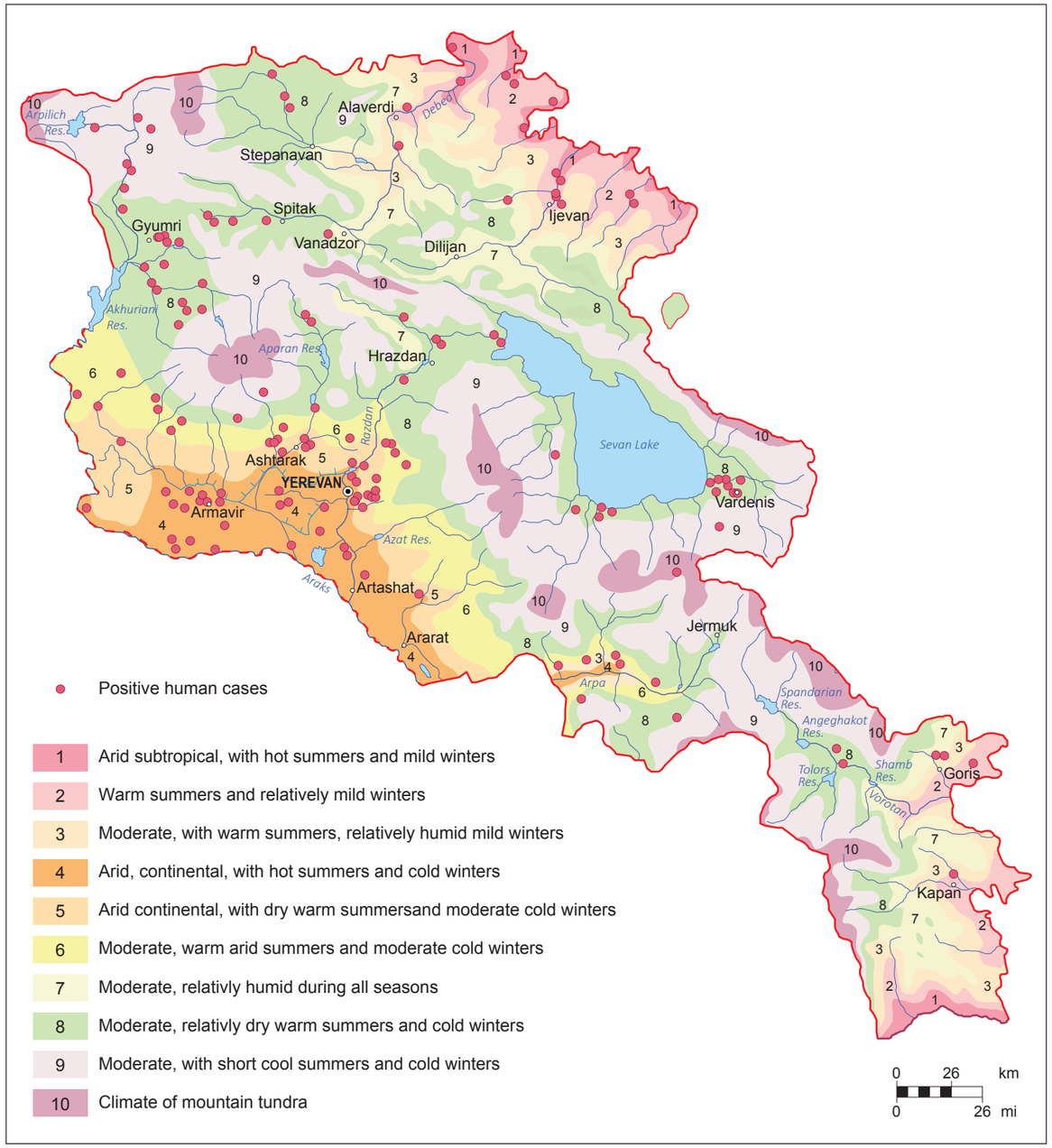
Distribution of Anthrax Positive Soil Samples by Climate Types in Azerbaijan, 1950-2019



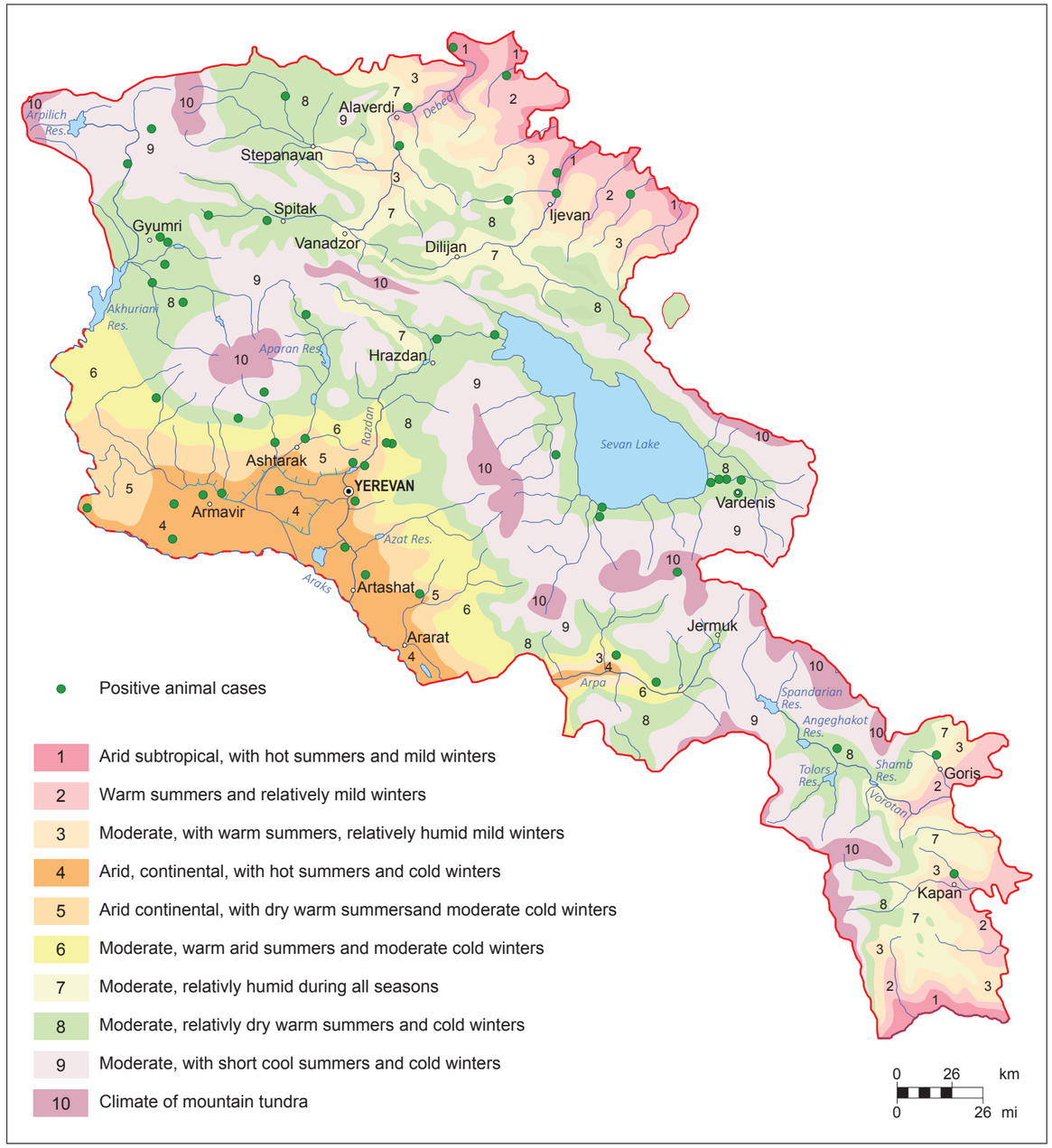
- Positive soil samples

1. Climate of semi-deserts and dry steppes with mild winter and dry hot summer
2. Climate of semi-deserts and dry steppes with cold winter and dry hot summer
3. Temperately warm climate with dry winter
4. Temperately warm climate with dry summer
5. Temperately warm climate with even distribution of precipitation
6. Cold climate with dry summer
7. Cold climate with dry winter
8. Cold climate with abundant precipitation during all seasons
9. Climate of mountain tundra

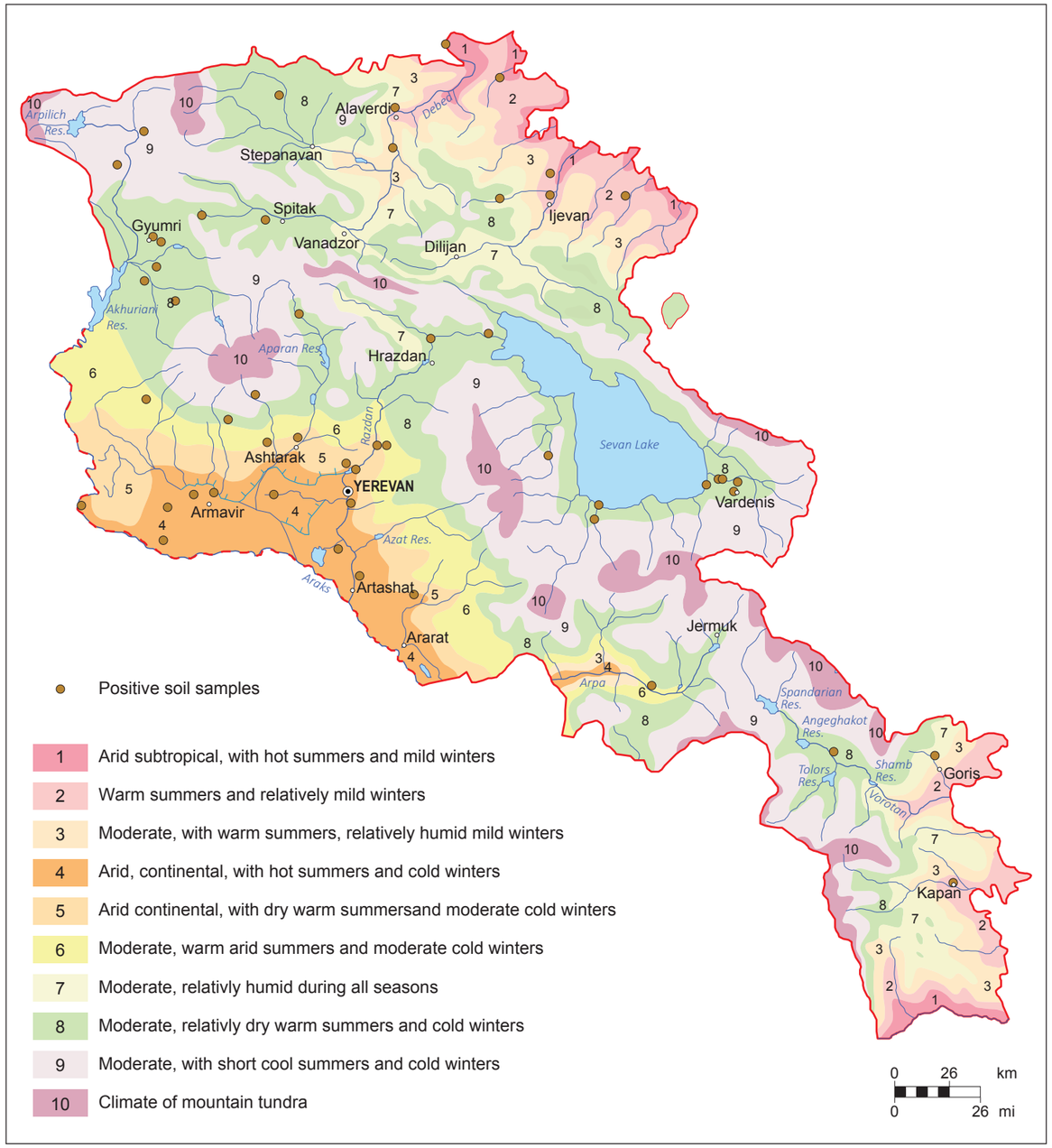
Distribution of Anthrax Human Cases by Climate Types in Armenia, 1961-2019



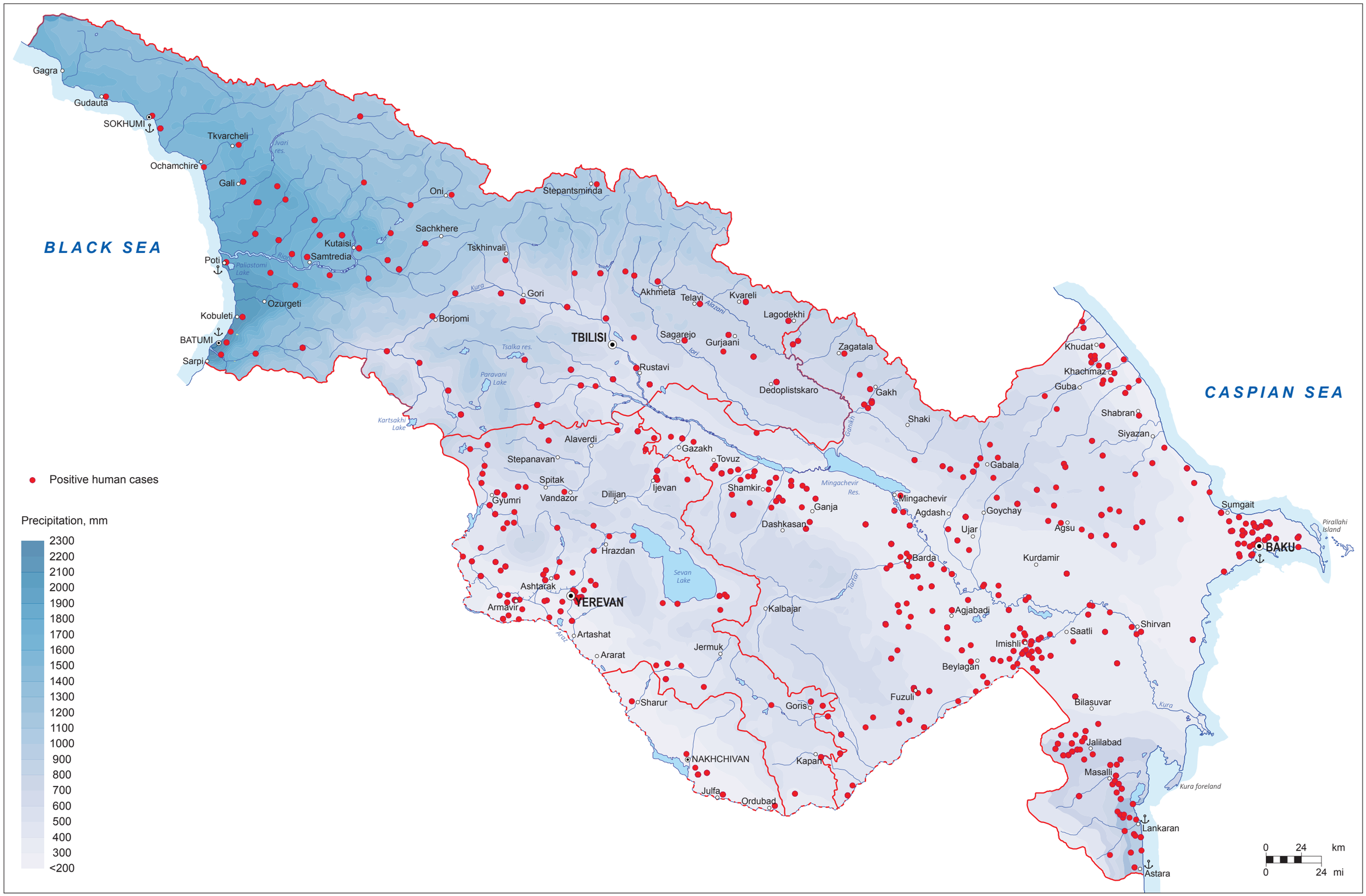
Distribution of Anthrax Animal Cases by Climate Types in Armenia, 1956-2019



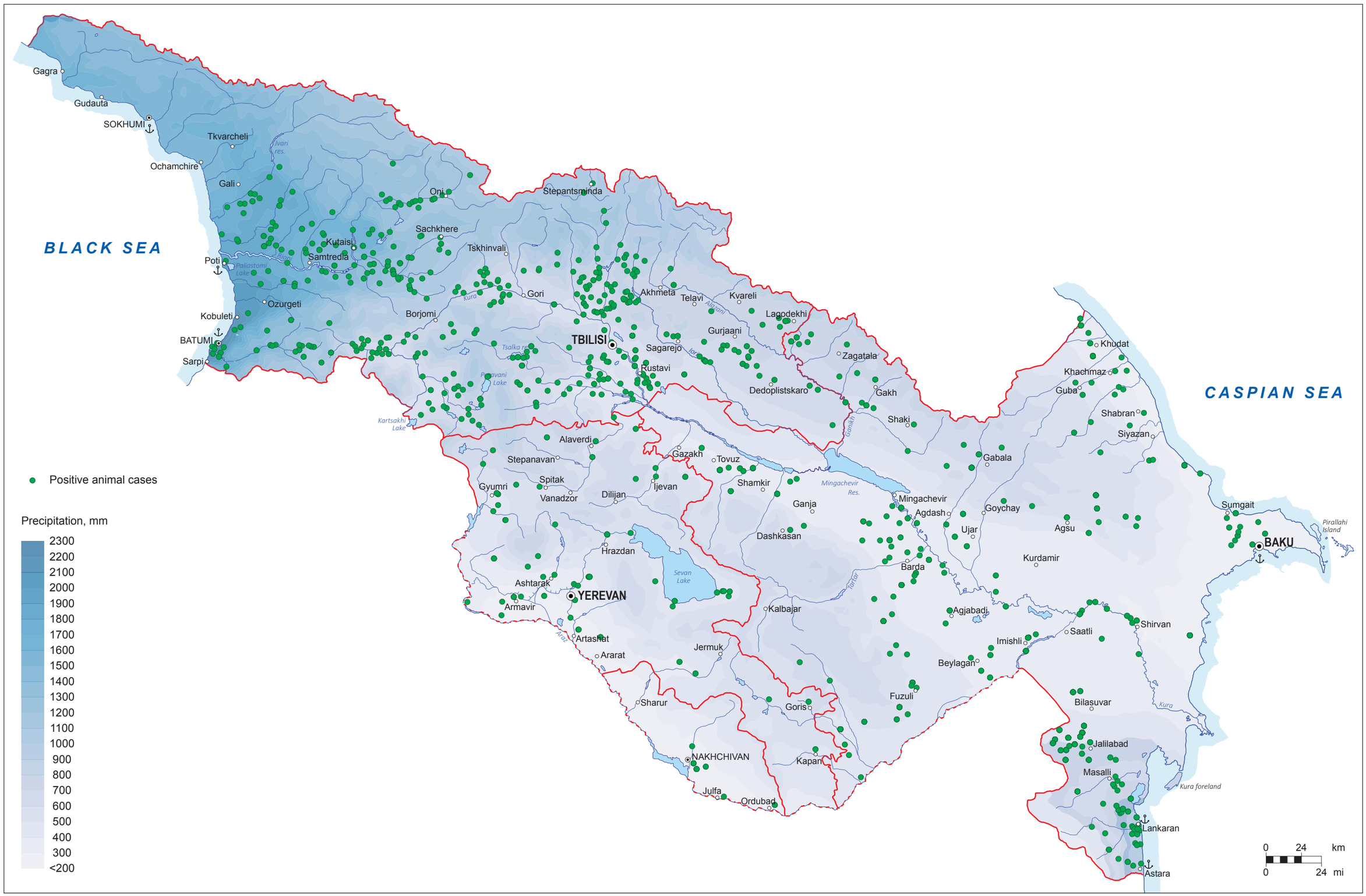
Distribution of Anthrax Positive Soil Samples by Climate Types in Armenia, 1956-2019



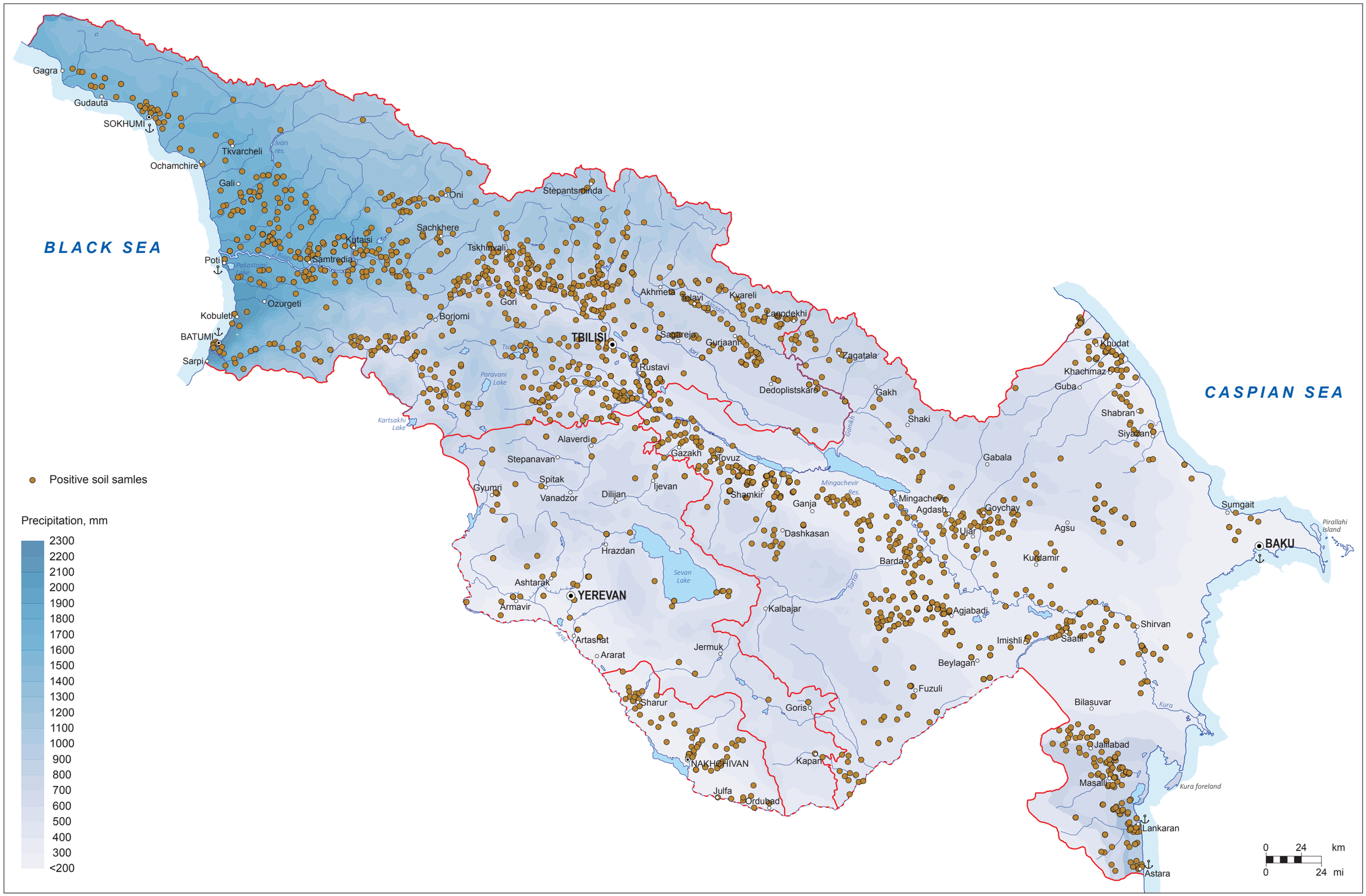
Distribution of Anthrax Human Cases by Precipitation in the South Caucasus, 1950-2019



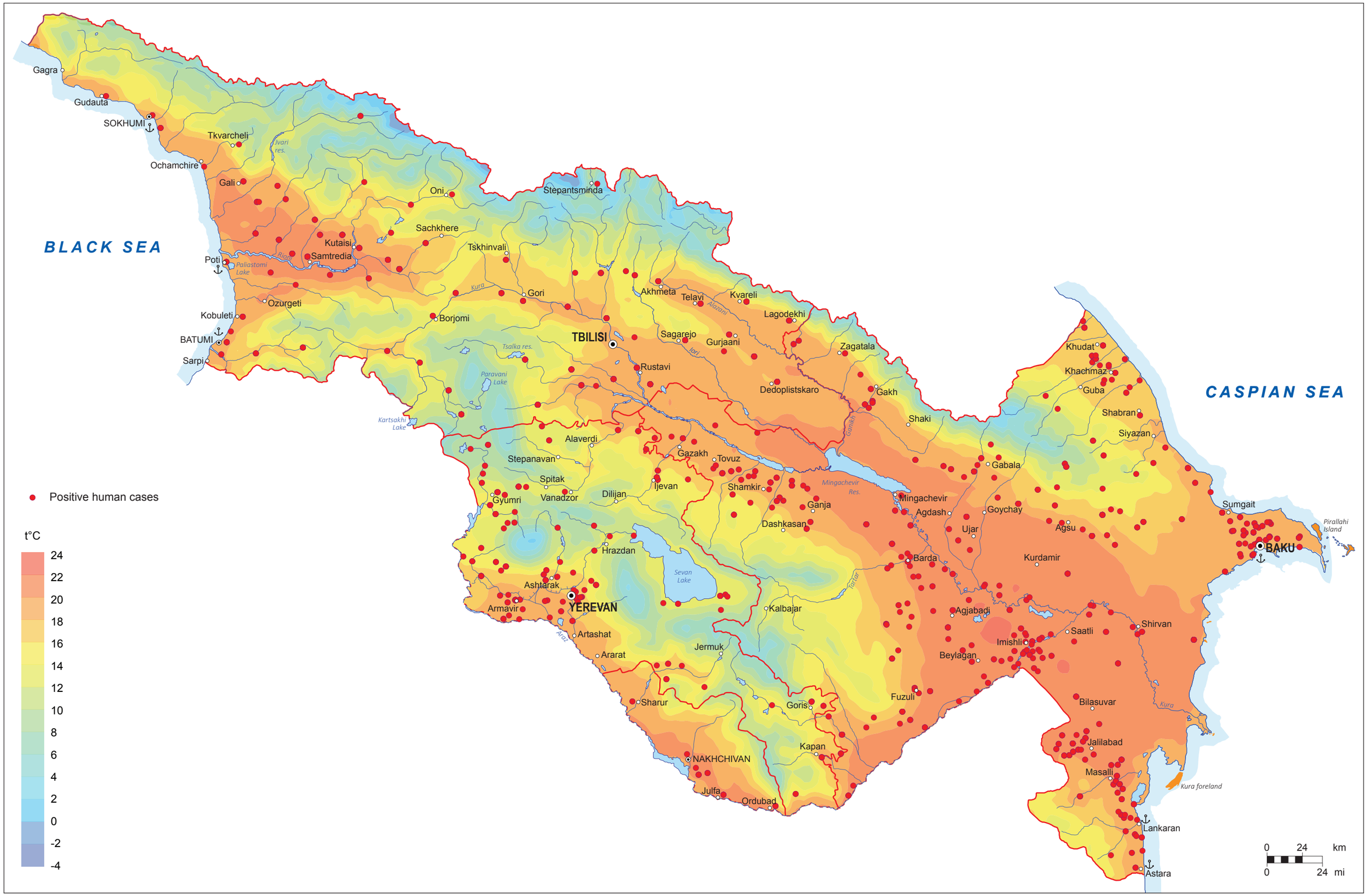
Distribution of Anthrax Animal Cases by Precipitation in the South Caucasus, 1950-2019



Distribution of Anthrax Positive Soil Samples by Precipitation in the South Caucasus, 1948-2019



Distribution of Anthrax Human Cases by Maximum Temperature in the South Caucasus, 1950-2019



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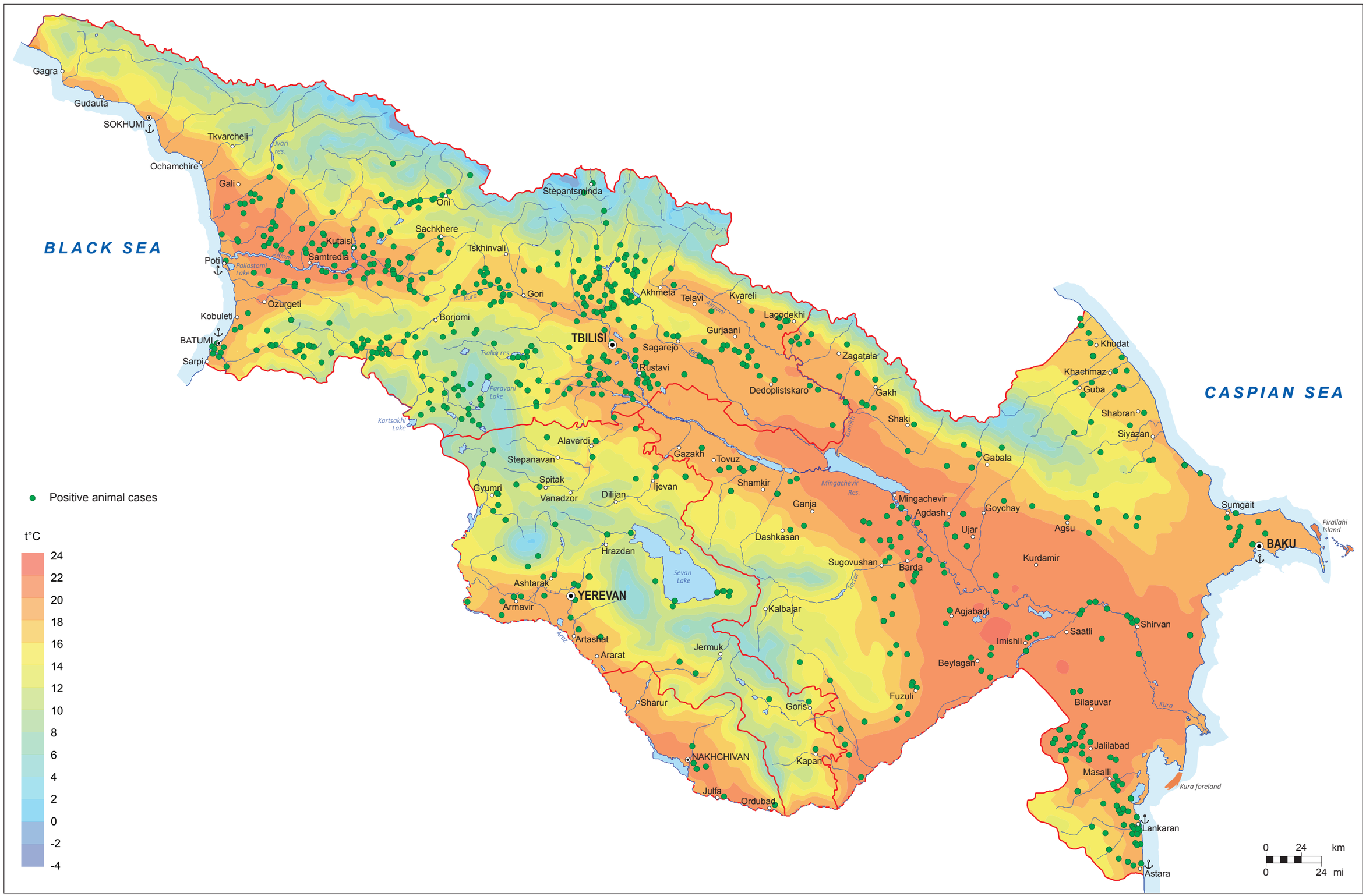
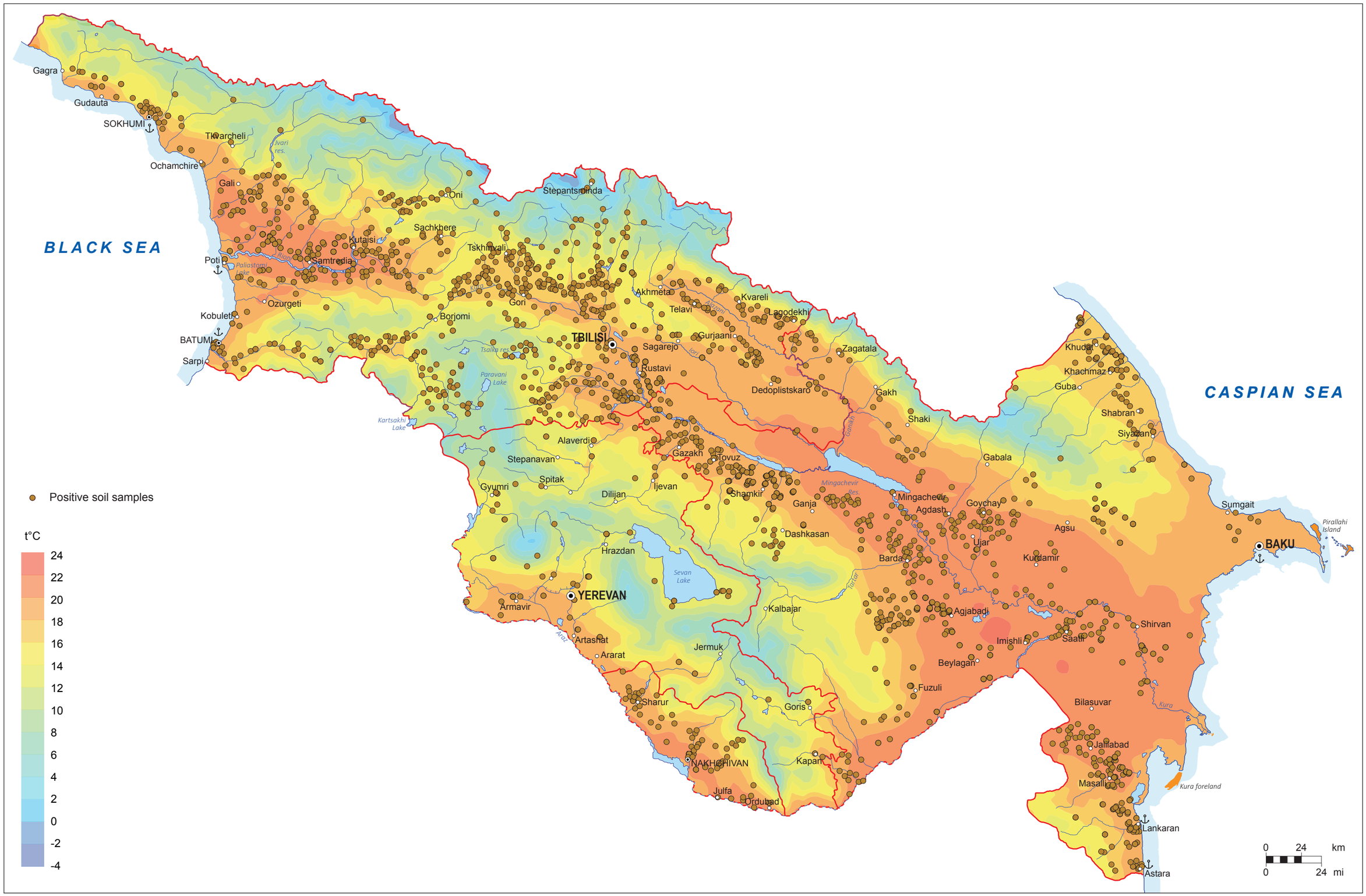
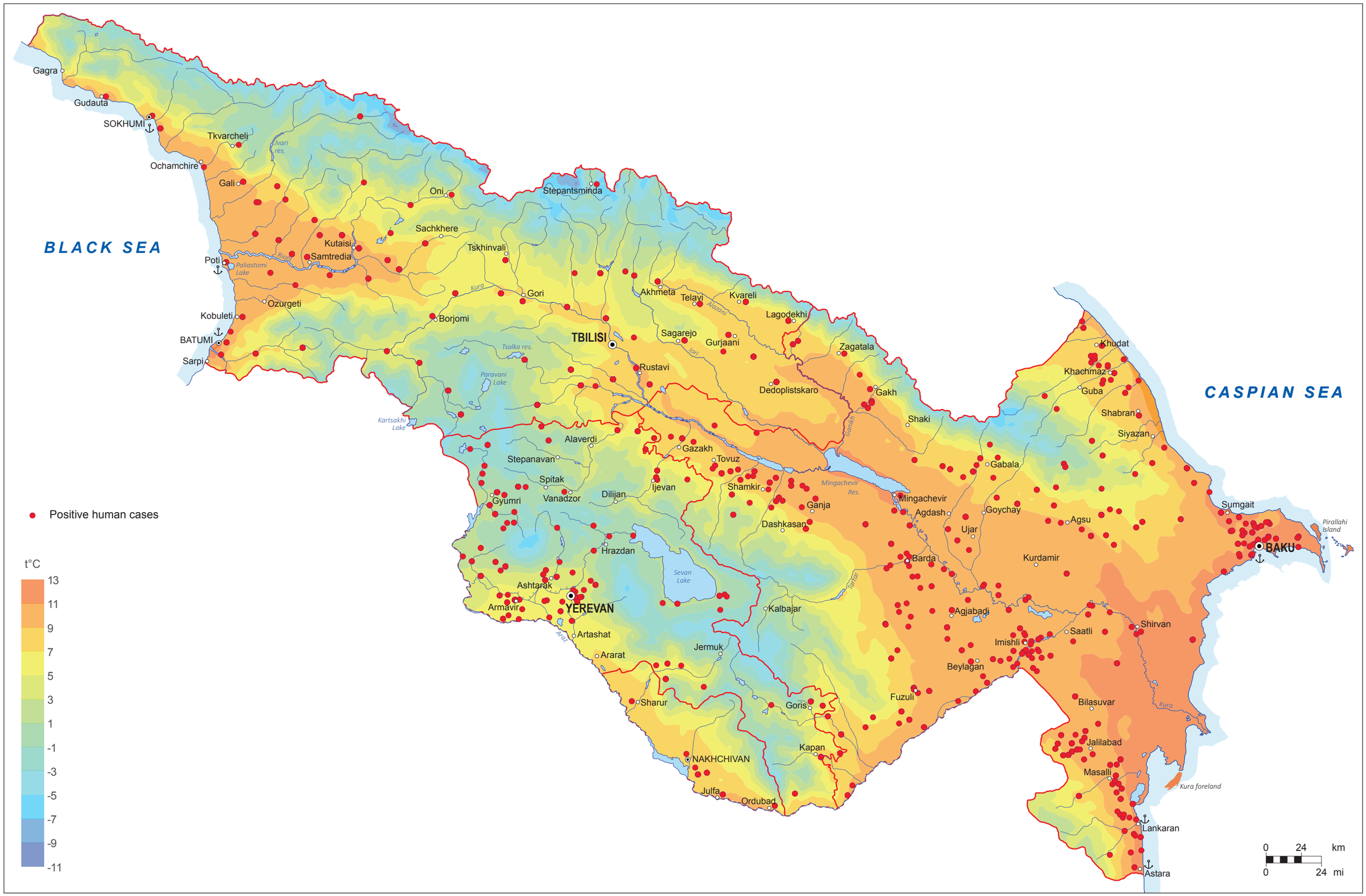


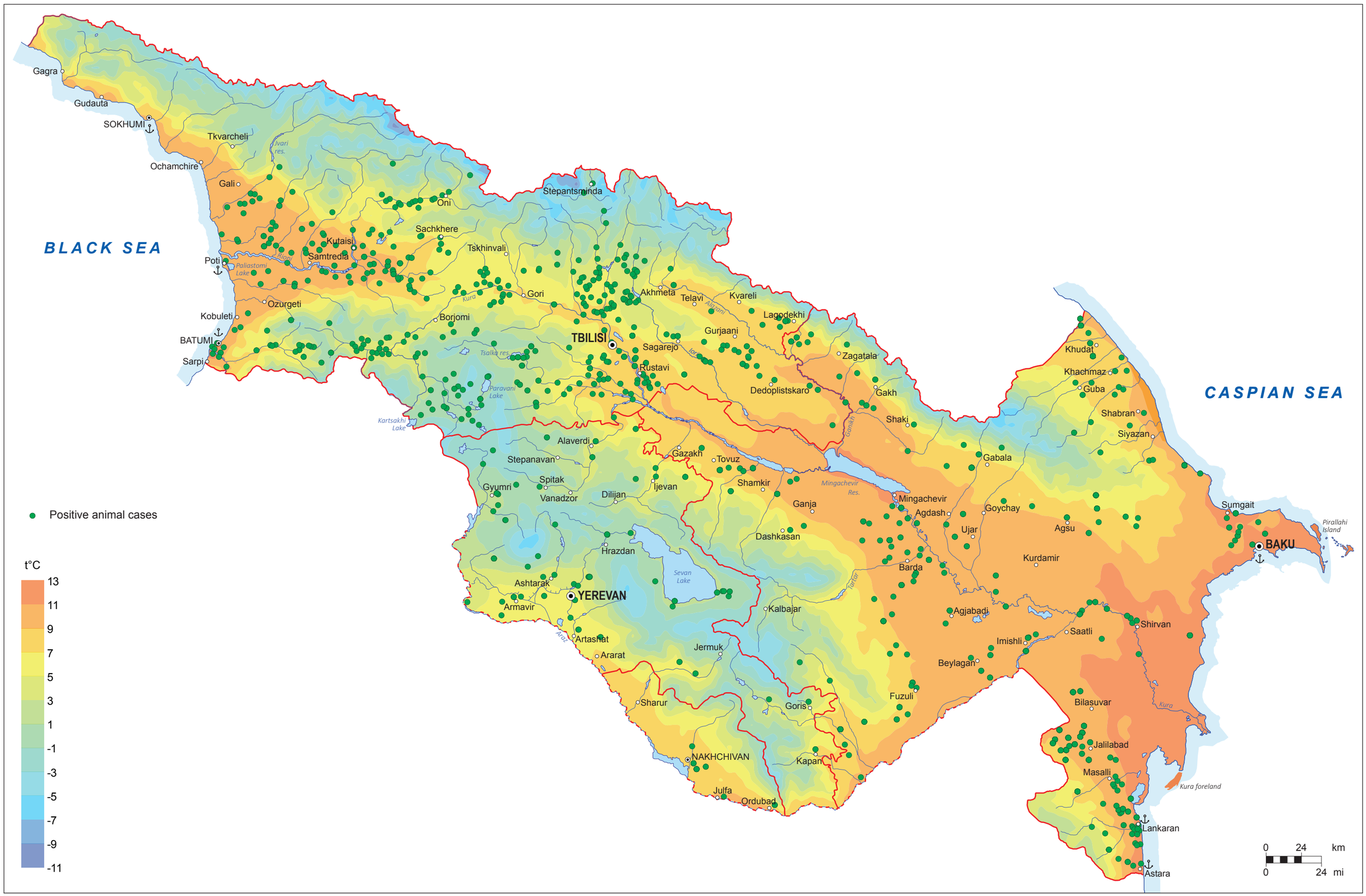
Distribution of Anthrax Positive Soil Samples by Maximum Temperature in the South Caucasus, 1948-2019



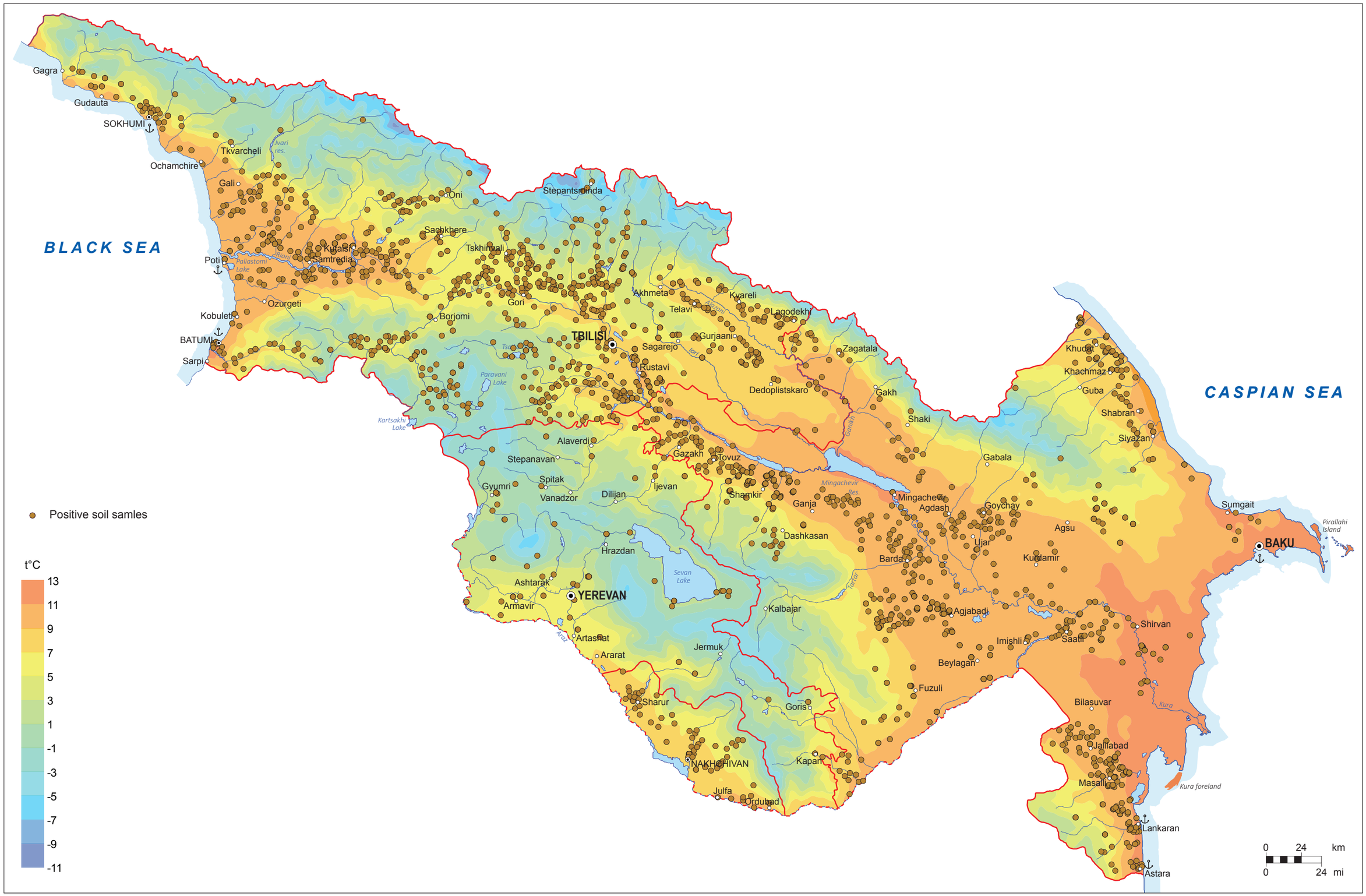
Distribution of Anthrax Human Cases by Minimum Temperature in the South Caucasus, 1950-2019



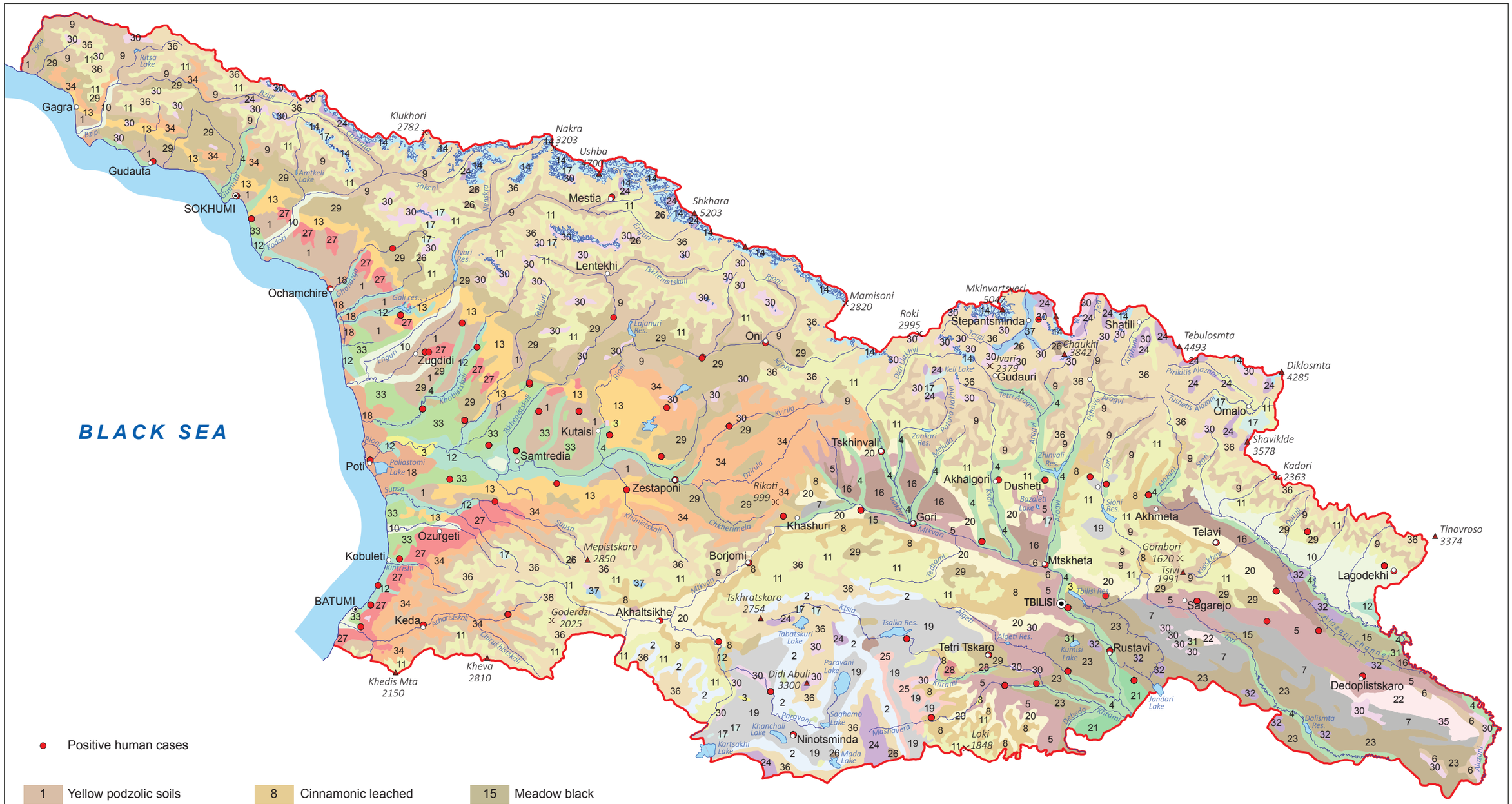
Distribution of Anthrax Animal Cases by Minimum Temperature in the South Caucasus, 1950-2019



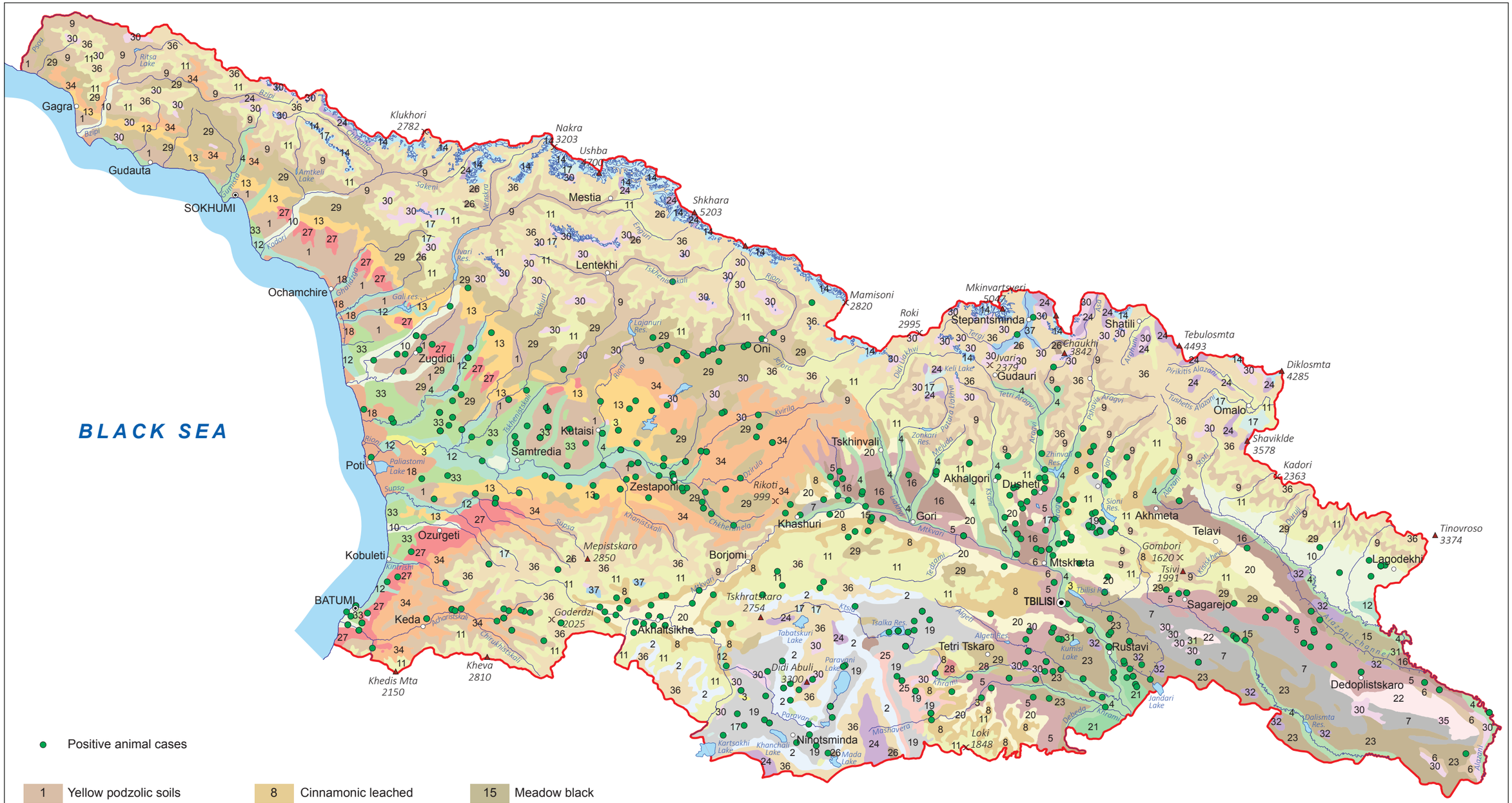
Distribution of Anthrax Positive Soil Samples by Minimum Temperature in the South Caucasus, 1948-2019



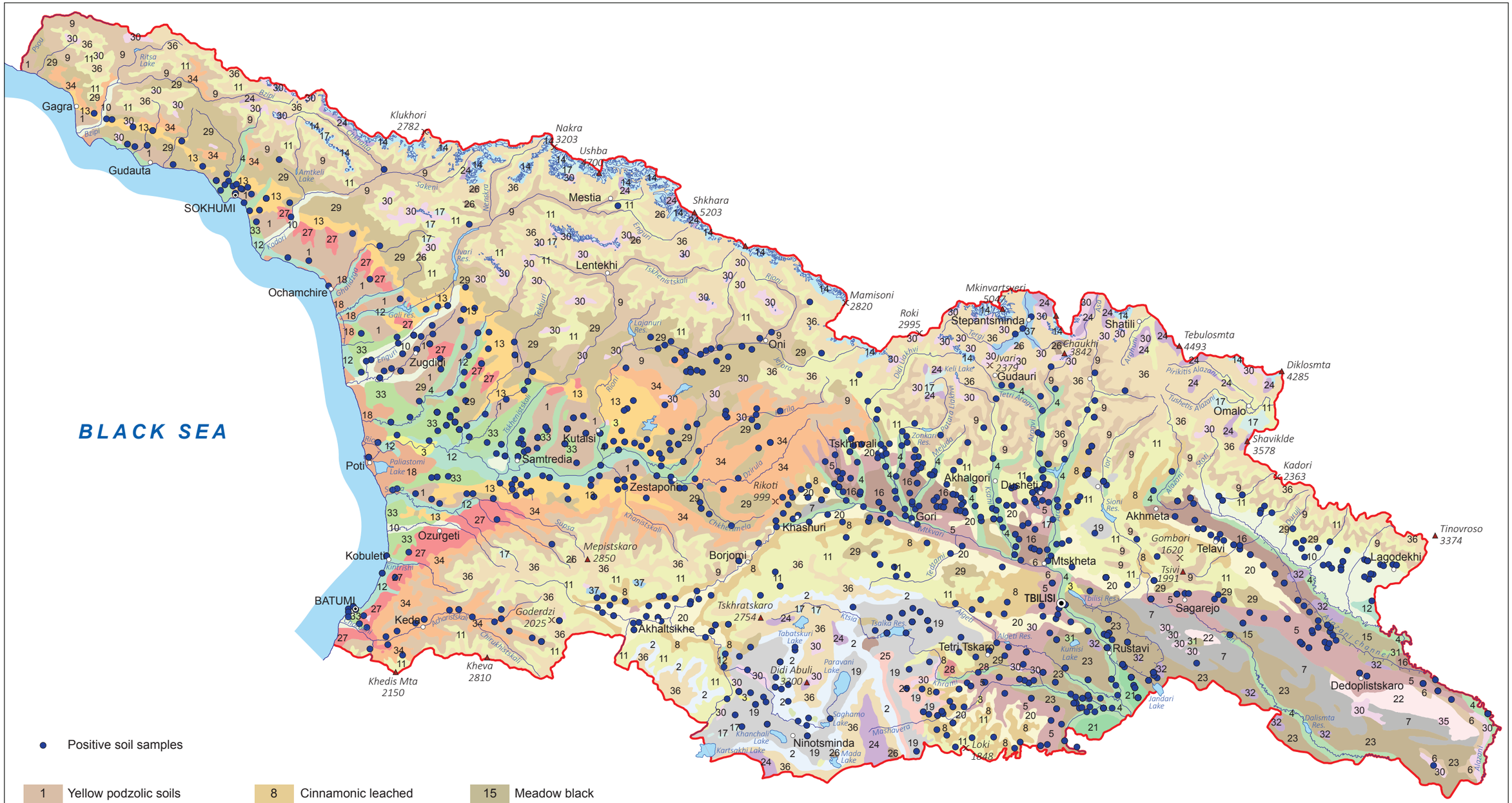
Distribution of Anthrax Human Cases by Soil Types in Georgia, 1956-2019



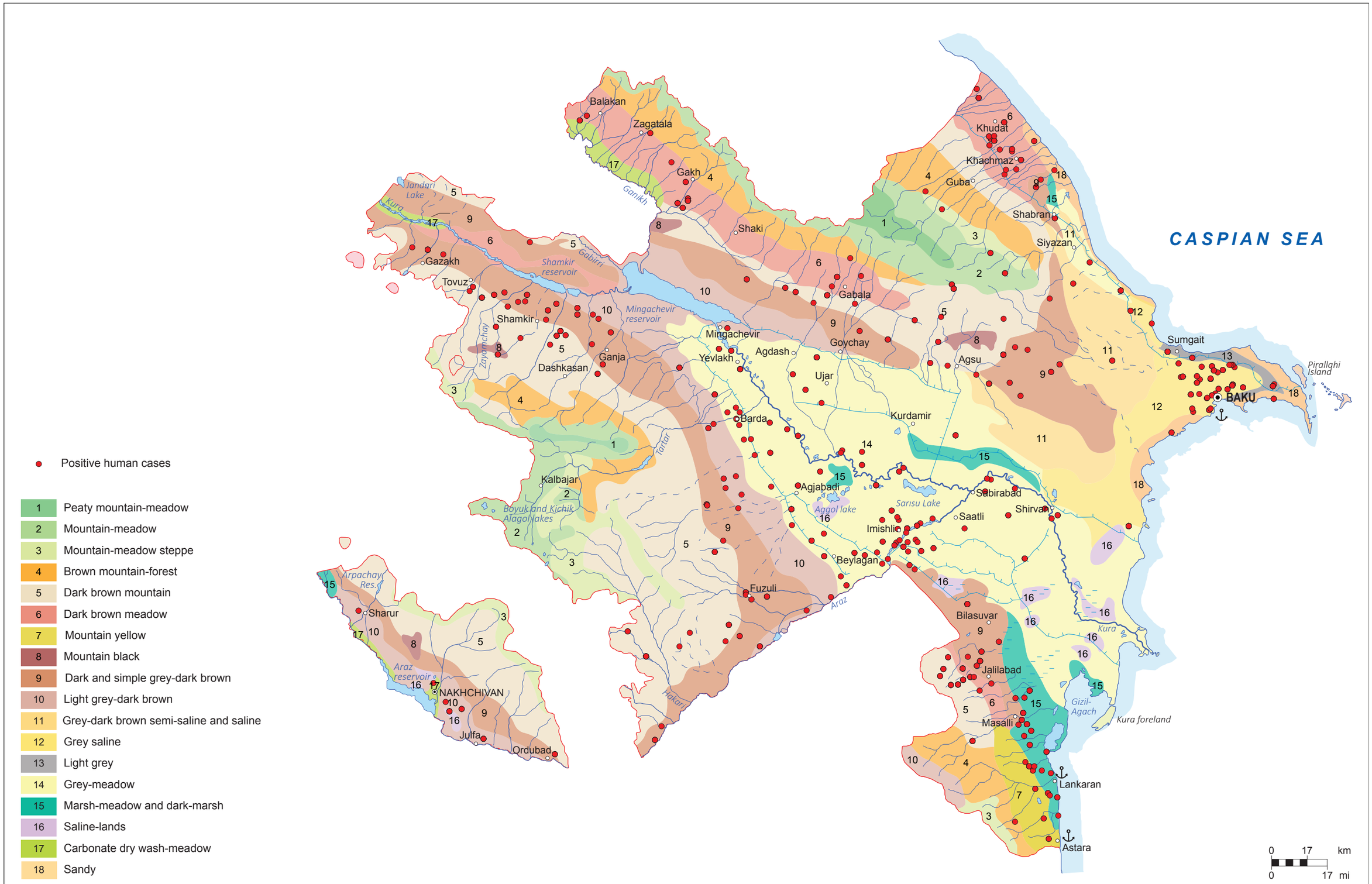
Distribution of Anthrax Animal Cases by Soil Types in Georgia, 1951-2019



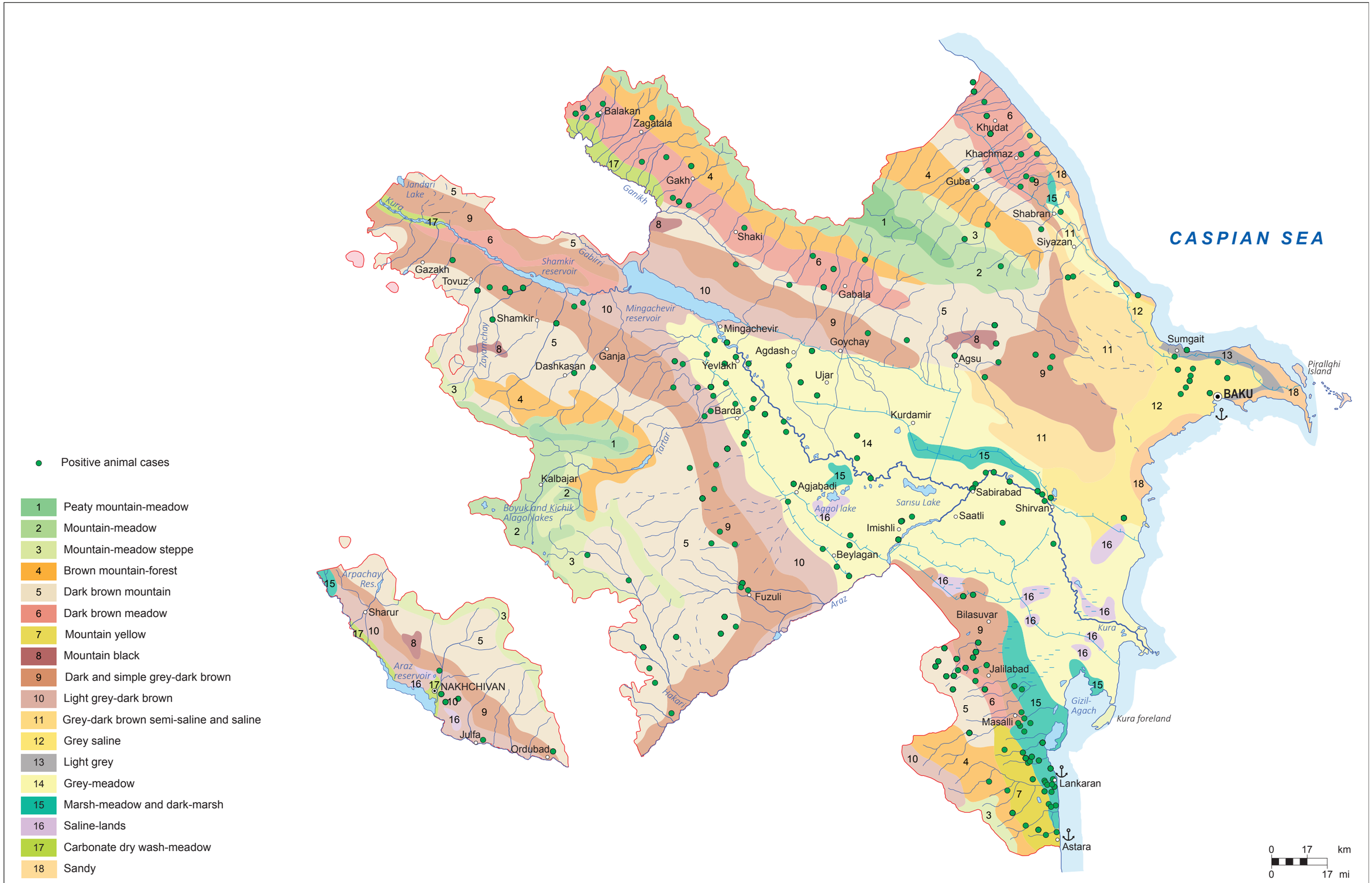
Distribution of Anthrax Positive Soil Samples by Soil Types in Georgia, 1948-2019



Distribution of Anthrax Human Cases by Soil Types in Azerbaijan, 1950-2019



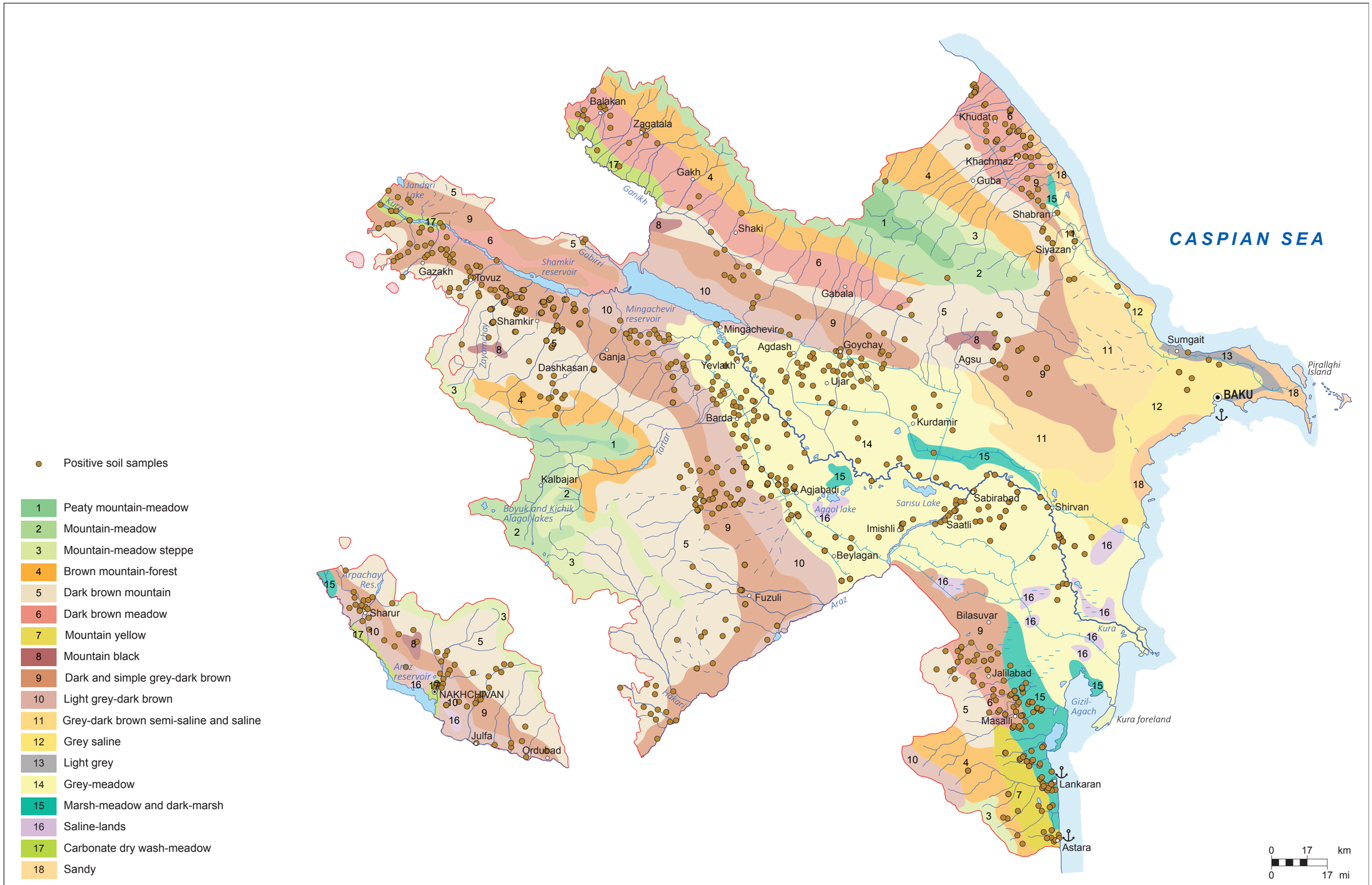
Distribution of Anthrax Animal Cases by Soil Types in Azerbaijan, 1950-2019



- Positive animal cases

1	Peaty mountain-meadow
2	Mountain-meadow
3	Mountain-meadow steppe
4	Brown mountain-forest
5	Dark brown mountain
6	Dark brown meadow
7	Mountain yellow
8	Mountain black
9	Dark and simple grey-dark brown
10	Light grey-dark brown
11	Grey-dark brown semi-saline and saline
12	Grey saline
13	Light grey
14	Grey-meadow
15	Marsh-meadow and dark-marsh
16	Saline-lands
17	Carbonate dry wash-meadow
18	Sandy

Distribution of Anthrax Positive Soil Samples by Soil Types in Azerbaijan, 1950-2019



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12	Grey saline
13	Light grey
14	Grey-meadow
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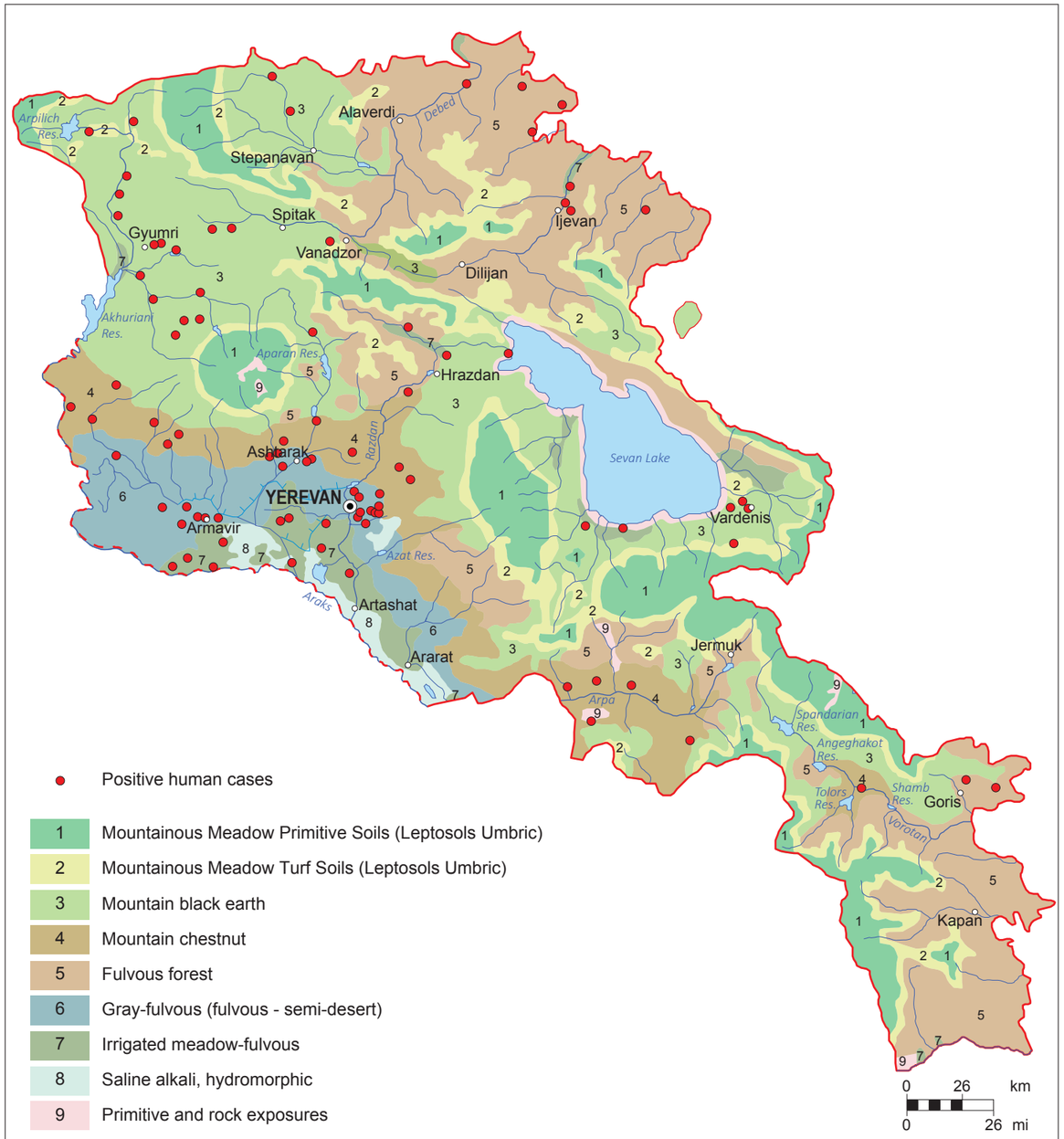
16	Saline-lands
17	Carbonate dry wash-meadow
18	Sandy

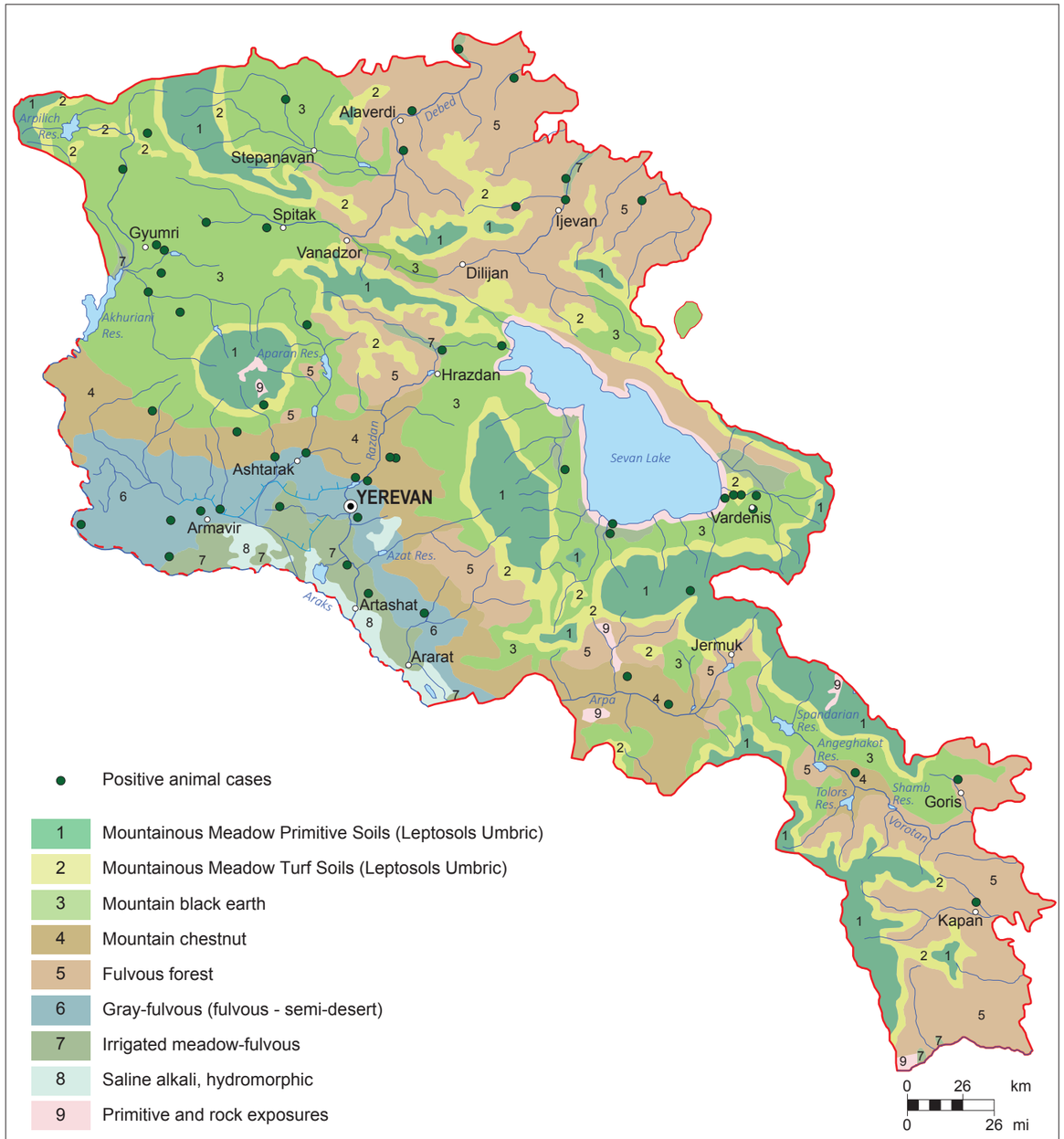
Distribution of Anthrax Human Cases by Soil Types in Armenia, 1961-2019



Positive human cases

1	Mountainous Meadow Primitive Soils (Leptosols Umbric)
2	Mountainous Meadow Turf Soils (Leptosols Umbric)
3	Mountain black earth
4	Mountain chestnut
5	Fulvous forest
6	Gray-fulvous (fulvous - semi-desert)
7	Irrigated meadow-fulvous
8	Saline alkali, hydromorphic
9	Primitive and rock exposures

Distribution of Anthrax Animal Cases by Soil Types in Armenia, 1956-2019



Positive animal cases

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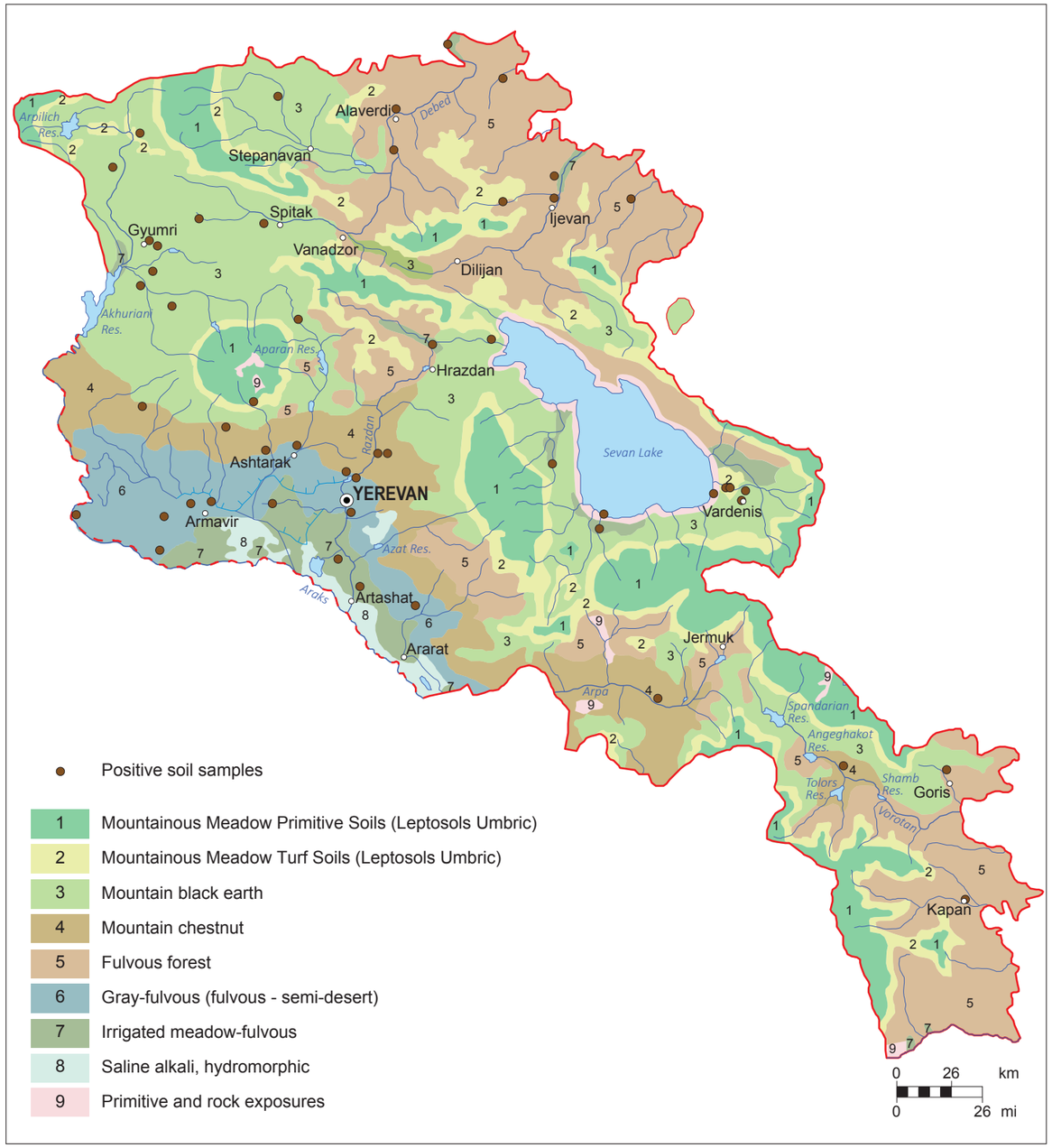
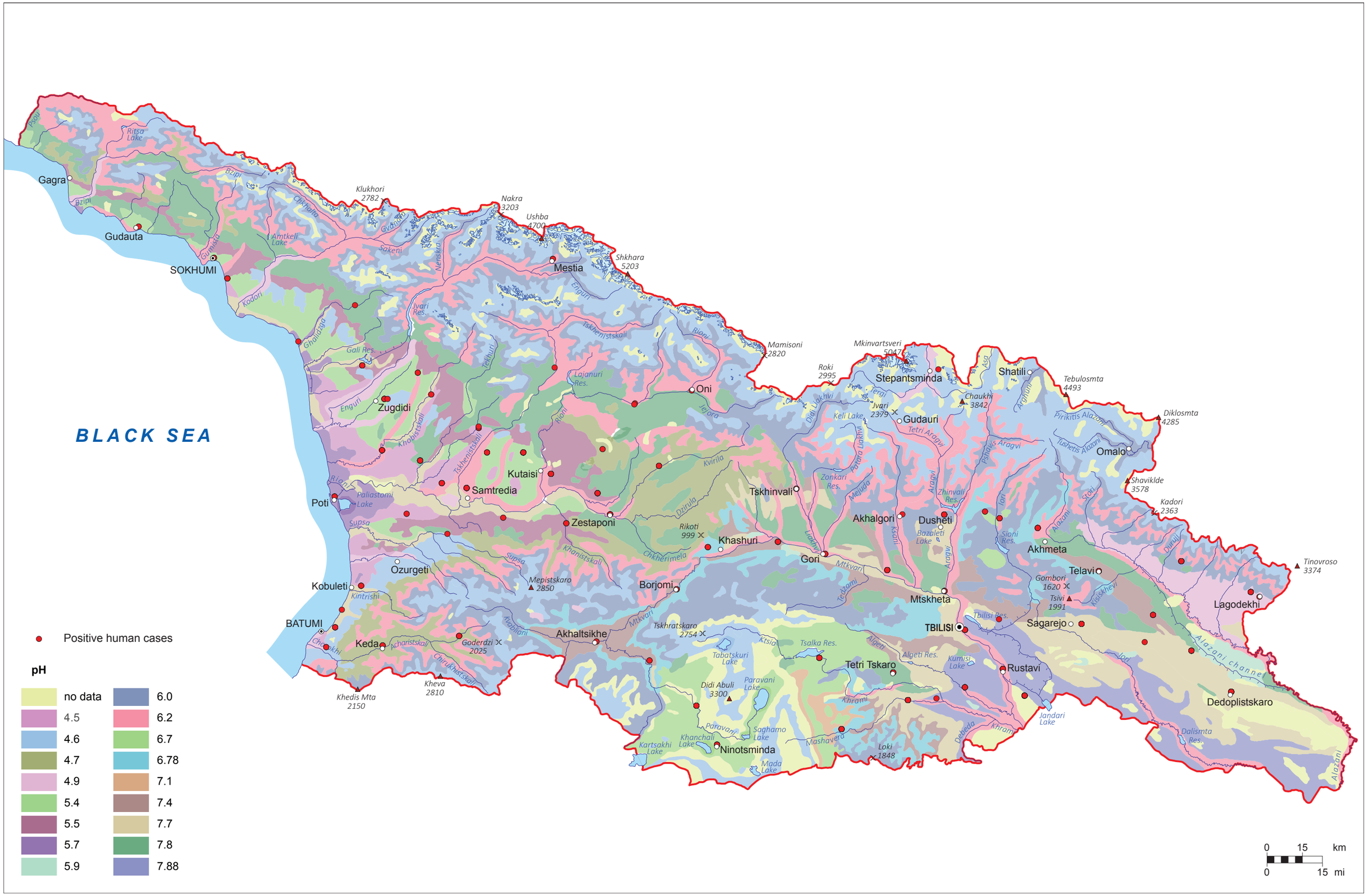
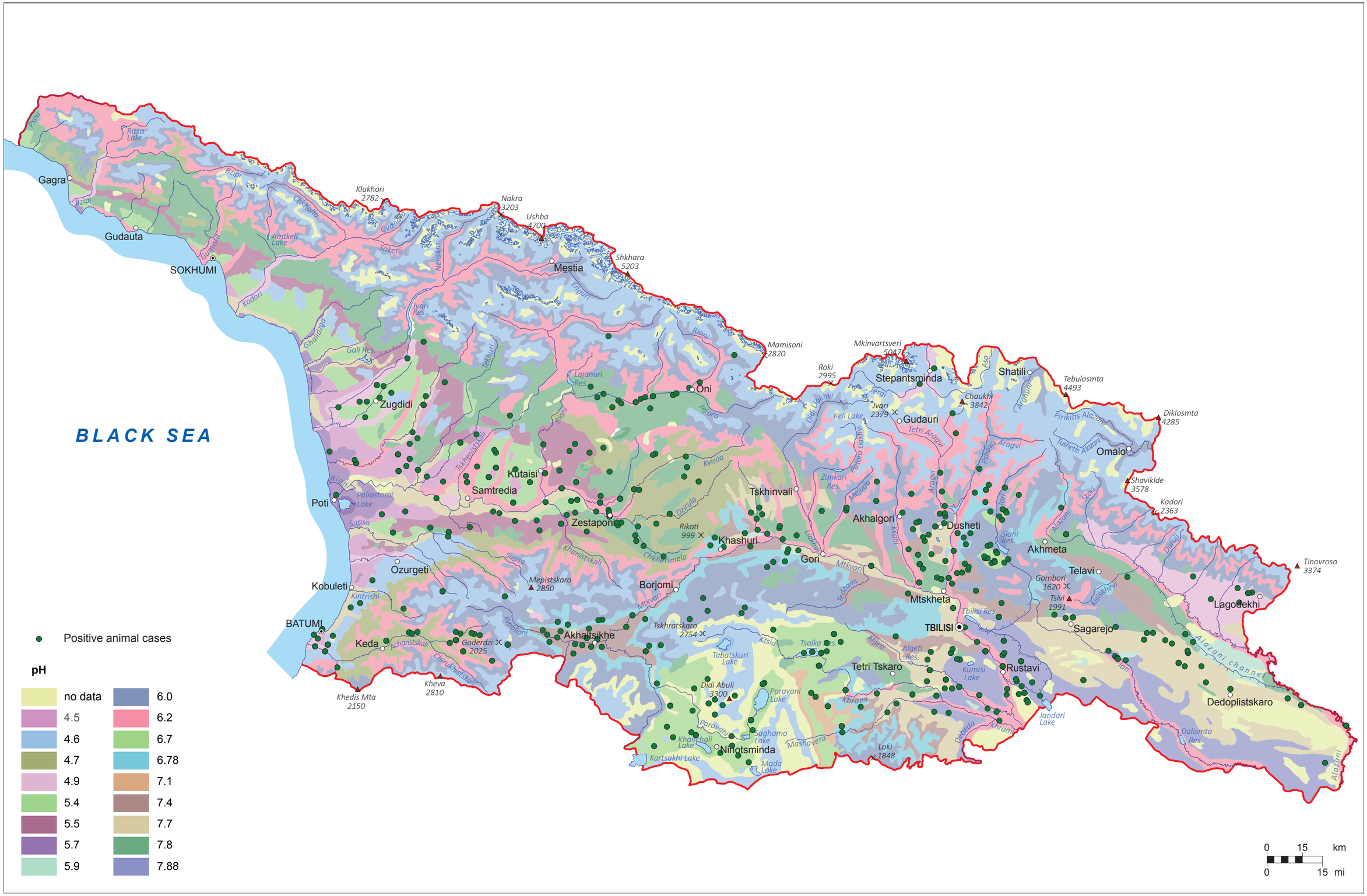
Distribution of Anthrax Positive Soil Samples by Soil Types in Armenia, 1956-2019



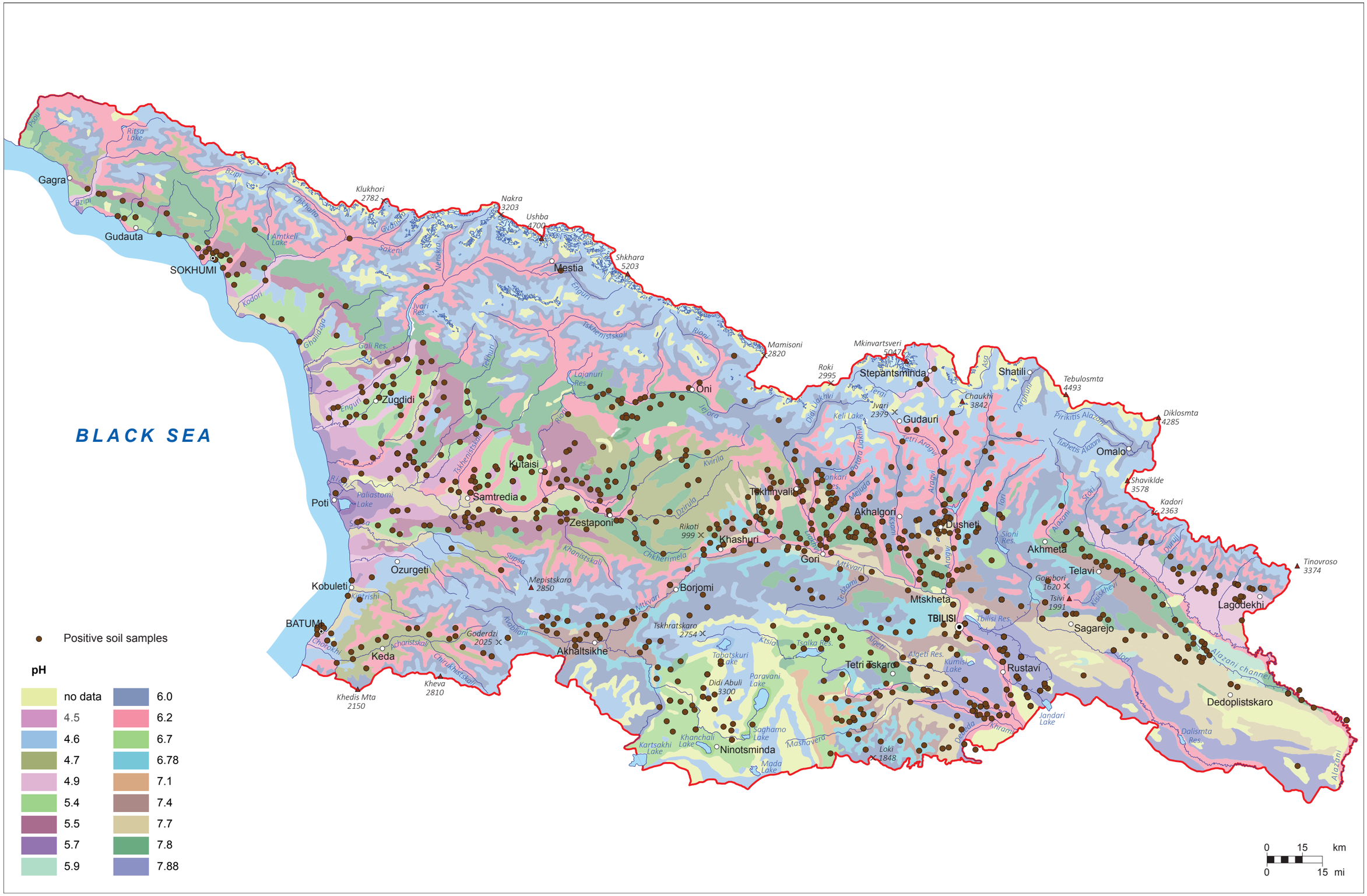
Distribution of Anthrax Human Cases by Soil pH in Georgia, 1956-2019



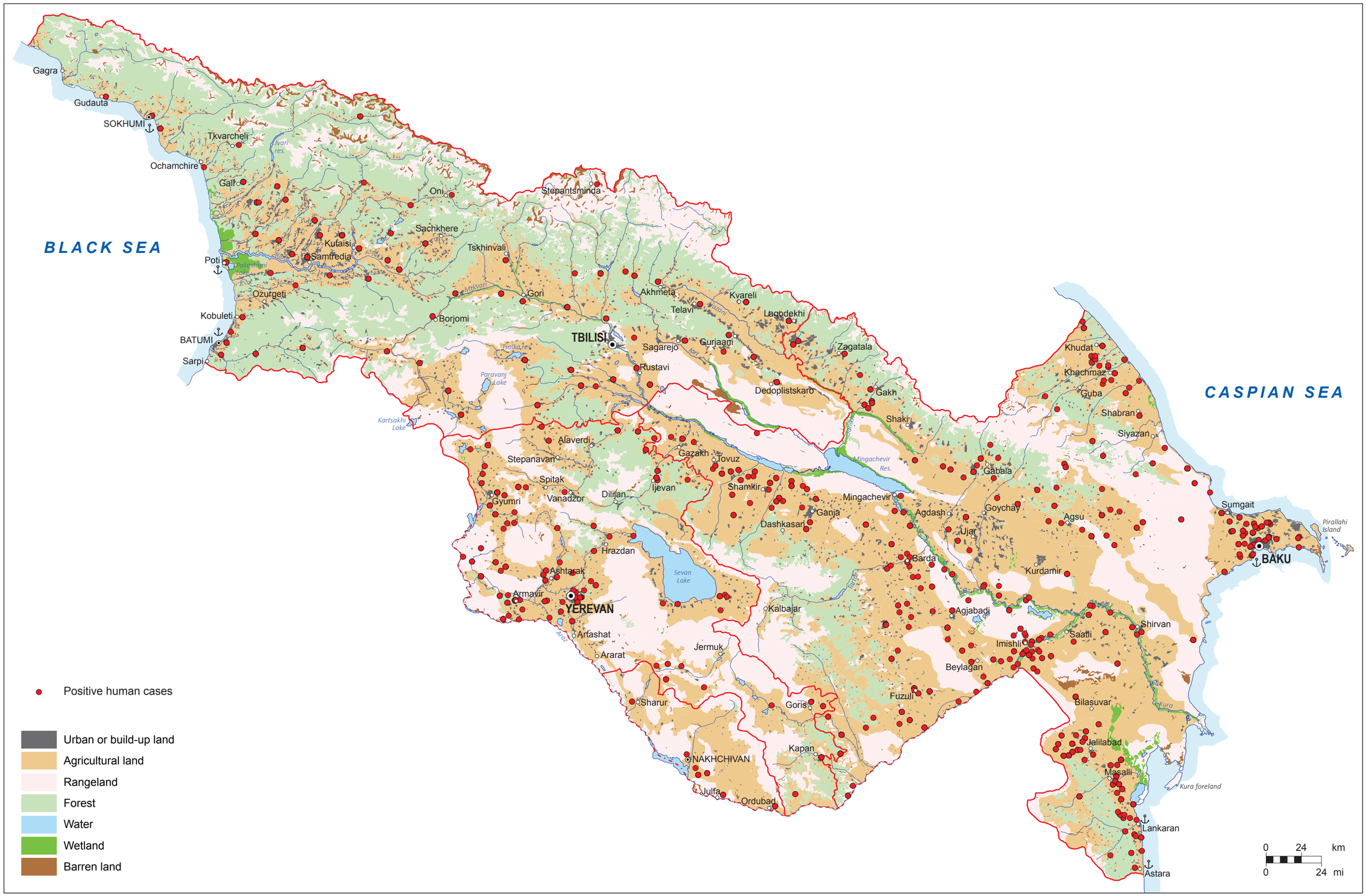
Distribution of Anthrax Animal Cases by Soil pH in Georgia, 1951-2019



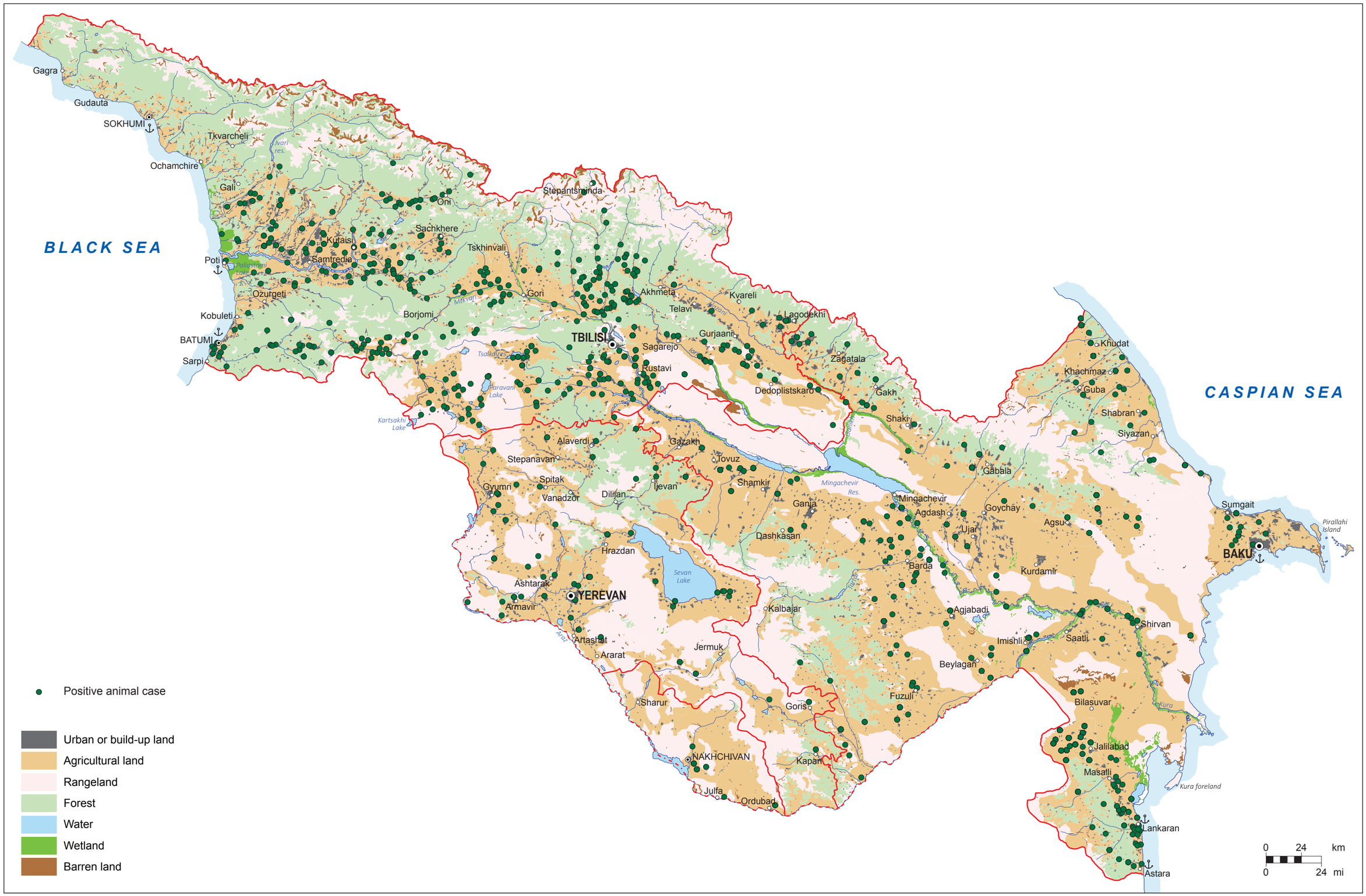
Distribution of Anthrax Positive Soil Samples by Soil pH in Georgia, 1948-2019



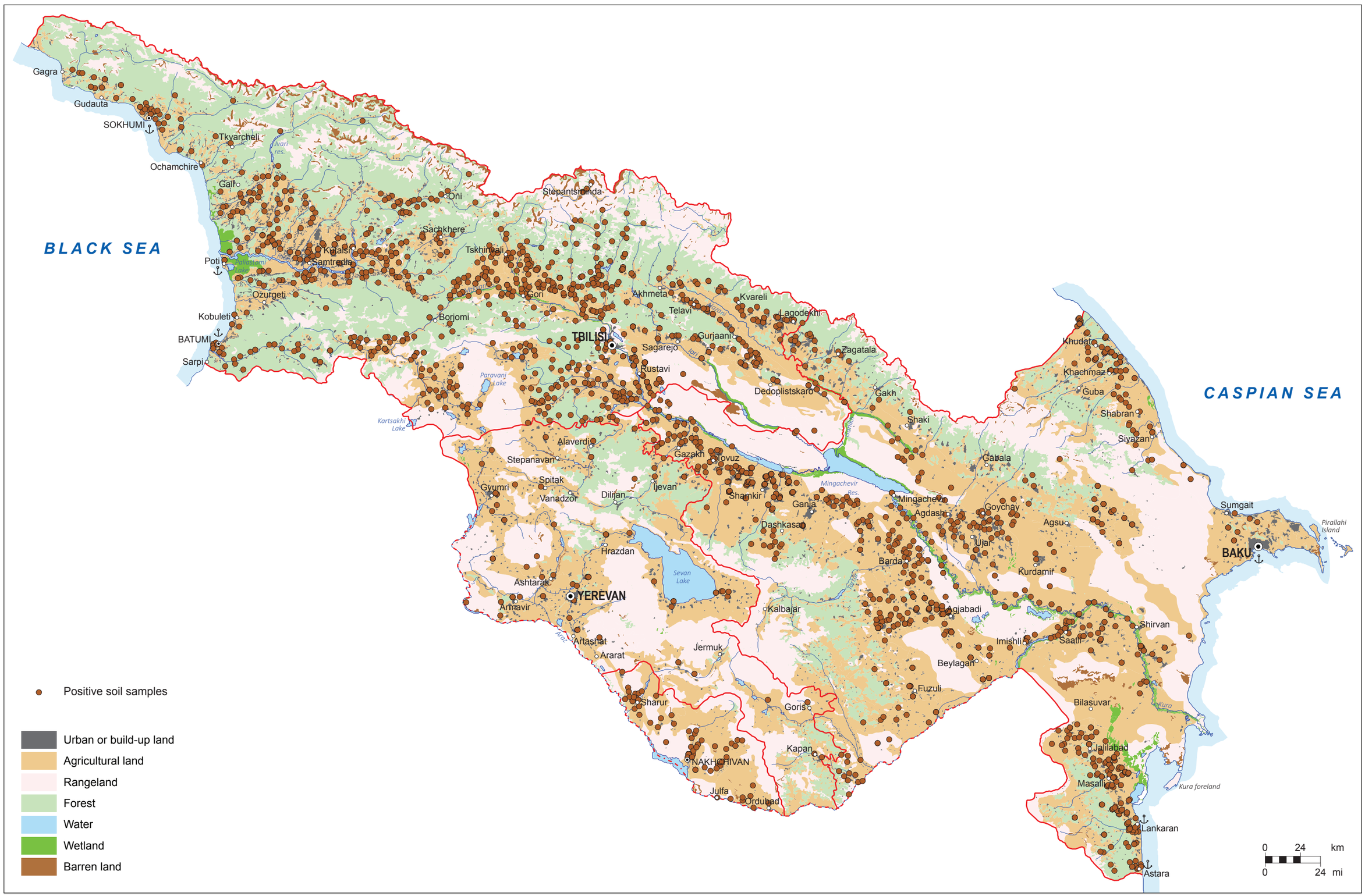
Distribution of Anthrax Human Cases by Land Use in the South Caucasus, 1950-2019



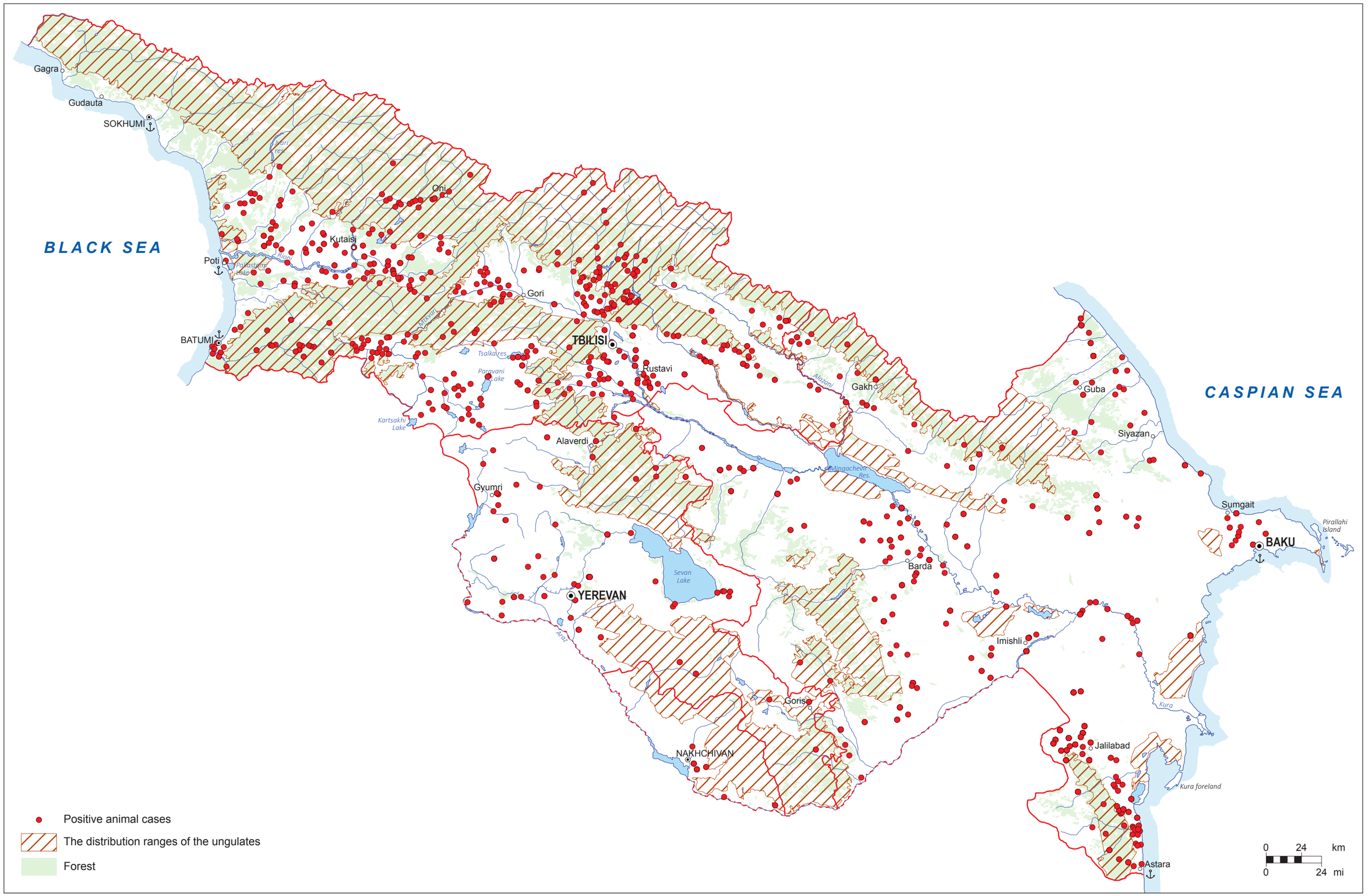
Distribution of Anthrax Animal Cases by Land Use in the South Caucasus, 1950-2019



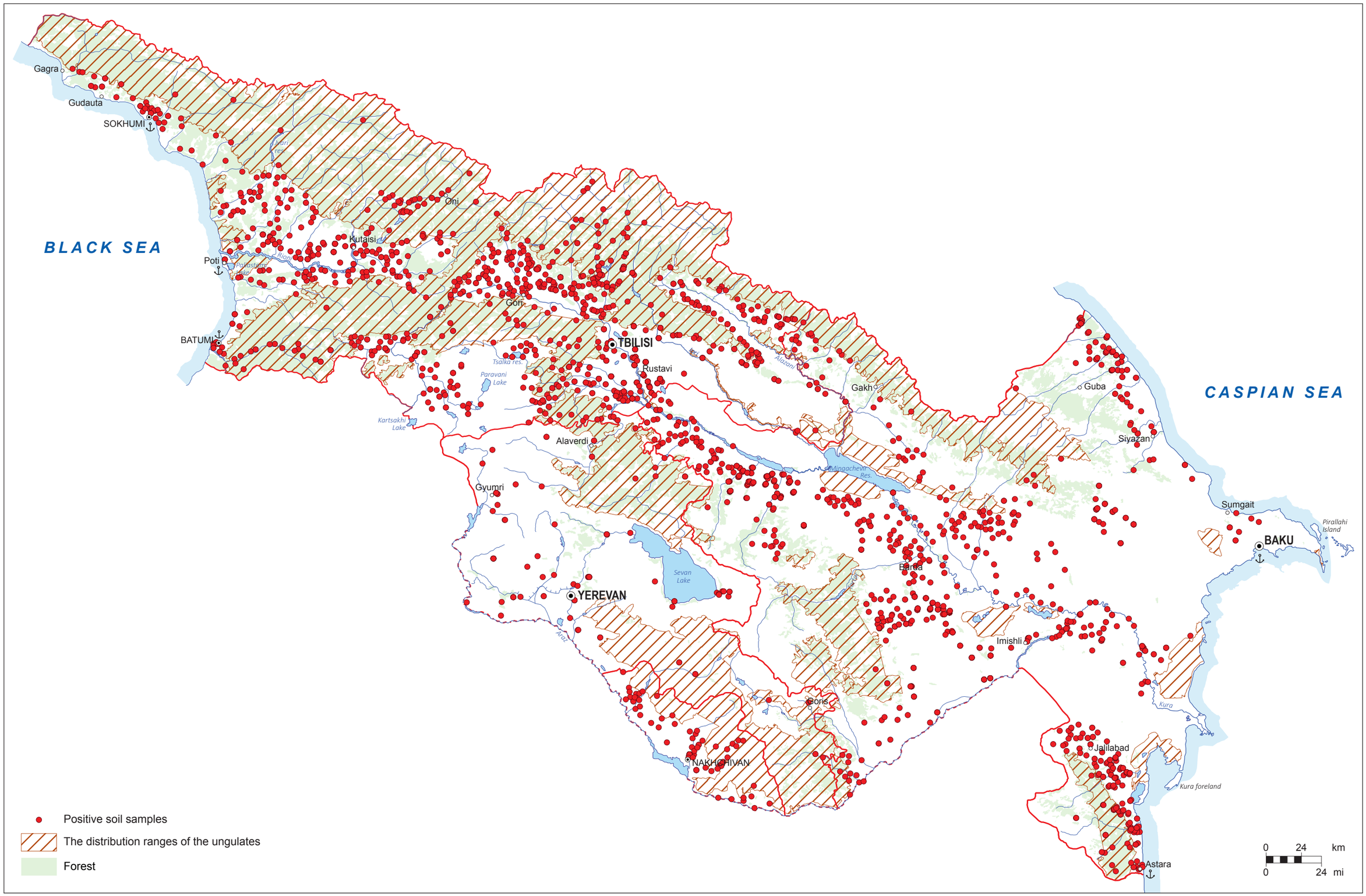
Distribution of Anthrax Positive Soil Samples by Land Use in the South Caucasus, 1948-2019



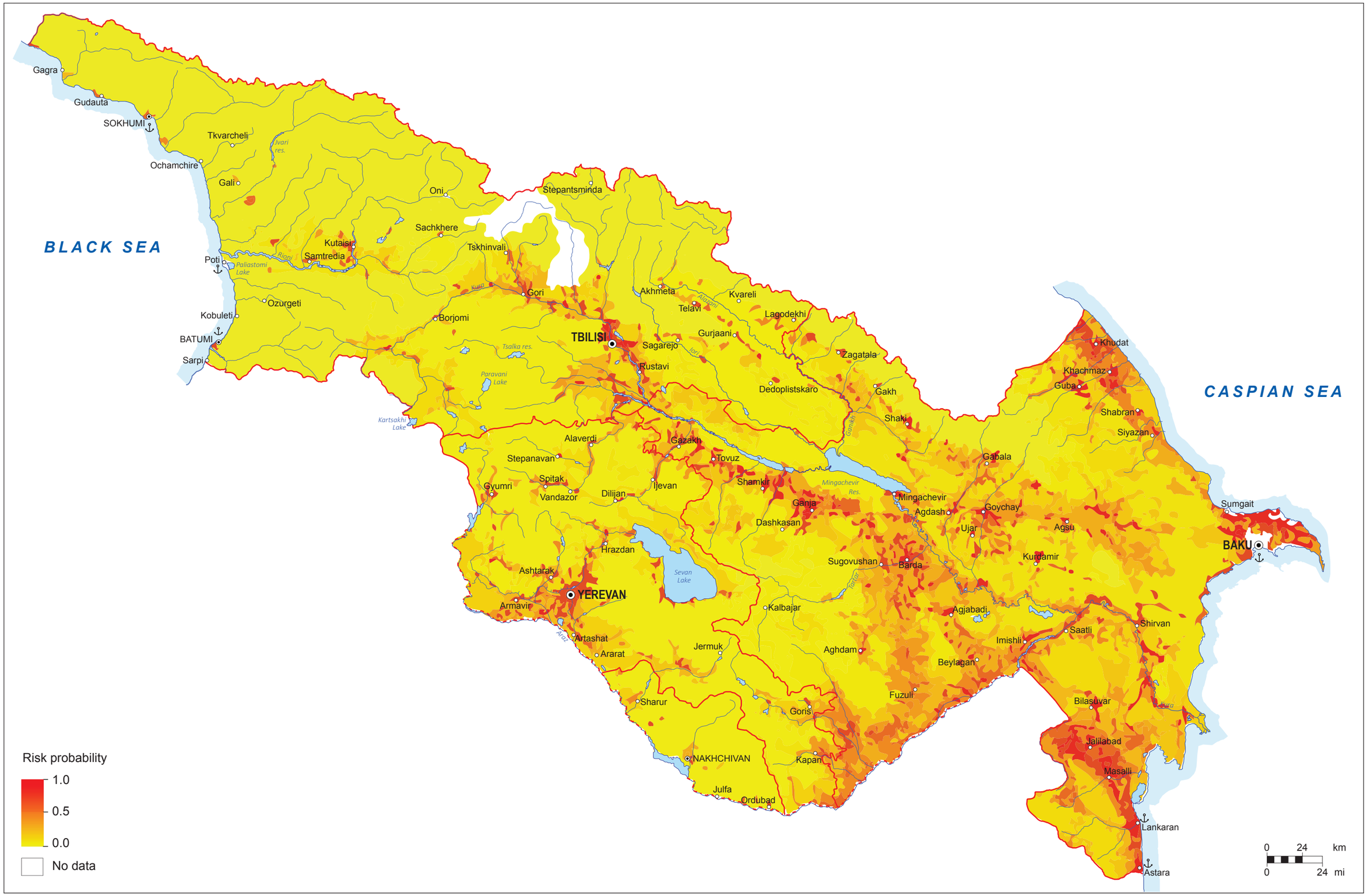
Distribution of Anthrax Animal Cases and Distribution Ranges of Ungulates in the South Caucasus, 1950-2019



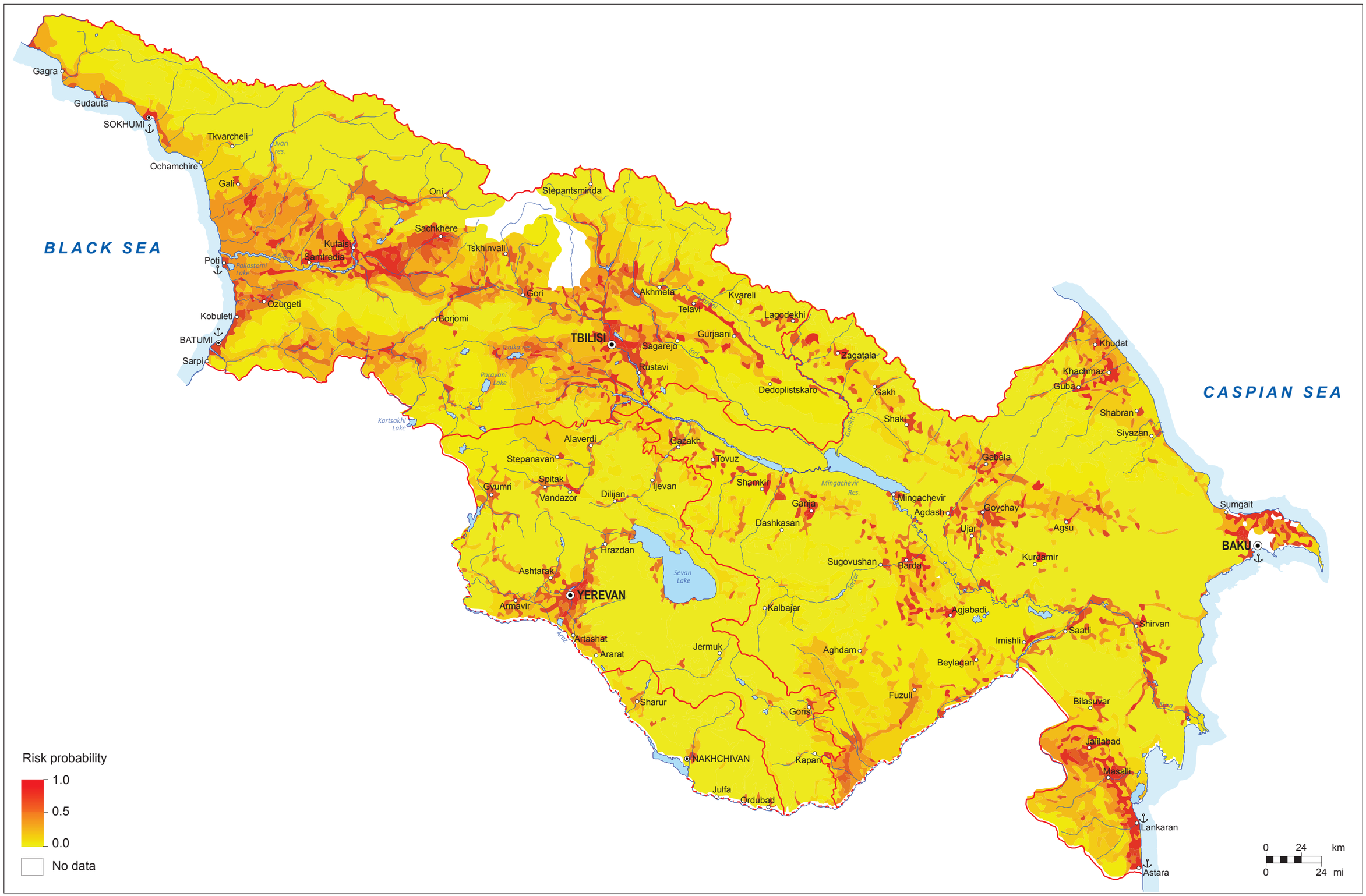
Distribution of Anthrax Positive Soil Samples and Distribution Ranges of Ungulates in the South Caucasus, 1950-2019



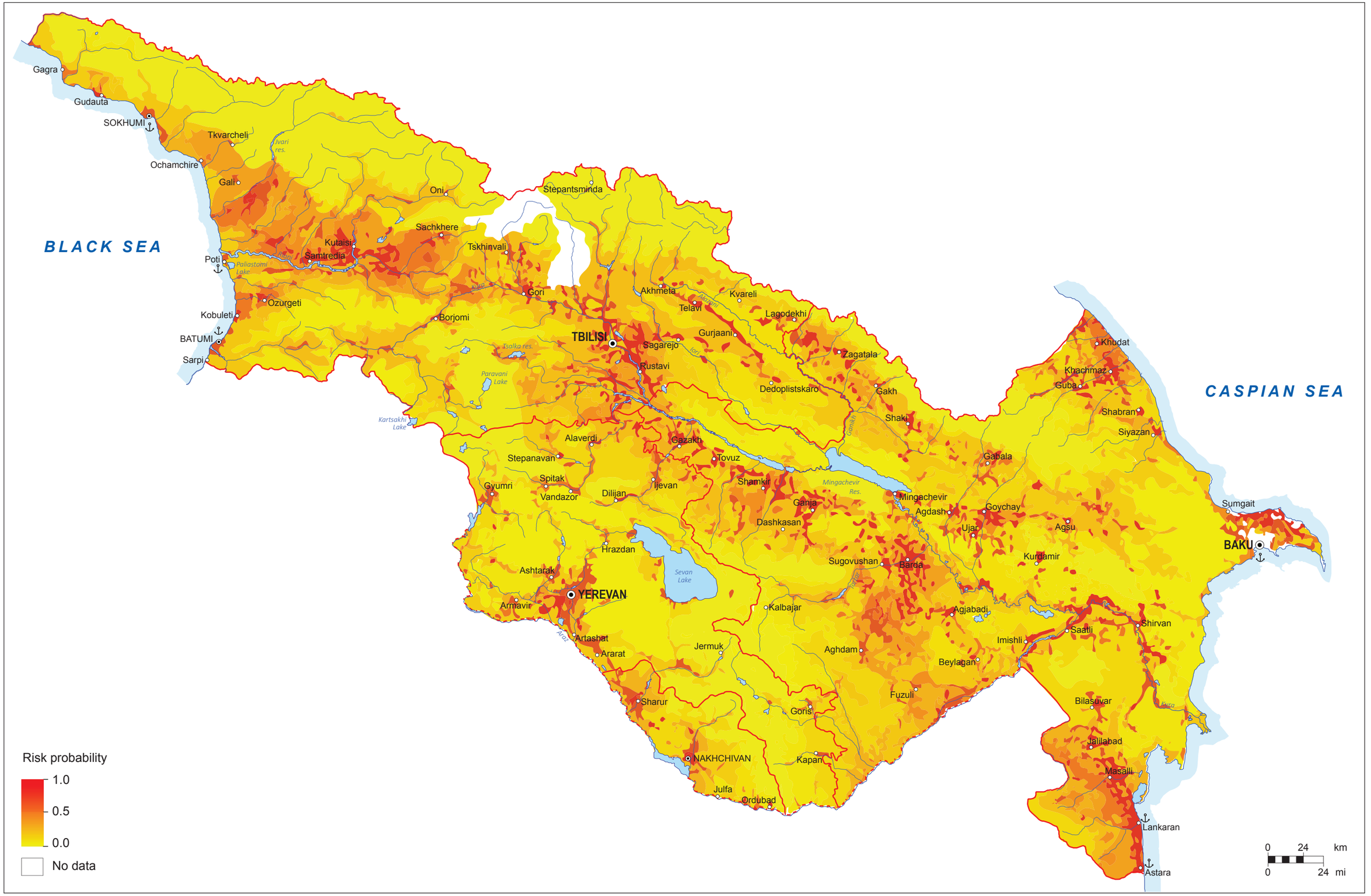
Anthrax Human Cases Risk in the South Caucasus



Anthrax Animal Cases Risk in the South Caucasus

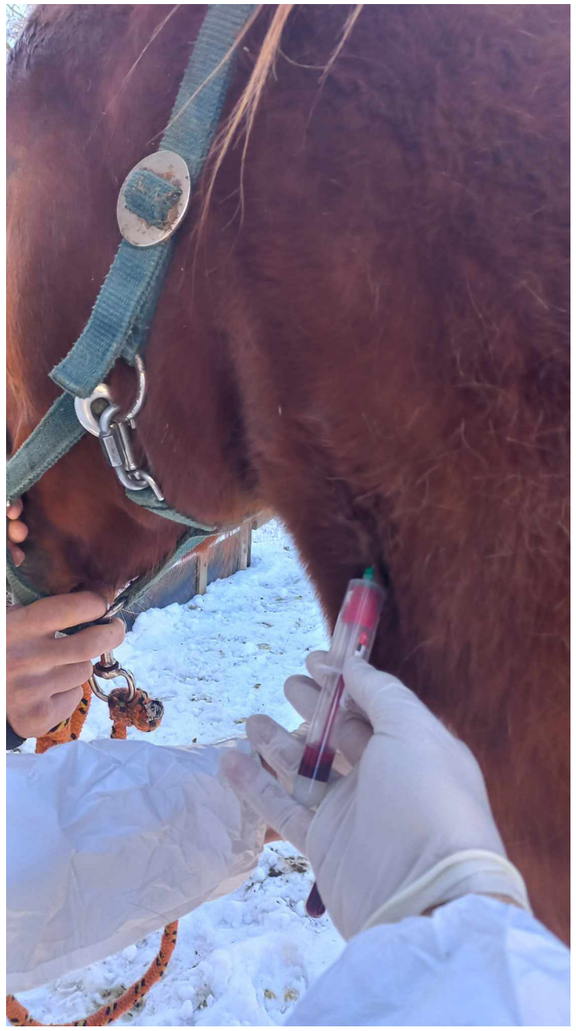


Anthrax Positive Soil Samples Risk in the South Caucasus



Brucellosis

Brucellosis, a bacterial disease, is one of the most common zoonoses caused by various Brucella species. It mainly affects cattle, sheep, goats, pigs, and dogs. Humans usually become infected by direct contact with infected animals, by eating or drinking contaminated animal products like unpasteurized milk or cheese, or by inhaling airborne agents. It affects people of all ages and sexes. Brucellosis occurs globally and is a notifiable disease in most countries. It is more common in countries that lack effective public health and domestic animal health programs. The brucellosis bacterium is considered an agent of bioterrorism, and because it is easily spread by aerosol, represents a significant threat in microbiological laboratories. In endemic areas, human brucellosis has a serious impact on public health. The expansion of animal husbandry, industry and urbanization and the insecurity of hygienic measures in animal husbandry and food production are partly related to the fact that brucellosis continues to be a threat to public health.



Animal samples collection (from a horse) for Brucellosis laboratory investigation © Tengiz Chaligava

The causative agent of brucellosis circulates on all continents and affects hundreds of thousands of people and animals worldwide, but it is more common in Europe, Asia, the Middle East, Africa, and South and Central America. Brucellosis causes more than 500,000 infections per year worldwide, although the amount of brucellosis in humans is not truly known due to variation between countries and inadequate surveillance systems. Brucellosis is an occupational hazard for people employed in the livestock sector. Those who come into contact with animal blood, fetuses, placentas and uterine secretions are at increased risk of disease. Veterinarians, butchers, farmers, hunters and laboratory staff are most at risk, and people of all ages and sexes get the disease. Currently, eight species of *Brucella* are known, four of which cause human disease: *B. melitensis*, *B. abortus*, *B. suis*, and *B. canis*. More dangerous are *B. melitensis* - causing outbreaks, and *B. abortus* - causing sporadic disease. The natural reservoir of *B. melitensis* is sheep and goats, *B. abortus* is cattle, *B. suis* is pigs, and *B. canis* is dogs. *Brucella melitensis* is the most prevalent species worldwide causing brucellosis in humans, owing in part to difficulties in immunizing free-ranging goats and sheep. The incubation period of the disease is highly variable and may last from 1 week to 2 months, but is usually 2 to 4 weeks.

Prevention of brucellosis is mainly carried out by surveillance and prevention of exposure. Avoid unpasteurized dairy foods, cook meat thoroughly, wear gloves when handling sick or dead animals or animal tissue or when assisting an animal giving birth, take safety precautions in high-risk workplaces especially in a laboratory. Because there are no vaccines against brucellosis in humans, vaccination of domestic animals is important for reducing human risk. In addition, testing and slaughtering infected animals removes contaminated products from the food chain. Educational campaigns to avoid unpasteurized dairy products can be effective, as can marketing policies. In agricultural operations and meat processing, protective barriers and proper handling and disposal of post-partum, animal carcasses and internal organs are important prevention strategies.

Brucellosis has flu-like symptoms such as fever, weakness and weight loss. It can affect any organ system and therefore manifests in a variety of ways, particularly as prolonged fever of unknown origin with associated rheumatic features. The disease can manifest in many atypical forms and because many patients have mild symptoms, cases may go undetected. The mainstay of treatment is long-term combination antibiotic therapy, and may take a few weeks to several months to reduce the severity of illness and prevent recurrence of symptoms. There is disagreement about the optimum treatment regimen. Death from brucellosis is rare and does not exceed 2% of all cases.

Animal samples collection (from a goat) for Brucellosis laboratory investigation © Tengiz Chaligava

Data on Brucellosis had been collected from middle of 20th century from all three countries (1950-2019) from publications, annual reports, public health centers, former anti-plague stations, veterinary centers, and finished and/or ongoing scientific projects. Cases among humans and animals are registered almost every year in all three countries, and diagnostics mainly depend on serology methods. Historically, brucellosis human and animal cases have been registered in almost all territories of the South Caucasus (pp. 112-113). Most human cases occur in the 20-30 years age group in Georgia, 20-50 in Armenia, and almost equally in all groups from 10 to 60+ in Azerbaijan. More than 70% of human cases are male in all three countries. Most animal cases are found in sheep then cattle in Georgia. In Azerbaijan and Armenia, brucellosis occurs equally in cattle and sheep. Brucellosis infections are seasonal, and the majority of cases are reported during the hot season, when average maximum temperatures are between 14-20 degrees Celsius (pp. 125-126). In Georgia, most cases are reported in areas where the annual total precipitation is 800 mm to 2,000 mm (pp. 121-122). In Armenia and Azerbaijan, cases are registered where the annual total precipitation is 600 mm to 1000 mm (pp. 121-122).

Overall, Brucellosis cases in humans and animals are mostly found in agricultural territories within the South Caucasus (pp. 137-138).

Animal samples collection (from a goat) for Brucellosis laboratory investigation © Tengiz Chaligava

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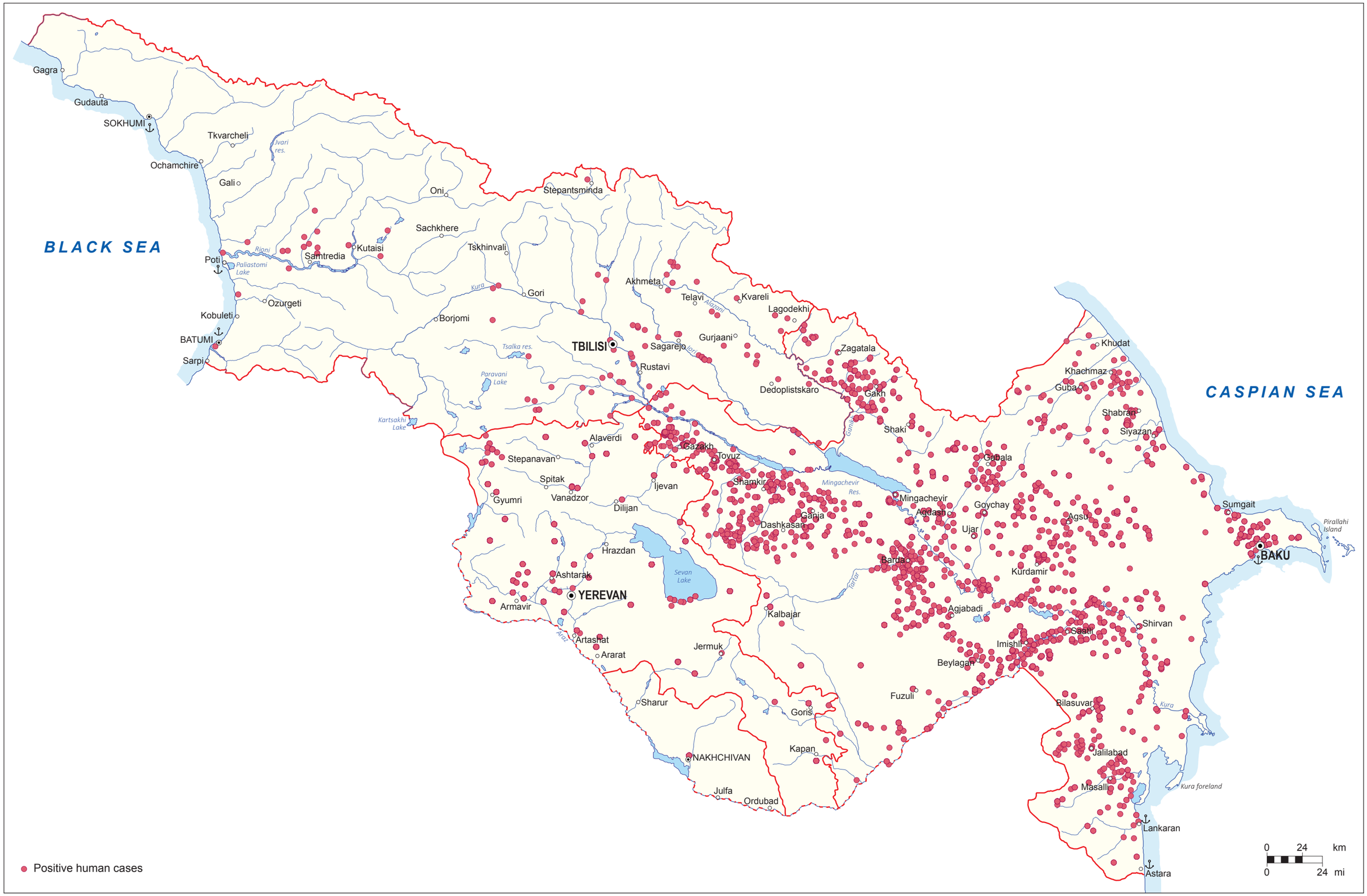
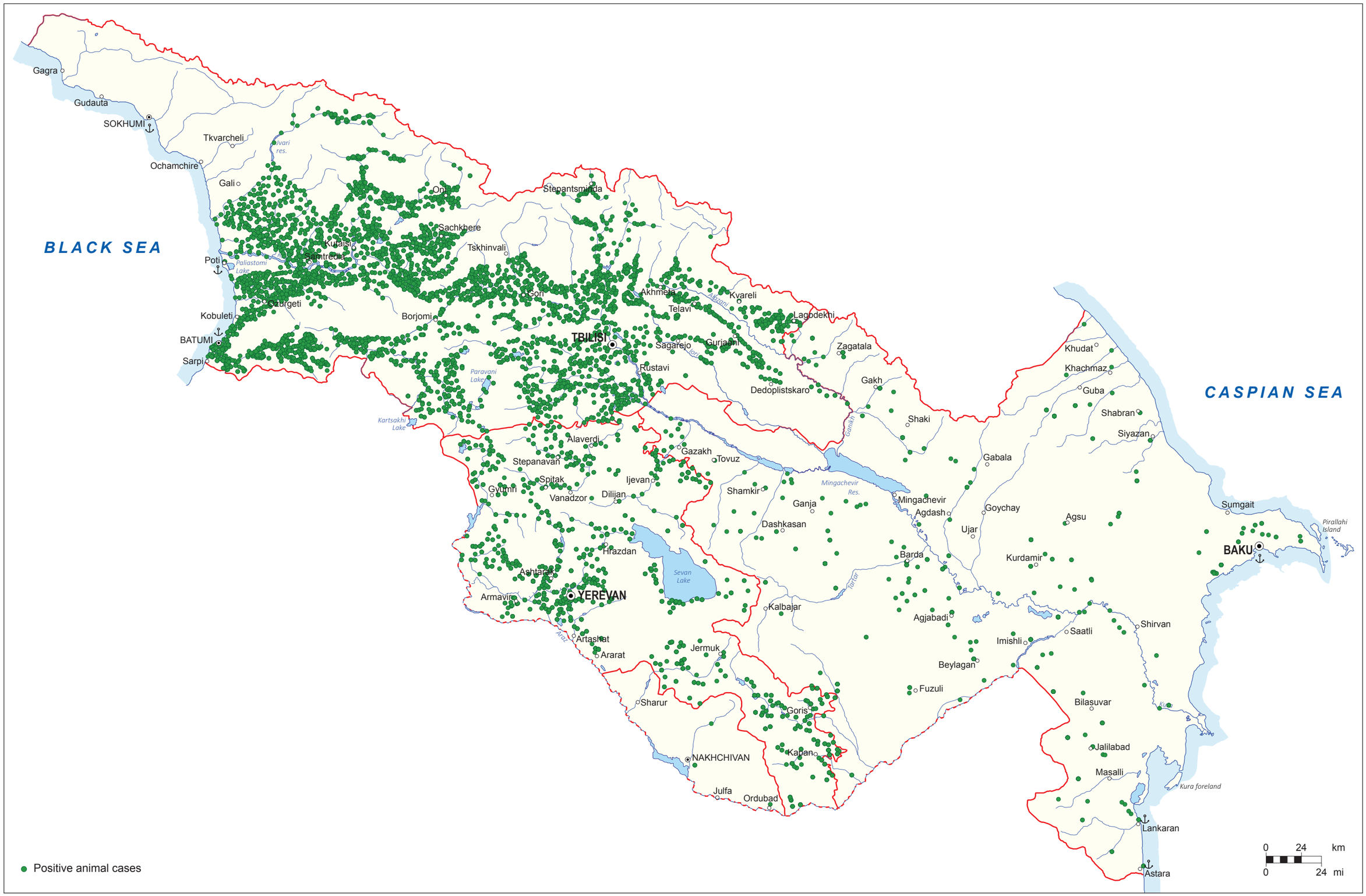
8. A.L. Rivas, S.D. Smith, T. Chaligava, L. Malania, I. Burjanadze, A.L. Hoogesteyn, K. Gilbertson, JH. Bertram, C.T. Webb, P. Imnadze, M. Kosoy. Geo-temporal patterns to design cost-effective interventions for zoonotic diseases - the case of brucellosis in the country of Georgia. Frontiers in Veterinary, Sec.Veterinary Epidemiology and Economics, volume 10-2023, Dec 20, *doi.org/10.3389/fvets.2023.1270505*

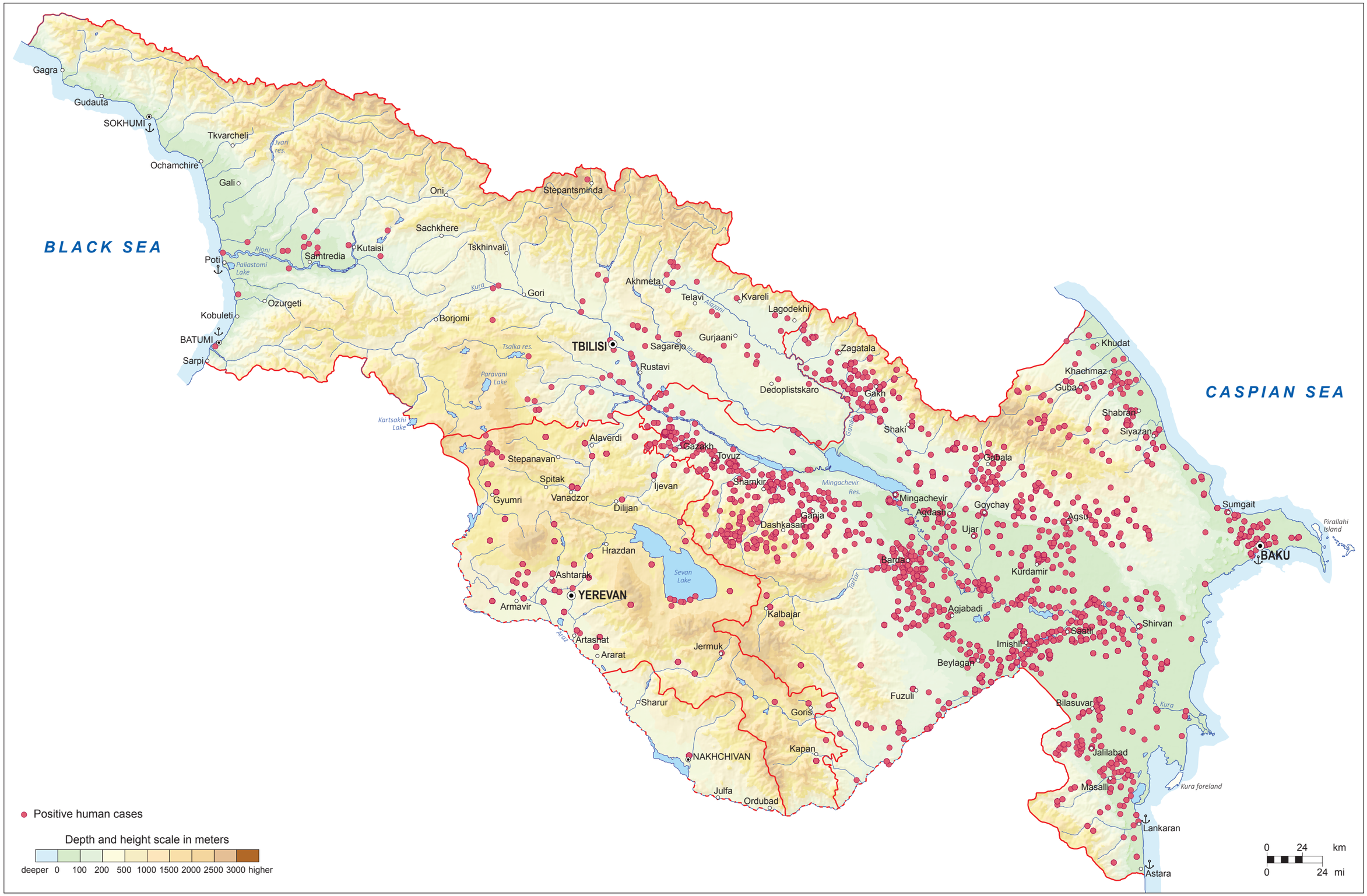
Distribution of Brucellosis Human Cases in the South Caucasus, 1950-2020



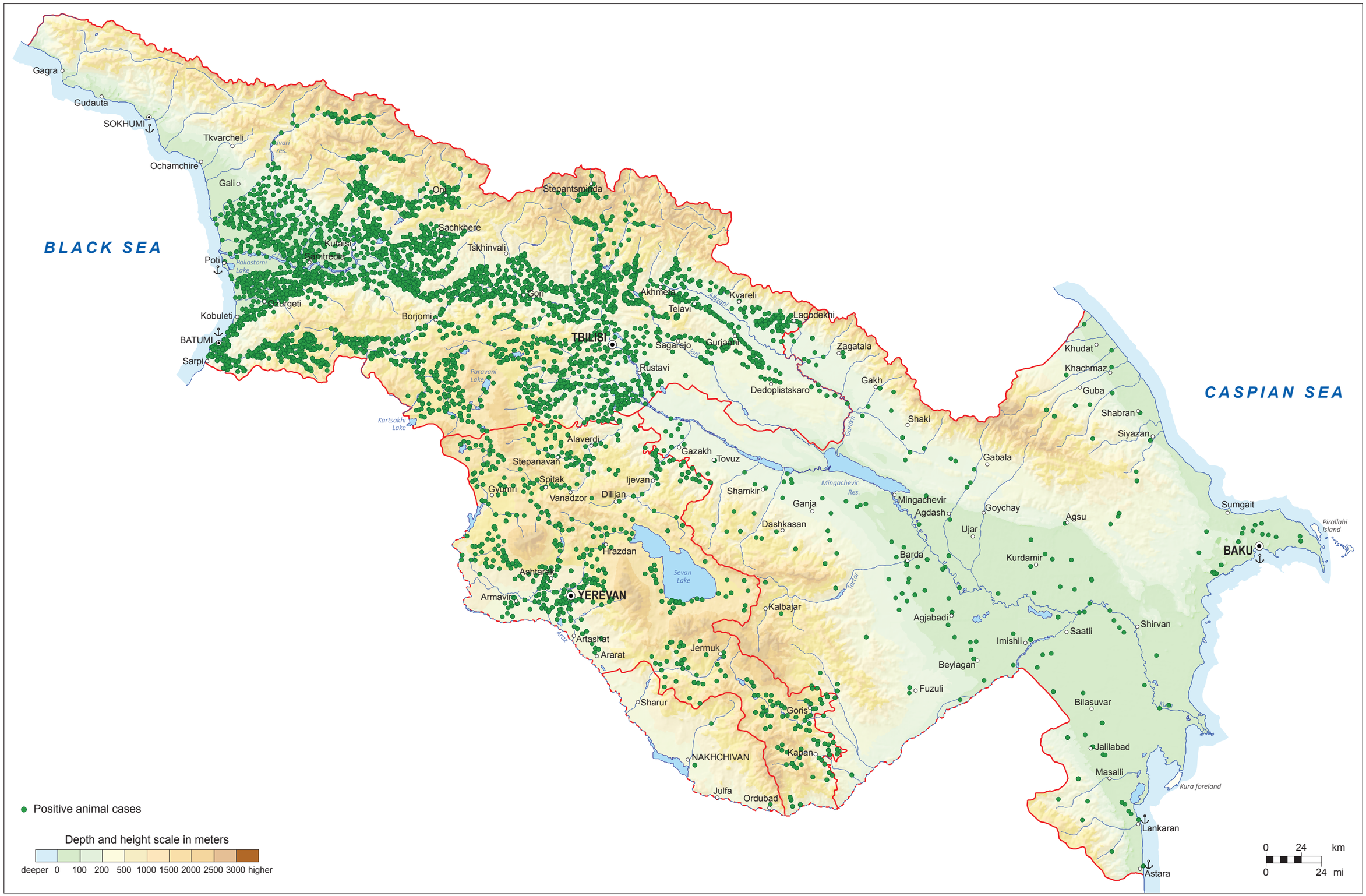
Distribution of Brucellosis Animal Cases in the South Caucasus, 1950-2020



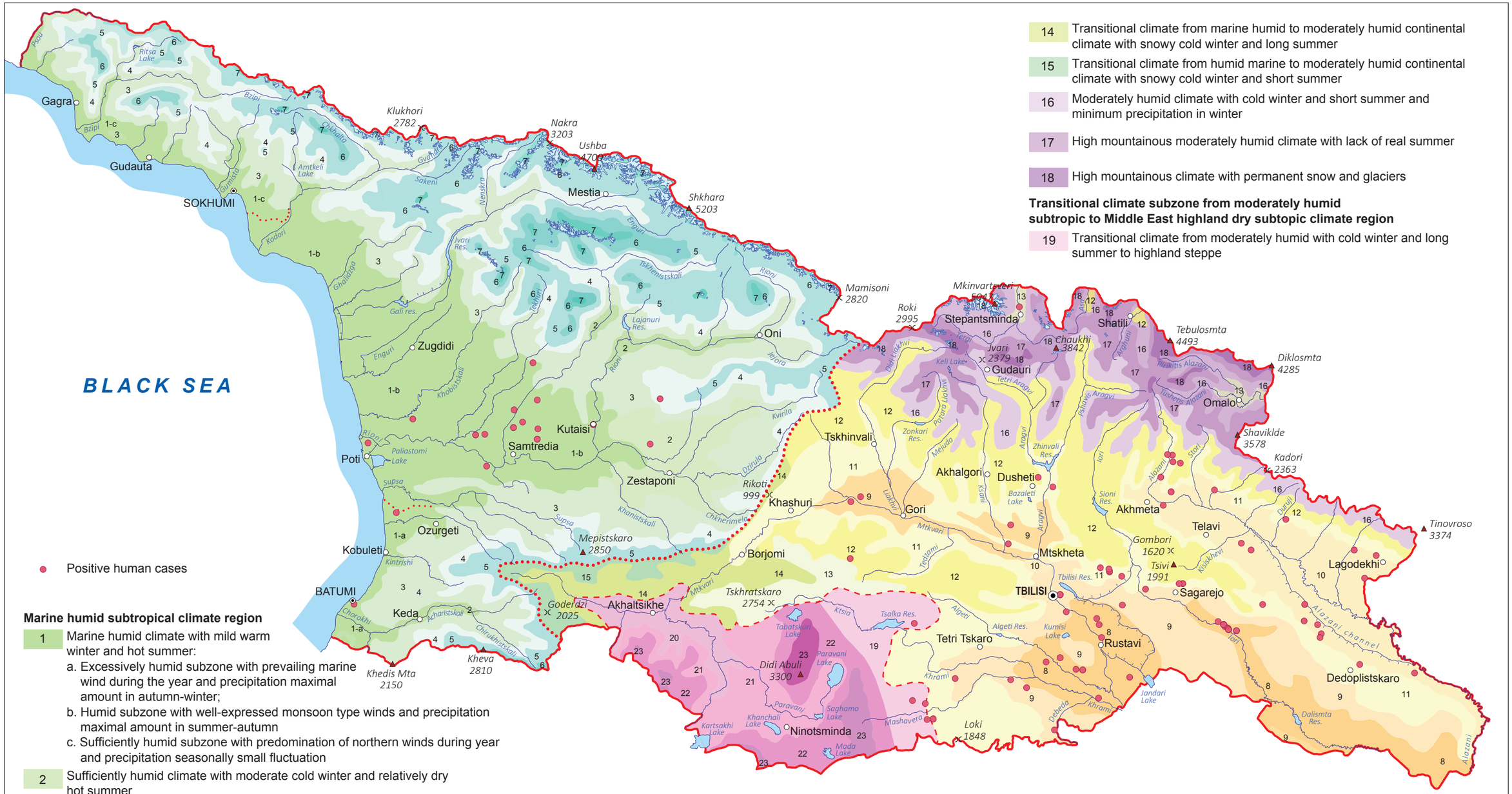
Distribution of Brucellosis Human Cases by Elevation in the South Caucasus, 1950-2020



Distribution of Brucellosis Animal Cases by Elevation in the South Caucasus, 1950-2020



Distribution of Brucellosis Human Cases by Climate Types in Georgia, 1956-2020



- Positive human cases

Marine humid subtropical climate region

- 1 Marine humid climate with mild warm winter and hot summer:
  - a. Excessively humid subzone with prevailing marine wind during the year and precipitation maximal amount in autumn-winter;
  - b. Humid subzone with well-expressed monsoon type winds and precipitation maximal amount in summer-autumn
  - c. Sufficiently humid subzone with predomination of northern winds during year and precipitation seasonally small fluctuation
- 2 Sufficiently humid climate with moderate cold winter and relatively dry hot summer
- 3 Humid climate with moderate cold winter and long warm summer
- 4 Humid climate with cold winter and long cool summer
- 5 Humid climate with cold winter and short summer
- 6 High mountainous humid climate with lack of real summer
- 7 High mountainous humid climate with year-round abundant snow and glaciers

Moderately humid subtropical climate region

- 8 Moderately warm steppe with hot summer and minimum precipitation twice a year
- 9 Transitional climate from a moderate warm steppe to a moderate humid one, with hot summer and minimum precipitation twice a year
- 10 Moderate humid climate with moderately cold Winter and hot summer and minimum precipitation twice a year
- 11 Moderate humid climate with moderately cold Winter and long warm summer and minimum precipitation twice a year
- 12 Moderate humid climate with cold Winter and long cold summer, minimum precipitation twice a year
- 13 Moderate humid climate with cold winter and long cool summer and minimum precipitation in winter
- 14 Transitional climate from marine humid to moderately humid continental climate with snowy cold winter and long summer
- 15 Transitional climate from humid marine to moderately humid continental climate with snowy cold winter and short summer
- 16 Moderately humid climate with cold winter and short summer and minimum precipitation in winter
- 17 High mountainous moderately humid climate with lack of real summer
- 18 High mountainous climate with permanent snow and glaciers

Transitional climate subzone from moderately humid subtropic to Middle East highland dry subtopic climate region

- 19 Transitional climate from moderately humid with cold winter and long summer to highland steppe
- 20 Highland steppe climate with less snowy, cold winter and long, warm summer
- 21 Highland steppe climate with less snowy, cold winter and long cool summer
- 22 Highland steppe climate with short summer and cold, less snowy winter
- 23 Highland moderately dry climate with lack of real summer

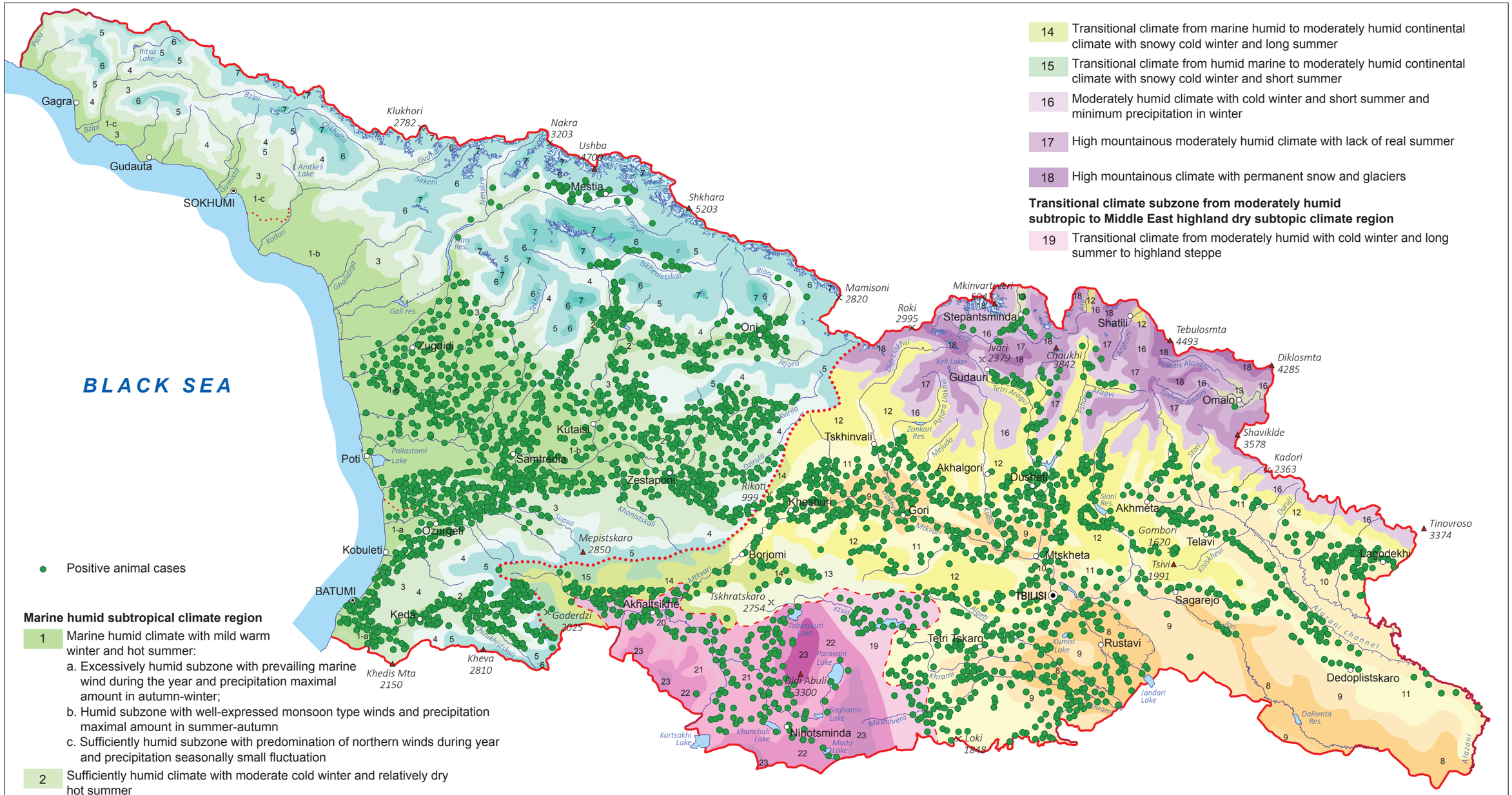
Climate region's border ····· Climate subzone's border

Subregion border

0 15 km

0 15 mi

Distribution of Brucellosis Animal Cases by Climate Types in Georgia, 1976-2020



- Positive animal cases

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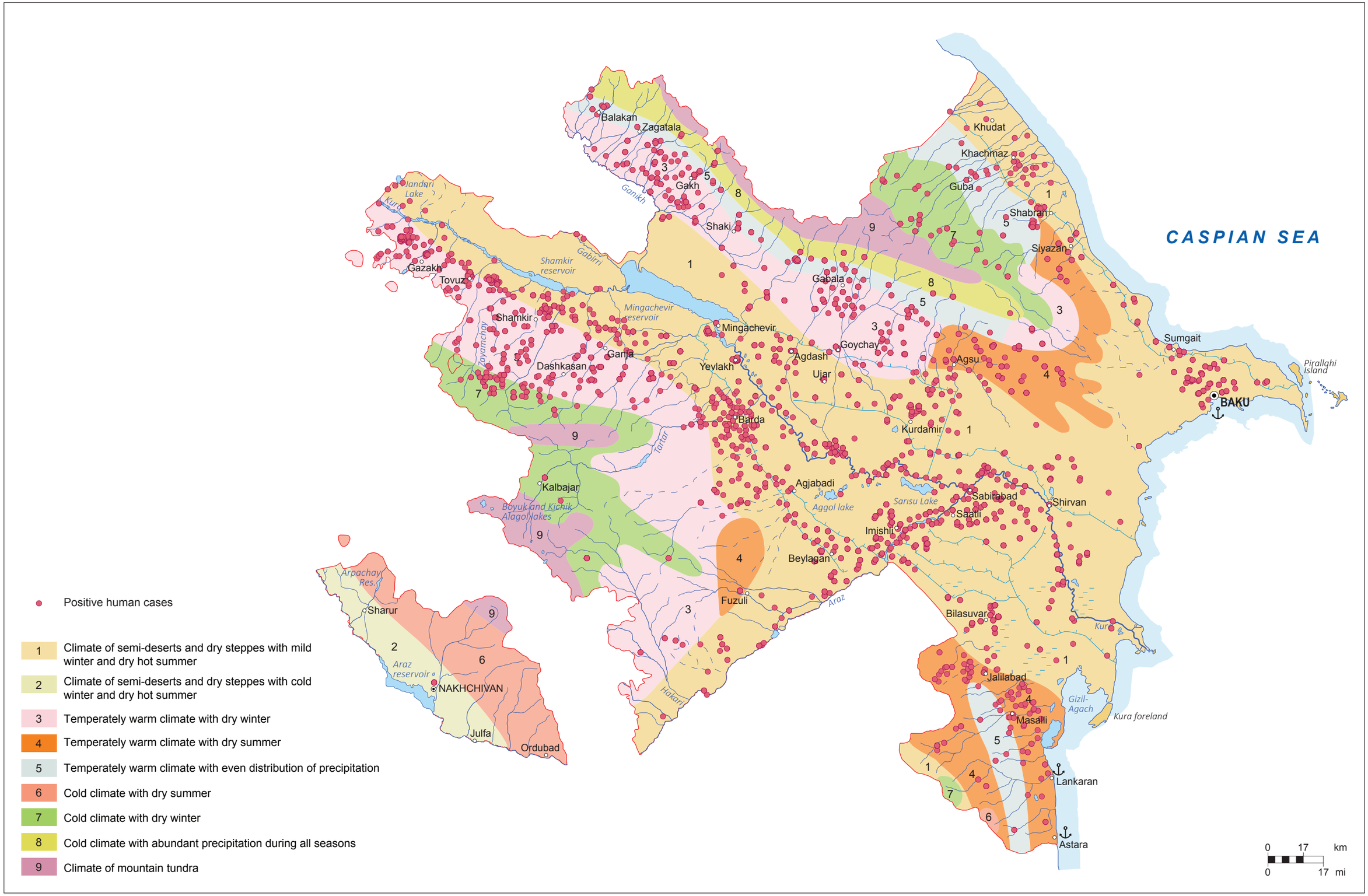
Climate region's border ····· Climate subzone's border

--- Subregion border

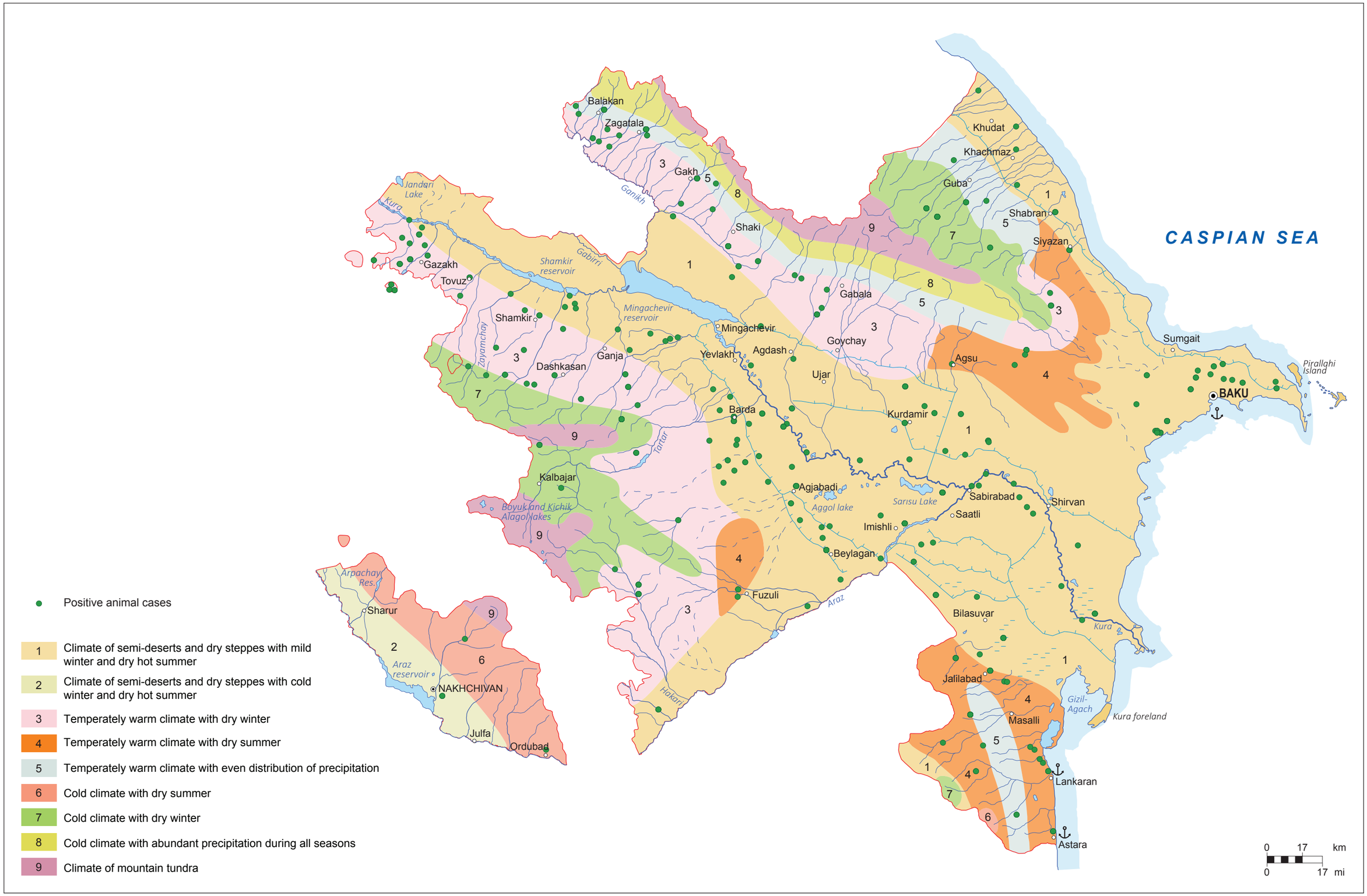
0 15 km

0 15 mi

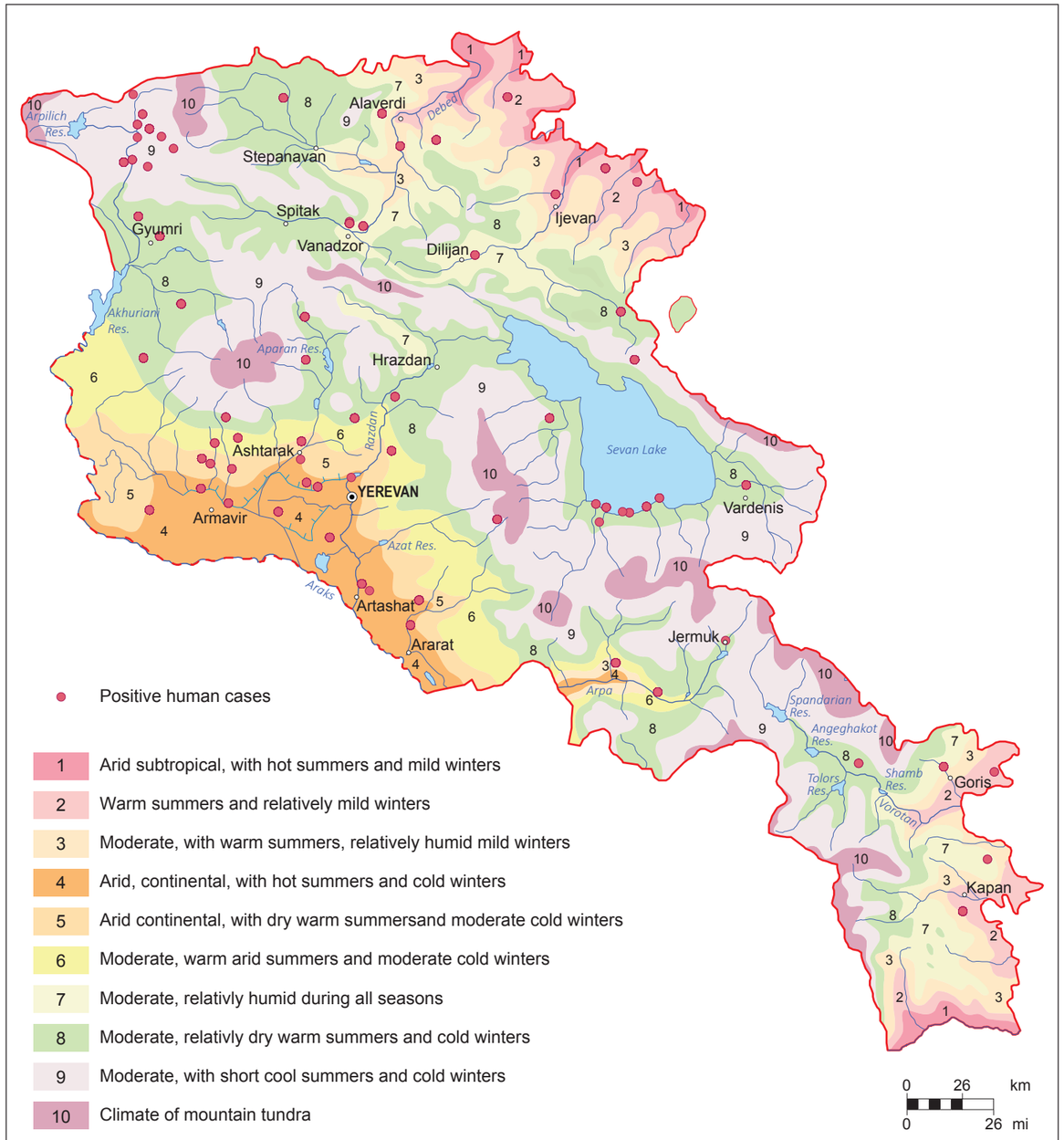
Distribution of Brucellosis Human Cases by Climate Types in Azerbaijan, 1950-2020



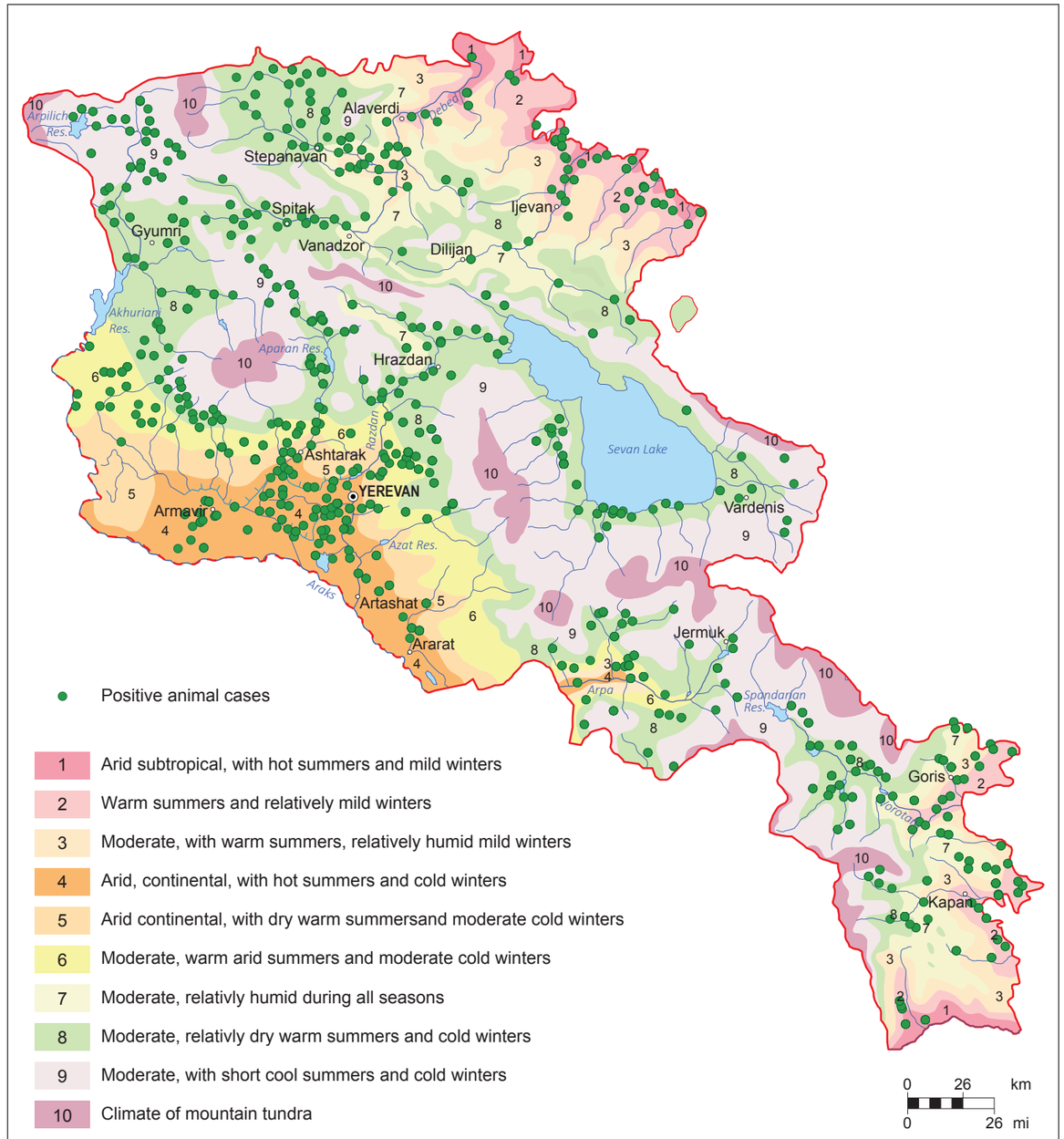
Distribution of Brucellosis Animal Cases by Climate Types in Azerbaijan, 1965-2020



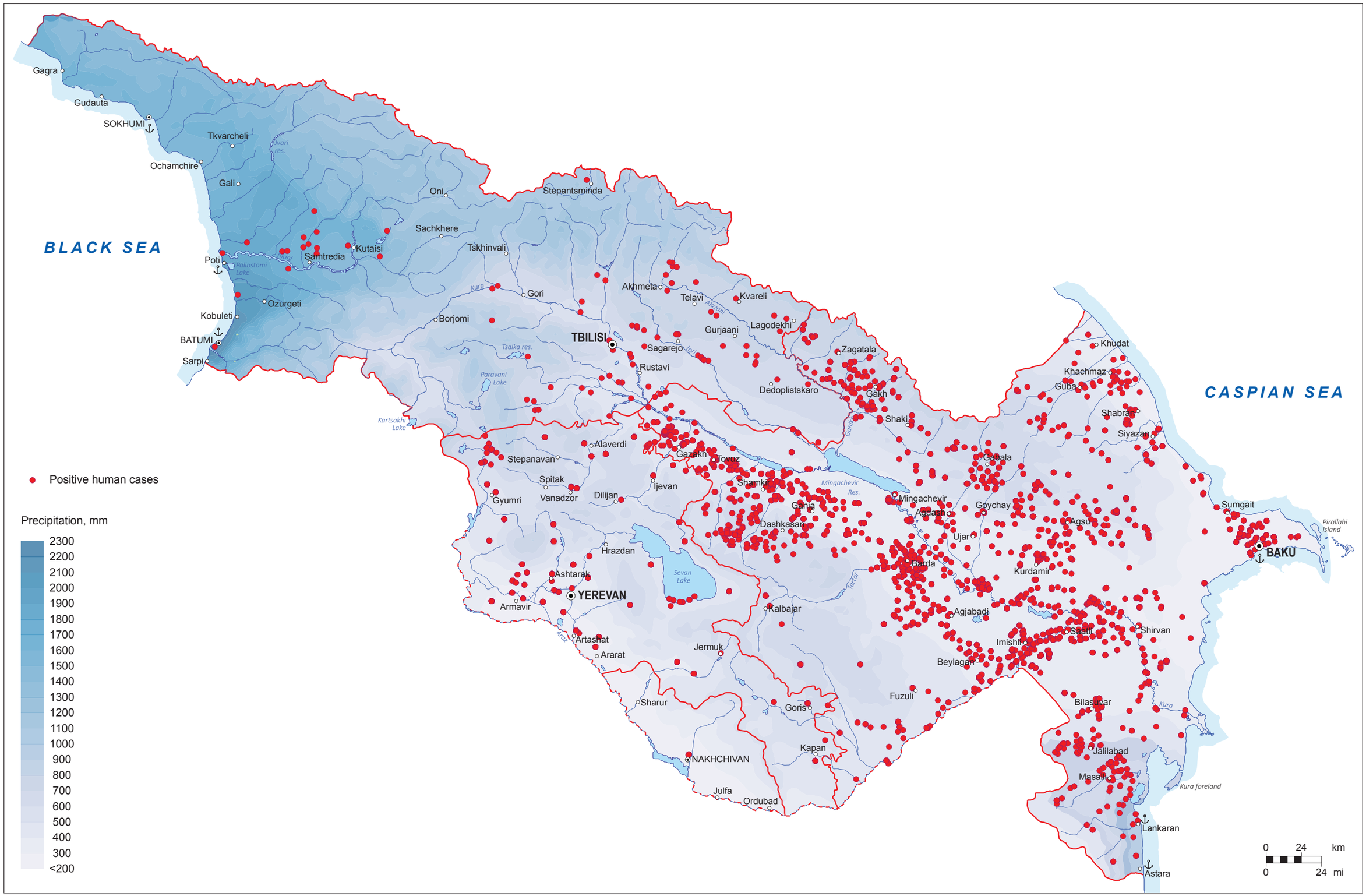
Distribution of Brucellosis Human Cases by Climate Types in Armenia, 1960-2020



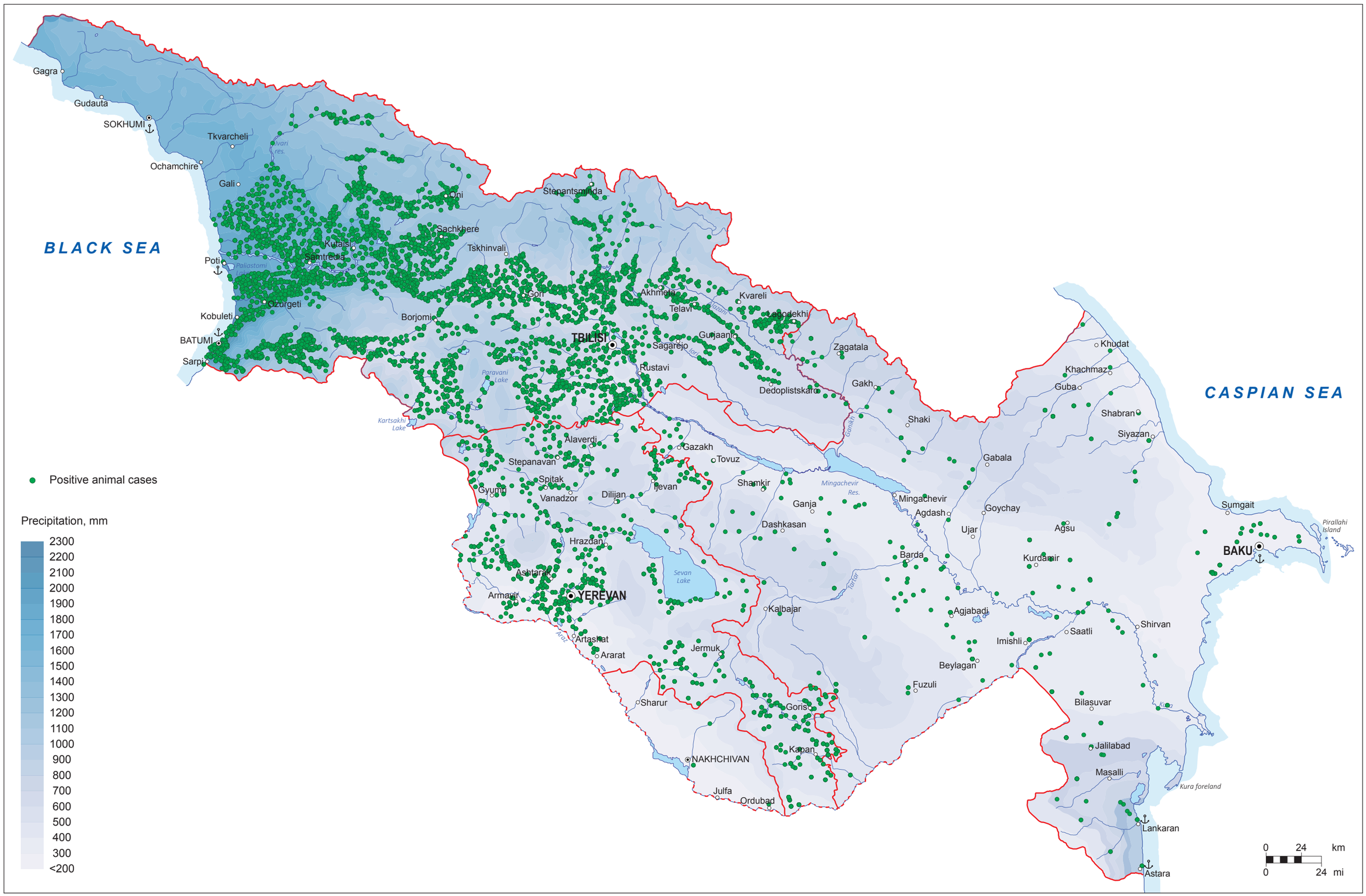
Distribution of Brucellosis Animal Cases by Climate Types in Armenia, 1950-2020



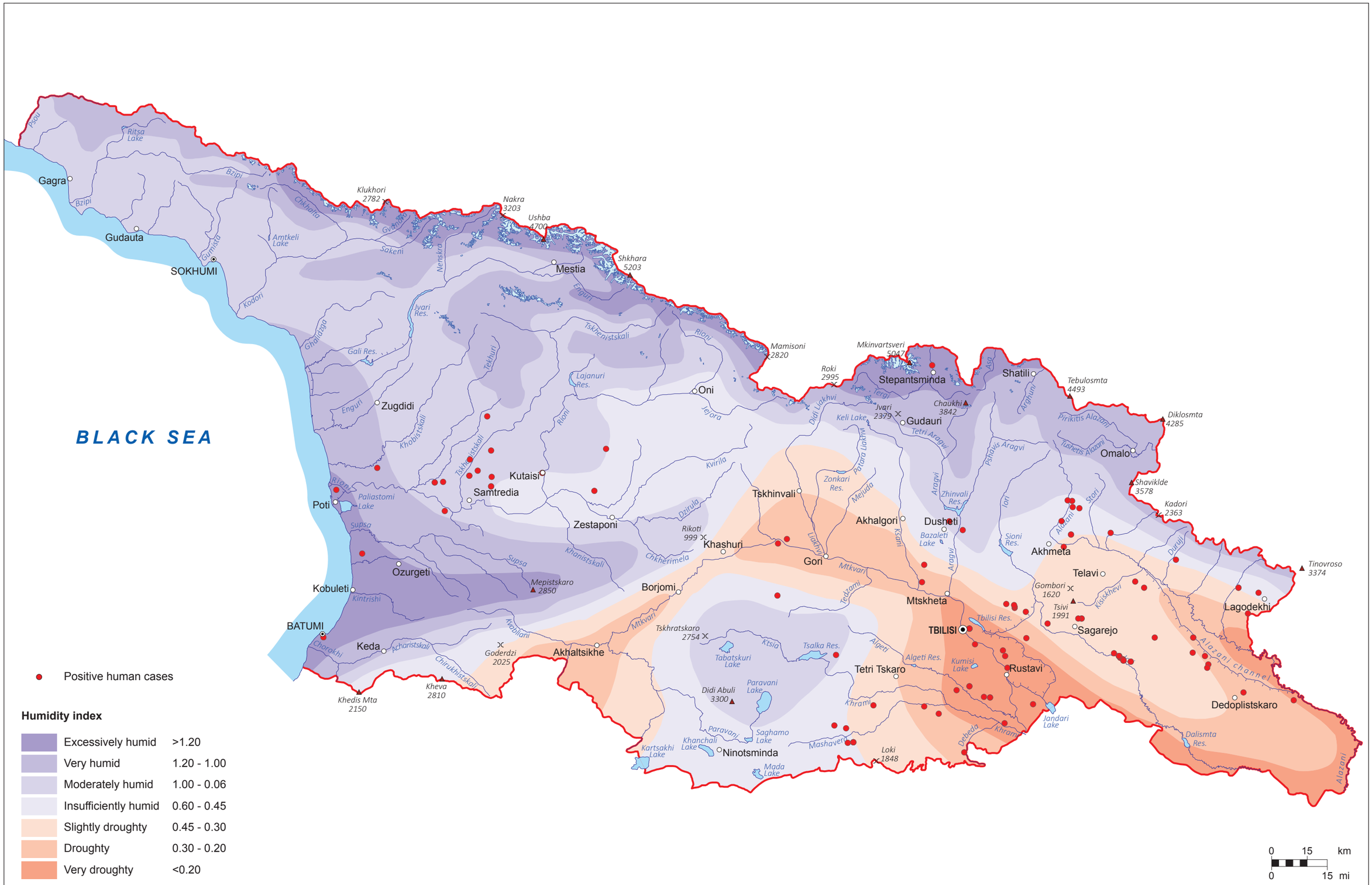
Distribution of Brucellosis Human Cases by Precipitation in the South Caucasus, 1950-2020



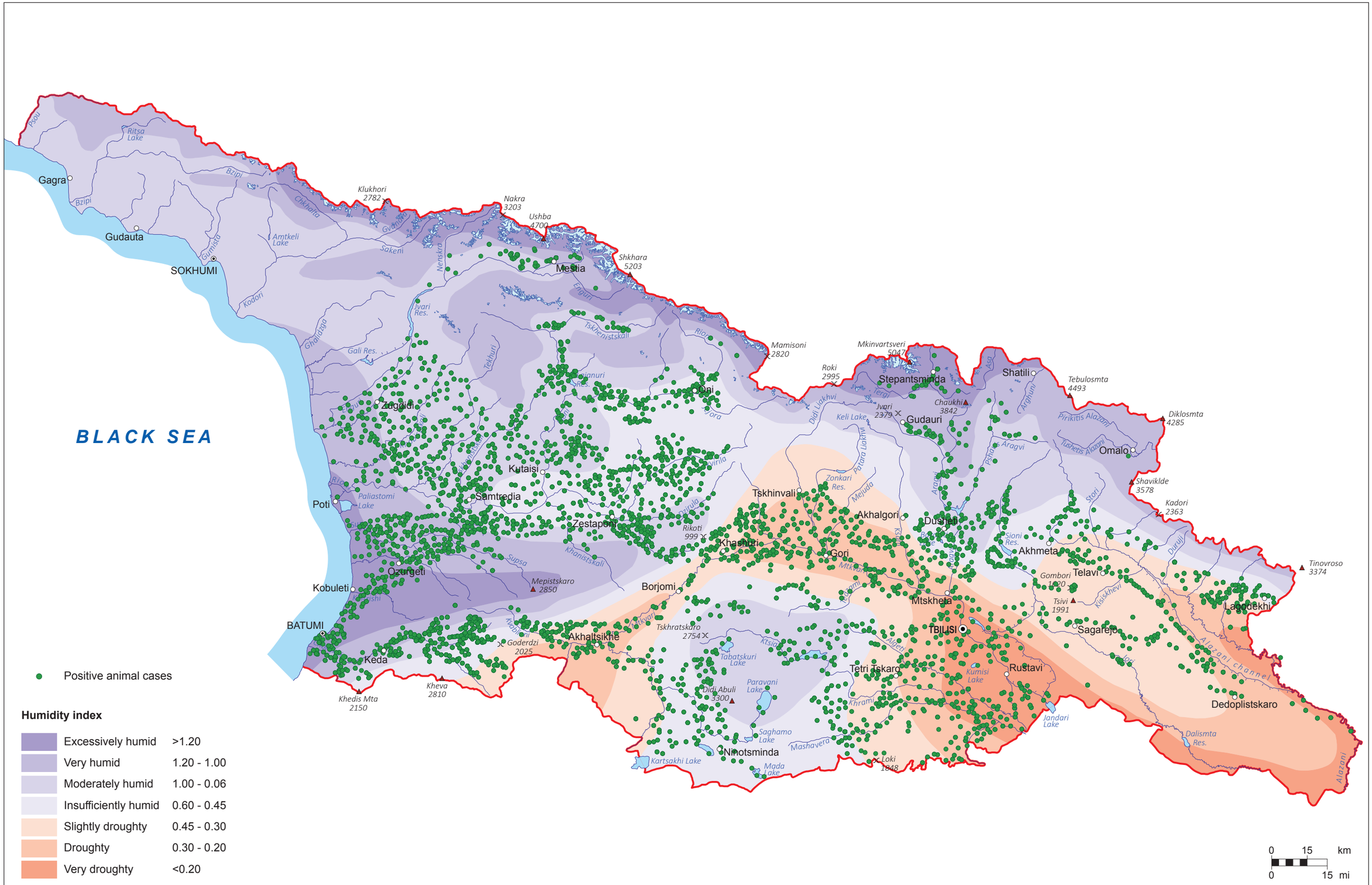
Distribution of Brucellosis Animal Cases by Precipitation in the South Caucasus, 1950-2020



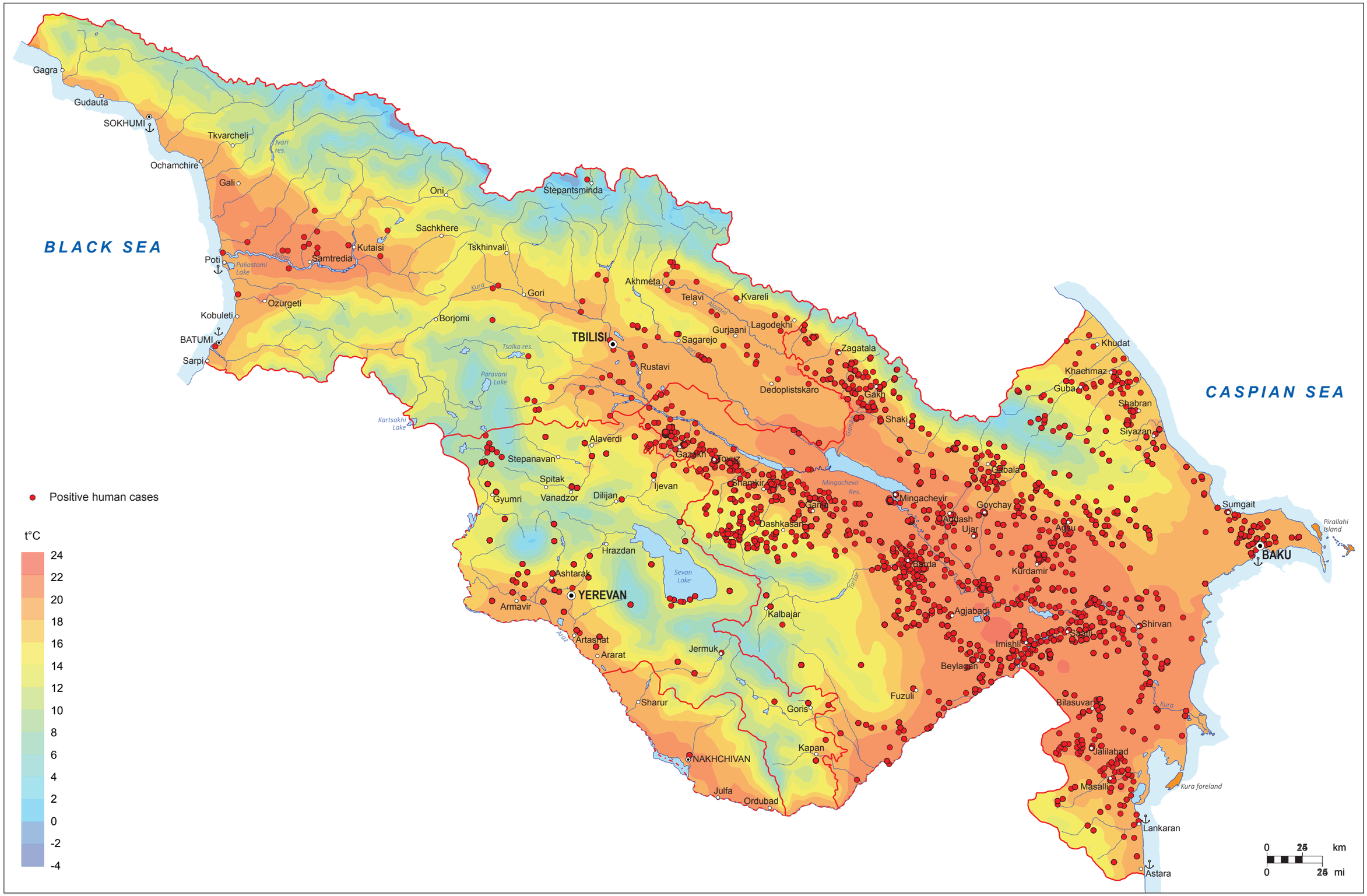
Distribution of Brucellosis Human Cases by Humidity Index in Georgia, 1956-2020



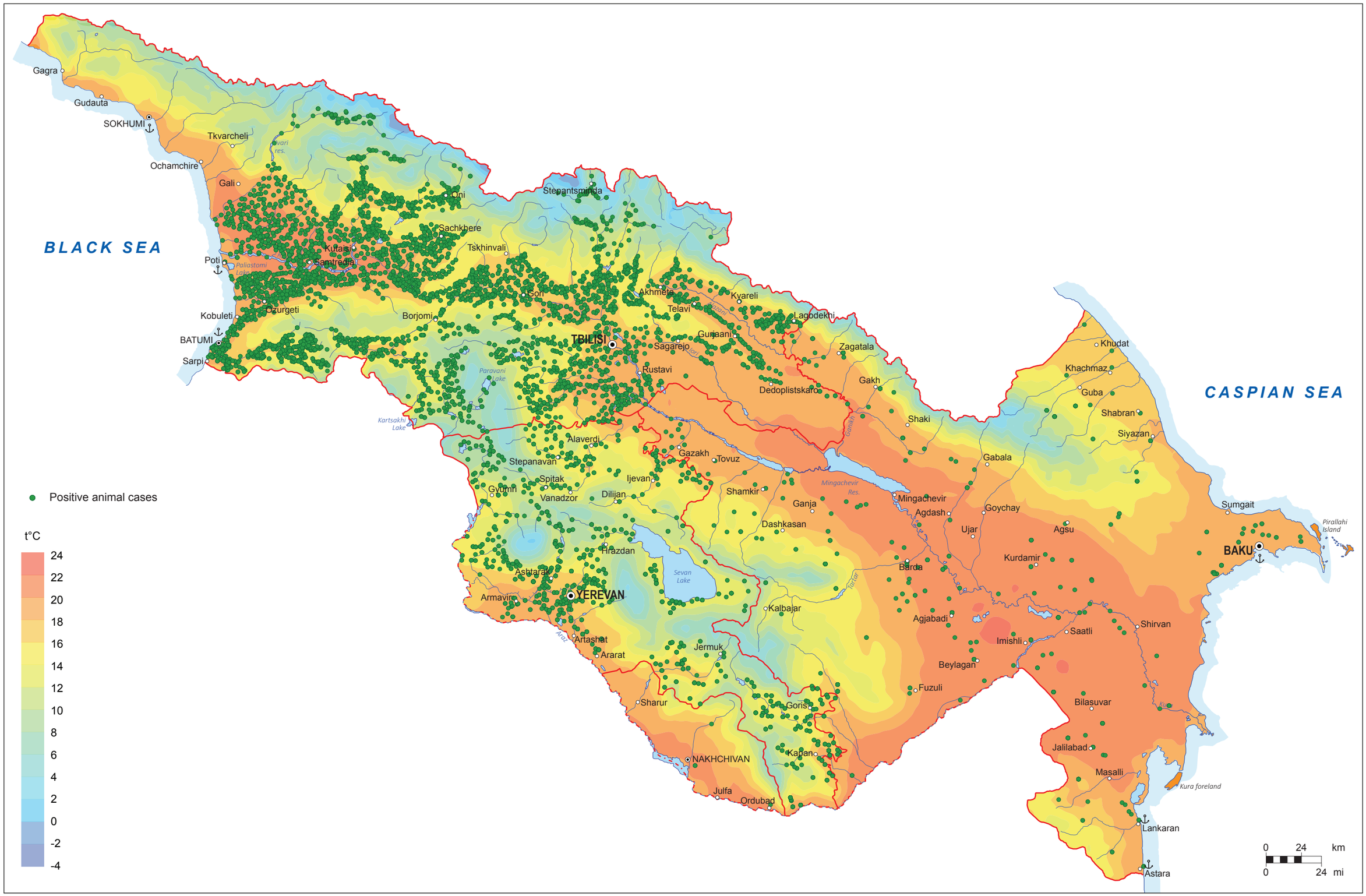
Distribution of Brucellosis Animal Cases by Humidity Index in Georgia, 1976-2020



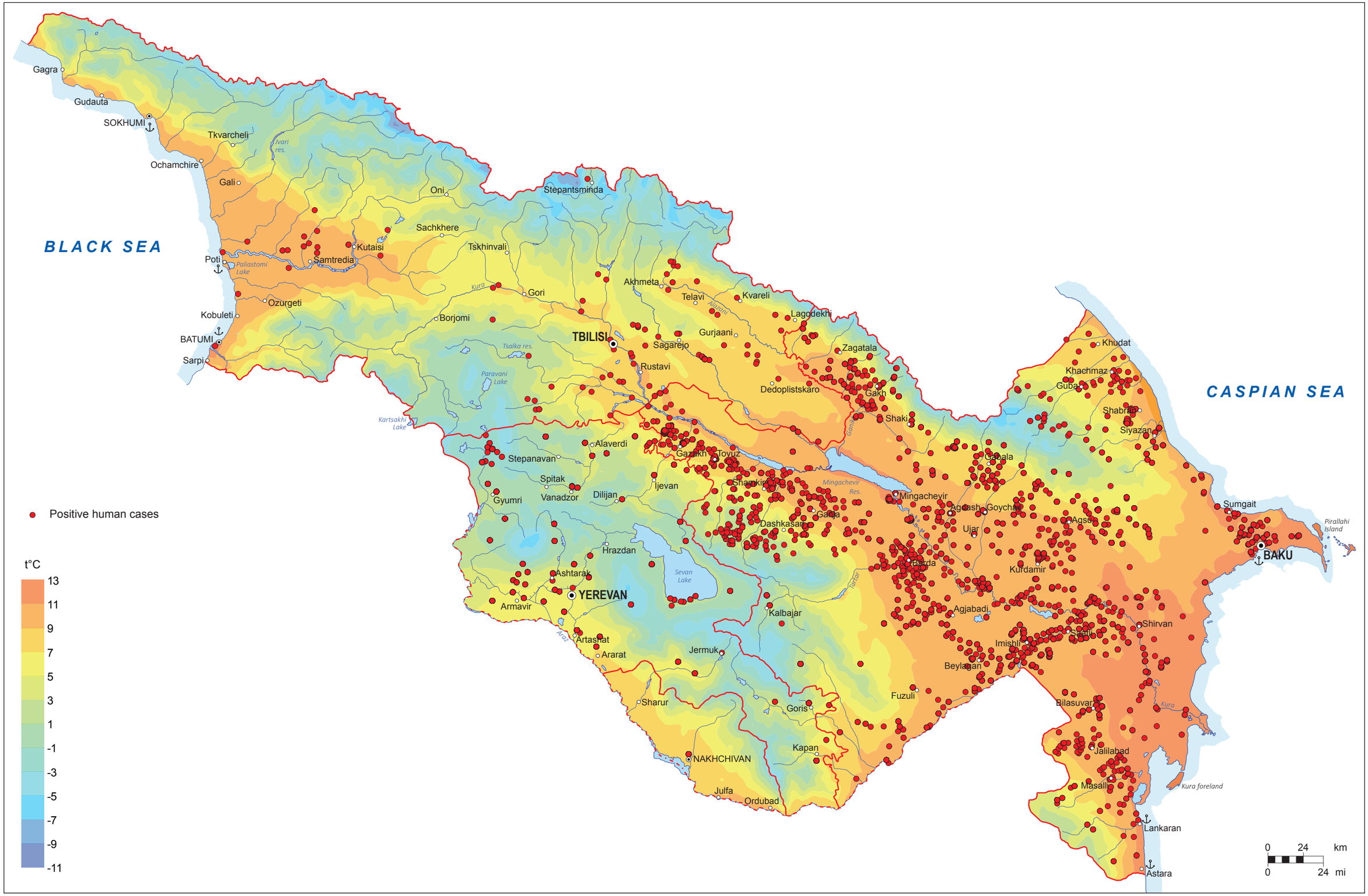
Distribution of Brucellosis Human Cases by Maximum Temperature in the South Caucasus, 1950-2020



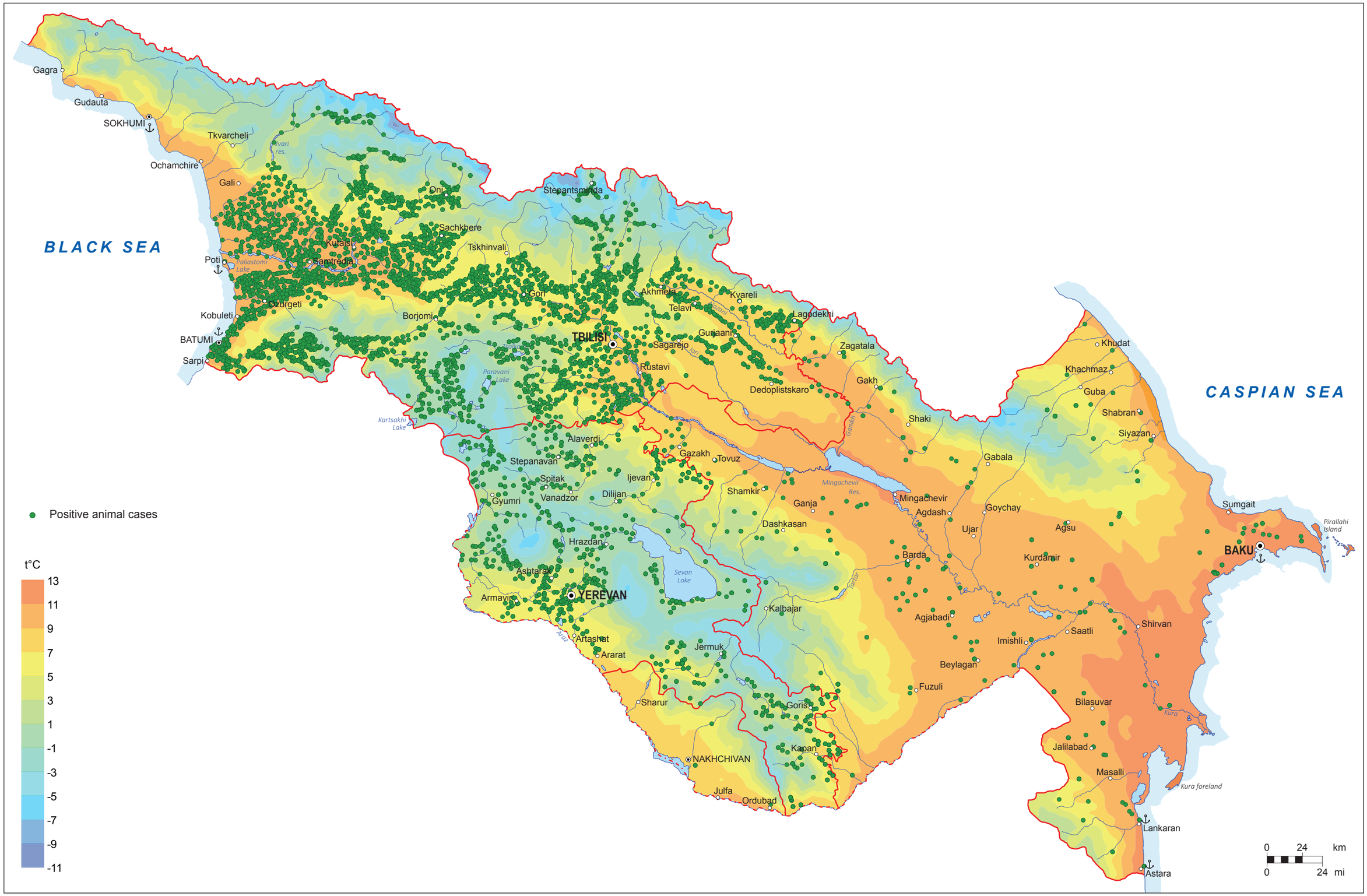
Distribution of Brucellosis Animal Cases by Maximum Temperature in the South Caucasus, 1950-2020



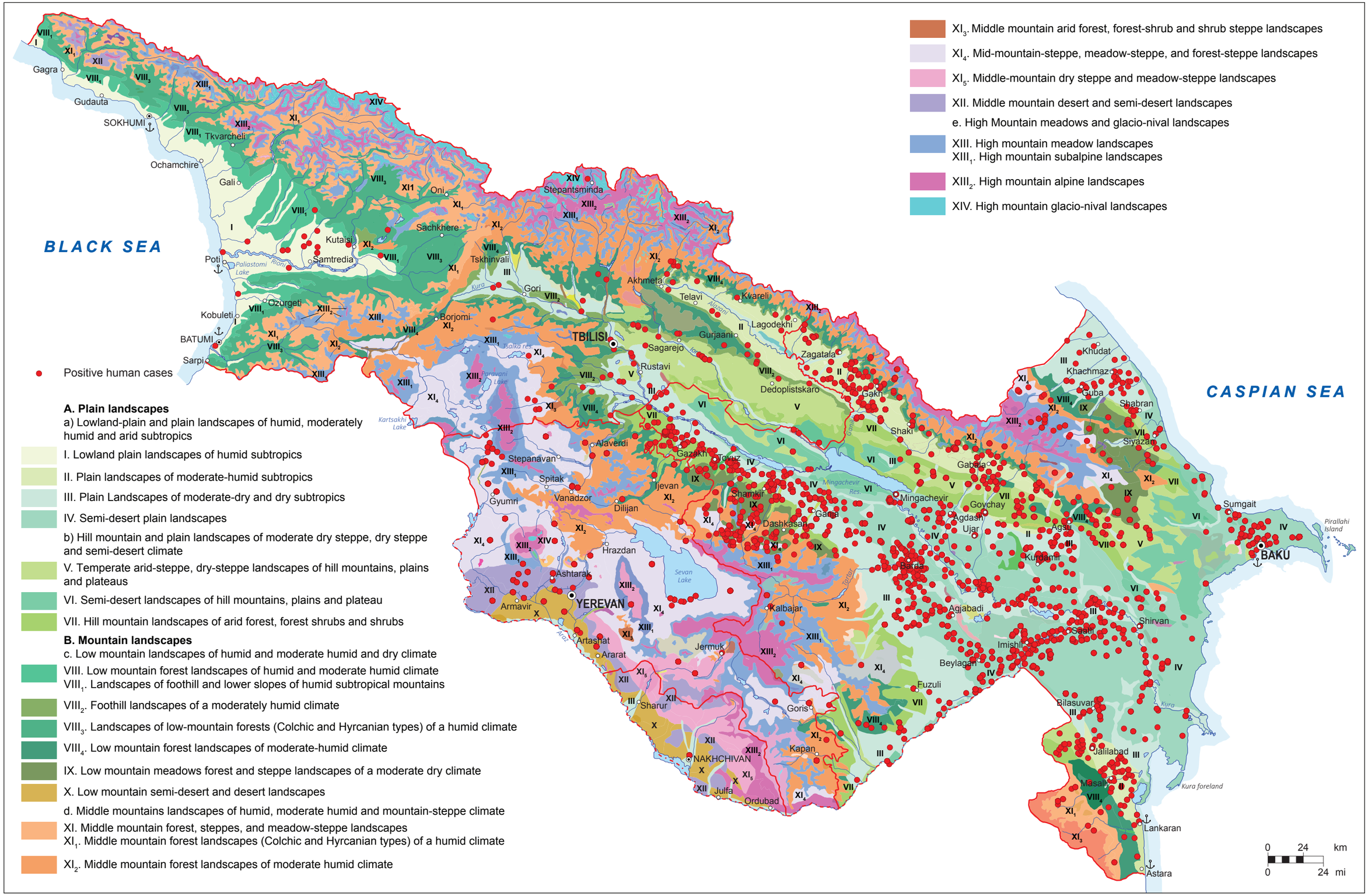
Distribution of Brucellosis Human Cases by Minimum Temperature in the South Caucasus, 1950-2020



Distribution of Brucellosis Animal Cases by Minimum Temperature in the South Caucasus, 1950-2020



Distribution of Brucellosis Human Cases by Landscape in the South Caucasus, 1950-2020



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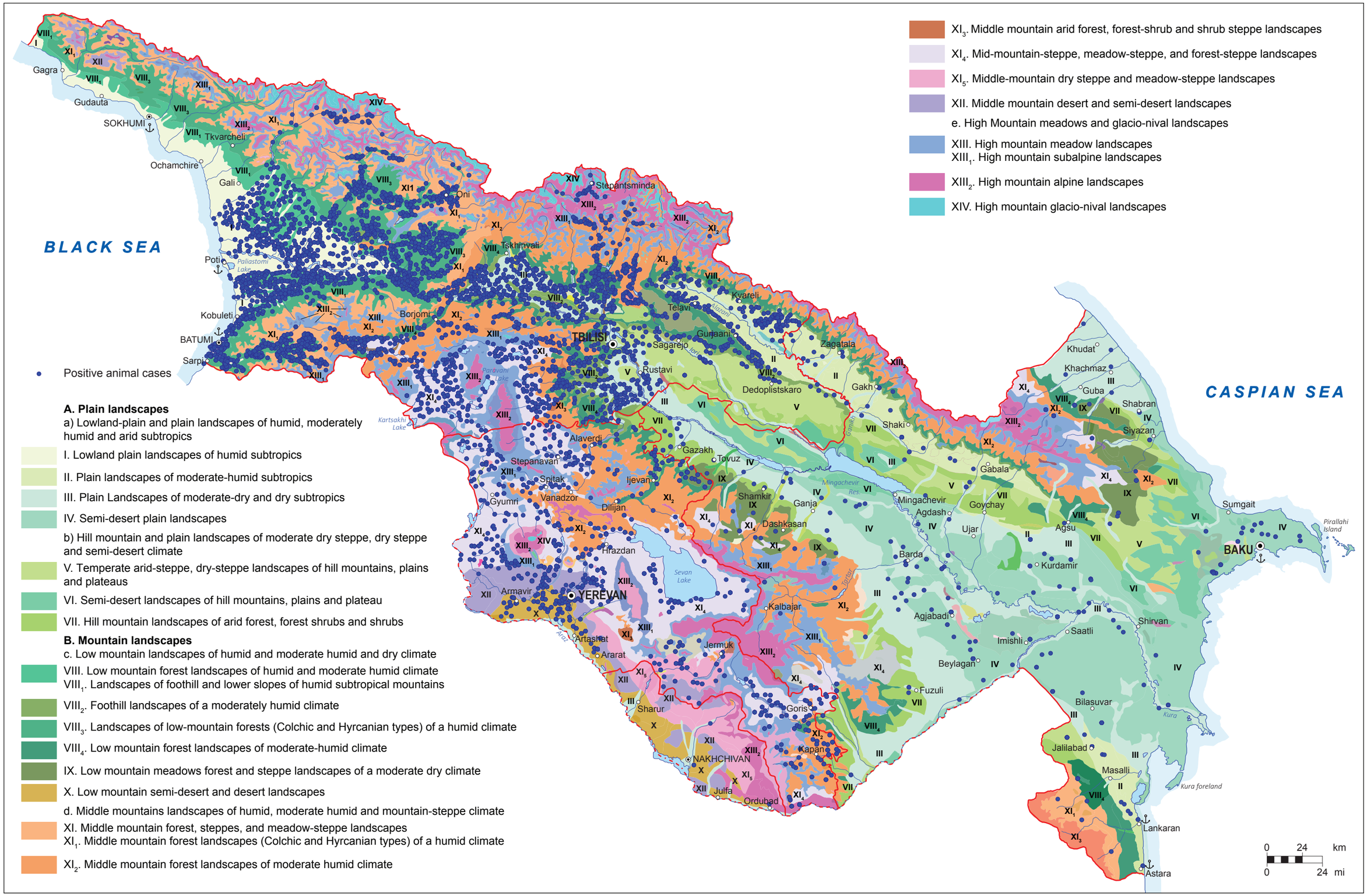


- Positive animal cases

A. Plain landscapes

a) Lowland-plain and plain landscapes of humid, moderately humid and arid subtropics

I. Lowland plain landscapes of humid subtropics

II. Plain landscapes of moderate-humid subtropics

III. Plain Landscapes of moderate-dry and dry subtropics

IV. Semi-desert plain landscapes

b) Hill mountain and plain landscapes of moderate dry steppe, dry steppe and semi-desert climate

V. Temperate arid-steppe, dry-steppe landscapes of hill mountains, plains and plateaus

VI. Semi-desert landscapes of hill mountains, plains and plateau

VII. Hill mountain landscapes of arid forest, forest shrubs and shrubs

B. Mountain landscapes

c. Low mountain landscapes of humid and moderate humid and dry climate

VIII. Low mountain forest landscapes of humid and moderate humid climate

$VIII_1$. Landscapes of foothill and lower slopes of humid subtropical mountains

$VIII_2$. Foothill landscapes of a moderately humid climate

$VIII_3$. Landscapes of low-mountain forests (Colchic and Hyrcanian types) of a humid climate

$VIII_4$. Low mountain forest landscapes of moderate-humid climate

IX. Low mountain meadows forest and steppe landscapes of a moderate dry climate

X. Low mountain semi-desert and desert landscapes

d. Middle mountains landscapes of humid, moderate humid and mountain-steppe climate

XI. Middle mountain forest, steppes, and meadow-steppe landscapes

XI_1. Middle mountain forest landscapes (Colchic and Hyrcanian types) of a humid climate

XI_2. Middle mountain forest landscapes of moderate humid climate

XI_3. Middle mountain arid forest, forest-shrub and shrub steppe landscapes

XI_4. Mid-mountain-steppe, meadow-steppe, and forest-steppe landscapes

XI_5. Middle-mountain dry steppe and meadow-steppe landscapes

XII. Middle mountain desert and semi-desert landscapes

e. High Mountain meadows and glacio-nival landscapes

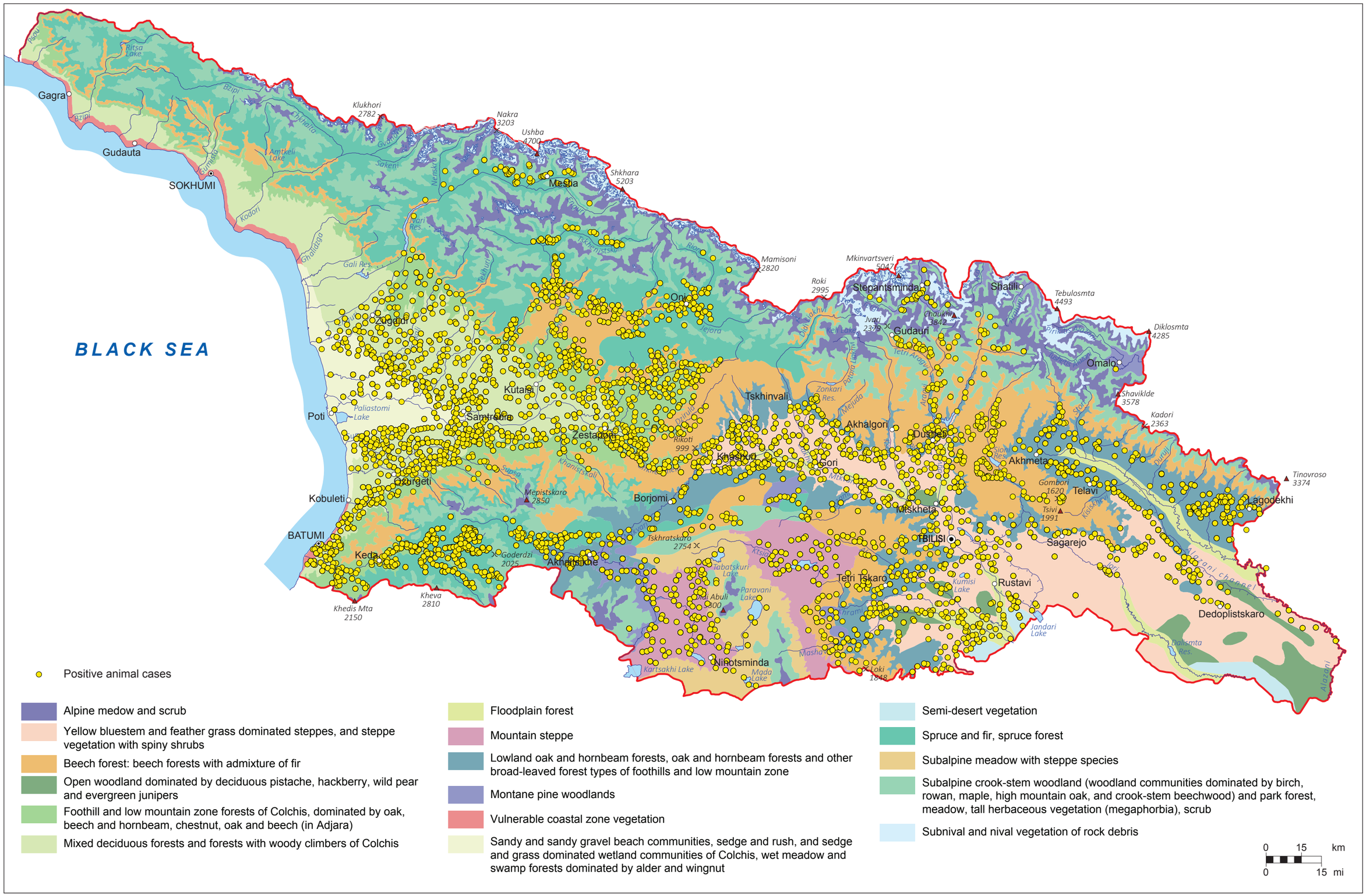
XIII. High mountain meadow landscapes

$XIII_1$. High mountain subalpine landscapes

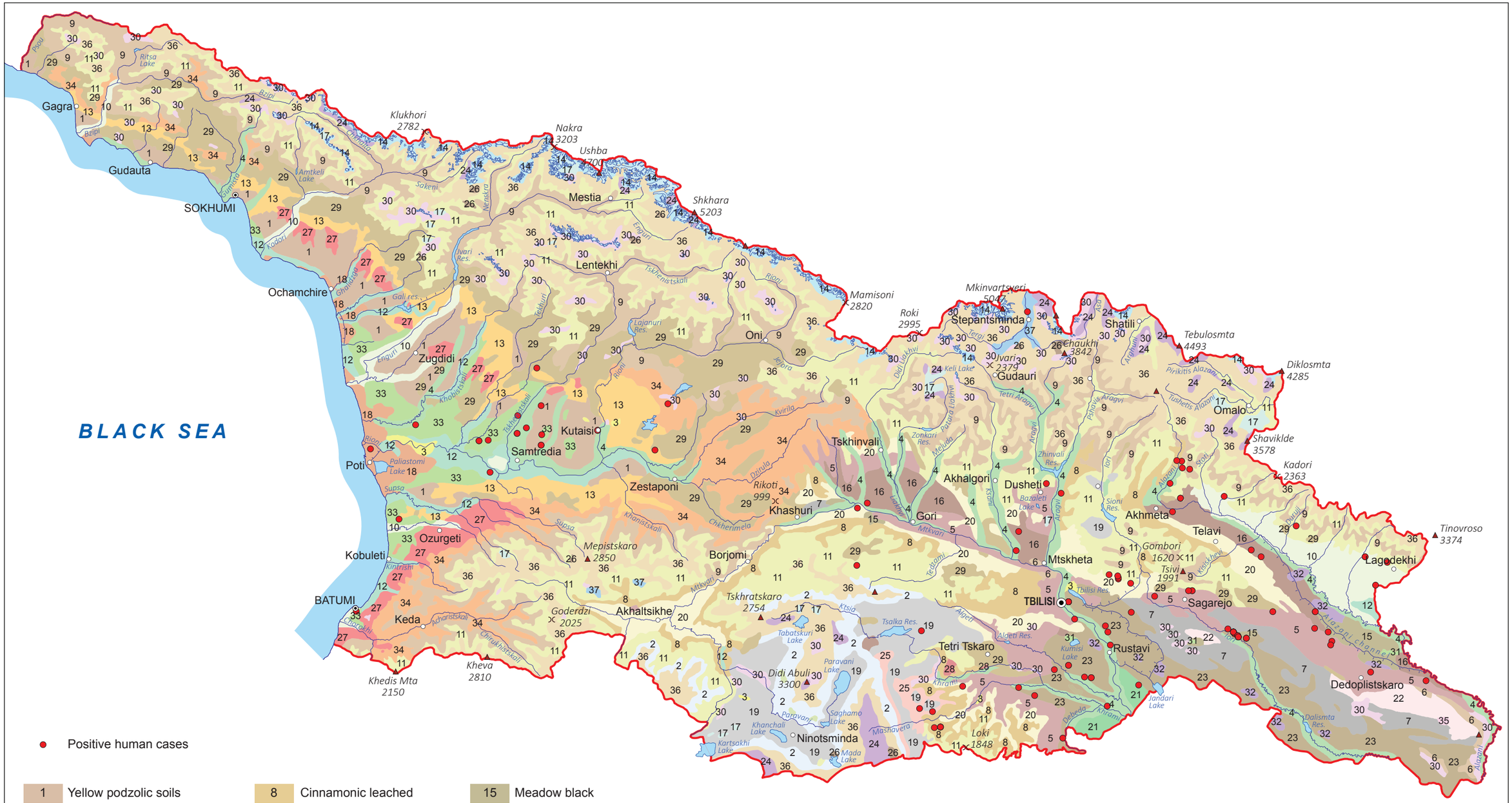
$XIII_2$. High mountain alpine landscapes

XIV. High mountain glacio-nival landscapes

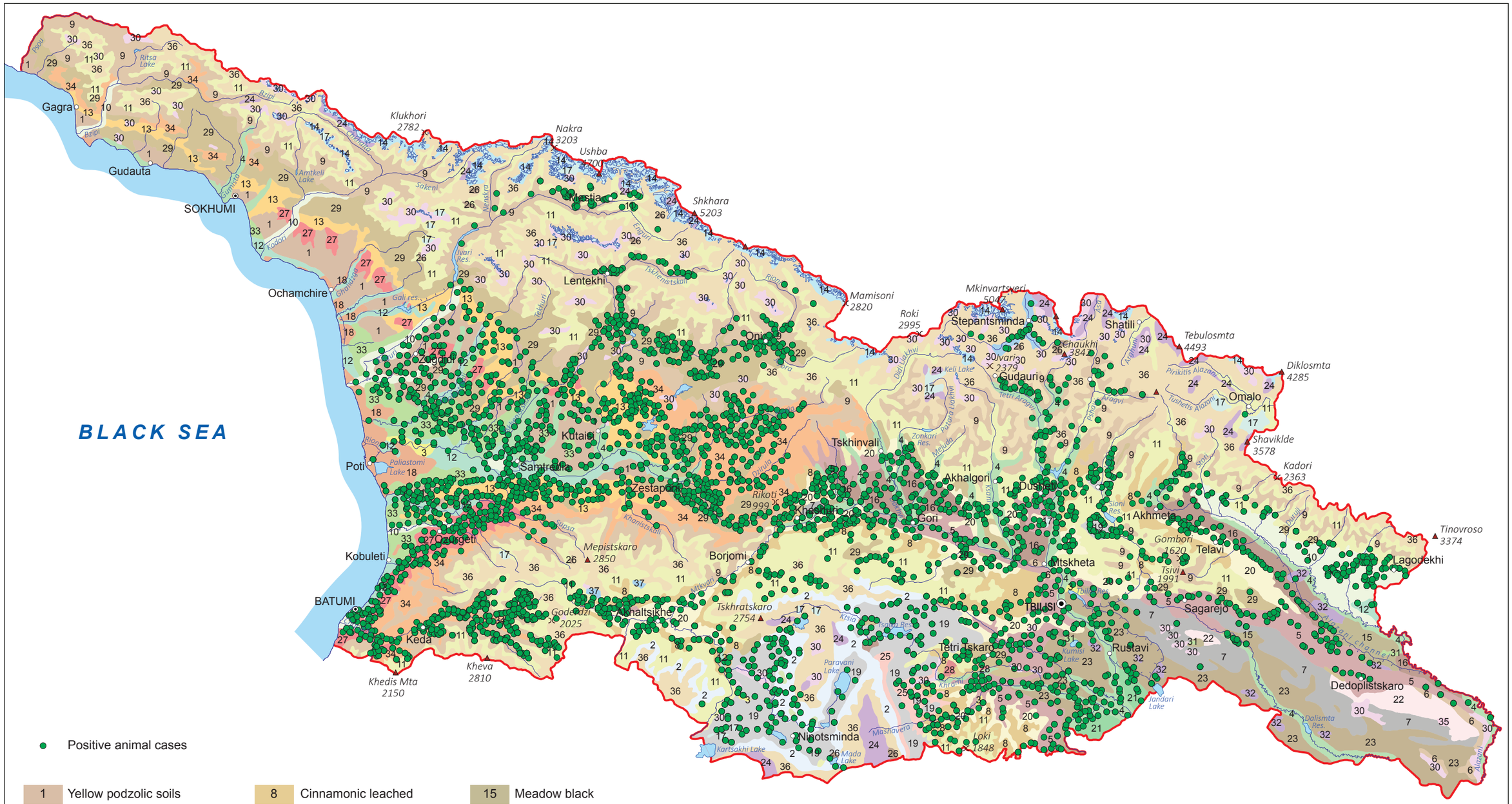
Distribution of Brucellosis Animal Cases by Vegetation in Georgia, 1976-2020



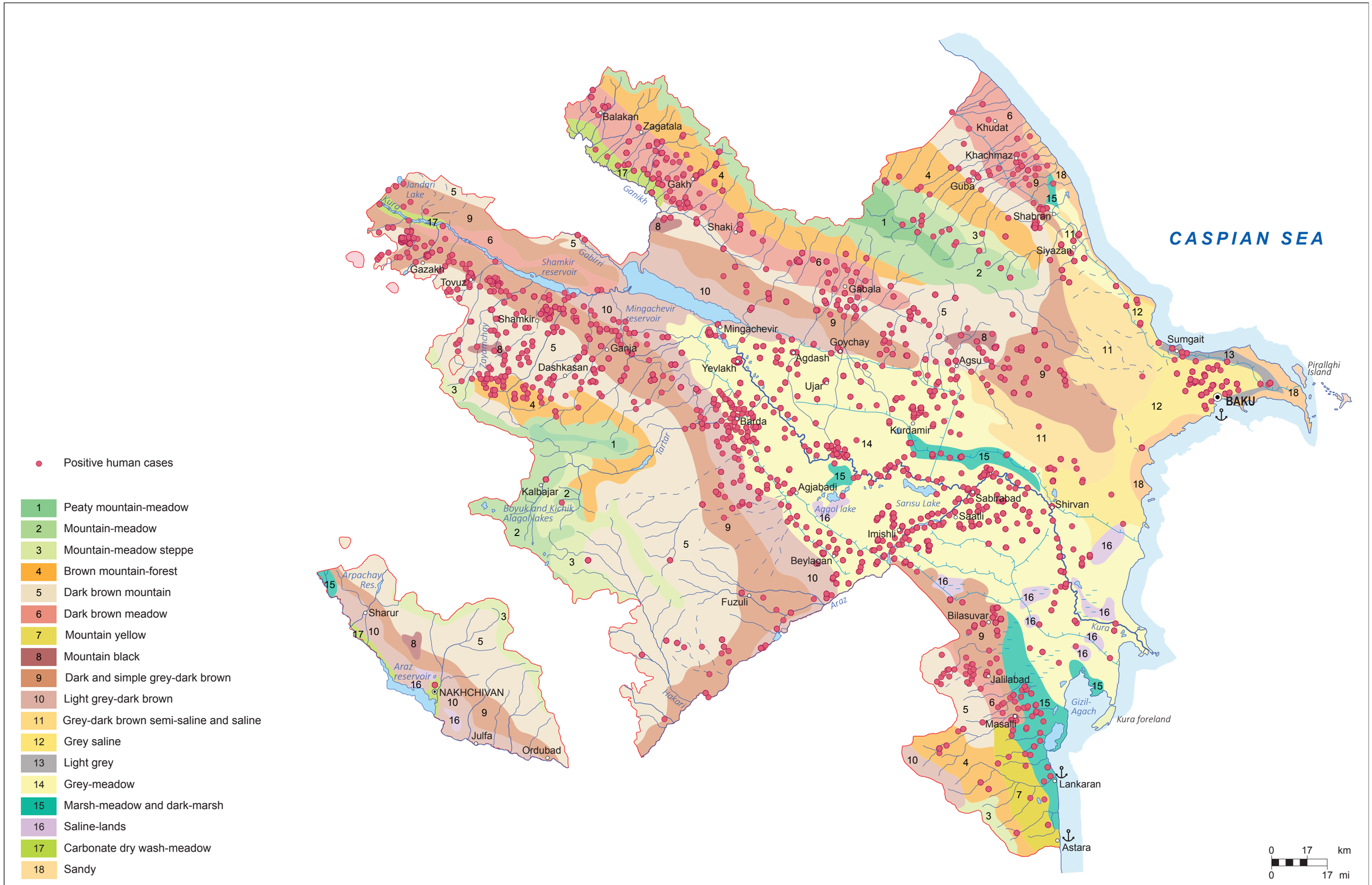
Distribution of Brucellosis Human Cases by Soil Types in Georgia, 1956-2020



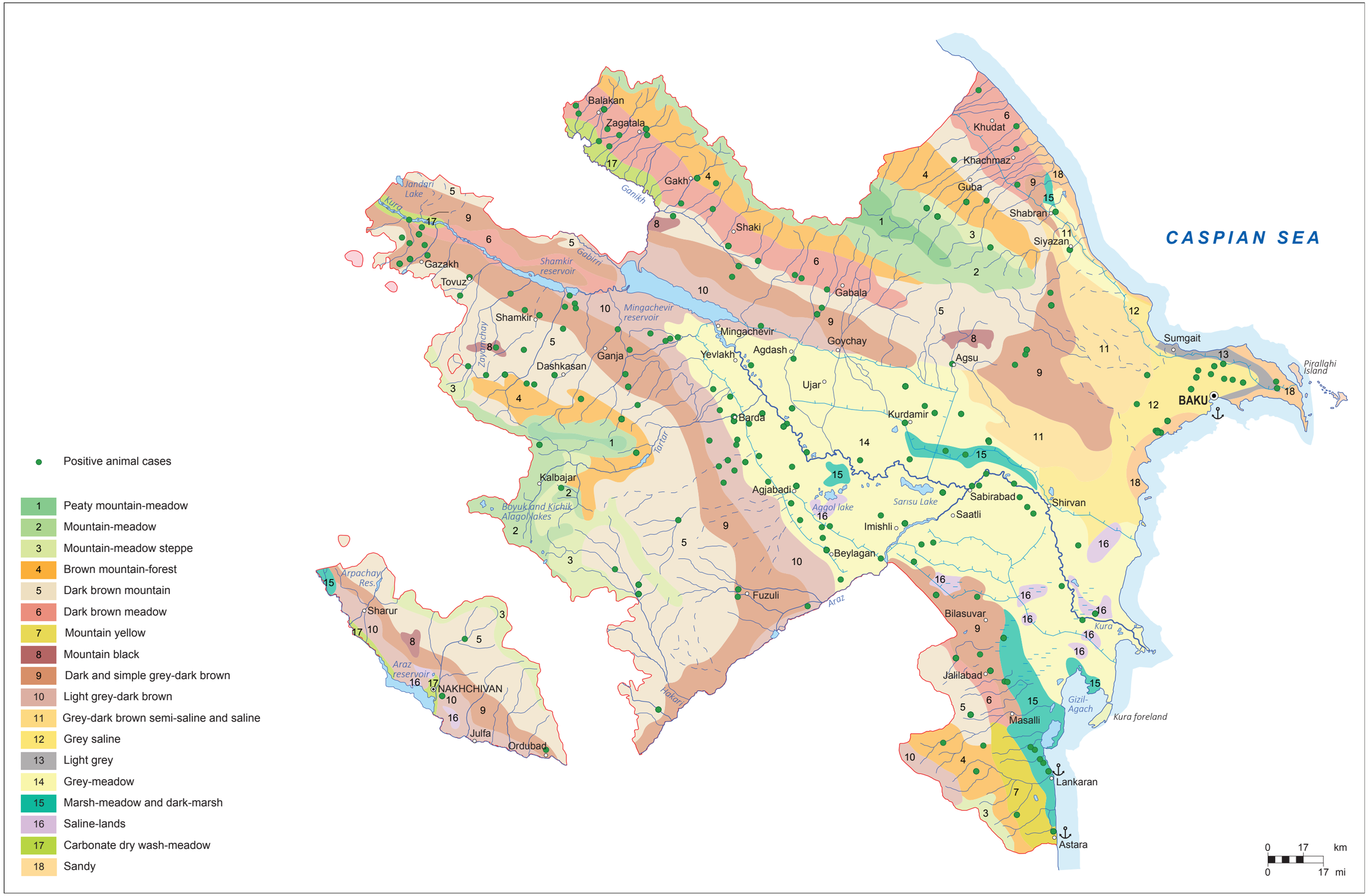
Distribution of Brucellosis Animal Cases by Soil Types in Georgia, 1976-2020



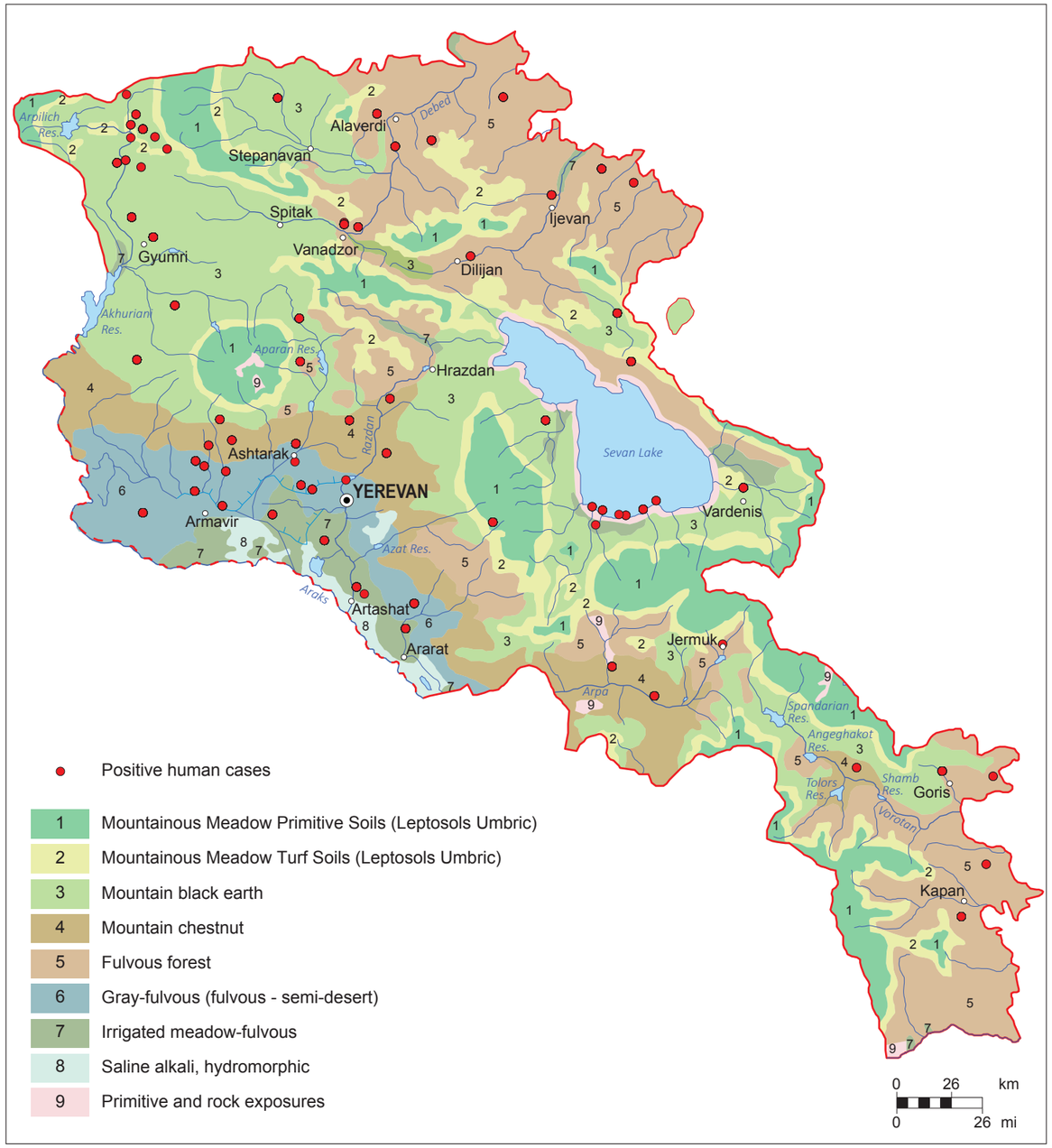
Distribution of Brucellosis Human Cases by Soil Types in Azerbaijan, 1950-2020



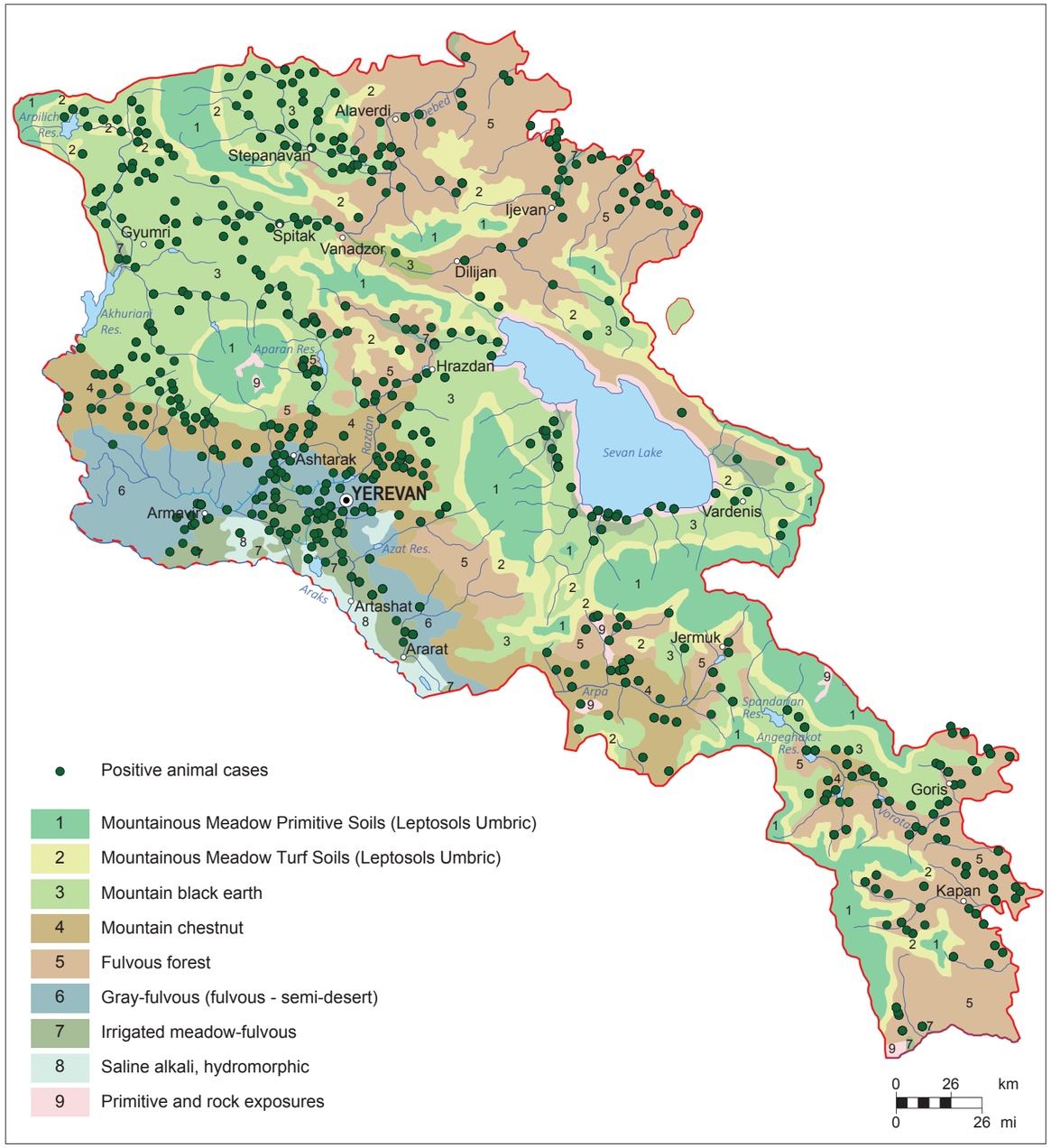
Distribution of Brucellosis Animal Cases by Soil Types in Azerbaijan, 1965-2020



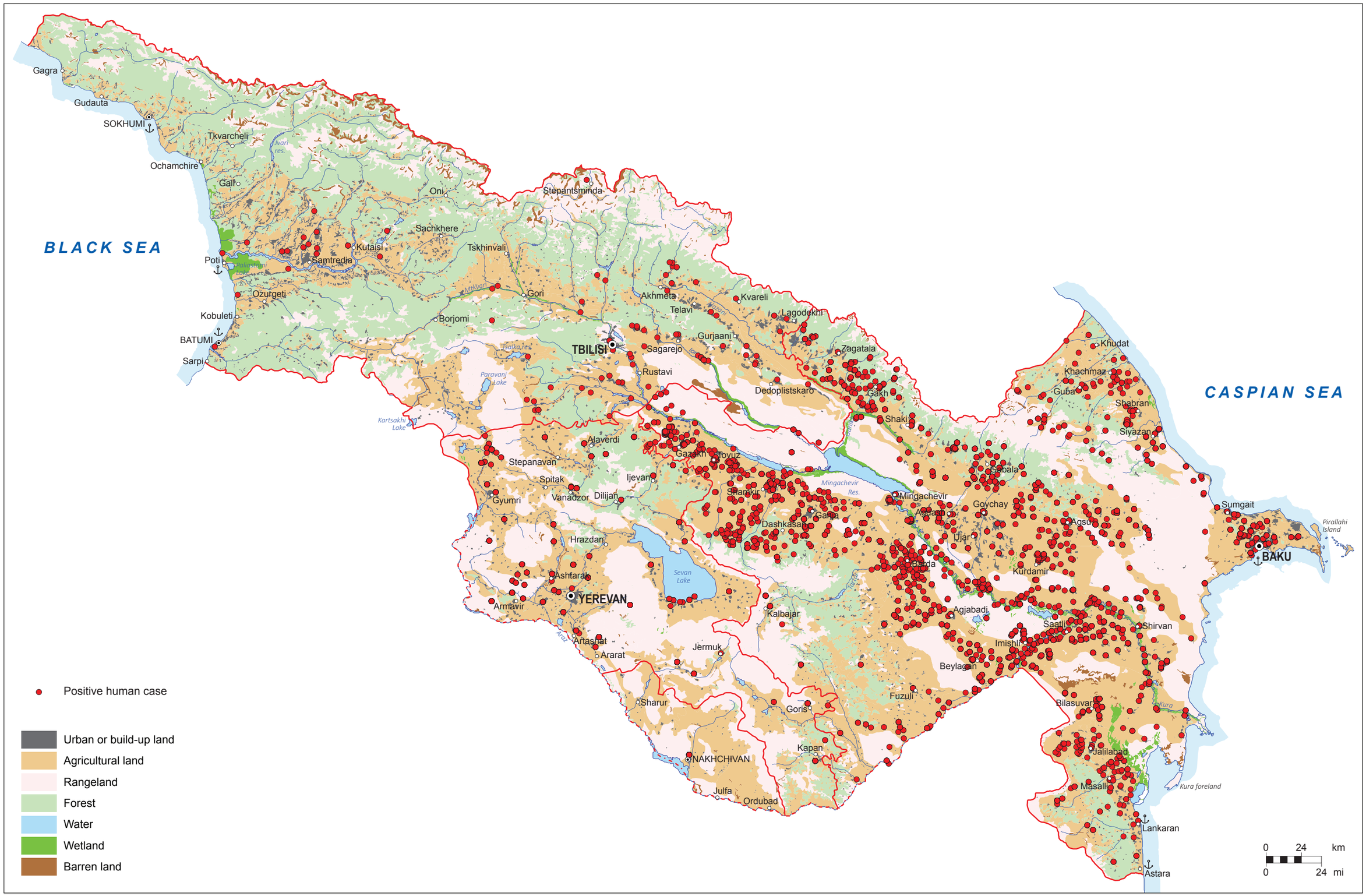
Distribution of Brucellosis Human Cases by Soil Types in Armenia, 1960-2020



Distribution of Brucellosis Animal Cases by Soil Types in Armenia, 1950-2020



Distribution of Brucellosis Human Cases by Land Use in the South Caucasus, 1950-2020



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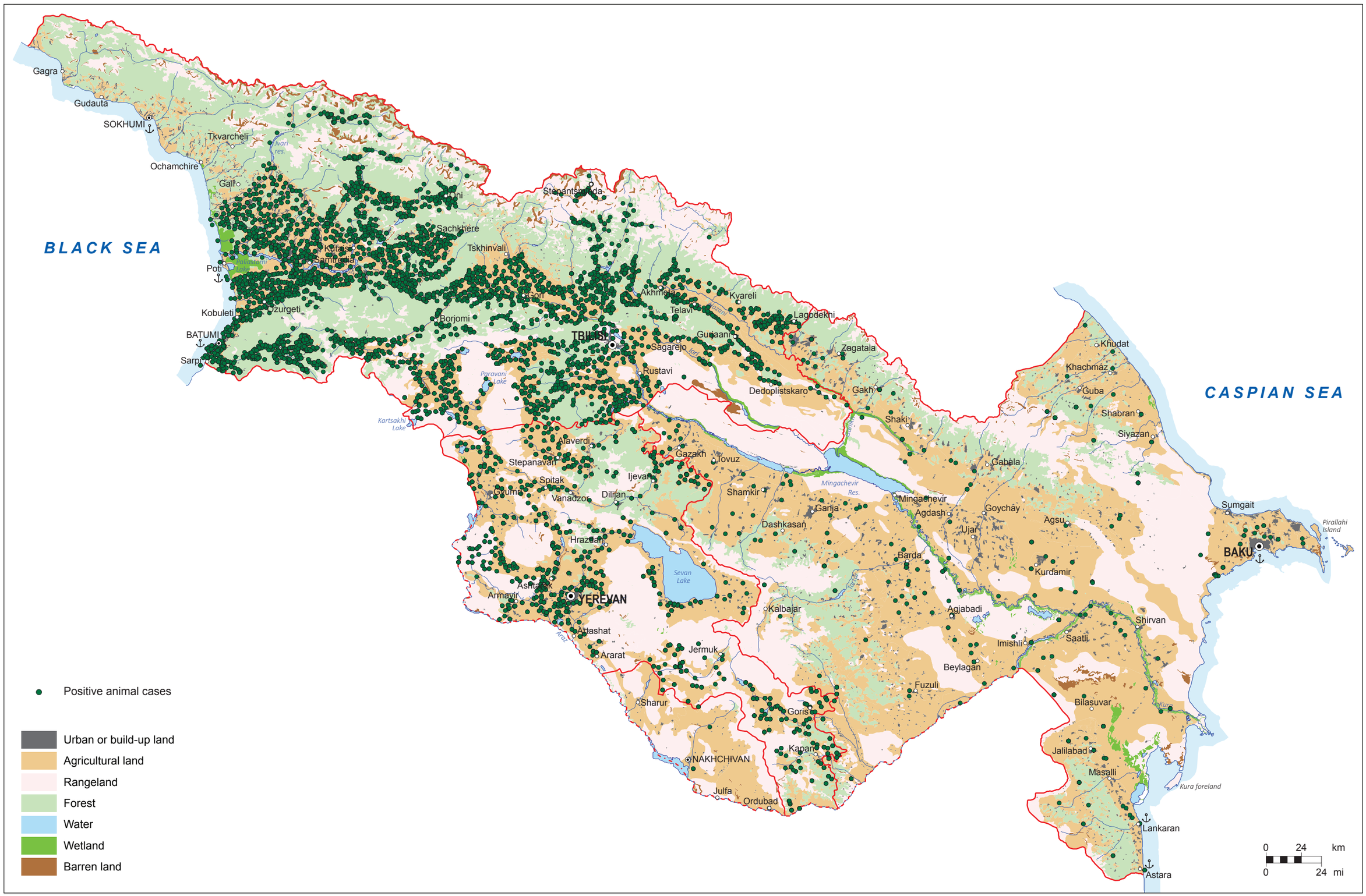
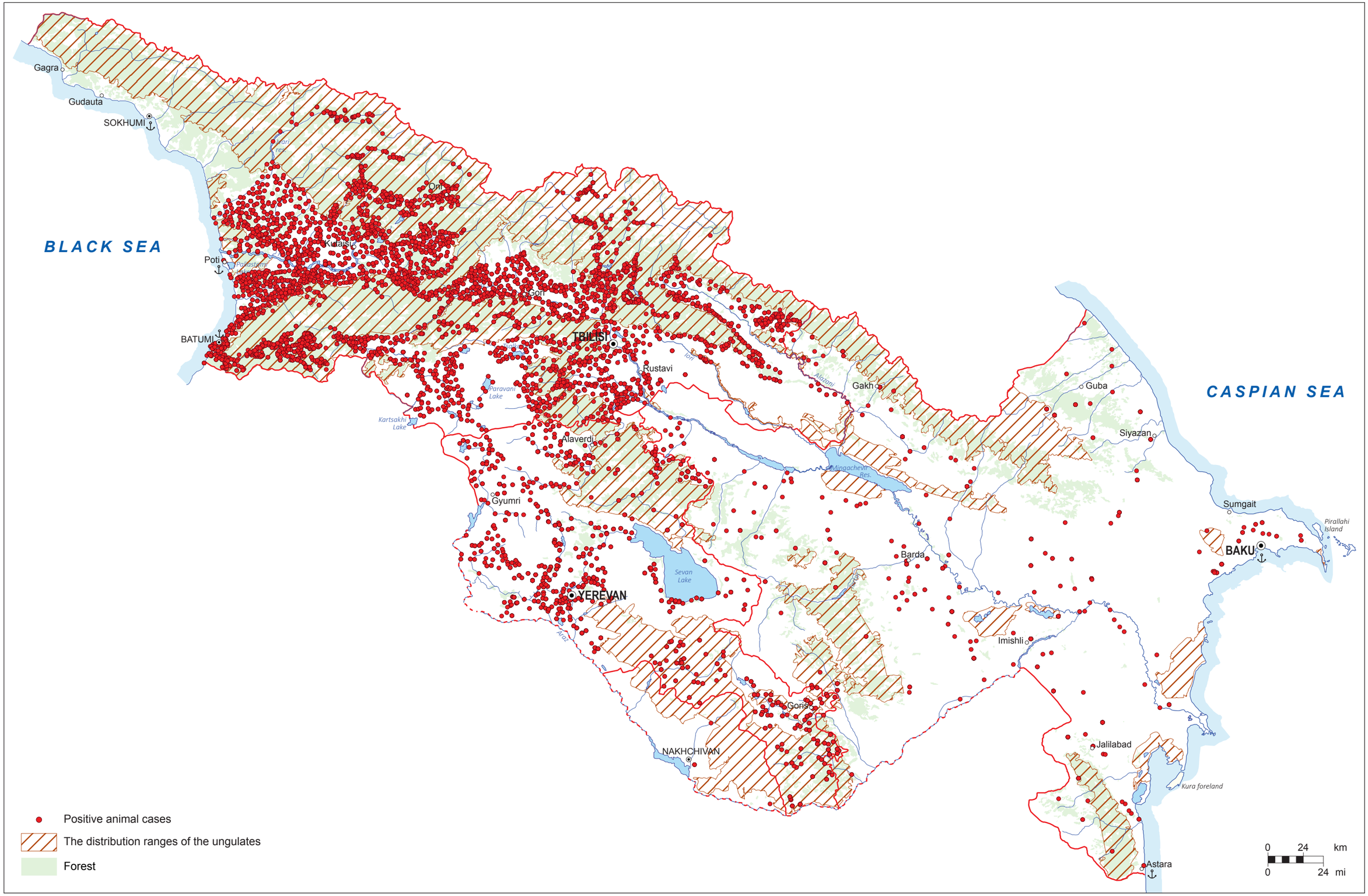
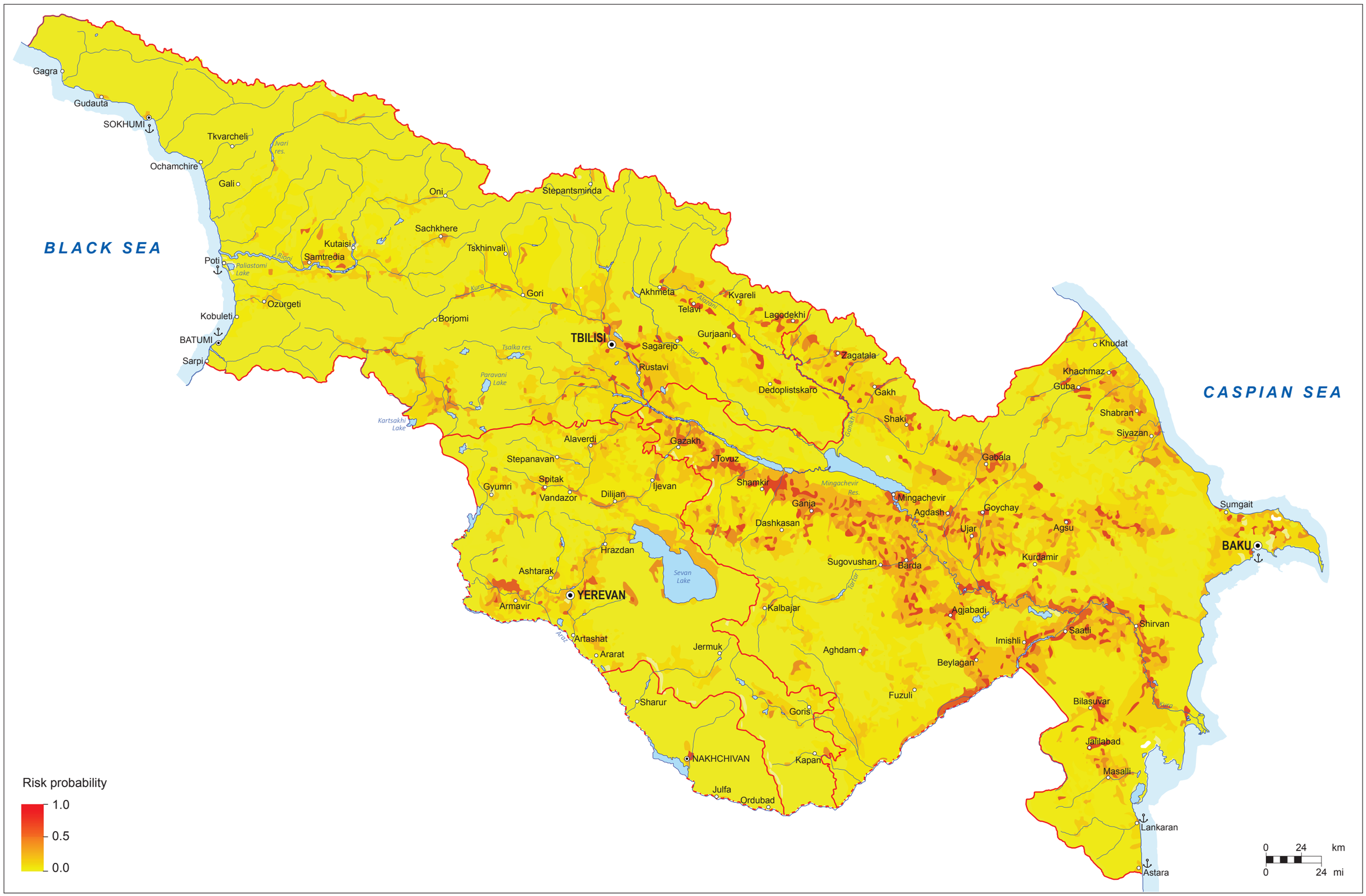


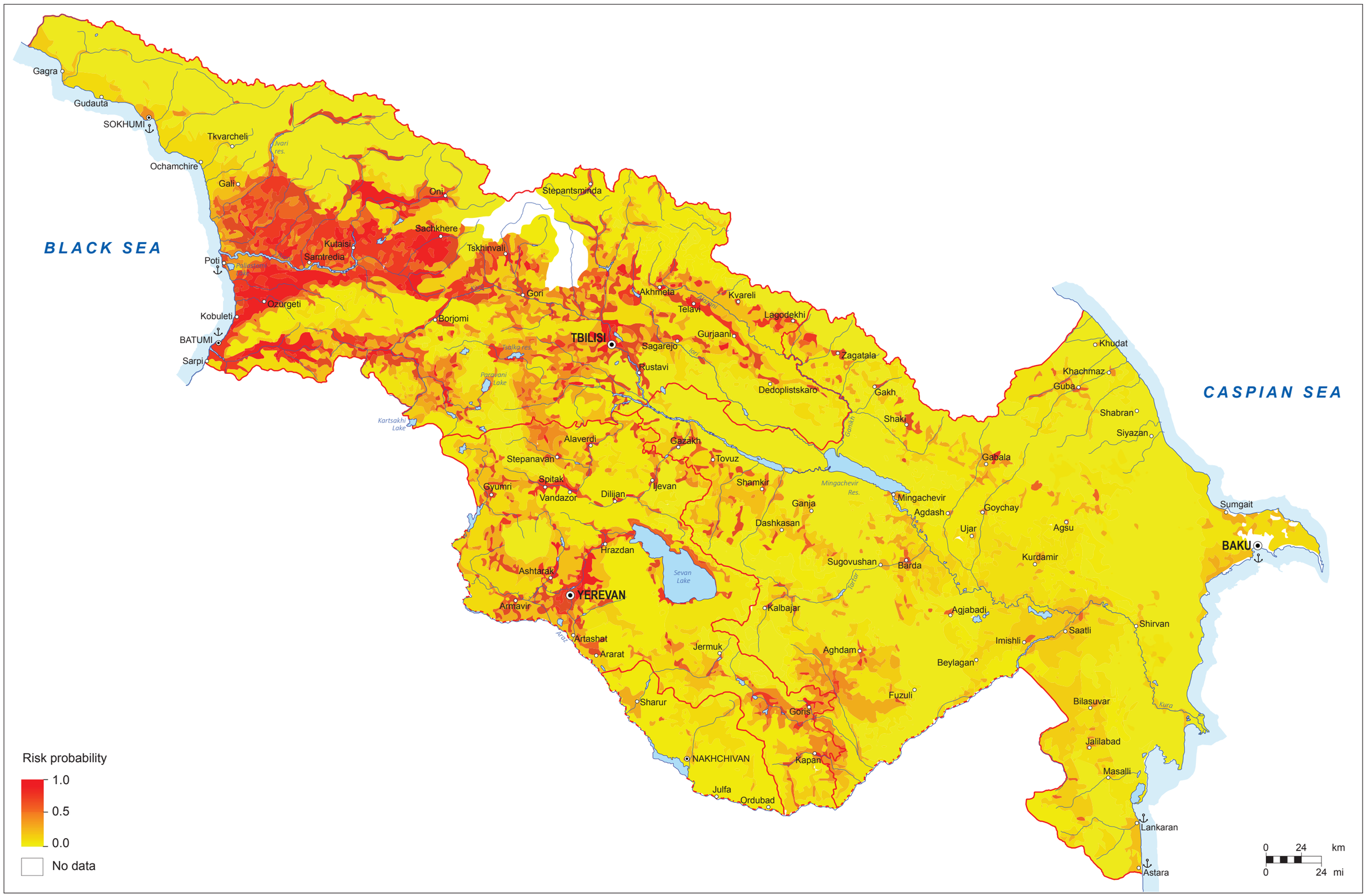
Distribution of Brucellosis Animal Cases and Distribution Ranges of Ungulates in the South Caucasus, 1950-2020



Brucellosis Human Cases Risk in the South Caucasus



Brucellosis Animal Cases Risk in the South Caucasus

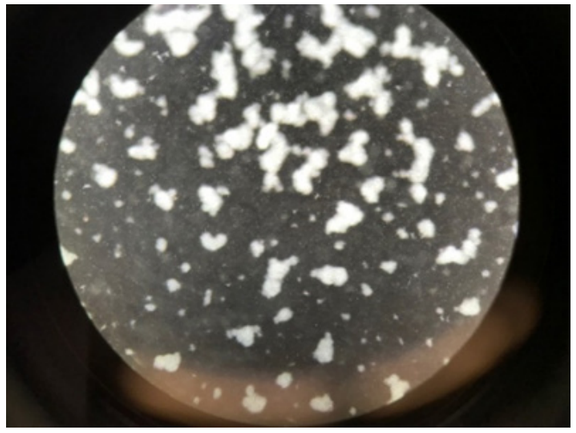


Leptospirosis

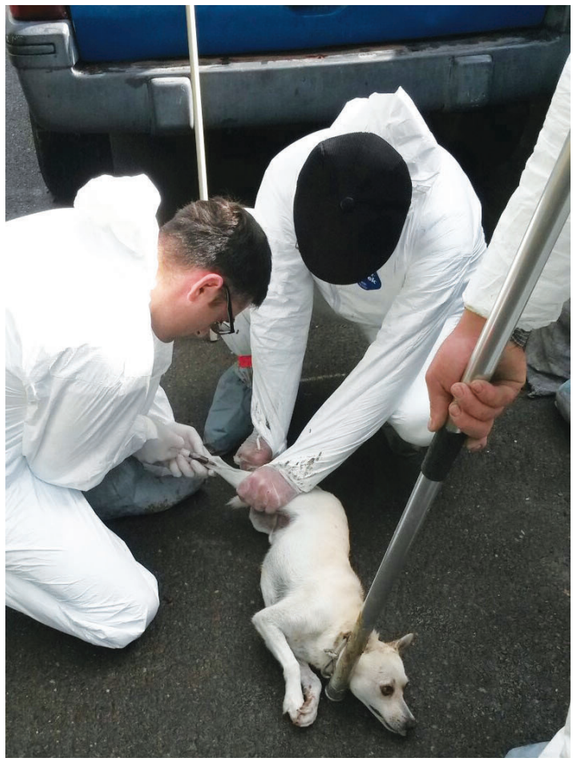
Leptospirosis, caused by gram negative bacteria of the genus Leptospira, affects humans and animals. Leptospirosis is the world's most widespread zoonosis, with estimated one million cases and 600,000 deaths per year. Humans become infected via direct contact with infected animal urine or from urine-contaminated environments. Bacteria contaminates water or soil, where it can persist for weeks or months. Infected animals may show no symptoms of disease and continue to excrete the bacteria into the environment. Leptospirosis outbreaks are commonly associated with floods and natural disasters and occur in both rural and urban areas. The bacteria can enter the body through damaged skin or the mucous membranes of the eyes, nose, or mouth. Human-to-human transmission is rare and infection rarely occurs through animal bites. Although rodents are an important reservoir for Leptospira, most mammals such as dogs, cattle, horses, pigs, and many other wildlife species can also be infected. Leptospirosis is a significant public health problem and is nationally notifiable condition in most countries.

Morbidity and mortality are highest in sub-Saharan Africa, Latin America and the Caribbean, as well as in South and Southeast Asia and Oceania. Leptospirosis occurs most often in adults and it is more common in men which may be related to increased risk of exposure. Worldwide, incidence is higher in tropical areas, and peaks during the rainy season. *Leptospira* serovar and species vary by different region. More than 300 pathogenic serovars are classified according to their antigenic properties. Leptospirosis can be co-infected with dengue, malaria, rickettsia and HIV infection. The average incubation period of Leptospirosis is 5 to 14 days, but can last up to 30 days.

Avoiding exposure to potentially contaminated fresh and flood waters, as well as potentially infected animals or their body fluids and areas infested with rodents is the most effective way to prevent leptospirosis. At times of increased risk, it is advisable to take additional preventive measures such as wearing protective clothing, especially shoes. Raising awareness about the risks of the disease is of the utmost importance. Boiling or chemical treatment of potentially contaminated drinking water is recommended for populations at risk of leptospirosis. Chemoprophylaxis with doxycycline 1 to 2 days before and during the exposure period may be effective in preventing clinical disease in adults and may be considered for high-risk and short-term exposures. A human vaccine is not widely available except in a limited number of countries.



Leptospira viewed with dark-field microscope © Nazibrola Chitadze



Animal samples collection (from a stray dog) for Leptospirosis laboratory investigation © Tengiz Chaligava

Alive trapped rodent for Leptospirosis laboratory investigation © Vaja Chitiashvili

Early diagnosis is crucial for leptospirosis treatment. Diagnosis relies on serological studies in all three countries. Oral antibiotics are recommended for mild cases, and large doses of penicillin are prescribed for severe cases. Therefore, it is imperative that individuals with symptoms of leptospirosis immediately seek a medical provider. In some cases, in addition to antibiotic therapy, other treatment methods such as dialysis and hydration therapy may be necessary. If a pet is diagnosed with leptospirosis, the next steps to be taken will depend on the type of contact with the pet. If there is no contact with the animal's biological fluids and tissues and no assistance during birth, then it is not considered high risk. If fever, muscle pain, or headache develop within three weeks of high-risk contact with an infected pet, a physician should be consulted to determine whether the disease has developed. There are both mild and severe forms of the disease which can cause life-threatening complications such as severe bleeding from the lungs. In untreated patients, recovery may take several months.

Data on Leptospirosis had been collected from all three countries from 1950 to 2019 from the publications, annual reports, public health centers, former anti-plague stations, veterinary centers, and ongoing and/or finished scientific projects.

Leptospirosis is an endemic disease in the South Caucasus and cases of human disease are registered almost every year in Georgia, more rarely in Armenia and Azerbaijan (p. 144-145).

Most of human cases occurred in the 20 to 60+ age group in all three countries. Distribution of human cases by gender is as follows: in Georgia about 60% of cases are male, in Armenia and Azerbaijan most human cases (~90%) are male. Most cases in Georgia present as Weil's syndrome, characterized by jaundice and renal failure. In Armenia and Azerbaijan most of the reported cases are mild, influenza-like illnesses. Animal positive cases in Armenia and Azerbaijan are registered among *Apodemus sp.* (recorded as *Apodemus sylvaticus)*, *Meriones persicus*, *Meriones vinogradovi*, *Microtus obscurus*, *Microtus socialis*, *Mus musculus*, *Rattus rattus*, and *Apodemus uralensis*. We were unable to collect animal data from Georgia due to the absence of archival records.

In Georgia, most human cases are found in the eastern part of the country, although cases are also common in the central and eastern parts of Georgia. In Armenia, cases are concentrated in the southwest part of the country, and cases in Azerbaijan are distributed throughout the country (p. 144-145). In Armenia, positive cases of animals (about 1,300 positive rodents) are also distributed throughout the country.

In western Georgia most human cases are reported in territories which have a humid climate with moderately cold winters and comparatively dry, hot summers (p. 148). In eastern Georgia, most cases are reported in transitional climate zones from moderately warm steppes to moderate humid climates with hot summers and with minimum precipitation twice a year (p. 148). In Azerbaijan, most of the human cases occur in semi-deserts and dry steppes with mild winters and dry, hot summers (p. 149). The majority of human cases in Armenia are registered in arid continental, with hot summers and cold winters (p. 151). It is also noteworthy that the vast majority of human cases in the entire South Caucasus are reported in agricultural settlements (p. 167). Based on the Humidity index, cases in Georgia are more common in areas around 1.20 to 1.00 (p. 154). Leptospirosis cases are usually registered seasonally, based on an average maximum temperature of between 18 and 24 degrees Celsius (p. 155-156).

In Georgia majority of leptospirosis human cases are registered where the annual sum of precipitation is 1500 to 2300 mm (p. 152); while in Armenia and Azerbaijan, cases are reported where the annual sum of precipitation is 300 to 800 mm (p. 152).

References:

1. Costa F, Hagan JE, Calcagno J, Kane M, Torgerson P, Martinez-Silveira MS, et al. Global morbidity and mortality of leptospirosis: a systematic review. PLoS Negl Trop Dis. 2015;9(9):e0003898.
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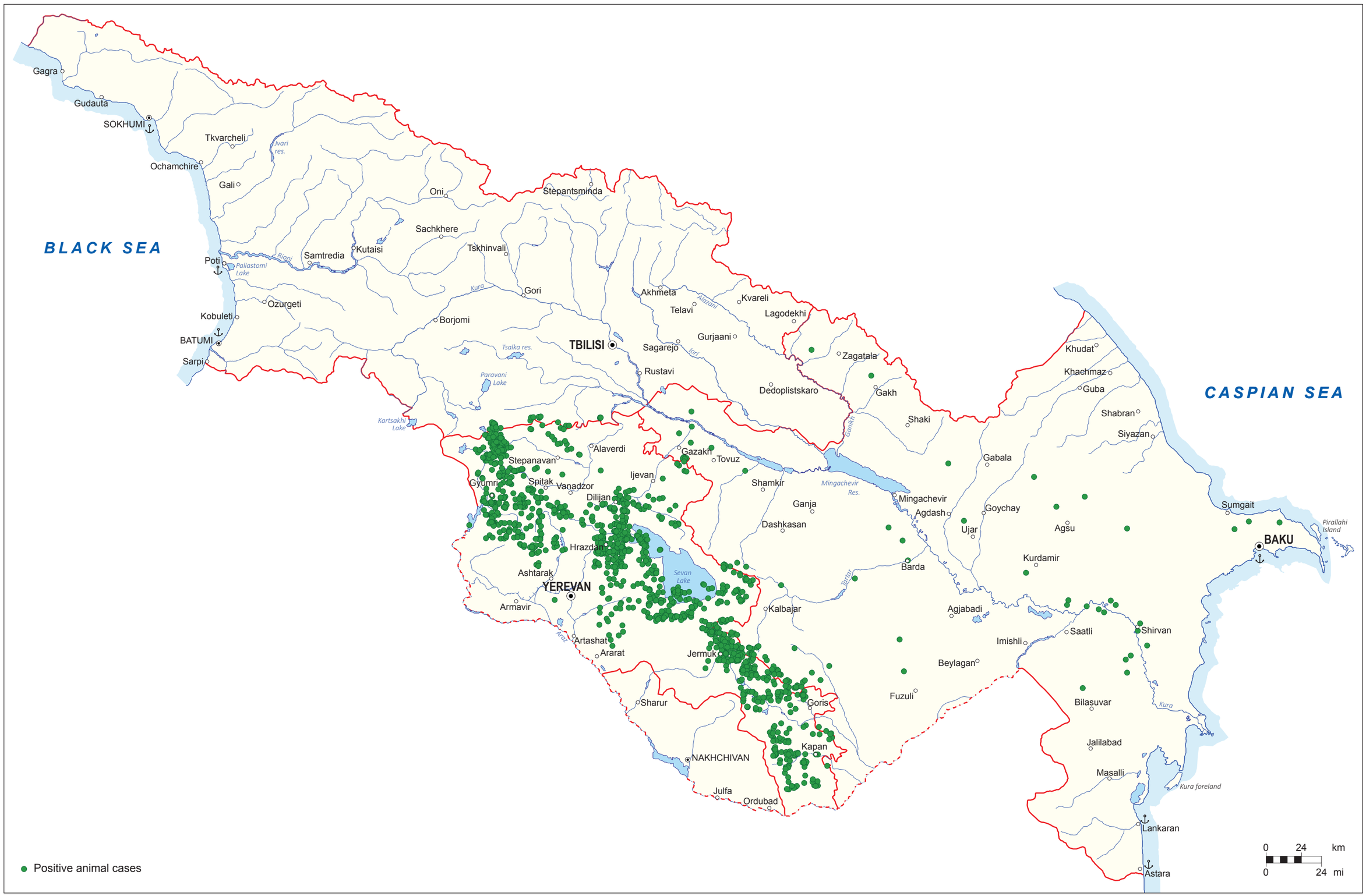
3. CDC Yellow Book 2024f Clinical Sciences, College of Veterinary Medicine, North Carolina State University, National Center for Emerging and Zoonotic Infectious Diseases (NCEZID)
4. Division of Global Migration Health (DGMH)
5. Human leptospirosis: guidance for diagnosis, surveillance and control. Emergency Preparedness (WPE), World Health Organization, pg.109, ISBN: 9241545895, ISBN: 9241545895
6. Leptospirosis Fact Sheet, WHO, *https://iris.who.int/bitstream/handle/10665/205437/B4221.pdf?sequence=1*
7. Leptospirosis - Symptoms, diagnosis and treatment, BMJ Best Practice, *https://bestpractice.bmj.com/topics/en-us/913*

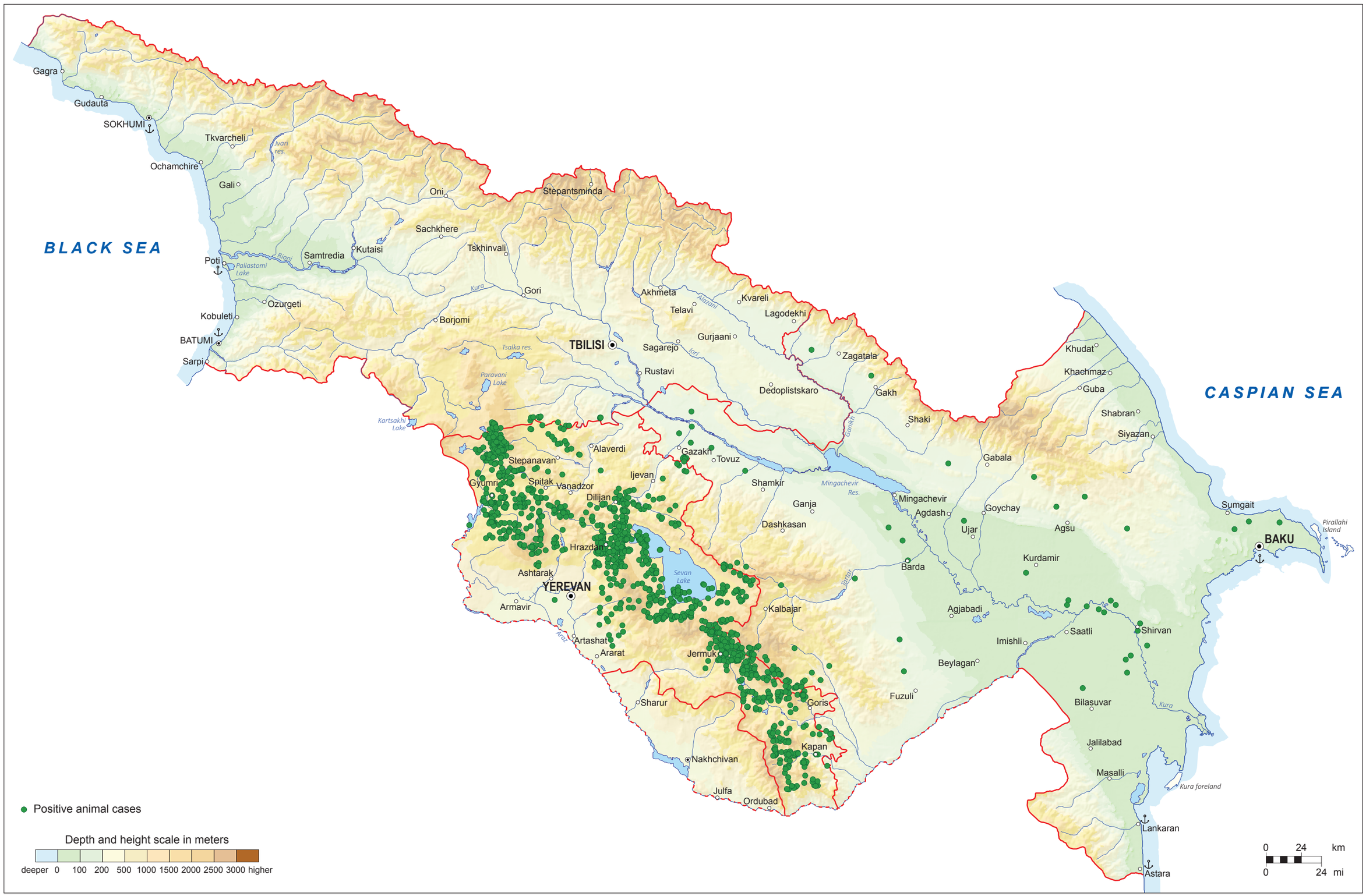
Distribution of Leptospirosis Human Cases in the South Caucasus, 1950-2020

Distribution of Leptospirosis Animal Cases in the South Caucasus, 1965-2020

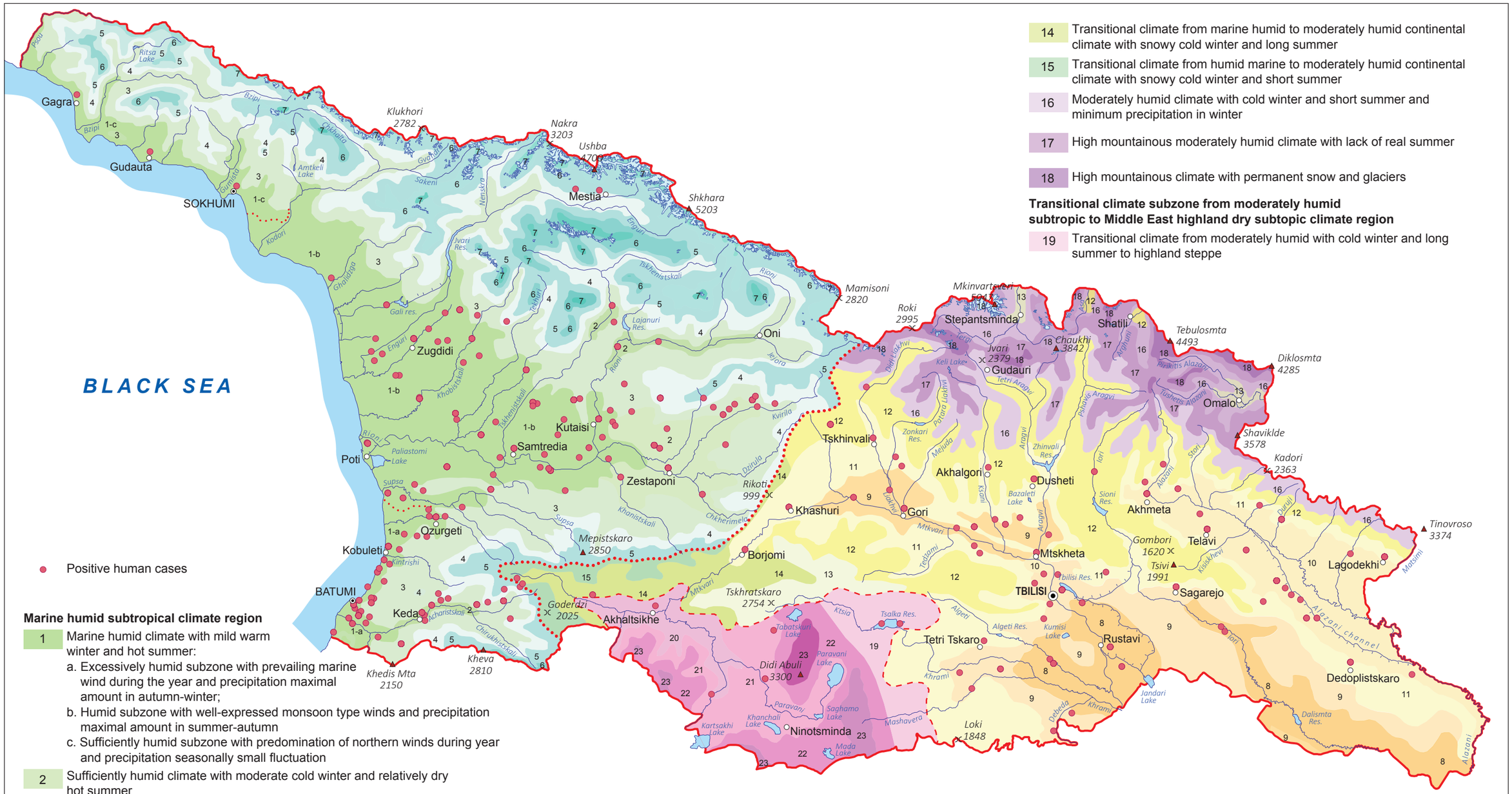


Distribution of Leptospirosis Human Cases by Elevation in the South Caucasus, 1950-2020

Distribution of Leptospirosis Animal Cases by Elevation in the South Caucasus, 1965-2020



Distribution of Leptospirosis Human Cases by Climate Types in Georgia, 1961-2020



14 Transitional climate from marine humid to moderately humid continental climate with snowy cold winter and long summer

15 Transitional climate from humid marine to moderately humid continental climate with snowy cold winter and short summer

16 Moderately humid climate with cold winter and short summer and minimum precipitation in winter

17 High mountainous moderately humid climate with lack of real summer

18 High mountainous climate with permanent snow and glaciers

Transitional climate subzone from moderately humid subtropic to Middle East highland dry subtopic climate region

19 Transitional climate from moderately humid with cold winter and long summer to highland steppe

Marine humid subtropical climate region

1 Marine humid climate with mild warm winter and hot summer:
- a. Excessively humid subzone with prevailing marine wind during the year and precipitation maximal amount in autumn-winter;
- b. Humid subzone with well-expressed monsoon type winds and precipitation maximal amount in summer-autumn
- c. Sufficiently humid subzone with predomination of northern winds during year and precipitation seasonally small fluctuation

2 Sufficiently humid climate with moderate cold winter and relatively dry hot summer

3 Humid climate with moderate cold winter and long warm summer

4 Humid climate with cold winter and long cool summer

5 Humid climate with cold winter and short summer

6 High mountainous humid climate with lack of real summer

7 High mountainous humid climate with year-round abundant snow and glaciers

Moderately humid subtropical climate region

8 Moderately warm steppe with hot summer and minimum precipitation twice a year

9 Transitional climate from a moderate warm steppe to a moderate humid one, with hot summer and minimum precipitation twice a year

10 Moderate humid climate with moderately cold Winter and hot summer and minimum precipitation twice a year

11 Moderate humid climate with moderately cold Winter and long warm summer and minimum precipitation twice a year

12 Moderate humid climate with cold Winter and long cold summer, minimum precipitation twice a year

13 Moderate humid climate with cold winter and long cool summer and minimum precipitation in winter

20 Highland steppe climate with less snowy, cold winter and long, warm summer

21 Highland steppe climate with less snowy, cold winter and long cool summer

22 Highland steppe climate with short summer and cold, less snowy winter

23 Highland moderately dry climate with lack of real summer

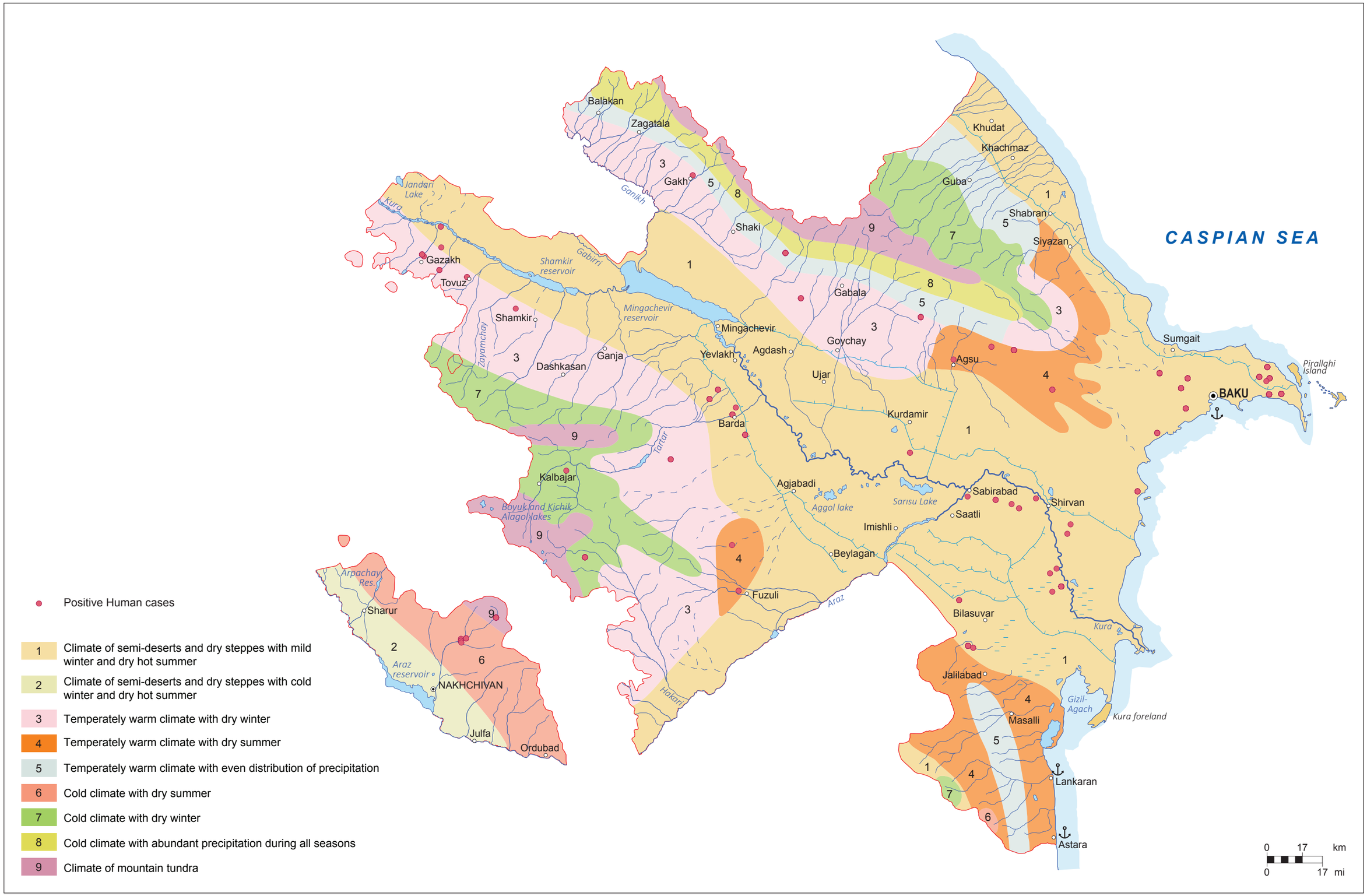
Climate region's border · · · · Climate subzone's border

Subregion border

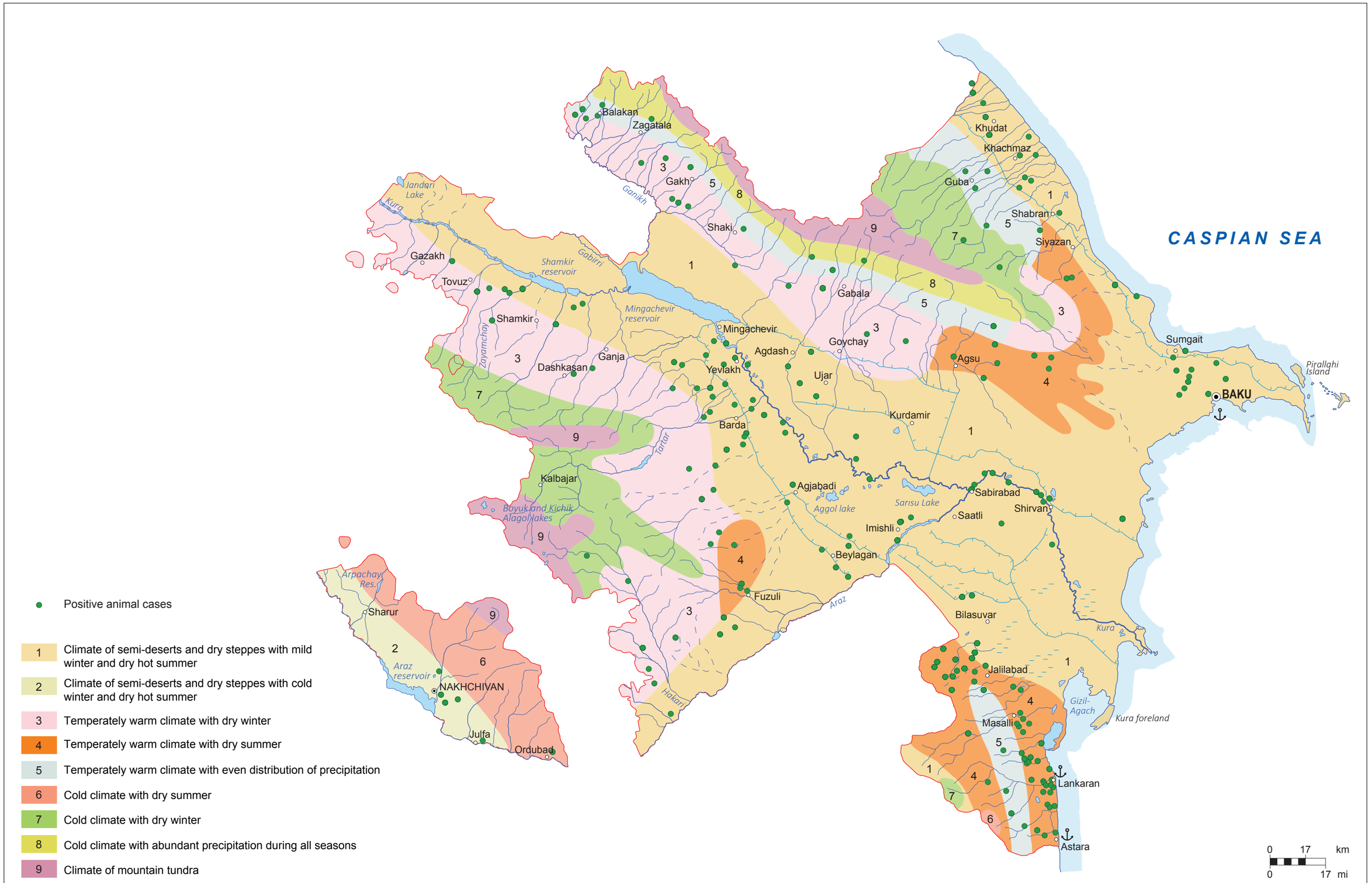
0 15 km

0 15 mi

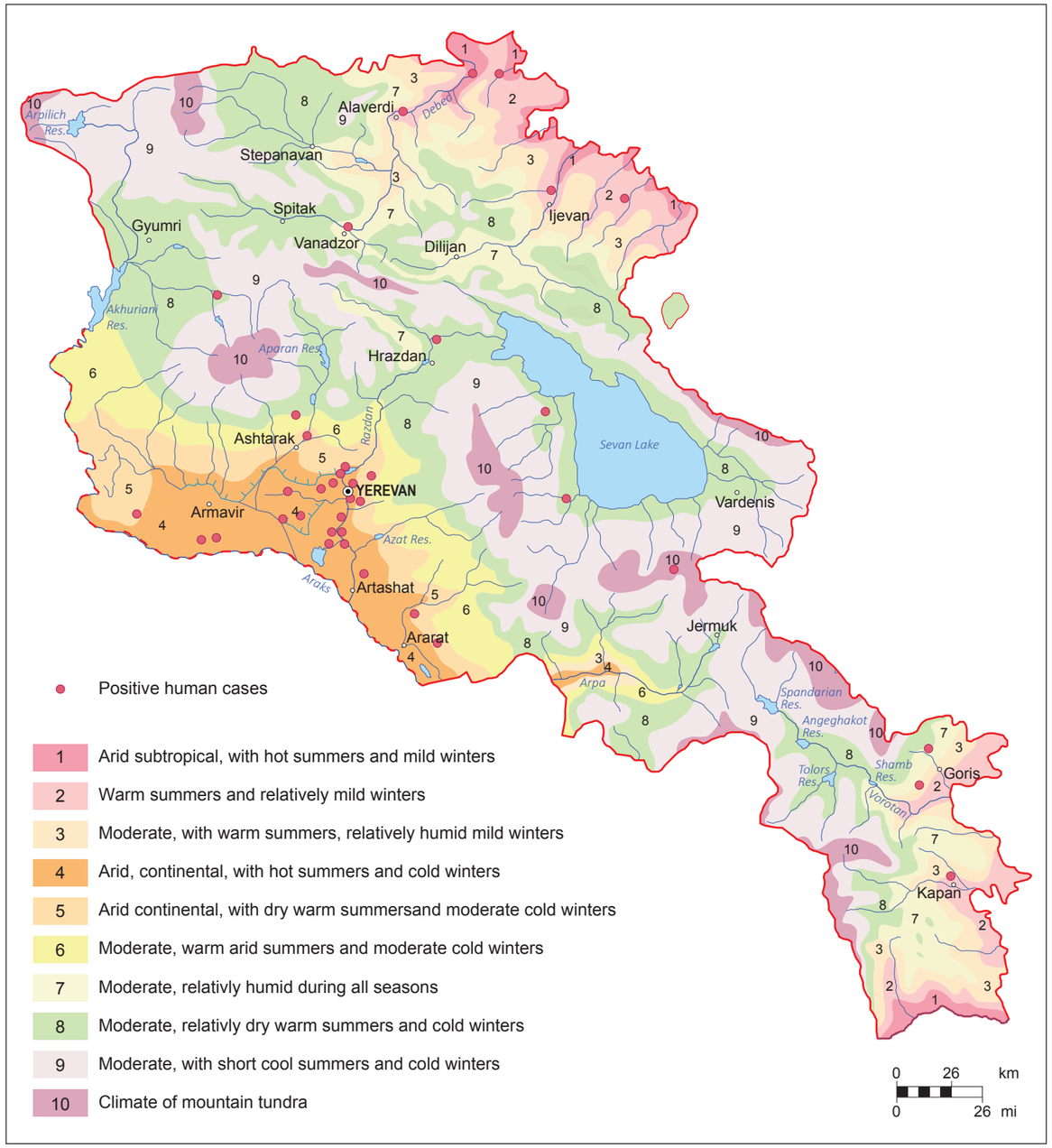
Distribution of Leptospirosis Human Cases by Climate Types in Azerbaijan, 1950-2019



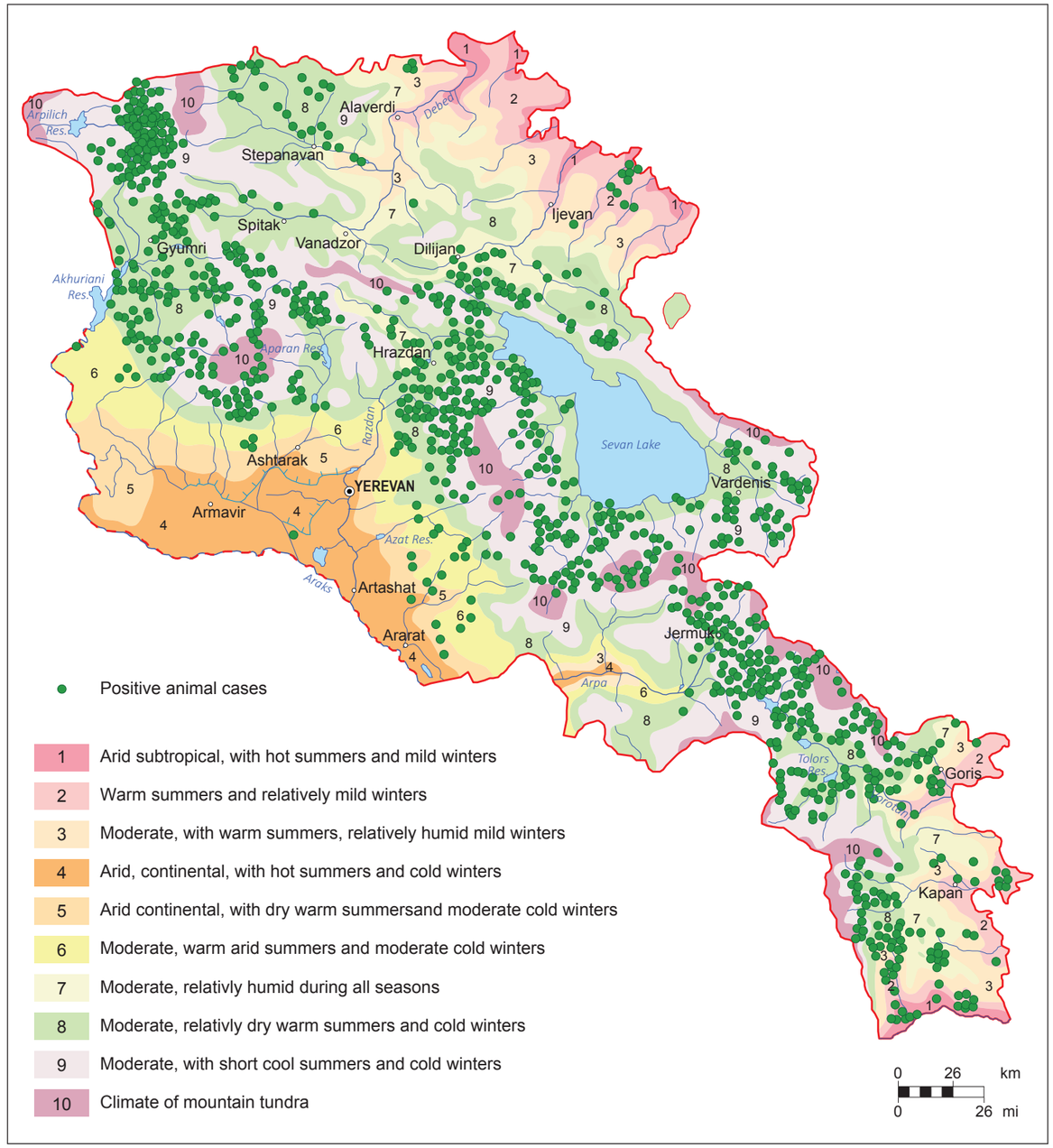
Distribution of Leptospirosis Animal Cases by Climate Types in Azerbaijan, 1965-2019



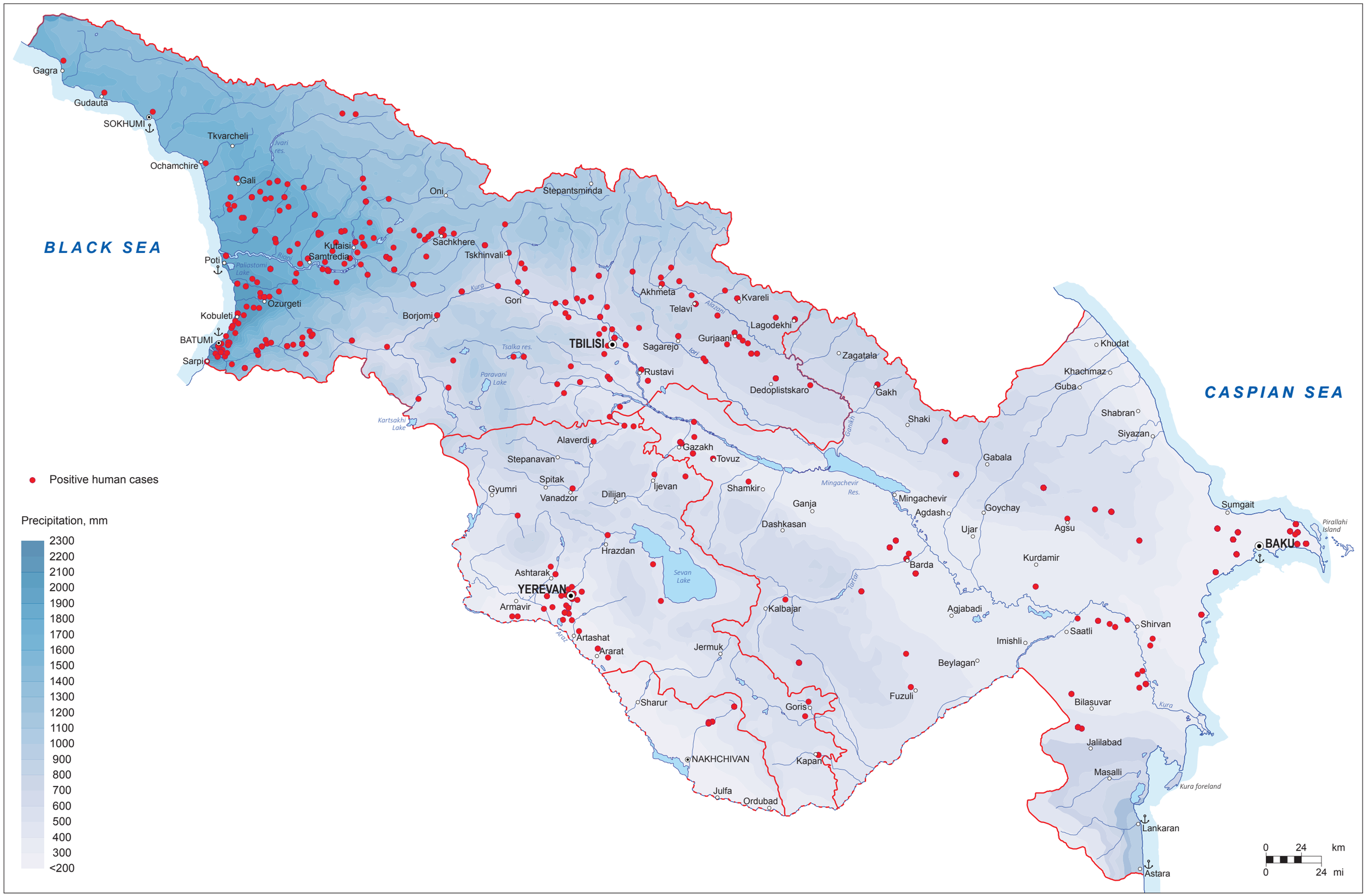
Distribution of Leptospirosis Human Cases by Climate Types in Armenia, 1991-2020



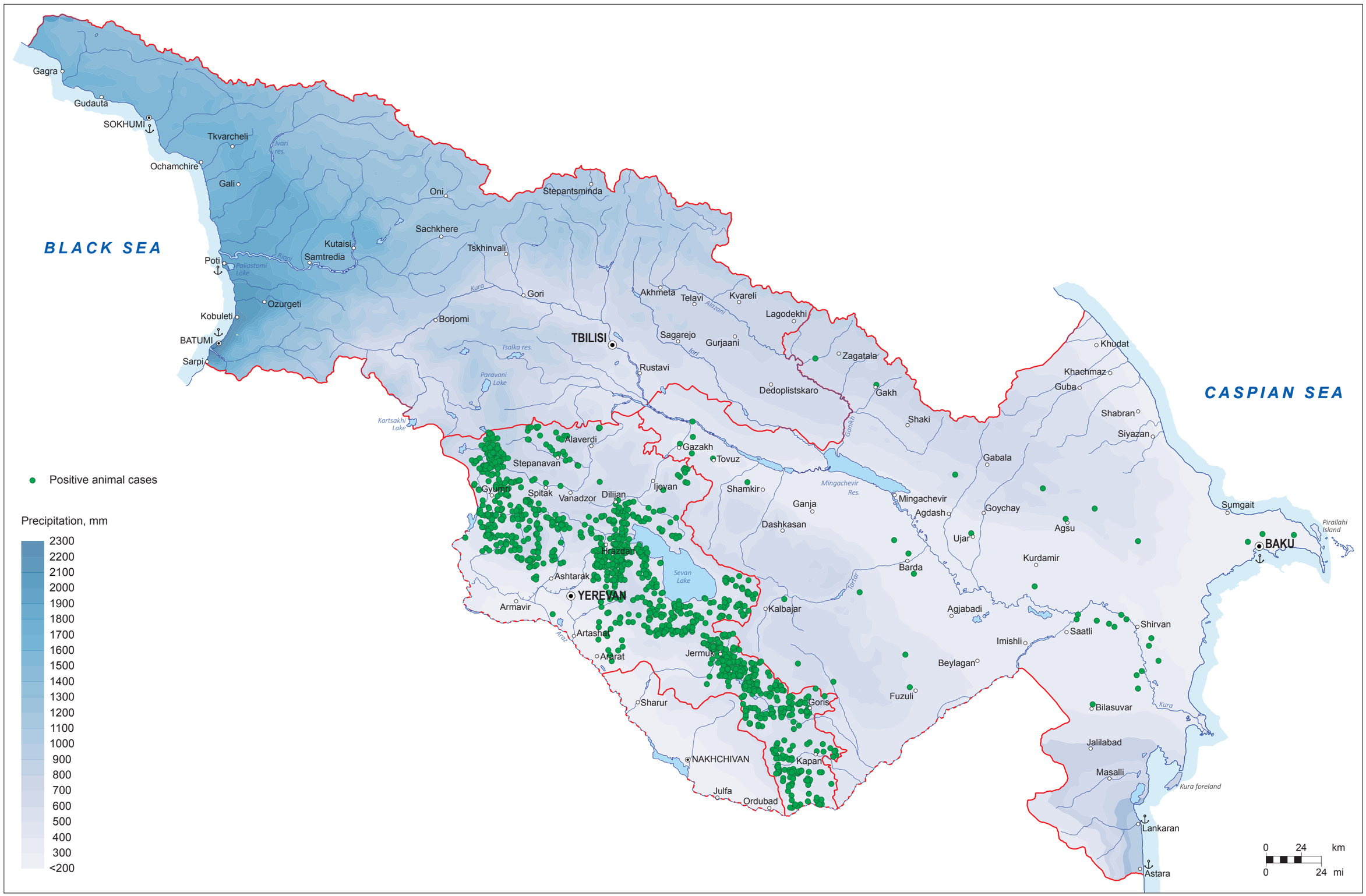
Distribution of Leptospirosis Animal Cases by Climate Types in Armenia, 2013-2020



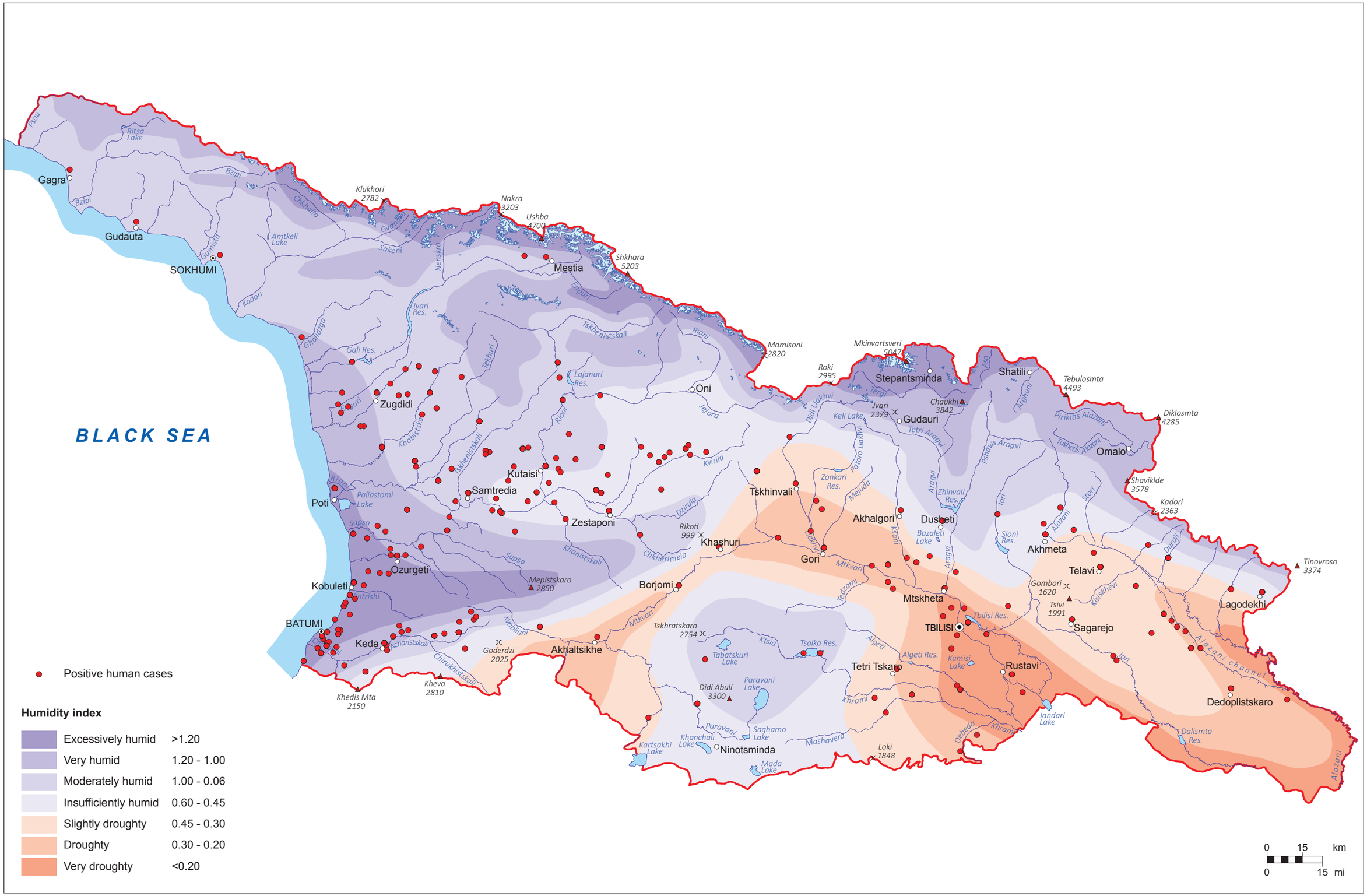
Distribution of Leptospirosis Human Cases by Precipitation in the South Caucasus, 1950-2020



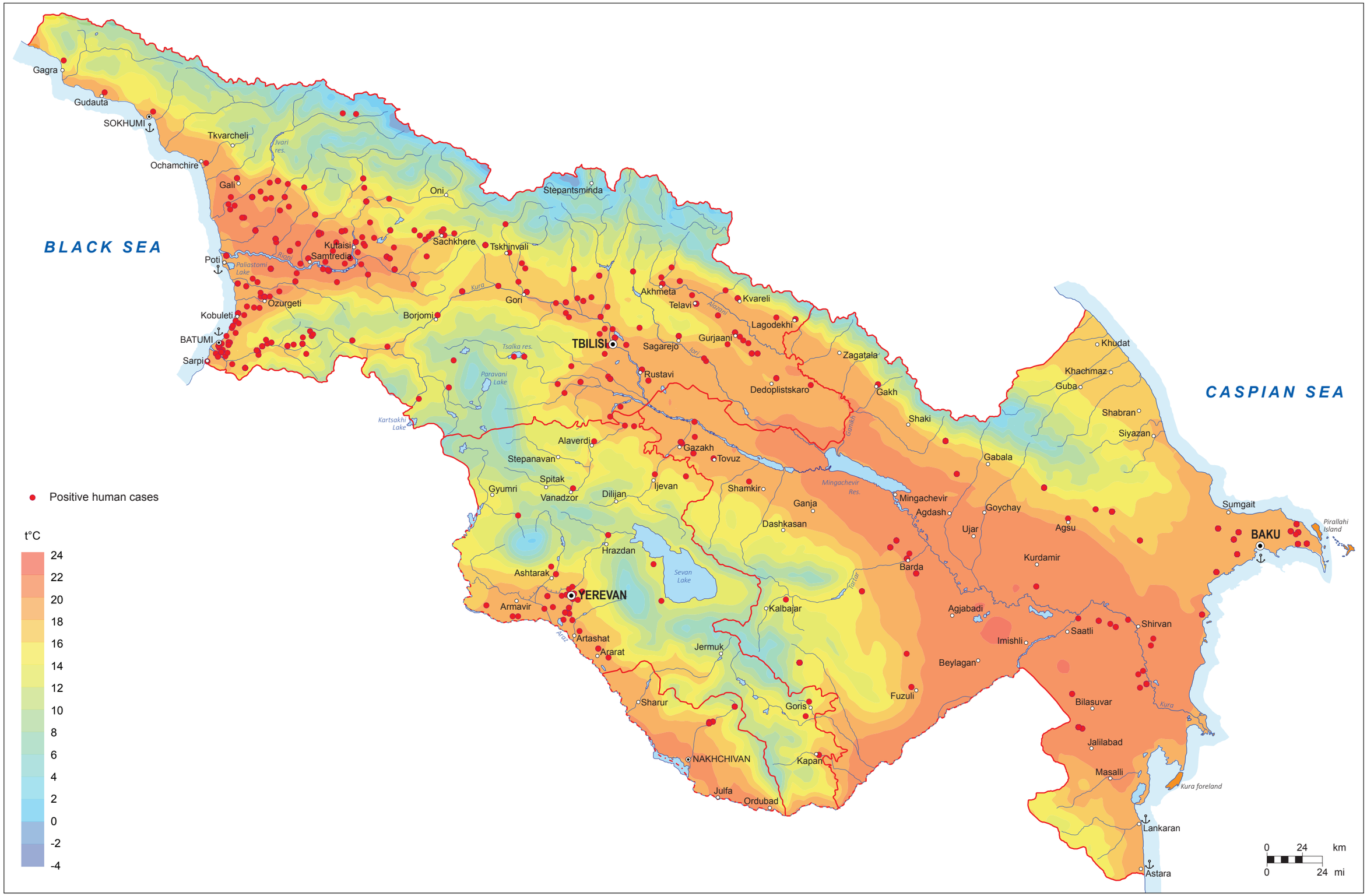
Distribution of Leptospirosis Animal Cases by Precipitation in the South Caucasus, 1965-2020



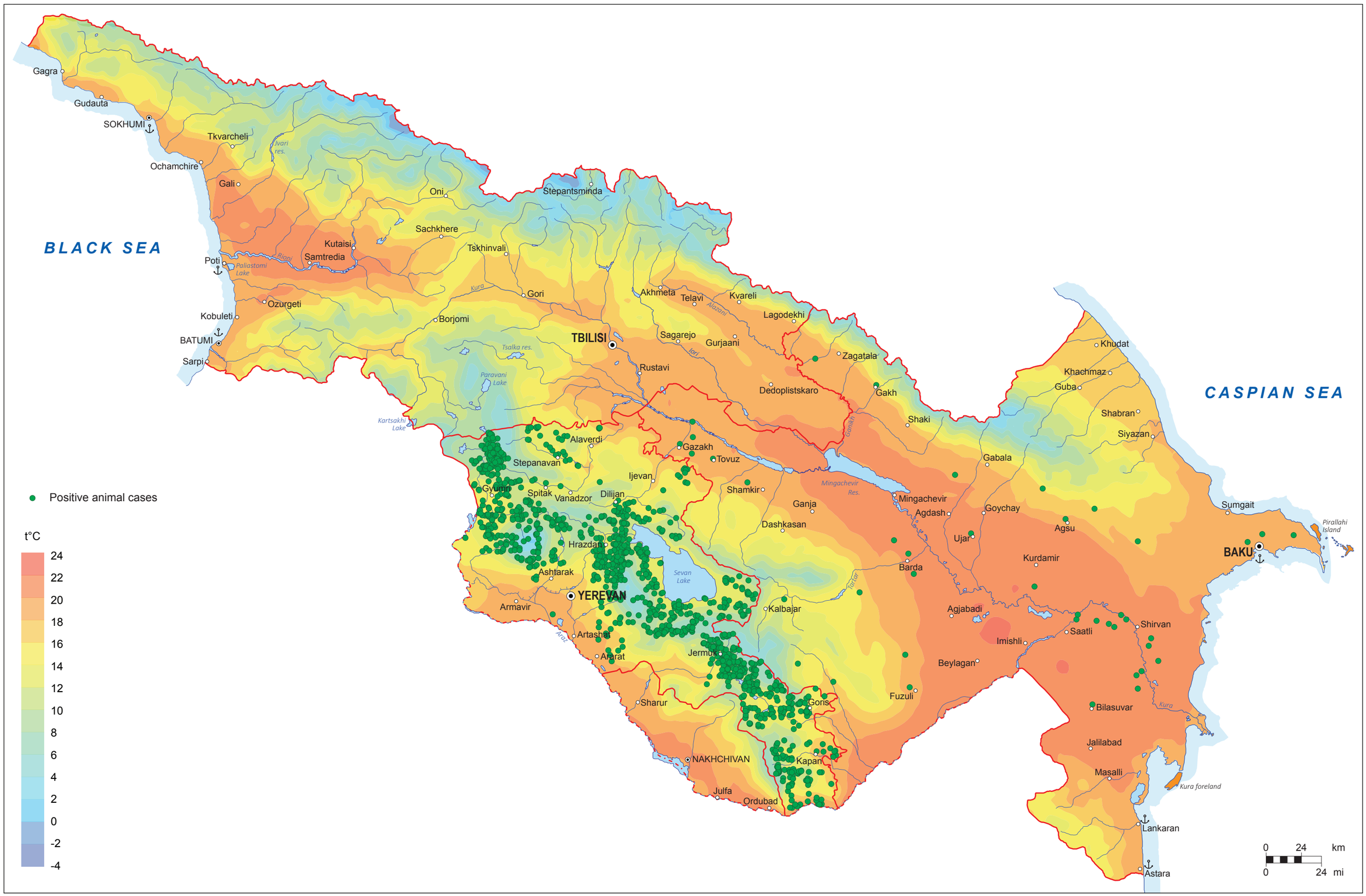
Distribution of Leptospirosis Human Cases by Humidity Index in Georgia, 1961-2020



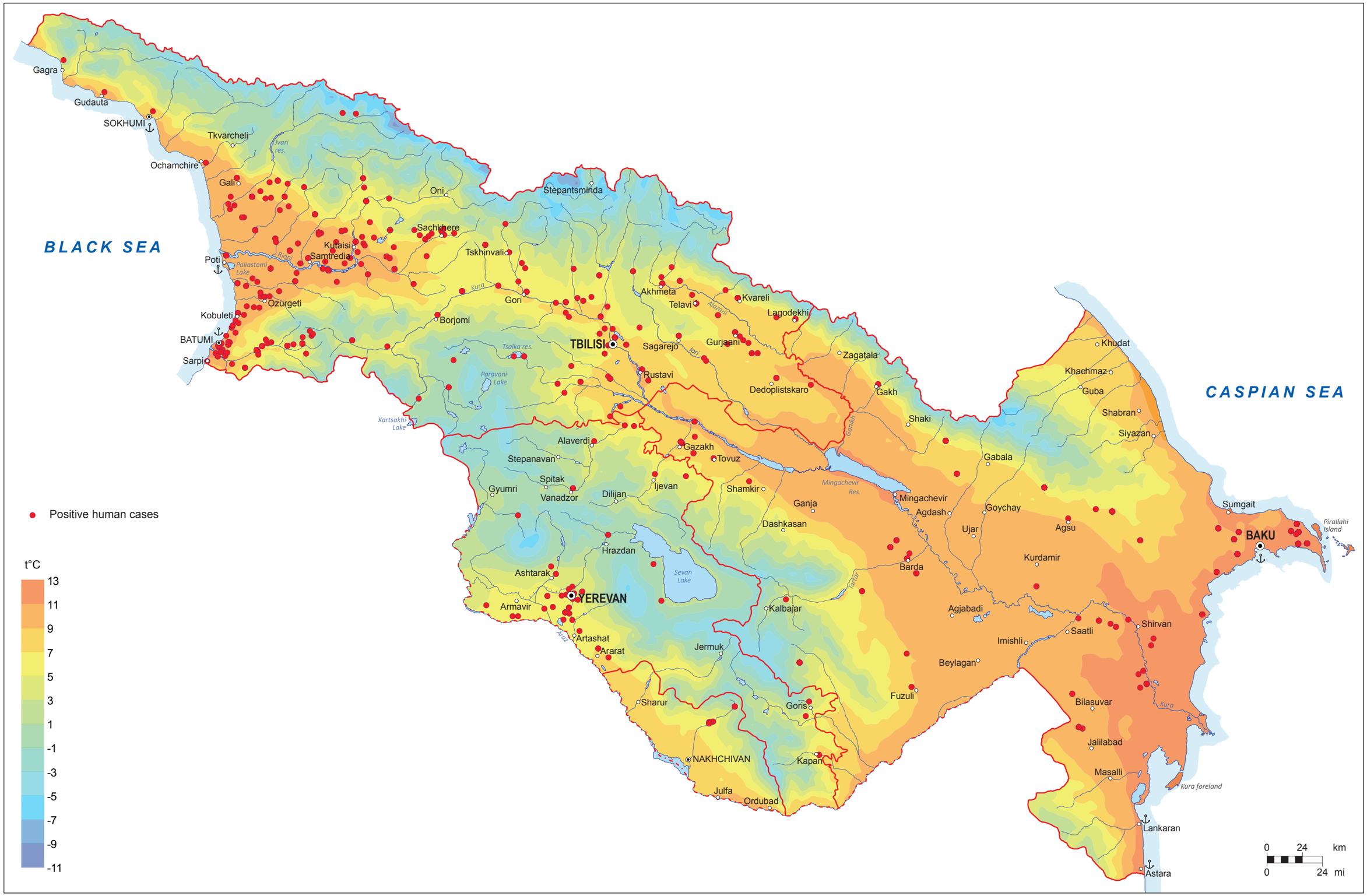
Distribution of Leptospirosis Human Cases by Maximum Temperature in the South Caucasus, 1950-2020



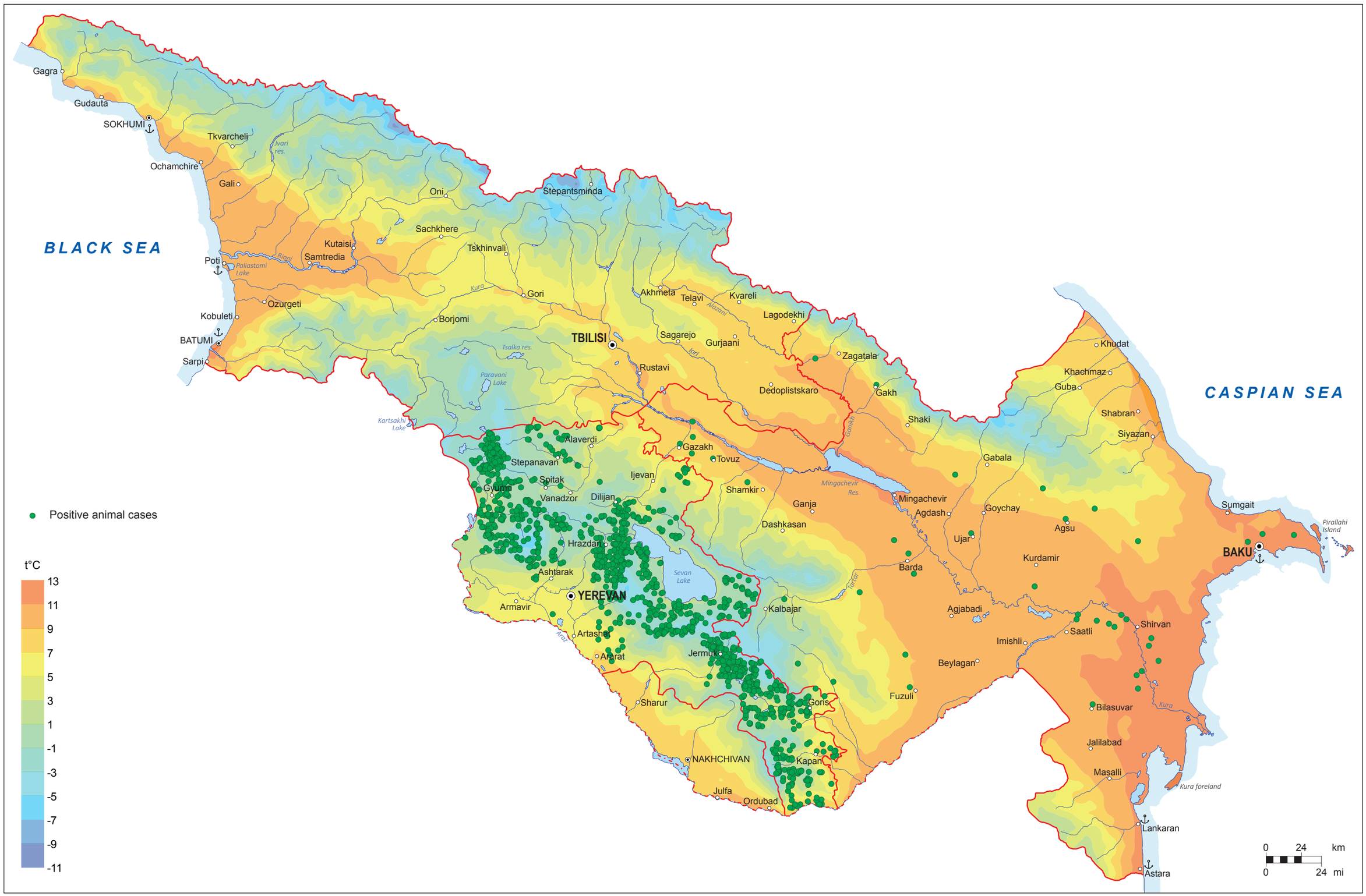
Distribution of Leptospirosis Animal Cases by Maximum Temperature in the South Caucasus, 1965-2020



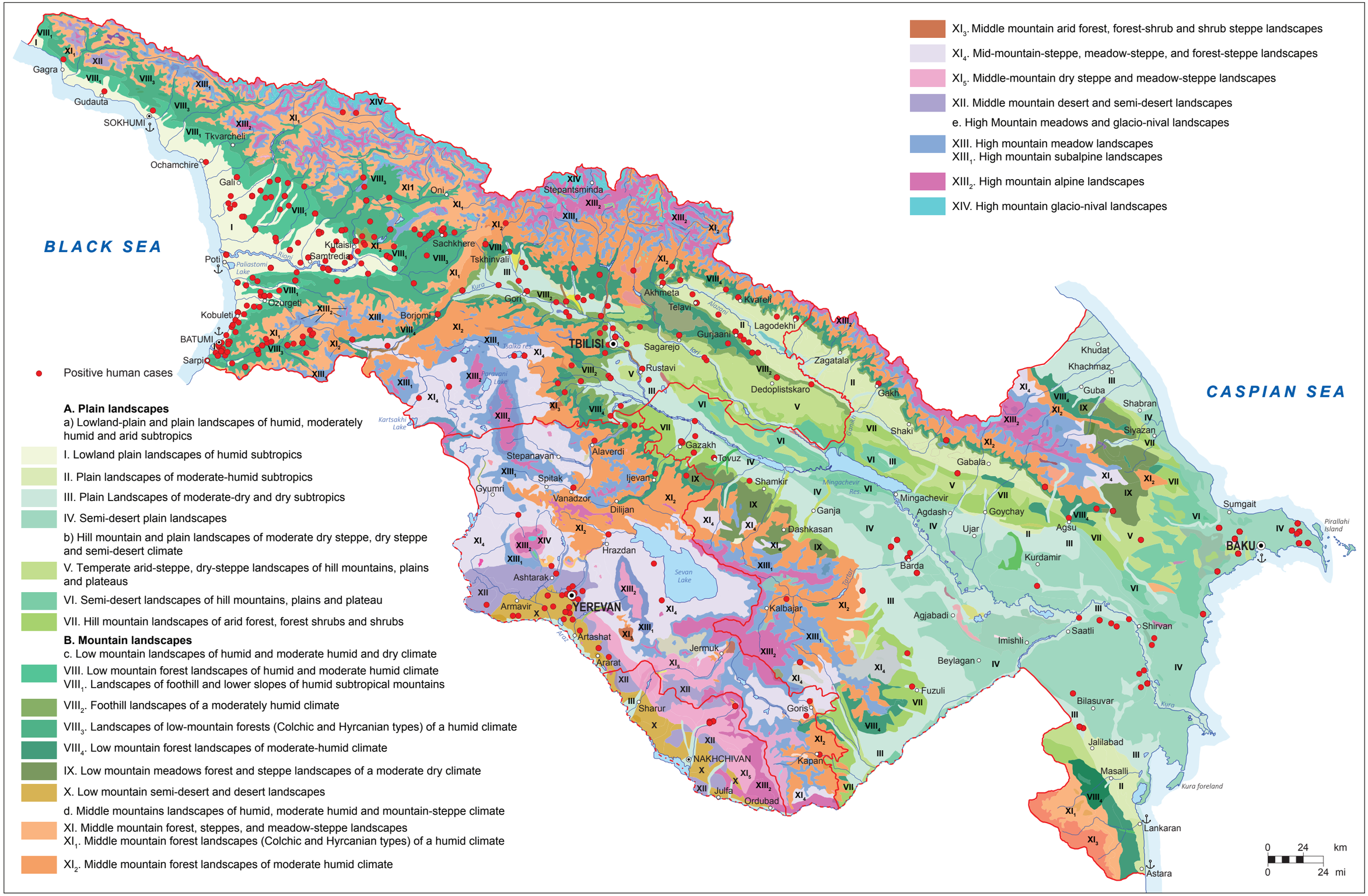
Distribution of Leptospirosis Human Cases by Minimum Temperature in the South Caucasus, 1950-2020



Distribution of Leptospirosis Animal Cases by Minimum Temperature in the South Caucasus, 1965-2020



Distribution of Leptospirosis Human Cases by Landscape in the South Caucasus, 1950-2020



- Positive human cases

A. Plain landscapes

a) Lowland-plain and plain landscapes of humid, moderately humid and arid subtropics

- I. Lowland plain landscapes of humid subtropics
- II. Plain landscapes of moderate-humid subtropics
- III. Plain Landscapes of moderate-dry and dry subtropics
- IV. Semi-desert plain landscapes

b) Hill mountain and plain landscapes of moderate dry steppe, dry steppe and semi-desert climate

- V. Temperate arid-steppe, dry-steppe landscapes of hill mountains, plains and plateaus
- VI. Semi-desert landscapes of hill mountains, plains and plateau
- VII. Hill mountain landscapes of arid forest, forest shrubs and shrubs

B. Mountain landscapes

c. Low mountain landscapes of humid and moderate humid and dry climate

- VIII. Low mountain forest landscapes of humid and moderate humid climate
- $VIII_1$. Landscapes of foothill and lower slopes of humid subtropical mountains
- $VIII_2$. Foothill landscapes of a moderately humid climate
- $VIII_3$. Landscapes of low-mountain forests (Colchic and Hyrcanian types) of a humid climate
- $VIII_4$. Low mountain forest landscapes of moderate-humid climate
- IX. Low mountain meadows forest and steppe landscapes of a moderate dry climate
- X. Low mountain semi-desert and desert landscapes

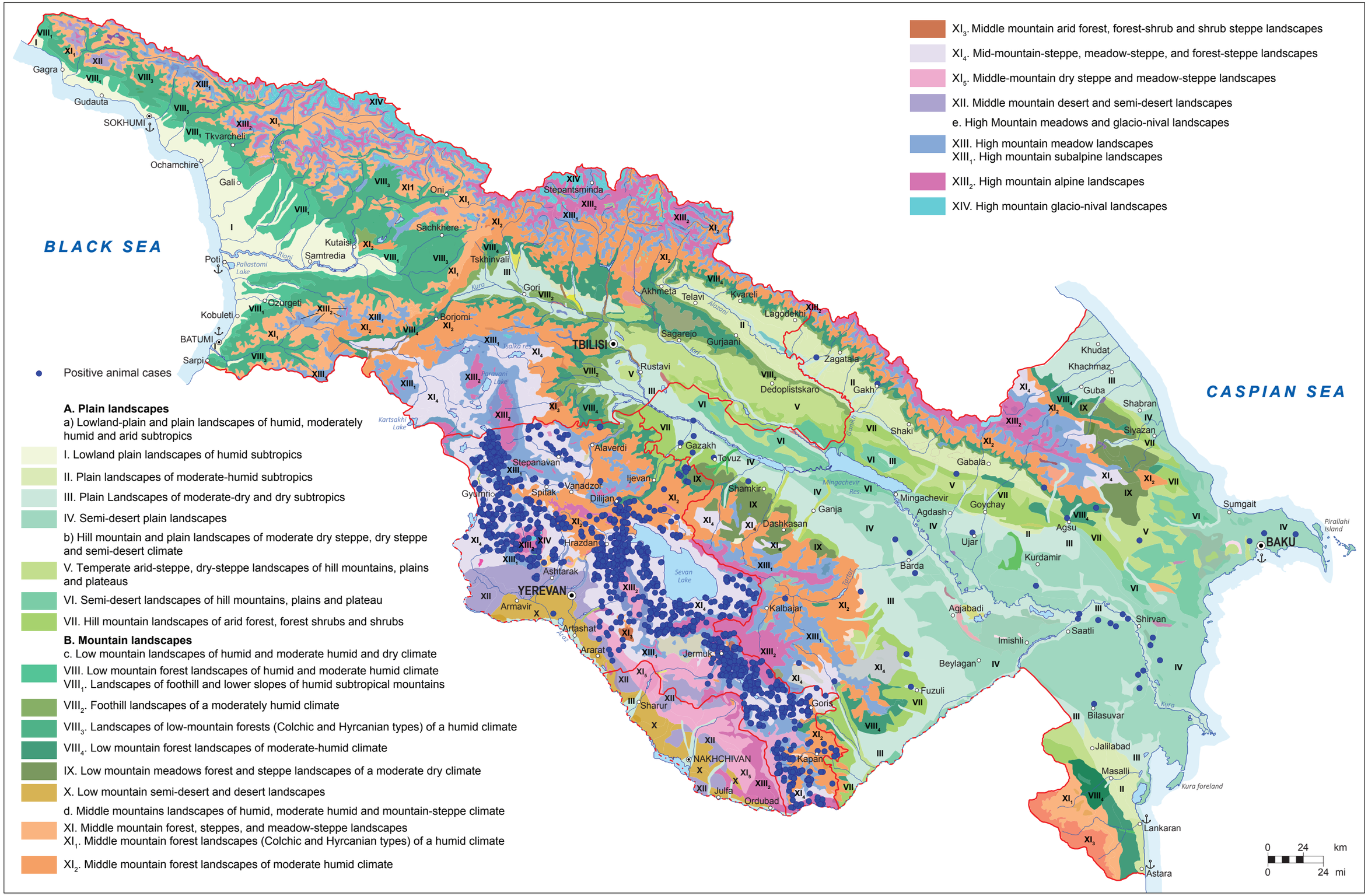
d. Middle mountains landscapes of humid, moderate humid and mountain-steppe climate

- XI. Middle mountain forest, steppes, and meadow-steppe landscapes
- XI_1. Middle mountain forest landscapes (Colchic and Hyrcanian types) of a humid climate
- XI_2. Middle mountain forest landscapes of moderate humid climate
- XI_3. Middle mountain arid forest, forest-shrub and shrub steppe landscapes
- XI_4. Mid-mountain-steppe, meadow-steppe, and forest-steppe landscapes
- XI_5. Middle-mountain dry steppe and meadow-steppe landscapes
- XII. Middle mountain desert and semi-desert landscapes

e. High Mountain meadows and glacio-nival landscapes

- XIII. High mountain meadow landscapes
- $XIII_1$. High mountain subalpine landscapes
- $XIII_2$. High mountain alpine landscapes
- XIV. High mountain glacio-nival landscapes

Distribution of Leptospirosis Animal Cases by Landscape in the South Caucasus, 1965-2020


BLACK SEA
CASPIAN SEA
TBILISI
YEREVAN
BAKU
NAKHCHIVAN
Gagra
Gudauta
SOKHUMI
Tkvarcheli
Ochamchire
Gali
Poti
Paliastomi Lake
Rioni
Kutaisi
Samtredia
Sachkhere
Oni
Stepantsminda
Tskhinvali
Gori
Kura
Akhmeta
Telavi
Kvareli
Lagodekhi
Sagarejo
Gurjaani
Alazani
Iori
Zagatala
Khudat
Khachmaz
Guba
Shabran
Siyazan
Gakh
Dedoplistskaro
Rustavi
Kobuleti
Ozurgeti
BATUMI
Sarpi
Borjomi
Tsalka
Paravani Lake
Kartsakhi Lake
Alaverdi
Gazakh
Tovuz
Shaki
Gabala
Agdash
Goychay
Mingachevir
Mingachevir Res.
Ganja
Dashkasan
Shamkir
Barda
Ujar
Agsu
Kurdamir
Sumgait
Pirallahi Island
Agjabadi
Saatli
Imishli
Shirvan
Beylagan
Fuzuli
Bilasuvar
Jalilabad
Masalli
Lankaran
Astara
Kura foreland
Stepanavan
Vanadzor
Spitak
Gyumri
Dilijan
Ijevan
Hrazdan
Ashtarak
Sevan Lake
Armavir
Artashat
Ararat
Araks
Jermuk
Kalbajar
Goris
Sharur
Kapan
Julfa
Ordubad
Martakert
Martuni
Vardenis
Sevan
Basarkechar
Qazax
Tovuz
Gadabay
Goranboy
Yevlakh
Ismayilli
Shamakhi
Gobustan
Khizi
Absheron
Qusar
Siyazan
Shabran
Khachmaz
Guba
Gakh
Zagatala
Balakan
Oguz
Sheki
Qabala
Ismayilli
Agsu
Shamakhi
Gobustan
Khizi
Absheron
Baku
Sumgait
Qusar
Shirvan
Salyan
Neftchala
Lankaran
Masalli
Jalilabad
Bilasuvar
Imishli
Saatli
Agjabadi
Beylagan
Fuzuli
Zangilan
Gubadly
Jabrayil
Kalbajar
Lachin
Goris
Kapan
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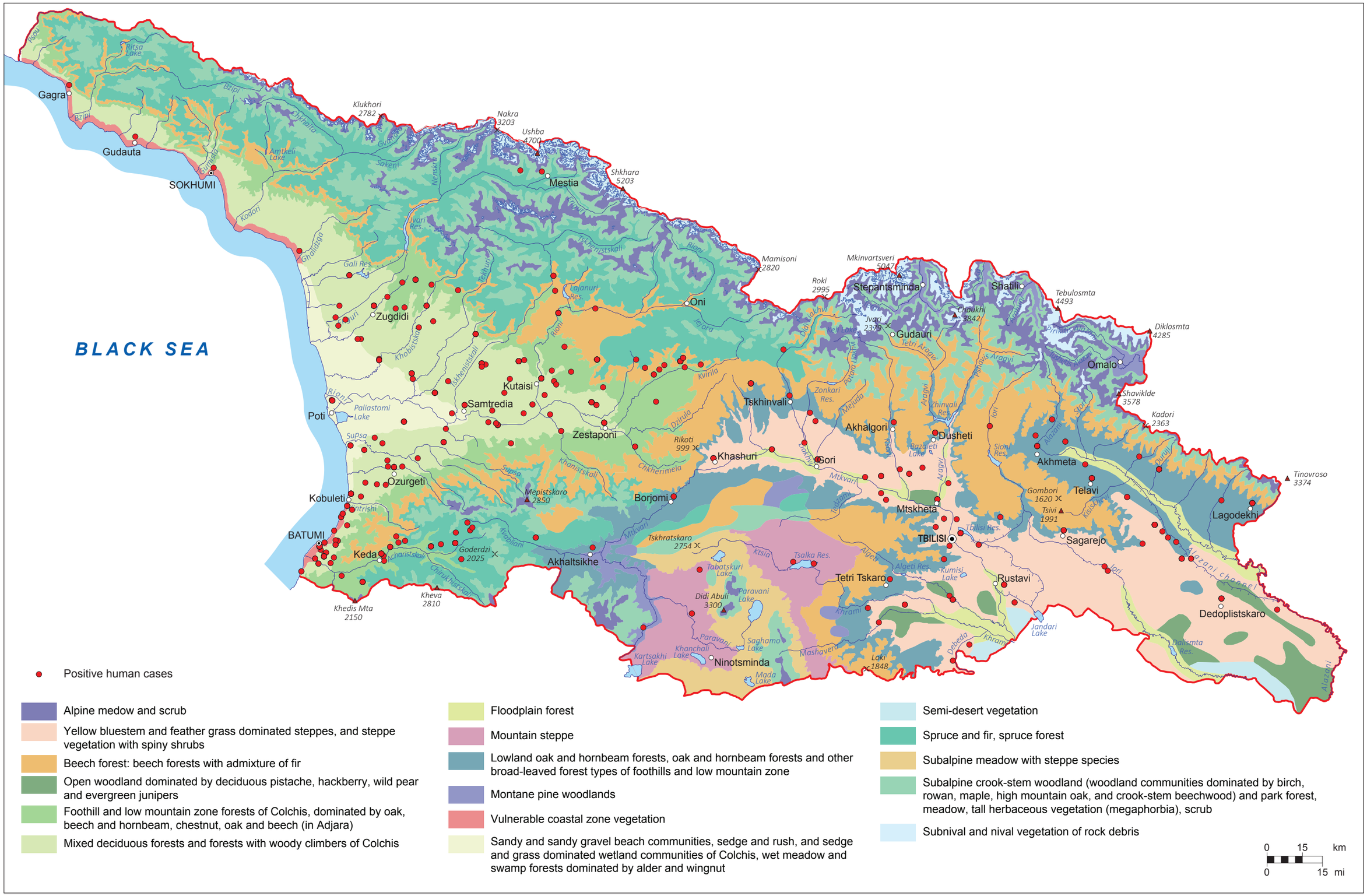
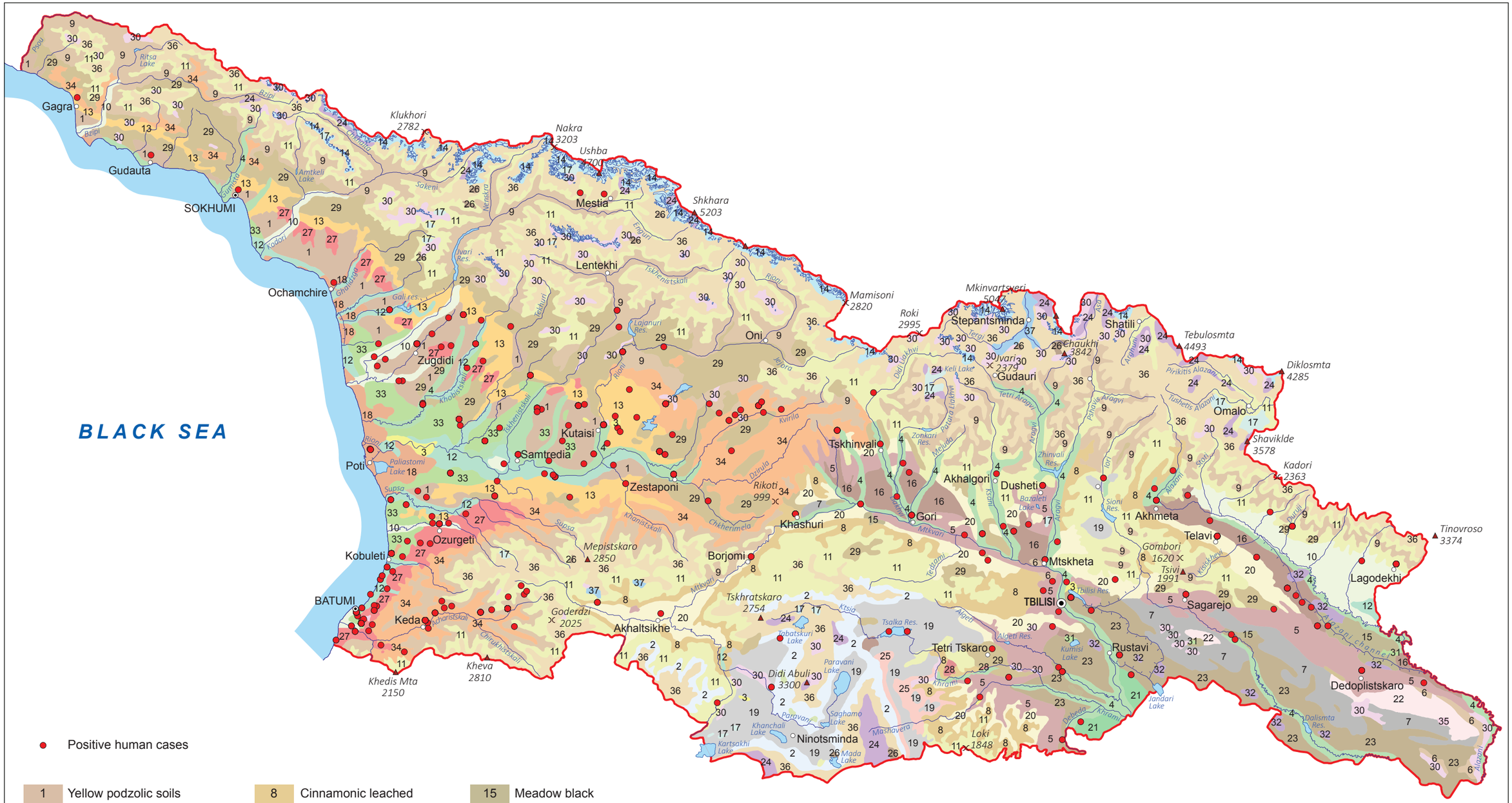
Julfa
Ordubad
Kurdamir
Barda
Agdash
Mingachevir
Ganja
Dashkasan
Shamkir
Tovuz
Gazakh
Alaverdi

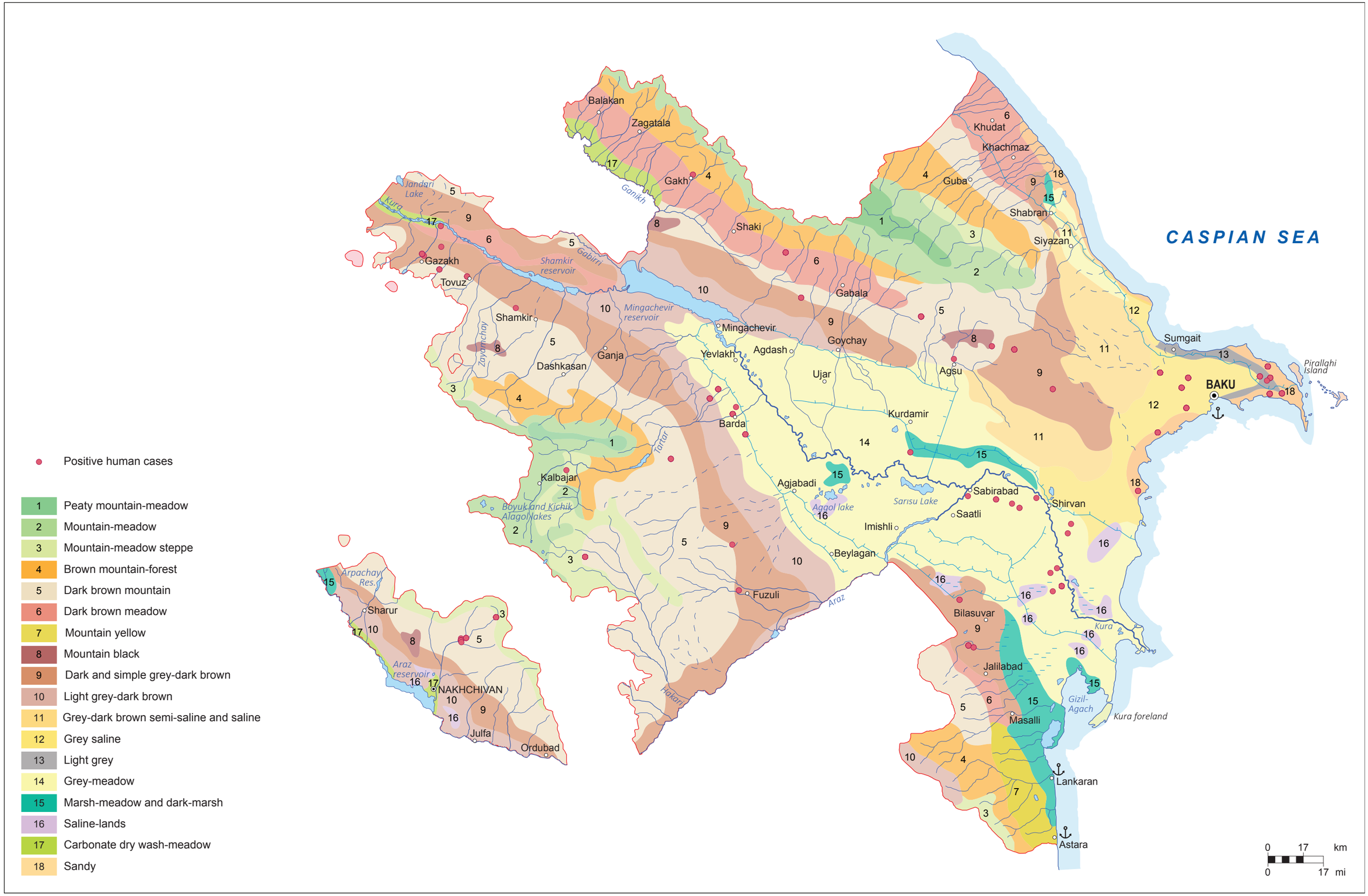
Distribution of Leptospirosis Human Cases by Vegetation in Georgia, 1961-2020



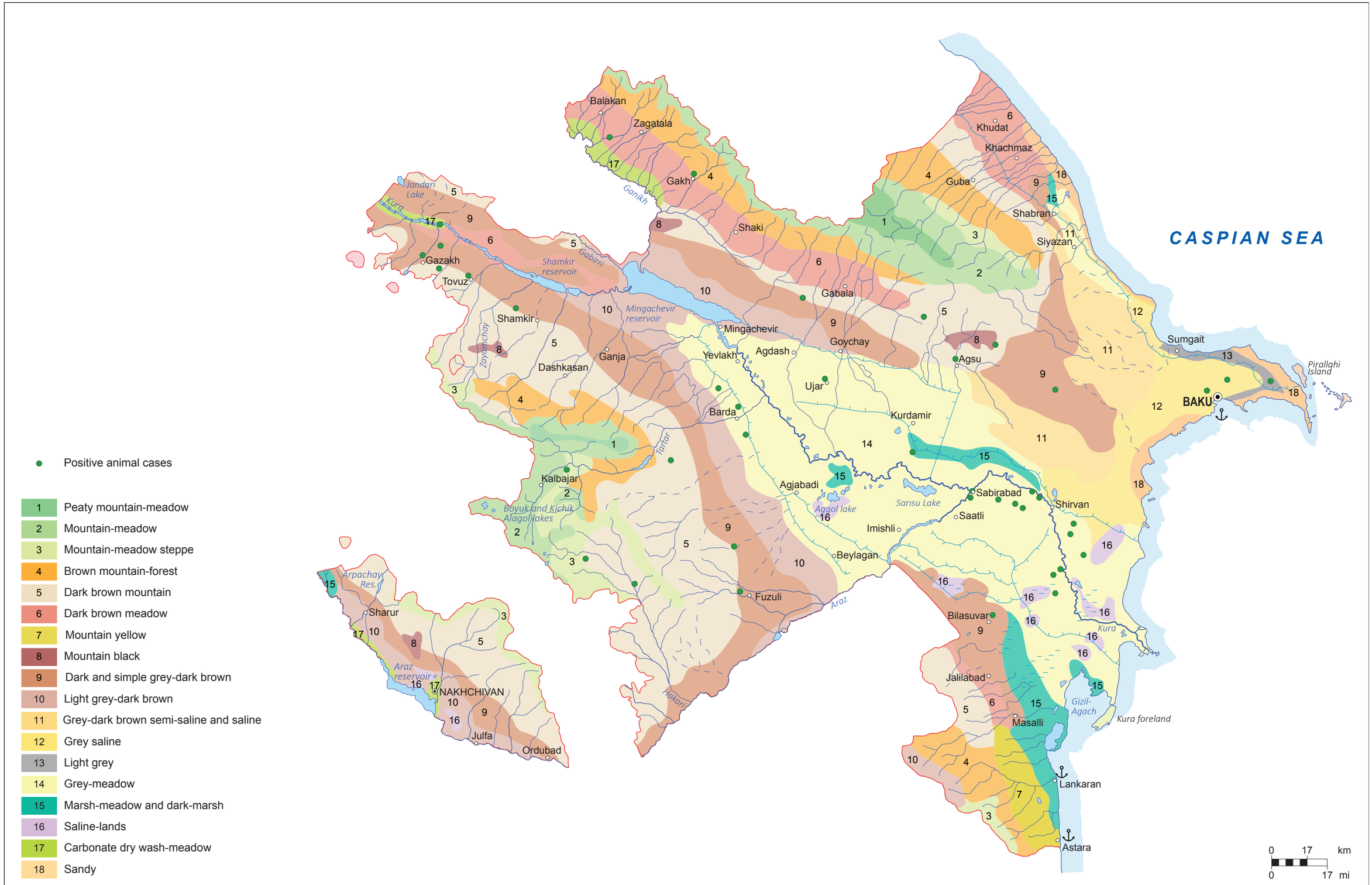
Distribution of Leptospirosis Human Cases by Soil Types in Georgia, 1961-2020



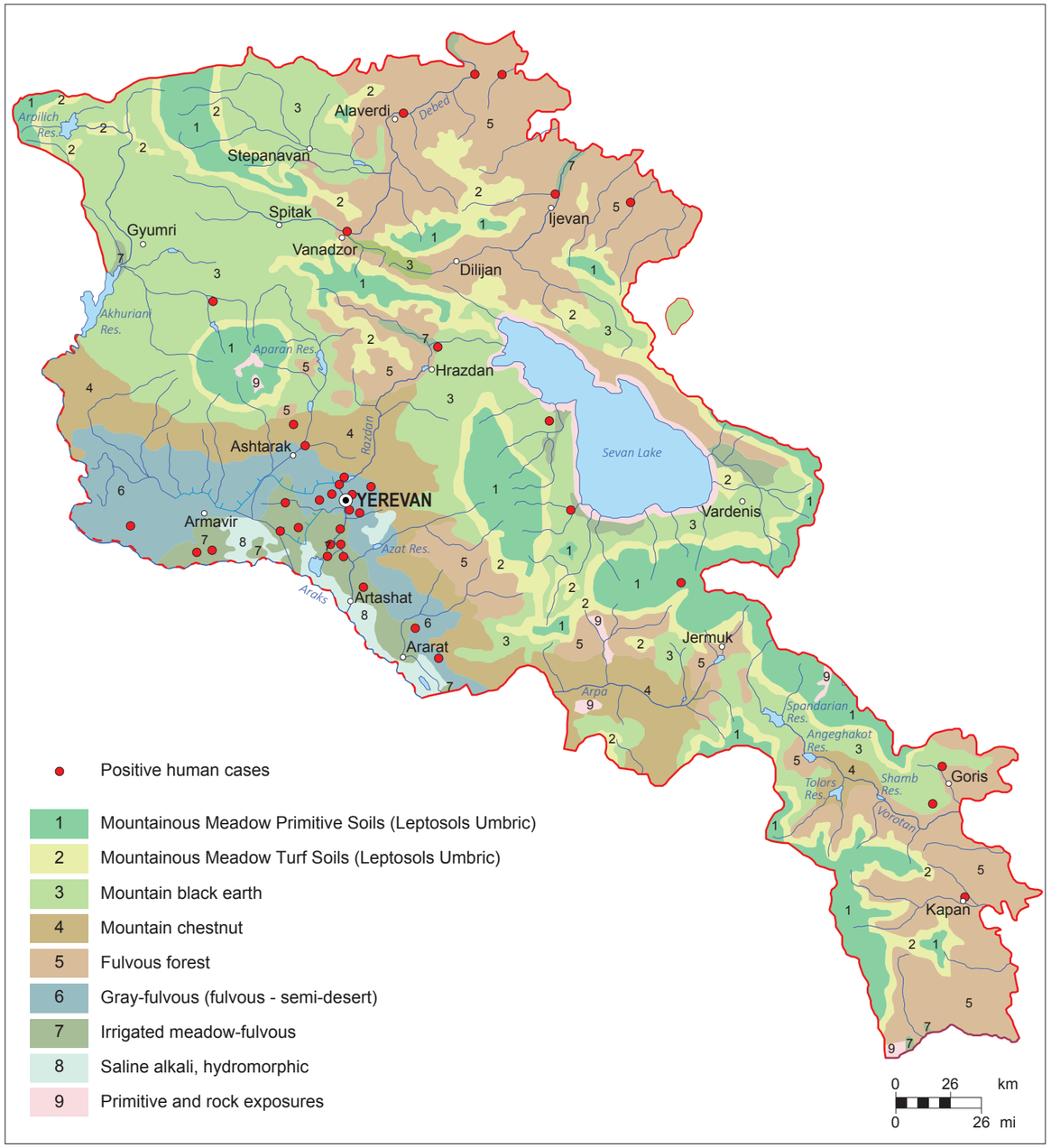
Distribution of Leptospirosis Human Cases by Soil Types in Azerbaijan, 1950-2019



Distribution of Leptospirosis Animal Cases by Soil Types in Azerbaijan, 1965-2019



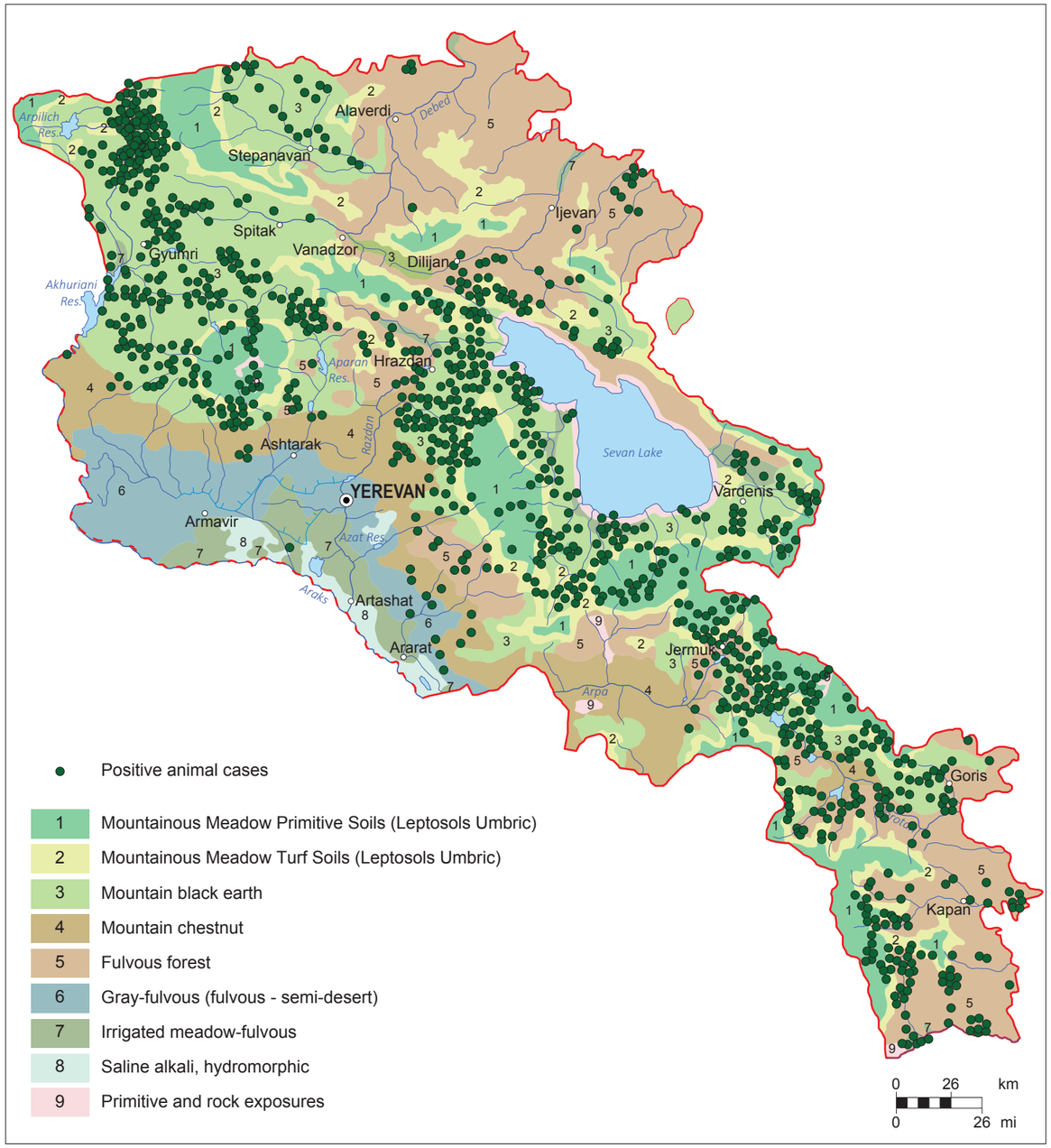
Distribution of Leptospirosis Human Cases by Soil Types in Armenia, 1991-2020



- Positive human cases

1	Mountainous Meadow Primitive Soils (Leptosols Umbric)
2	Mountainous Meadow Turf Soils (Leptosols Umbric)
3	Mountain black earth
4	Mountain chestnut
5	Fulvous forest
6	Gray-fulvous (fulvous - semi-desert)
7	Irrigated meadow-fulvous
8	Saline alkali, hydromorphic
9	Primitive and rock exposures

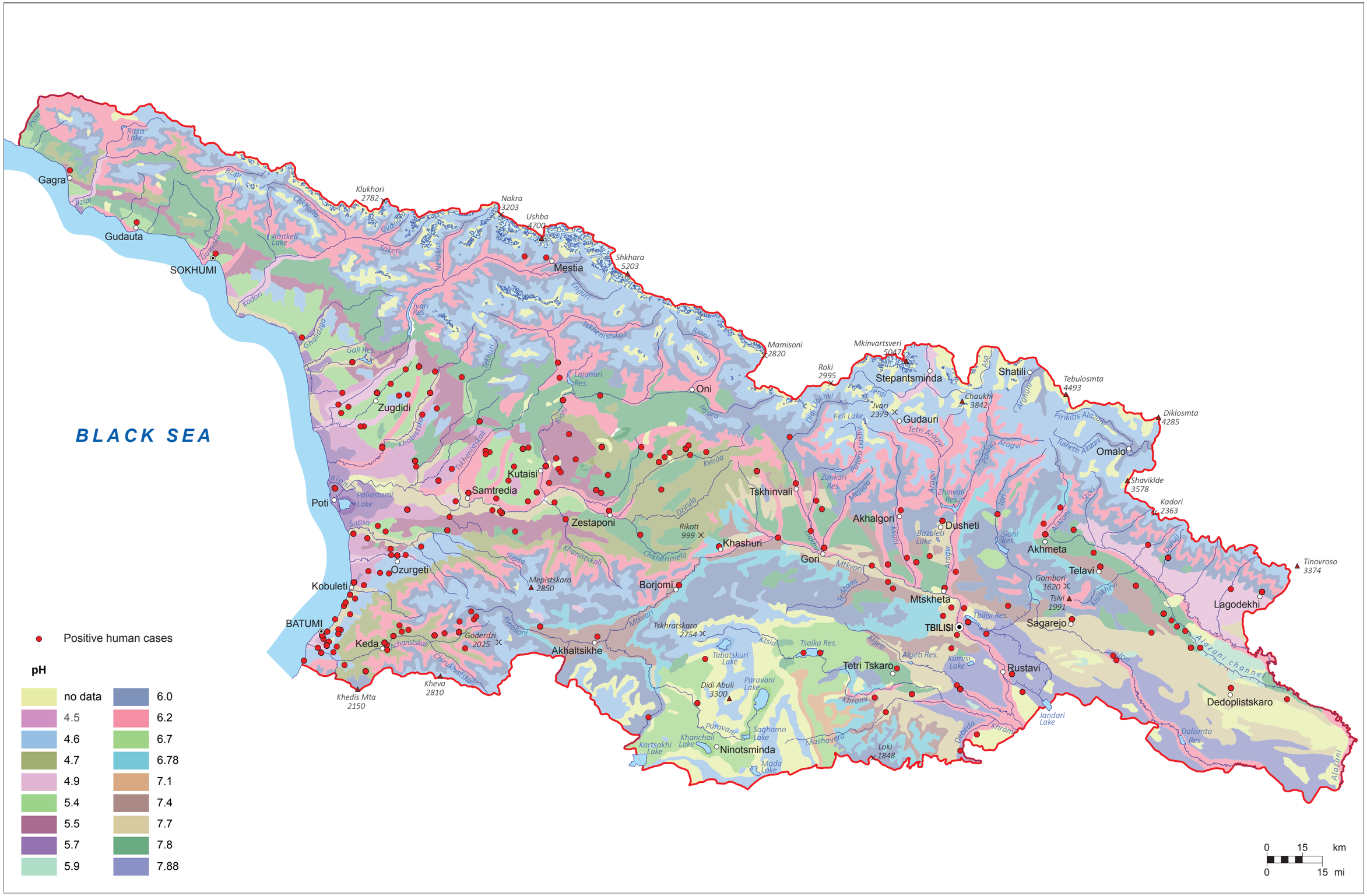
Distribution of Leptospirosis Animal Cases by Soil Types in Armenia, 2013-2020



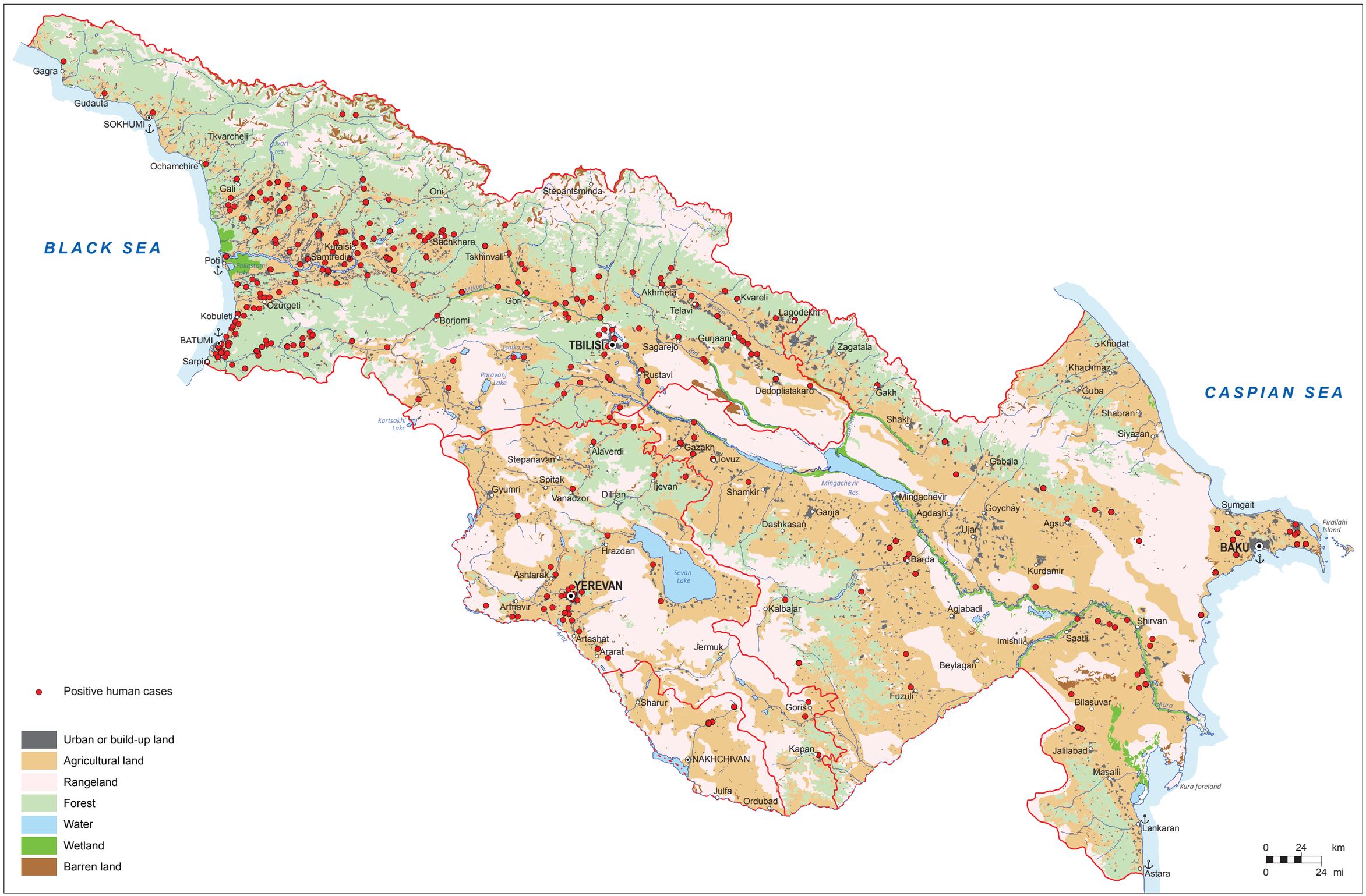
- Positive animal cases

1	Mountainous Meadow Primitive Soils (Leptosols Umbric)
2	Mountainous Meadow Turf Soils (Leptosols Umbric)
3	Mountain black earth
4	Mountain chestnut
5	Fulvous forest
6	Gray-fulvous (fulvous - semi-desert)
7	Irrigated meadow-fulvous
8	Saline alkali, hydromorphic
9	Primitive and rock exposures

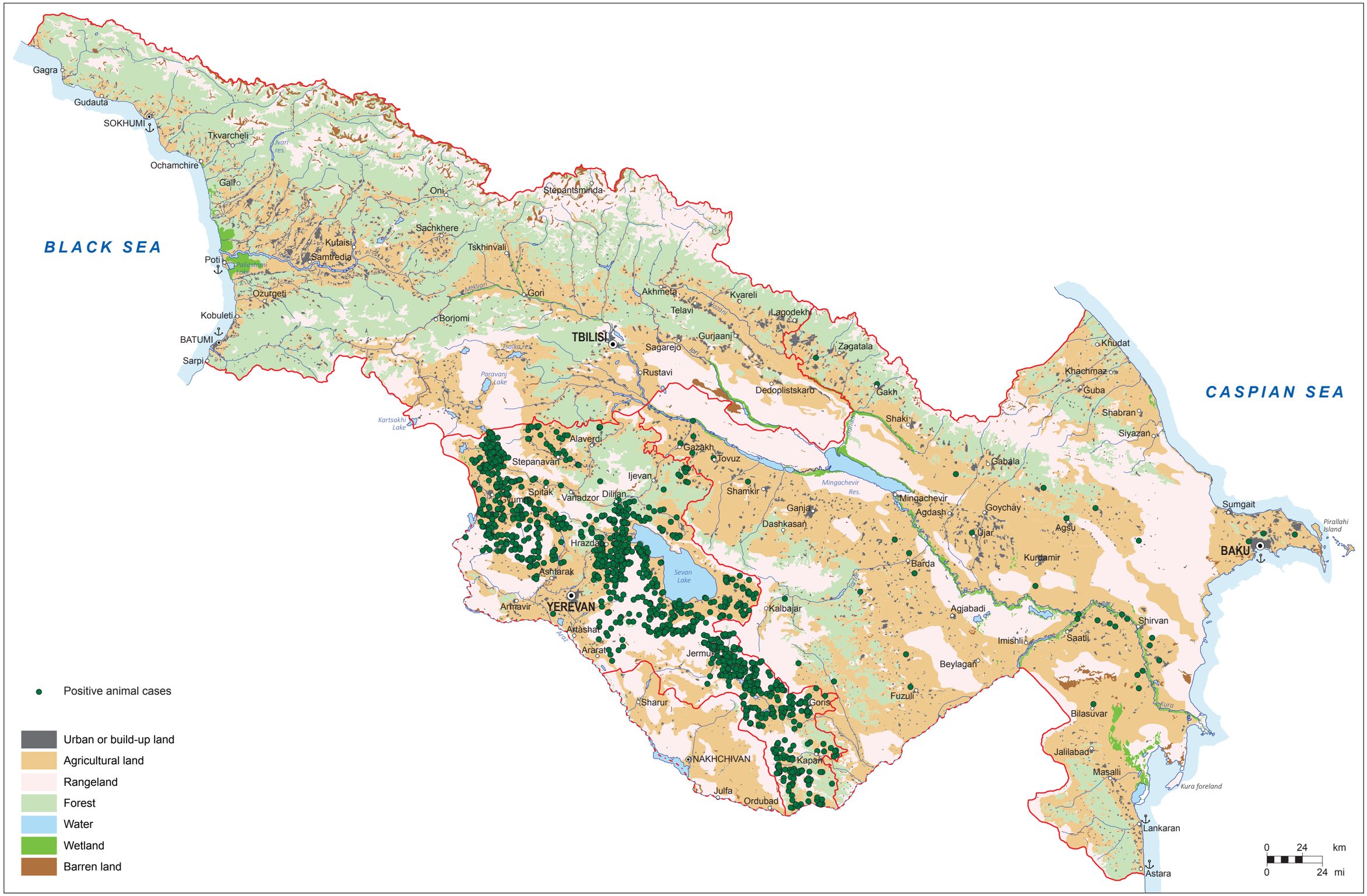
Distribution of Leptospirosis Human Cases by Soil pH in Georgia, 1961-2020



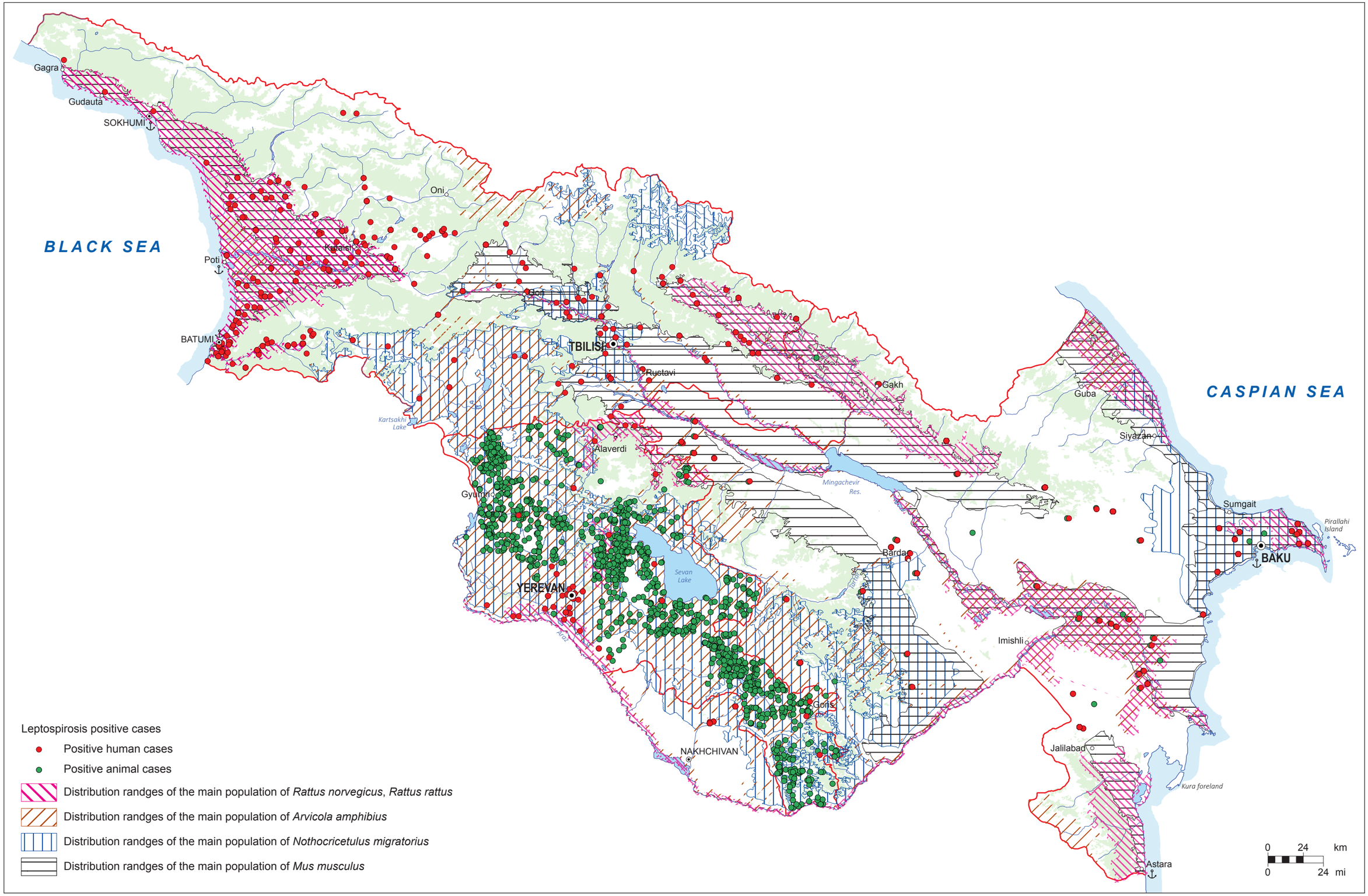
Distribution of Leptospirosis Human Cases by Land Use in the South Caucasus, 1950-2020



Distribution of Leptospirosis Animal Cases by Land Use in the South Caucasus, 1950-2020



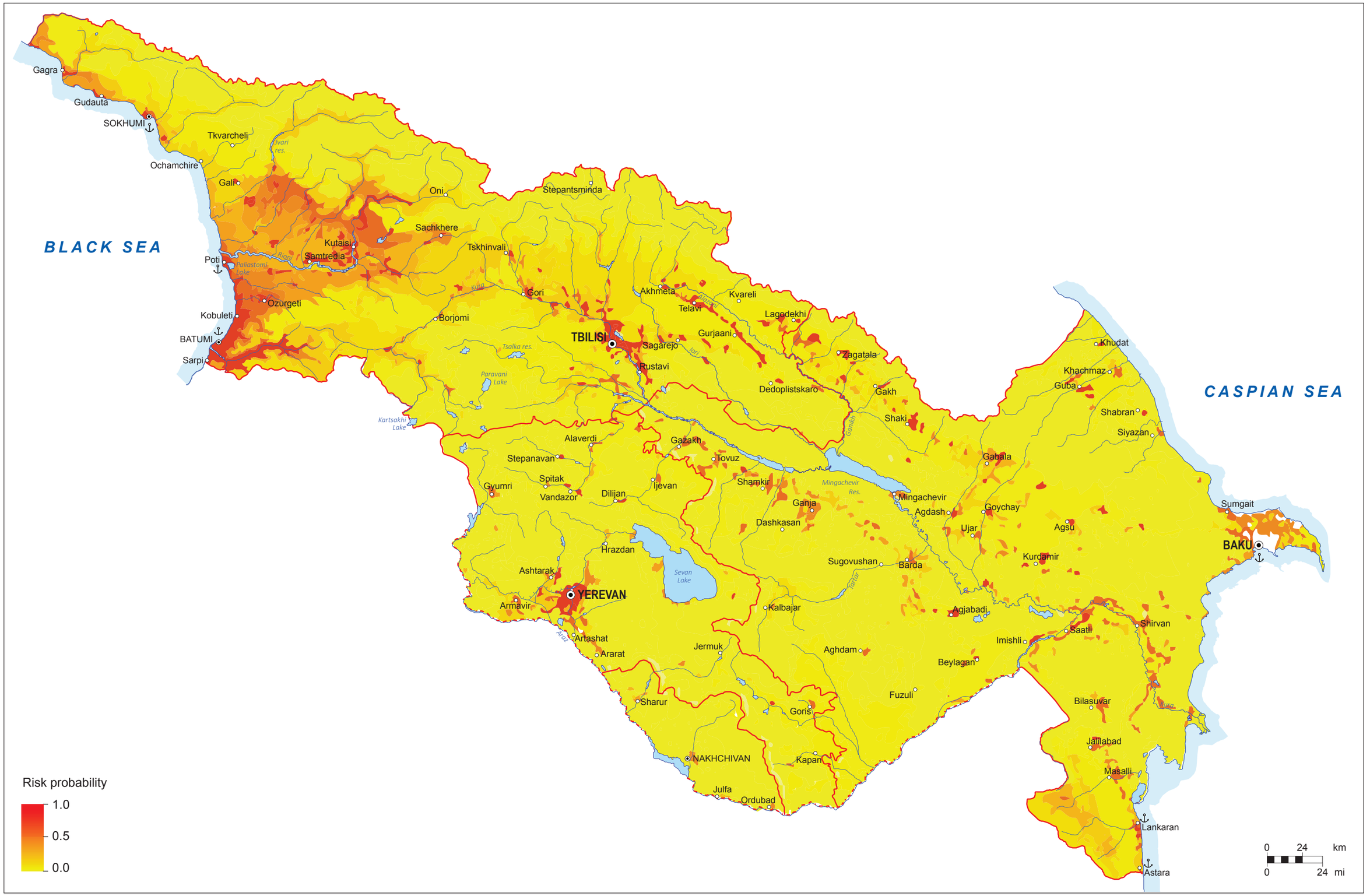
Distribution of Leptospirosis Human and Animal Cases and Distribution Ranges of the Main Population of Rodents in the South Caucasus, 1950-2020



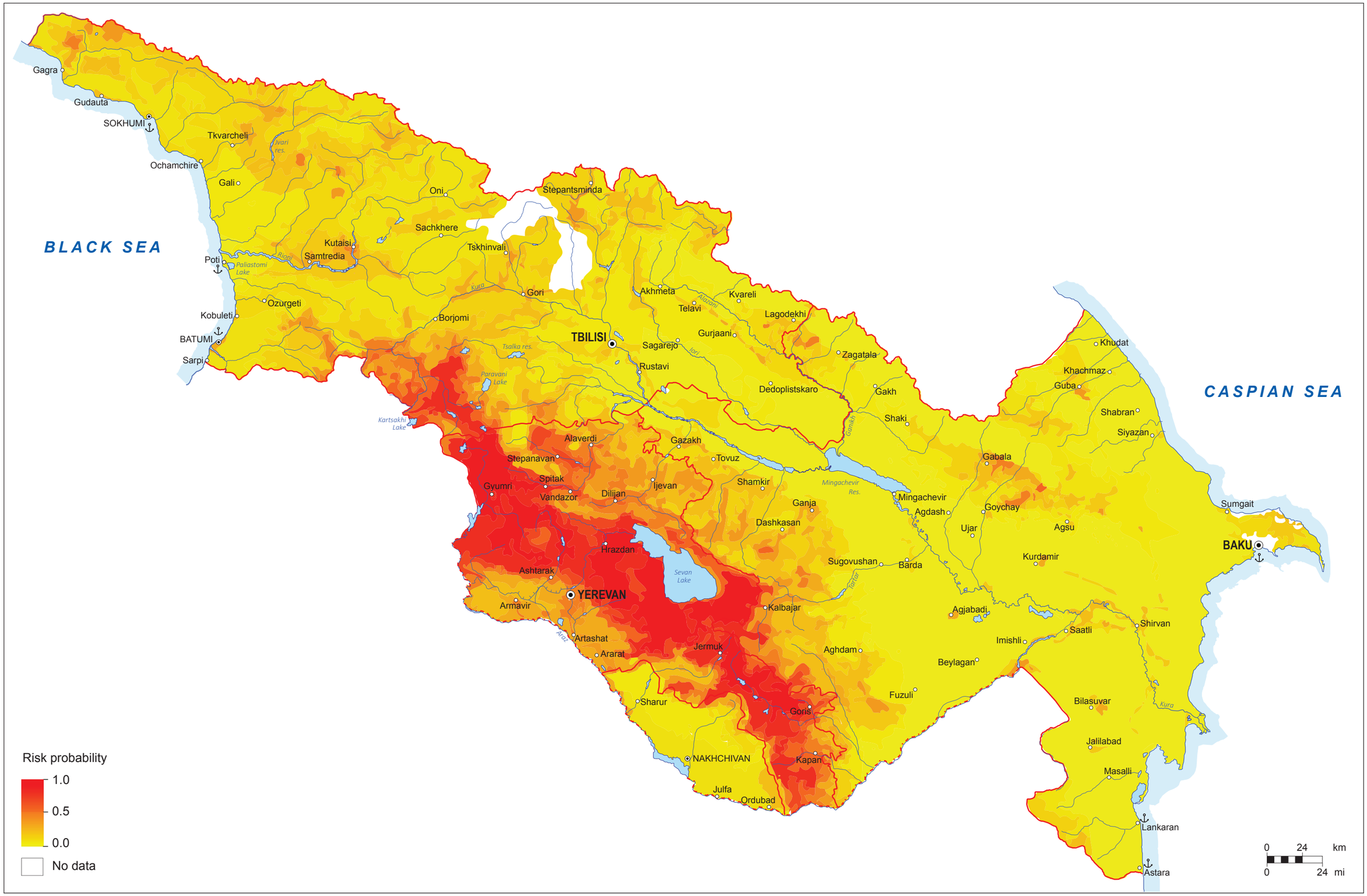
Leptospirosis positive cases

- Positive human cases
- Positive animal cases
- Distribution randges of the main population of *Rattus norvegicus*, *Rattus rattus*
- Distribution randges of the main population of *Arvicola amphibius*
- Distribution randges of the main population of *Nothocricetulus migratorius*
- Distribution randges of the main population of *Mus musculus*

Leptospirosis Human Cases Risk in the South Caucasus



Leptospirosis Animal Cases Risk in the South Caucasus



Plague

Plague is a zoonotic disease caused by the gram-negative coccobacillus *Yersinia pestis* infects humans and other mammals. The circulation of plague involves >280 species of rodents and their ectoparasites. The causative agent of plague has several routes of transmission, with the most common being flea bites. Infection can also be transmitted by direct contact with infected tissues, soil, and inhalation of contaminated respiratory droplets. Research on the species of animals and fleas involved in the plague cycle, development of environmental management programs, as well as active long-term surveillance of animal foci, combined with rapid response during animal outbreaks, have succeeded in reducing plague spread in humans. *Yersinia pestis* is highly pathogenic for humans and animals, and is classified as a Category A bioterrorism agent because of its high case fatality rate, even at low infectious doses.

The plague caused widespread pandemics through – out human history. Among them was the pandemic known as the Black Death, which killed more than 50 million people in Europe in the 14th century. It is still a serious public health problem in many countries around the world today. Currently, Madagascar, Democratic Republic of Congo (DRC), and Peru are considered the three countries with the highest risk for plague. There are three forms of plague: bubonic, septicemic, and pneumonic. Among these forms, bubonic is the most common. This form has the lowest mortality rate ranging from 30% to 60%. Pneumonic has the highest lethality, and is the only form able to transmit from person to person. The pneumonic type is always fatal when left untreated. Septicemic plague occurs when infection spreads through the bloodstream. Different forms of plague have different incubation periods. For example, the incubation period of bubonic plague is 3 to 7 days, and 1 to 3 days for pneumonic plague.

Field laboratory work on Plague, © Vakhtang Martashvili

Animal Samples Collection for Plague Laboratory Investigation, © Vakhtang Martashvili

Large parts of the world are endemic from plague. Public health workers in these regions are at particular risk. It is advisable to take precautions against flea bites, not to touch dead animals, avoid direct contact with contaminated tissues and body fluids. When collecting specimens from an infected patient appropriate equipment should be used. In the event of a case, education should be provided to local communities, along with continuous surveillance, and rapid notification. Vaccination is routinely not recommended except for high-risk groups, such as laboratory personnel and healthcare workers. None of the plague vaccines are approved by the US Food and drug Administration.

Plague can be cured with appropriate antibiotics, and treatment varies according to the severity of the disease and clinical manifestations. Several different classes of antimicrobials are effective in the treatment of plague, but aminoglycosides and fluoroquinolones are primarily used. If pneumonic plague is not treated, the outcome can quickly become fatal. Therefore, timely diagnosis and treatment are essential for survival and to reduce complications. People who have had close contact with a person with severe pneumonic plague should be evaluated and possibly placed under observation. They may also be given prophylactic antibiotic therapy, depending on the type and time of contact. If the patient is diagnosed in time, the use of antibiotics and supportive anti-plague therapy will be effective. The sooner a patient seeks medical care for treatment, the greater the chance of a full recovery.

Plague has been recognized in the Caucasus region for many centuries with the first reports date back to the fourth century. The first reports in Georgia date back to the eleventh century and in Azerbaijan to the seventh century. Large human outbreaks were first registered in both Georgia and Azerbaijan in the beginning of the twentieth century. Routine surveillance of plague activity was initiated in eastern Georgia (Kakheti) in 1953 and in southern Georgia and the high mountains of Armenia from 1958. Most of Azerbaijan and eastern Georgia are endemic for plague, and epizootics occurred periodically beginning in 1914, with recent cases documented in 1979-1983, 1992-1997, and 2019.

Data on Plague had been collected from middle of 20th century from all three countries (1946-2019) from the available publications, annual reports, unpublished data of the public health centers, former anti-plague stations and veterinary centers as well as from different finished and/or ongoing scientific projects reports.

In the Caucasus region, twelve natural plague foci are registered. Among them, two are located in the plain–foothill (Iori Valley) and the high mountains of Georgia (Bakanidze et al. 2010; Revazishvili et al. 2008). The high mountainous focus (200 to 250,000 ha) covers subalpine and alpine zones in the southern part of Georgia on the Javakheti plateau at an altitude of 1200 to 2200 meters, bordering the Armenian natural focus from the south with almost identical fauna, flora, and physical–geographical characteristics (pp. 176-177). The plain–foothill focus is located in the eastern part of Georgia in a semi-desert zone, including the border between Georgia and Azerbaijan, covering 350,000 ha at an average altitude of 500 to 800 meters (max. 1000 to 1200 meters) to continue in the "Djeiranchel" plague natural focus in Azerbaijan (pp. 176-177).

Plague activity is mainly observed during the hot months, when the average maximum temperature is 3 to 11 degrees Celsius (pp 185-186). Precipitation is considered an important factor in plague distribution with its activity mainly reported in areas with total precipitation is 600 to 800 millimeters (pp. 182-183). In the natural foci of the Armenia and Georgia border area, cases are observed in high altitude glacial-nival landscapes on agricultural land. In Georgia- and Azerbaijan-endemic foci, cases are found in moderate-dry steppe and dry steppe landscapes of shallow mountains, plains (structural basin) and plateaus, as well as semi-desert landscapes of shallows, plains and plateau landscapes. Cases here are found in the Rangeland landscape (pp 178-181).

Plague animal positive cases are registered among *Meriones lybicus* in Georgia, *Apodemus agrarius*, *Meriones libycus*, *Meriones vinogradovi*, and *Oryctolagus cunculus* in Azerbaijan. In Armenia animal positive cases are registered among *Meriones vinogradovi*, *Microtus obscurus*, *Apodemus uralensis*, *Arvicola amphibius*, *Nothocricetulus migratorius*, and *Mesocricetus brandti*. Positive flea samples were obtained from *Callopsylla caspia*, *Nosopsyllus laeviceps*, *Nosopsyllus consimilis* and *Xenopsylla conformis* in Georgia. In Azerbaijan flea positive cases were registered among *Nosopsyllus laeviceps*, *Nosopsyllus iranus*, *Ctenophthalmus secundus*, *Xenopsylla conformis*, and *Rhadinopsylla cedestis*. In Armenia flea positive samples are registered among *Amphipsylla rossica*, *Ceratophyllus caspius*, *Ceratophyllus consimilis*, *Ctenophthalmus teres*, *Ctenophthalmus wladimiri*, *Frontopsylla elata caucasica*, *Stenoponia ivanovi*, and *Xenopsylla conformis*.

Callopsylla caspia © Judith A. Stoffer

Filed work on Plague (Collecting Fleas from rodents borrows) © Vaja Chitiashvili

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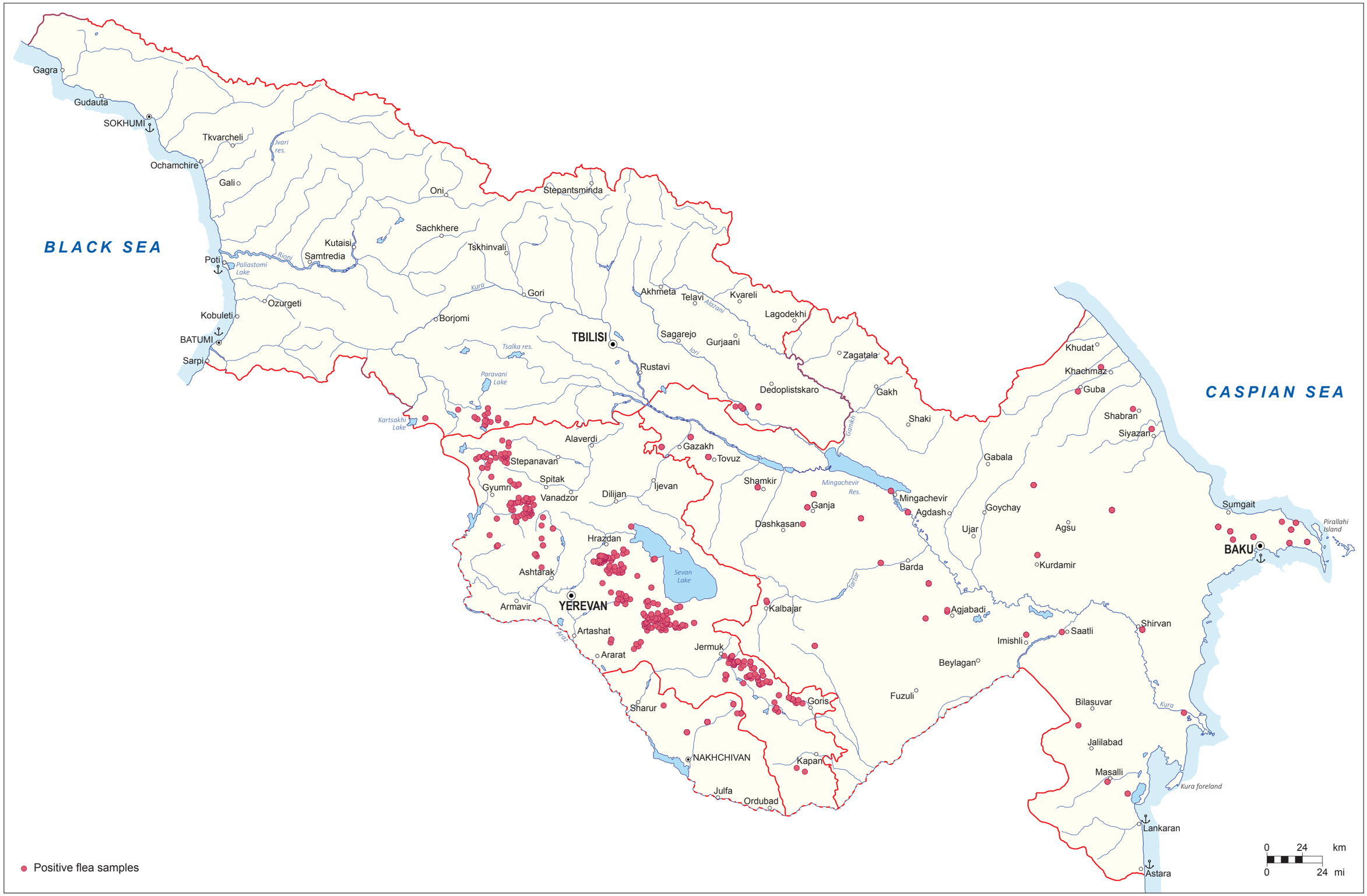
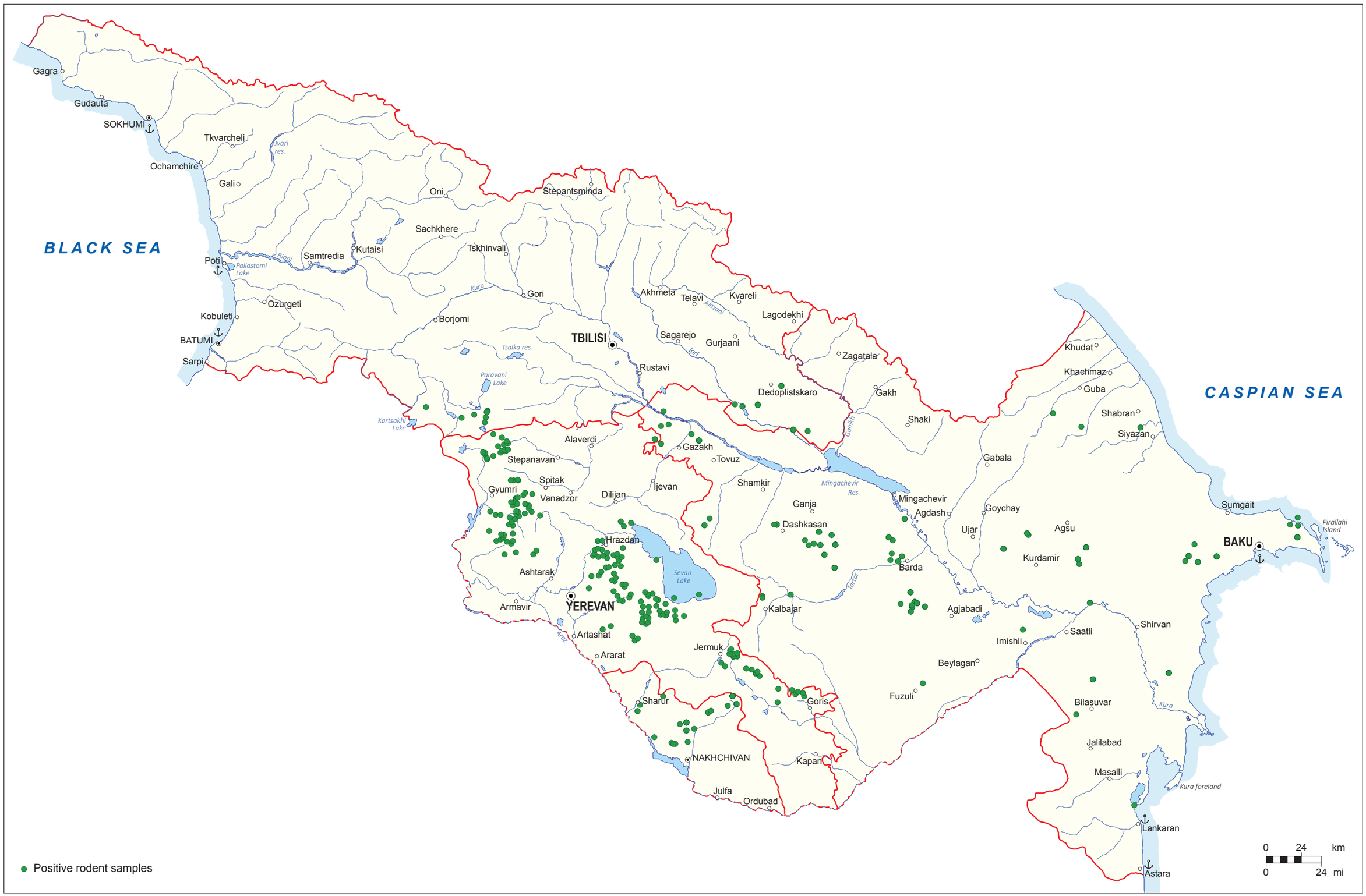
Distribution of Plague Positive Flea Samples in the South Caucasus, 1950-2019



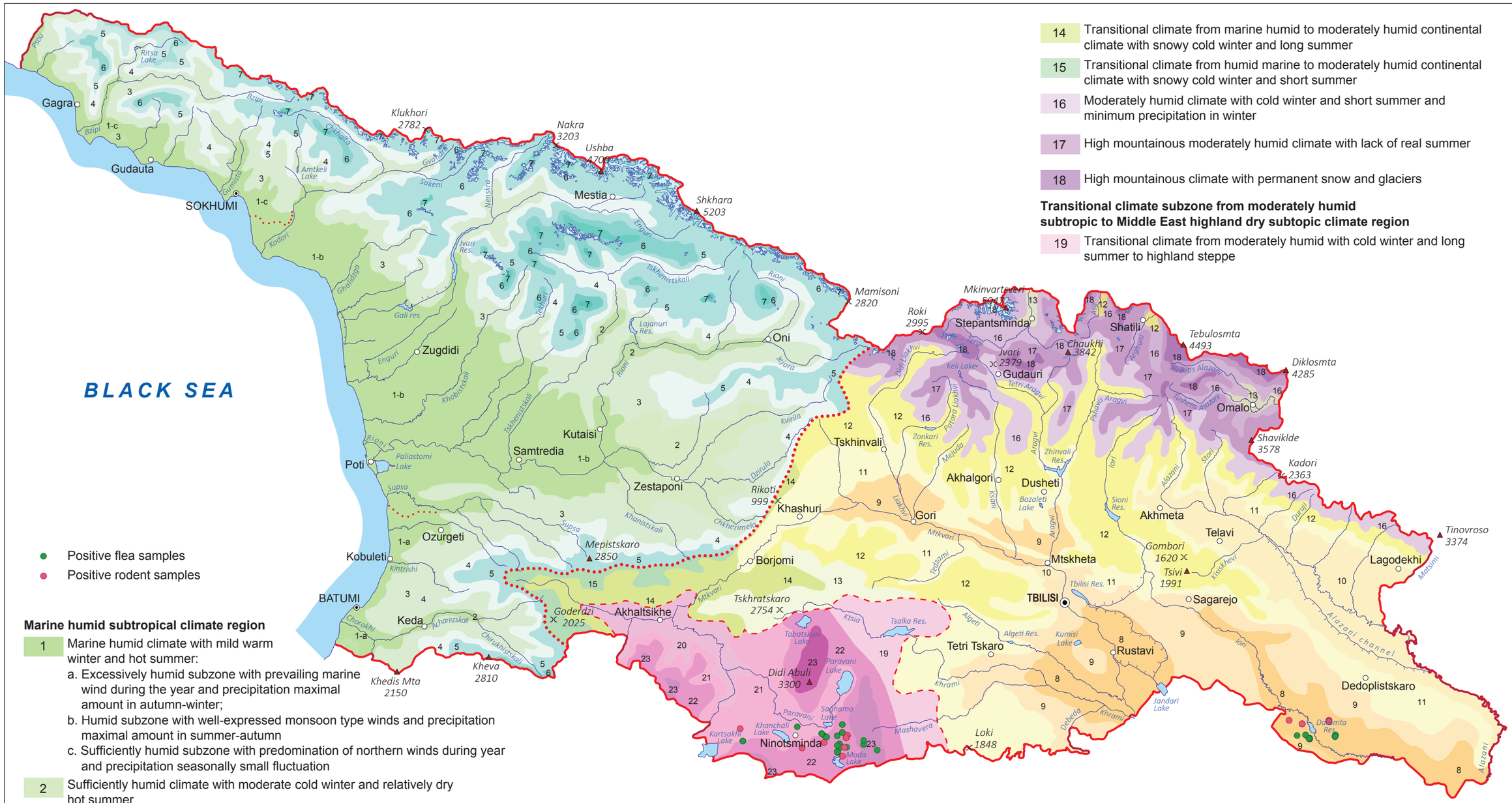
Distribution of Plague Positive Rodent Samples in the South Caucasus, 1950-2019



Distribution of Plague Positive Flea Samples by Elevation in the South Caucasus, 1950-2019

Distribution of Plague Positive Rodent Samples by Elevation in the South Caucasus, 1950-2019

Distribution of Plague Positive Flea and Rodent Samples by Climate Types in Georgia, 1950-2019



Marine humid subtropical climate region

1 Marine humid climate with mild warm winter and hot summer:
- a. Excessively humid subzone with prevailing marine wind during the year and precipitation maximal amount in autumn-winter;
- b. Humid subzone with well-expressed monsoon type winds and precipitation maximal amount in summer-autumn
- c. Sufficiently humid subzone with predomination of northern winds during year and precipitation seasonally small fluctuation

2 Sufficiently humid climate with moderate cold winter and relatively dry hot summer

3 Humid climate with moderate cold winter and long warm summer

4 Humid climate with cold winter and long cool summer

5 Humid climate with cold winter and short summer

6 High mountainous humid climate with lack of real summer

7 High mountainous humid climate with year-round abundant snow and glaciers

Moderately humid subtropical climate region

8 Moderately warm steppe with hot summer and minimum precipitation twice a year

9 Transitional climate from a moderate warm steppe to a moderate humid one, with hot summer and minimum precipitation twice a year

10 Moderate humid climate with moderately cold Winter and hot summer and minimum precipitation twice a year

11 Moderate humid climate with moderately cold Winter and long warm summer and minimum precipitation twice a year

12 Moderate humid climate with cold Winter and long cold summer, minimum precipitation twice a year

13 Moderate humid climate with cold winter and long cool summer and minimum precipitation in winter

14 Transitional climate from marine humid to moderately humid continental climate with snowy cold winter and long summer

15 Transitional climate from humid marine to moderately humid continental climate with snowy cold winter and short summer

16 Moderately humid climate with cold winter and short summer and minimum precipitation in winter

17 High mountainous moderately humid climate with lack of real summer

18 High mountainous climate with permanent snow and glaciers

Transitional climate subzone from moderately humid subtropic to Middle East highland dry subtopic climate region

19 Transitional climate from moderately humid with cold winter and long summer to highland steppe

20 Highland steppe climate with less snowy, cold winter and long, warm summer

21 Highland steppe climate with less snowy, cold winter and long cool summer

22 Highland steppe climate with short summer and cold, less snowy winter

23 Highland moderately dry climate with lack of real summer

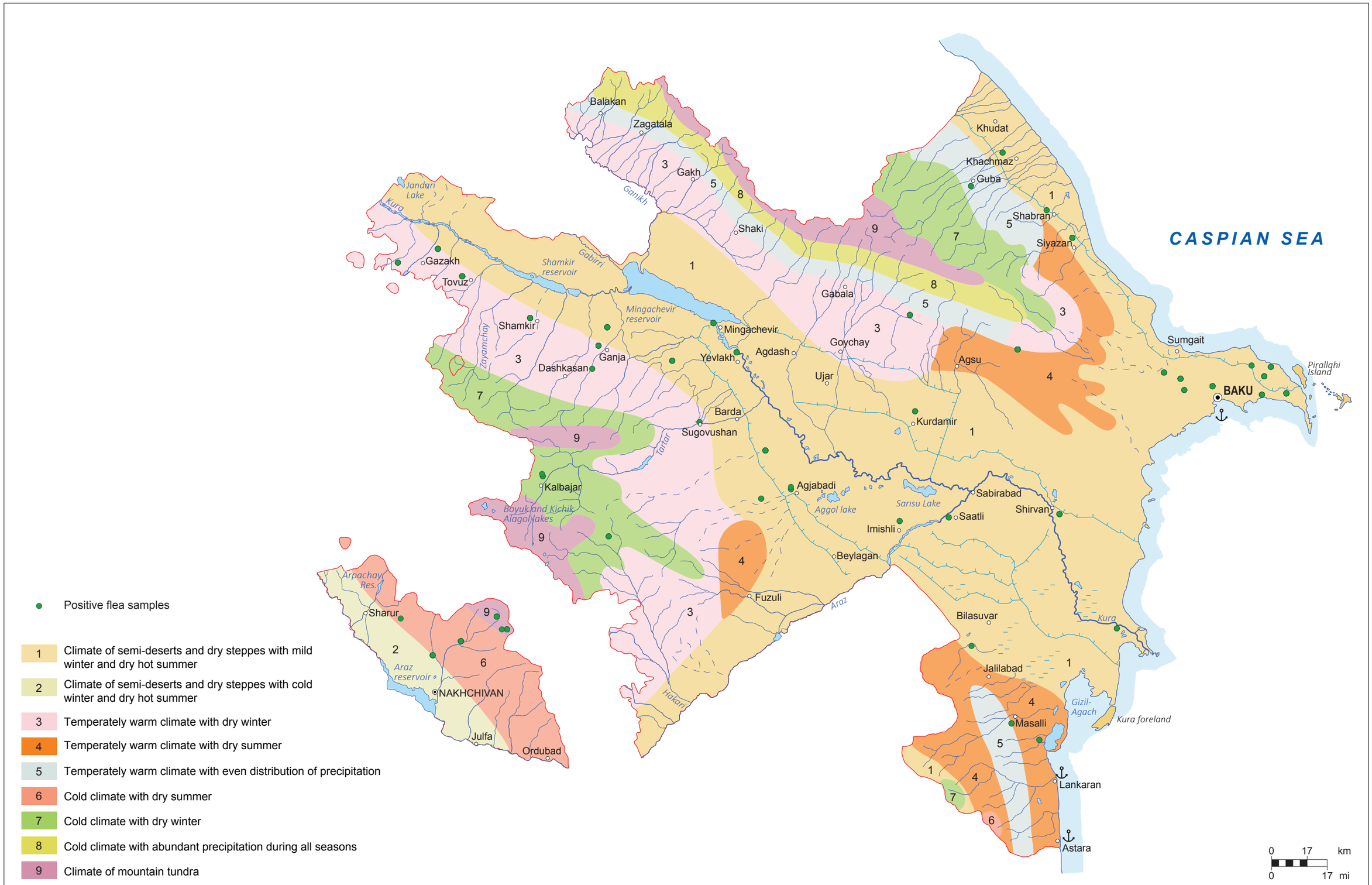
Climate region's border ····· Climate subzone's border

Subregion border

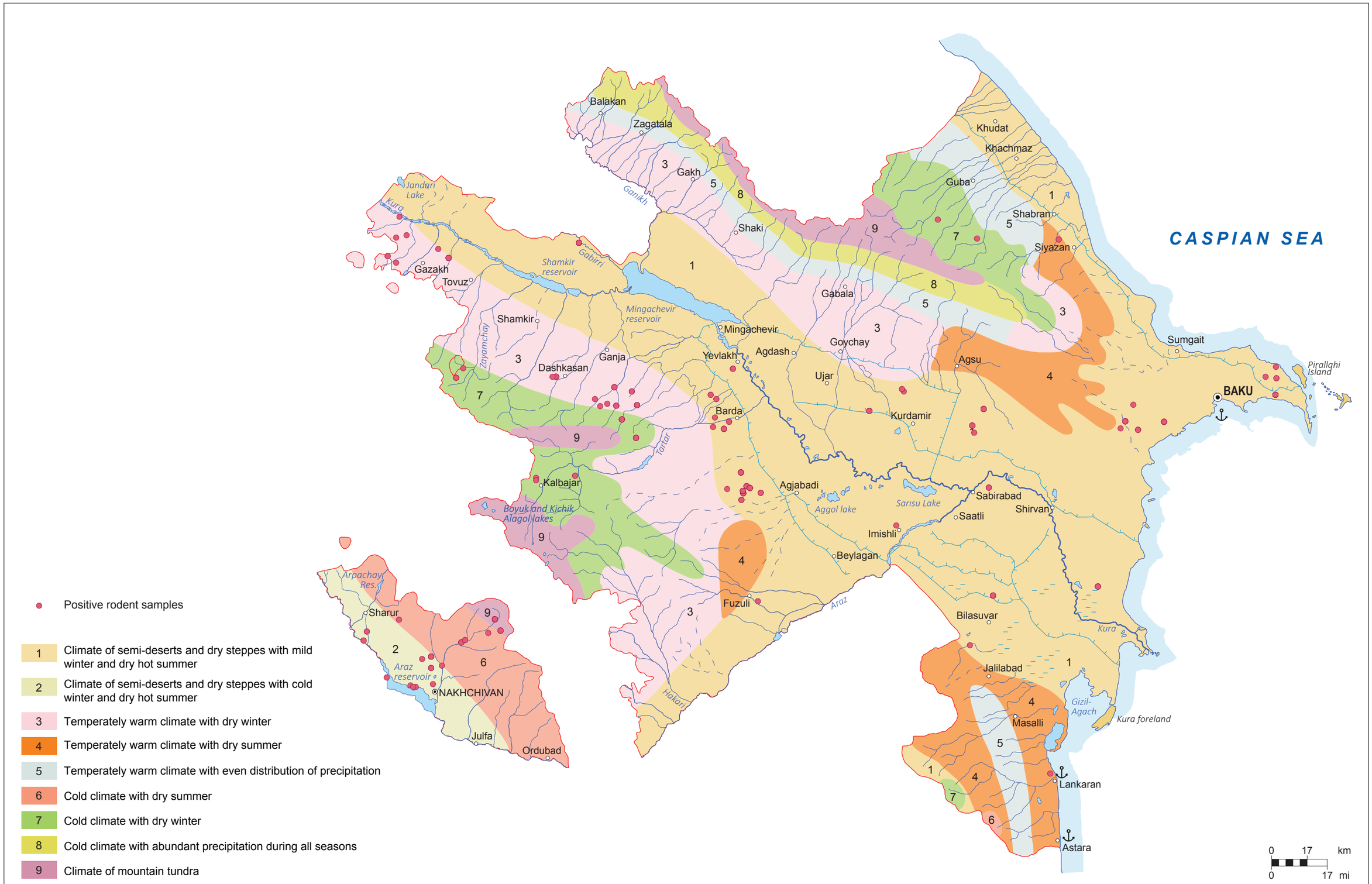
0 15 km

0 15 mi

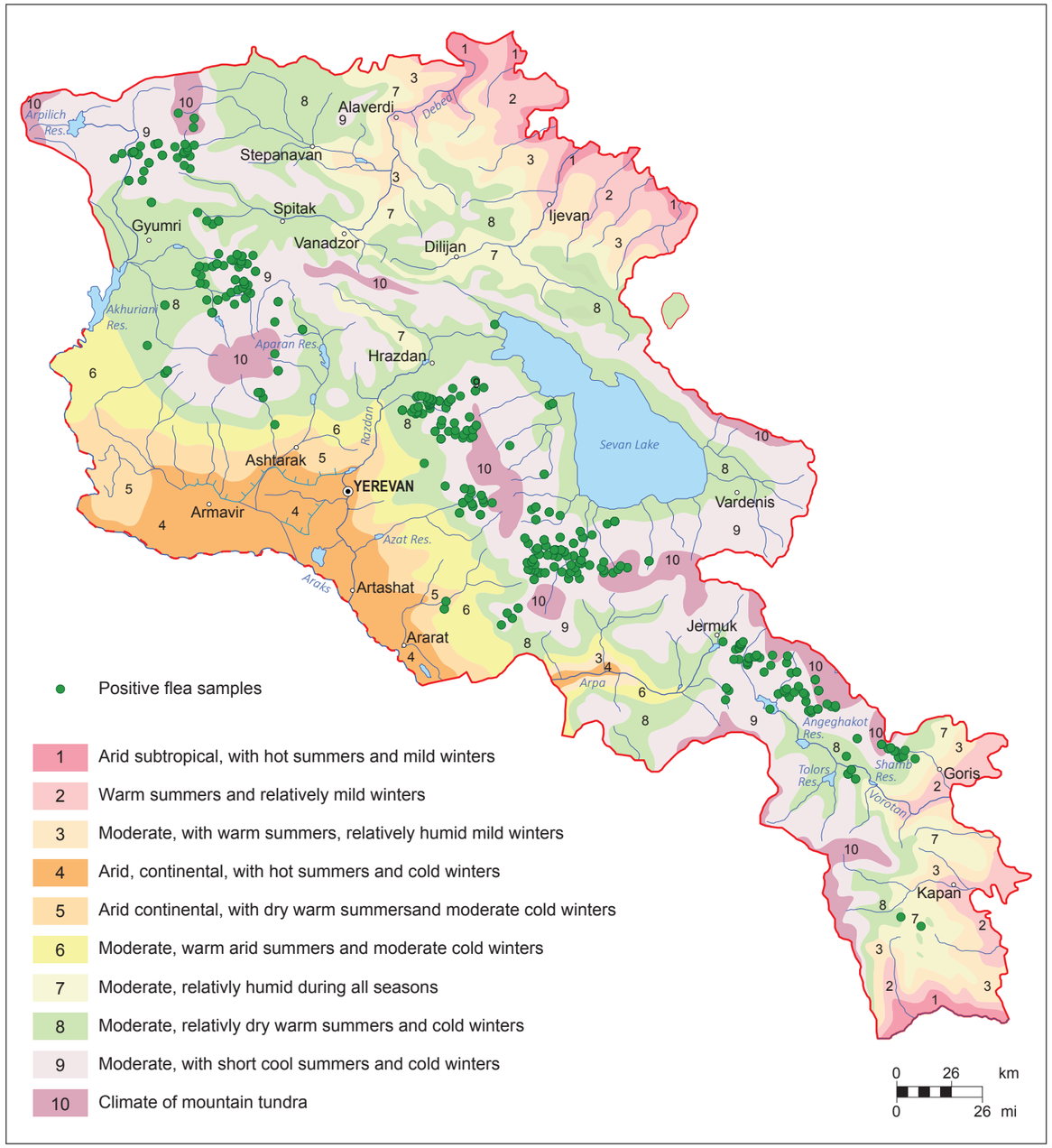
Distribution of Plague Positive Flea Samples by Climate Types in Azerbaijan, 1950-2019



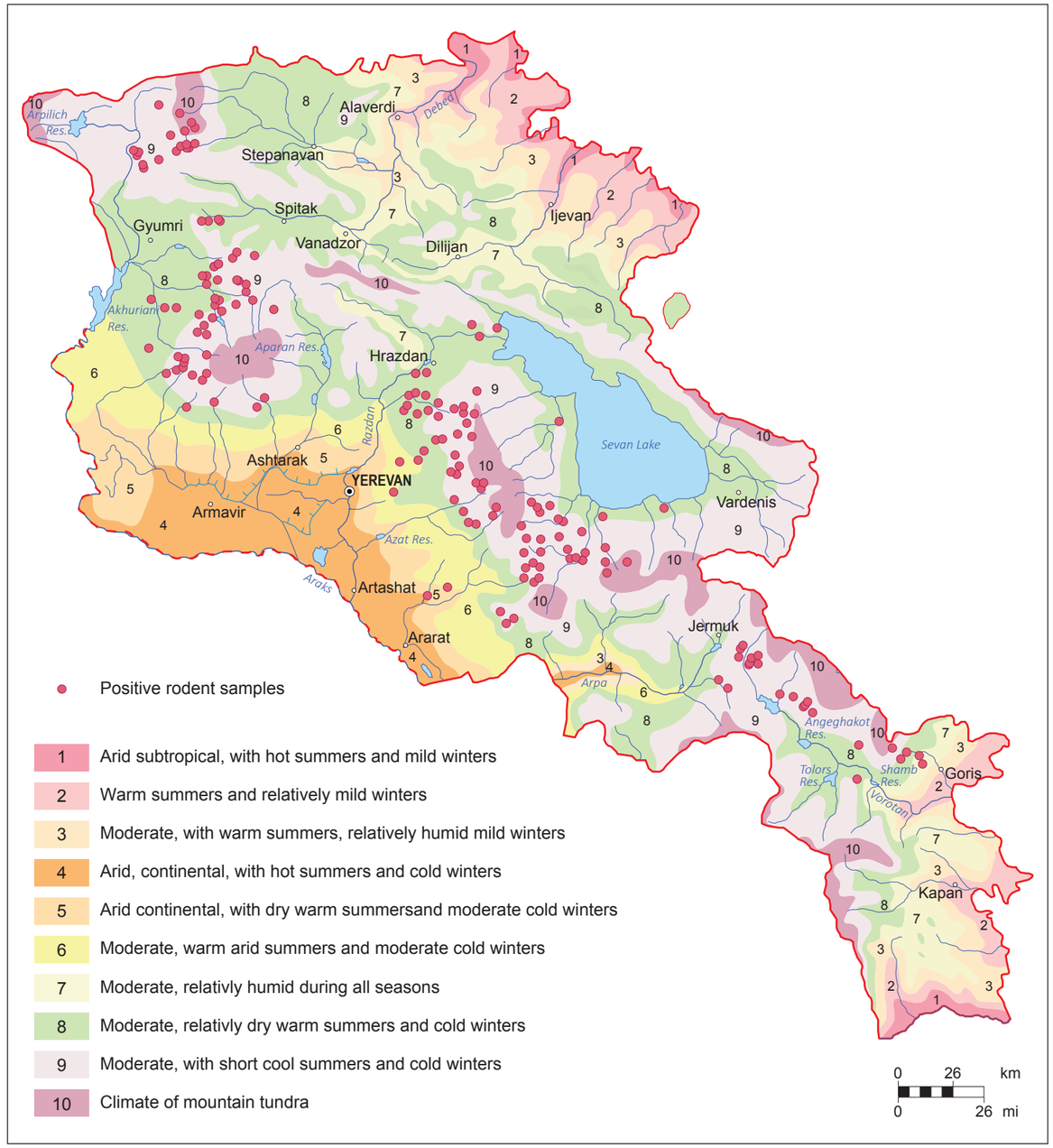
Distribution of Plague Positive Rodents Samples by Climate Types in Azerbaijan, 1950-2019



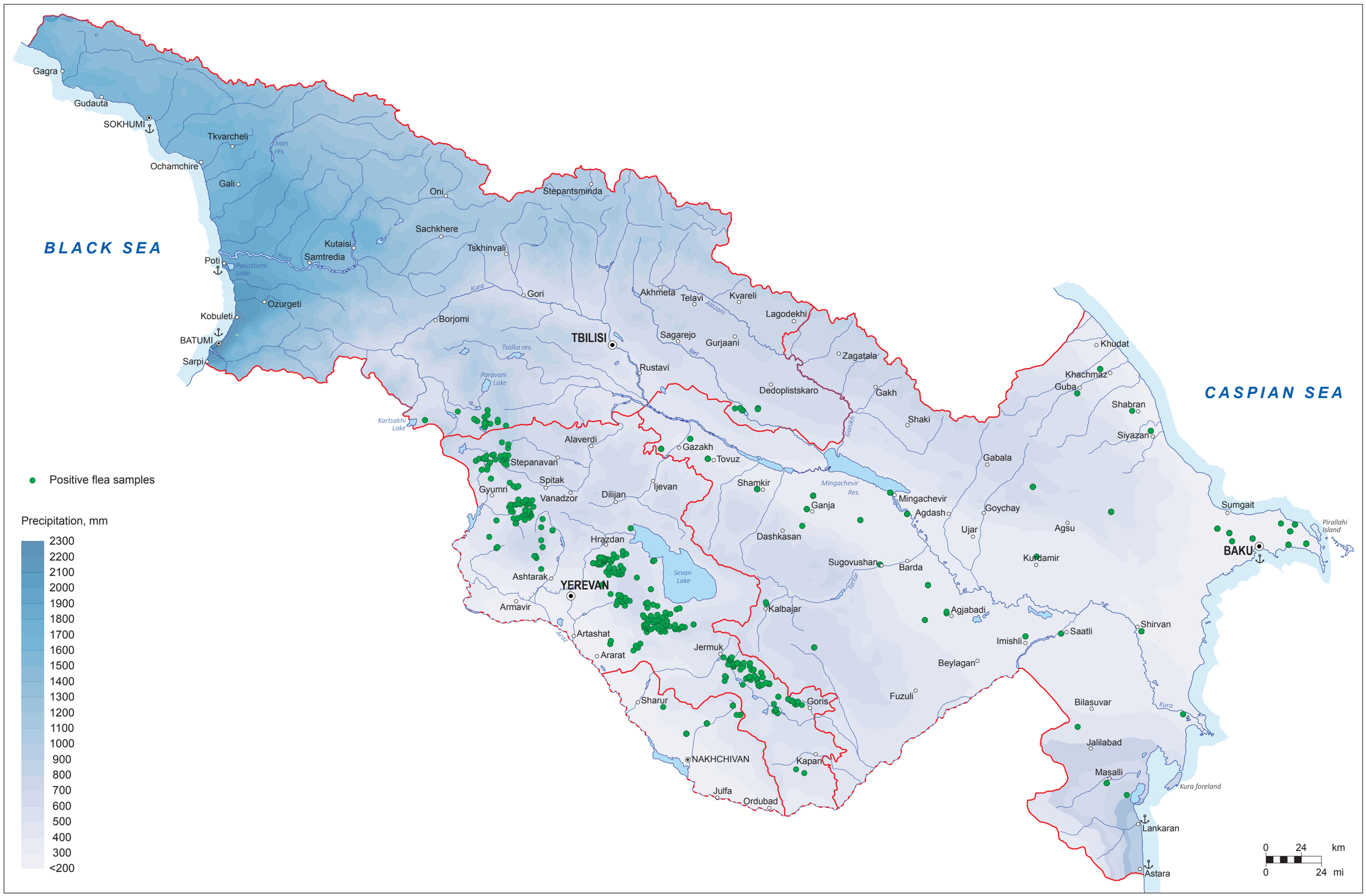
Distribution of Plague Positive Flea Samples by Climate Types in Armenia, 1950-2019



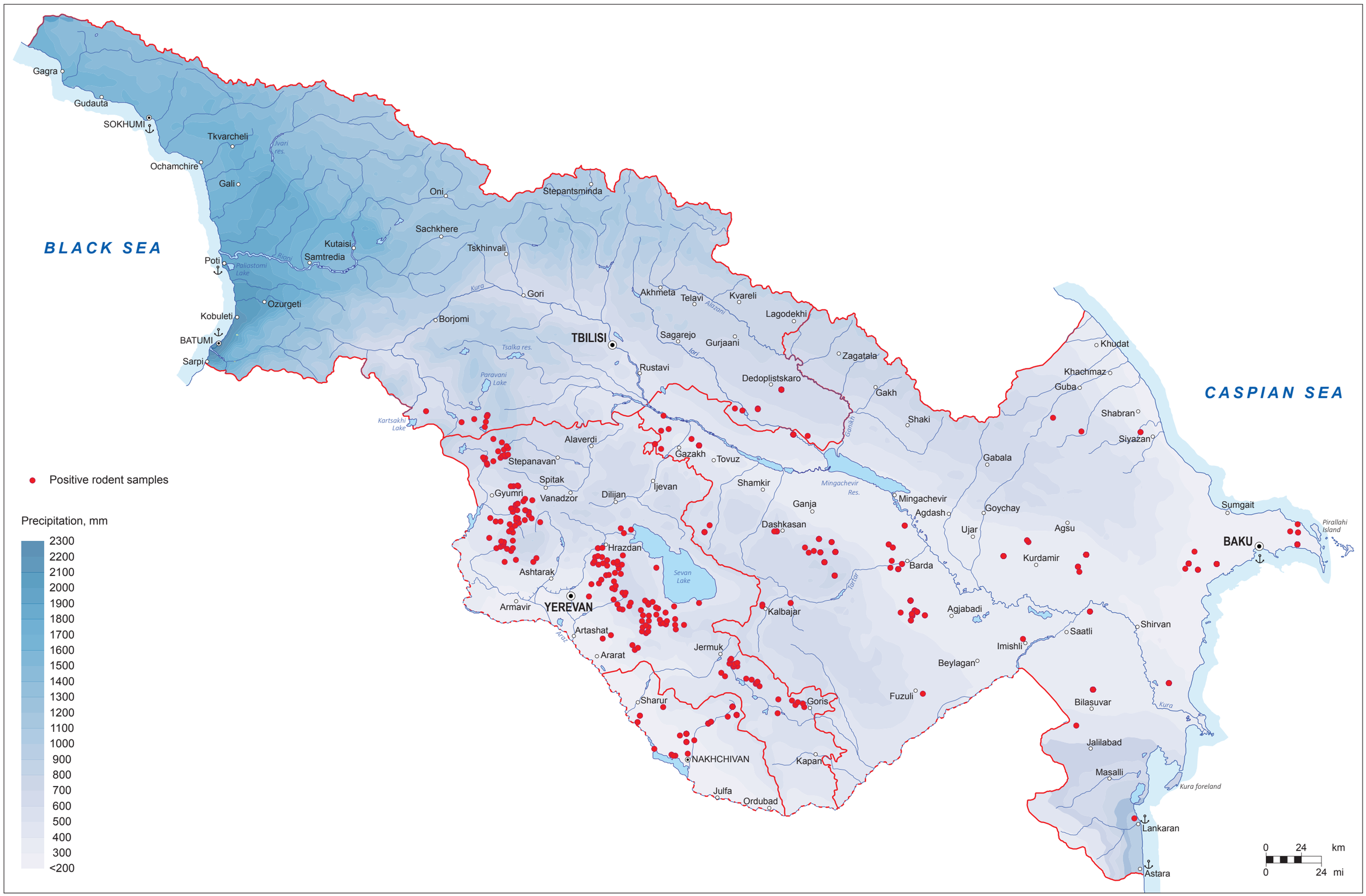
Distribution of Plague Positive Rodent Samples by Climate Types in Armenia, 1950-2019



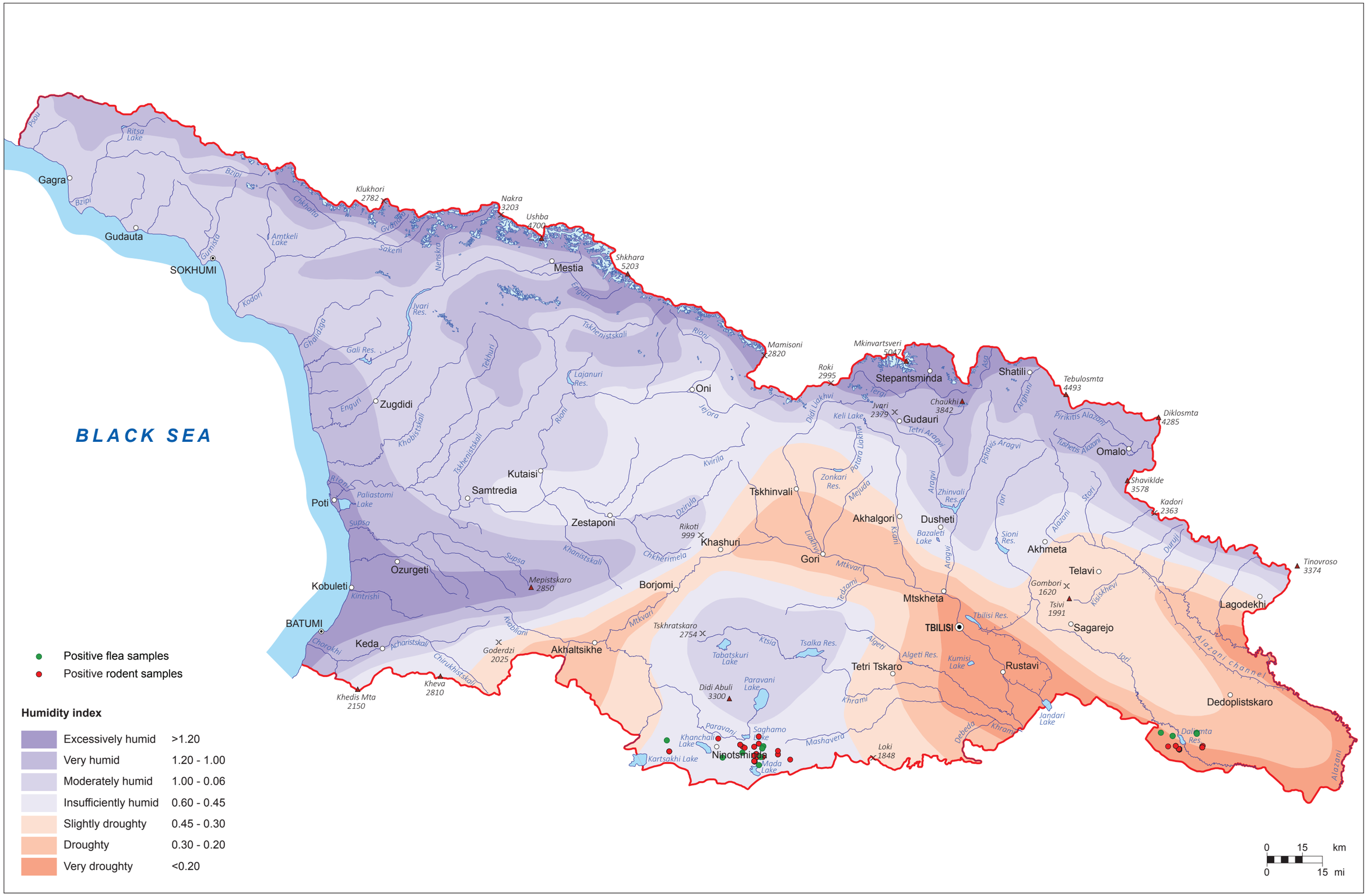
Distribution of Plague Positive Flea Samples by Precipitation in the South Caucasus, 1950-2019



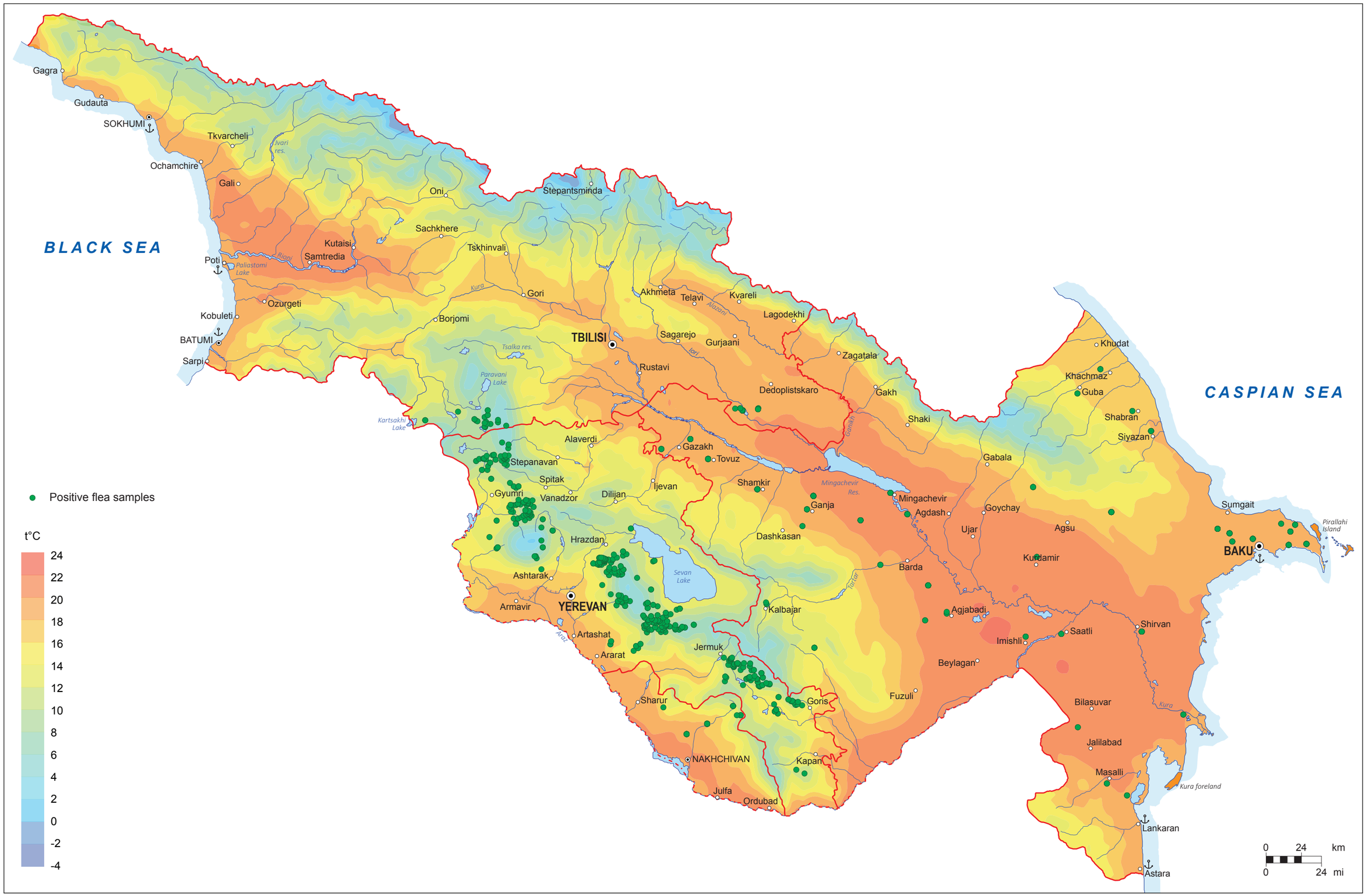
Distribution of Plague Positive Rodent Samples by Precipitation in the South Caucasus, 1950-2019



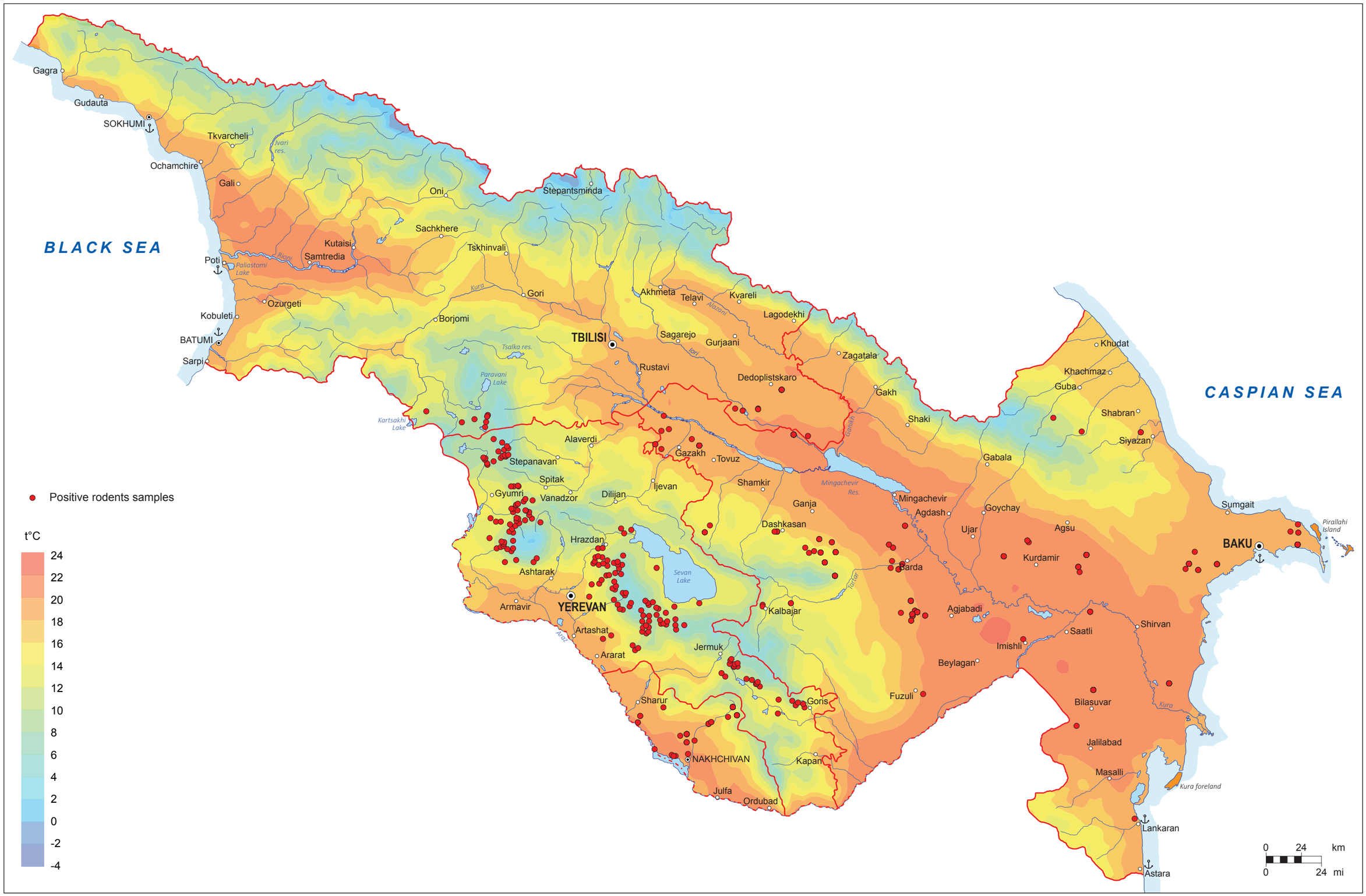
Distribution of Plague Positive Flea and Rodent Samples by Humidity Index in Georgia, 1950-2019



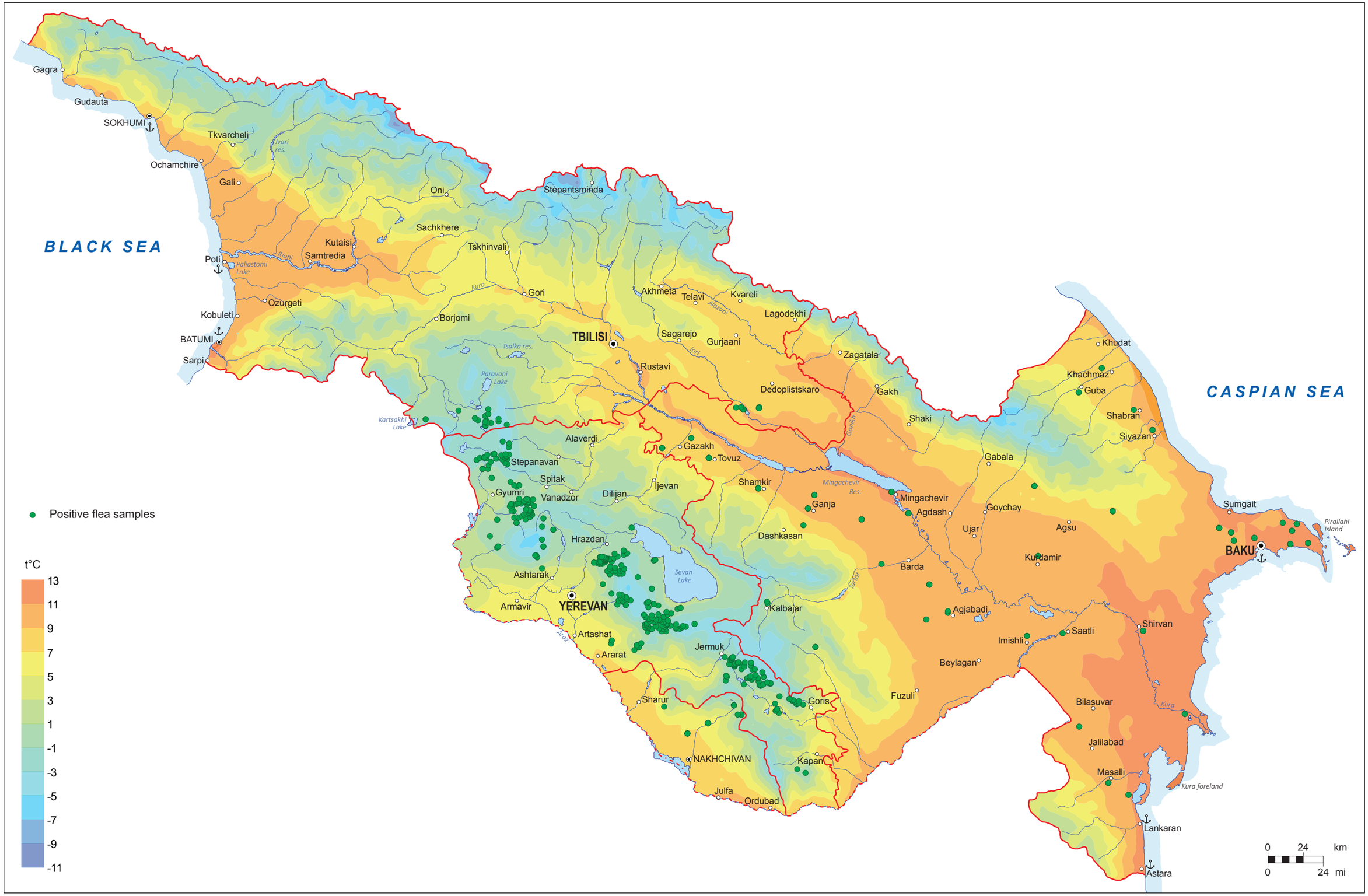
Distribution of Plague Positive Flea Samples by Maximum Temperature in the South Caucasus, 1950-2019



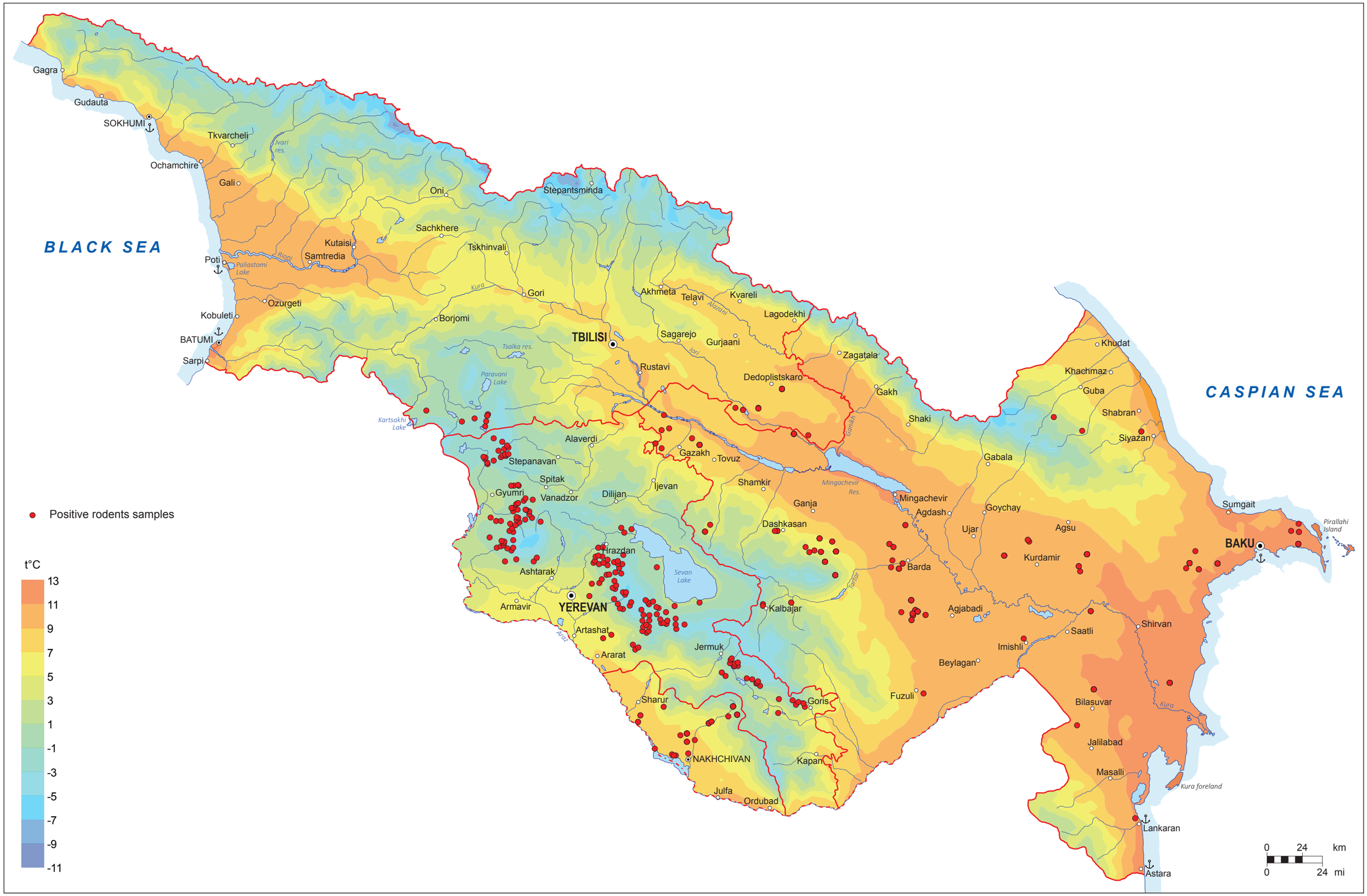
Distribution of Plague Positive Rodent Samples by Maximum Temperature in the South Caucasus, 1950-2019



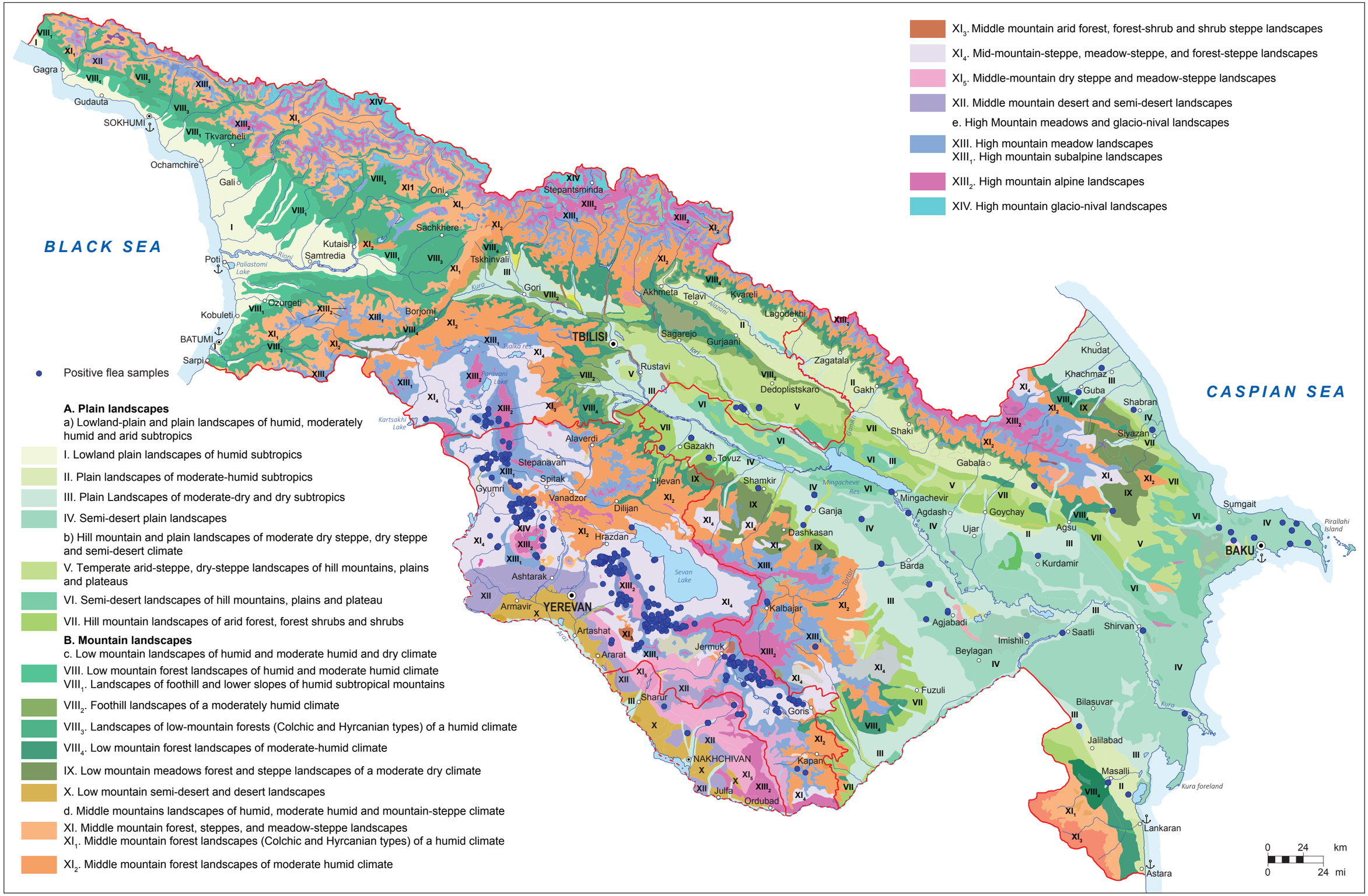
Distribution of Plague Positive Flea Samples by Minimum Temperature in the South Caucasus, 1950-2019



Distribution of Plague Positive Rodent Samples by Minimum Temperature in the South Caucasus, 1950-2019



Distribution of Plague Positive Flea Samples by Landscape in the South Caucasus, 1950-2019


BLACK SEA
CASPIAN SEA
TBILISI
YEREVAN
BAKU
NAKHCHIVAN
Gagra
Gudauta
SOKHUMI
Tkvarcheli
Ochamchire
Gali
Oni
Stepantsminda
Sachkhere
Kutaisi
Samtredia
Tskhinvali
Poti
Paliastomi Lake
Rioni
Kura
Gori
Akhmeta
Telavi
Kvareli
Lagodekhi
Ozurgeti
Kobuleti
Borjomi
Sagarejo
Gurjaani
Zagatala
BATUMI
Sarpi
Rustavi
Dedoplistskaro
Gakh
Khudat
Khachmaz
Guba
Shabran
Siyazan
Shaki
Gabala
Alazani
Iori
Tsalka res.
Paravani Lake
Kartsakhi Lake
Ganja
Gazakh
Tovuz
Alaverdi
Stepanavan
Spitak
Gyumri
Vanadzor
Ijevan
Dilijan
Shamkir
Mingachevir
Mingachevir Res.
Agdash
Goychay
Ujar
Agsu
Kurdamir
Sumgait
Pirallahi Island
Dashkasan
Hrazdan
Sevan Lake
Ashtarak
Armavir
Artashat
Ararat
Jermuk
Kalbajar
Barda
Agjabadi
Beylagan
Imishli
Saatli
Shirvan
Fuzuli
Goris
Sharur
Kapan
Julfa
Ordubad
Bilasuvar
Jalilabad
Masalli
Lankaran
Astara
Kura
Kura foreland
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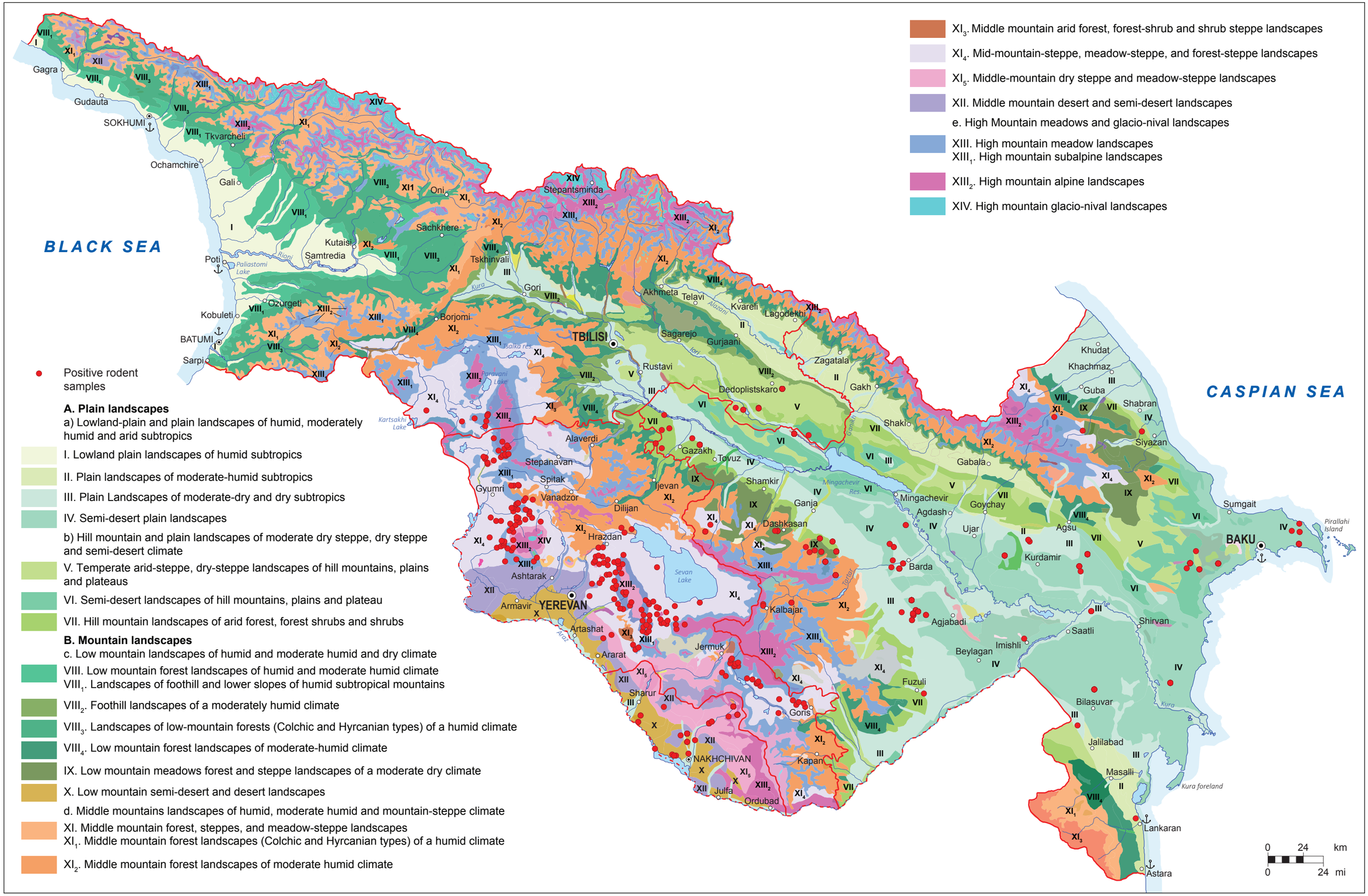
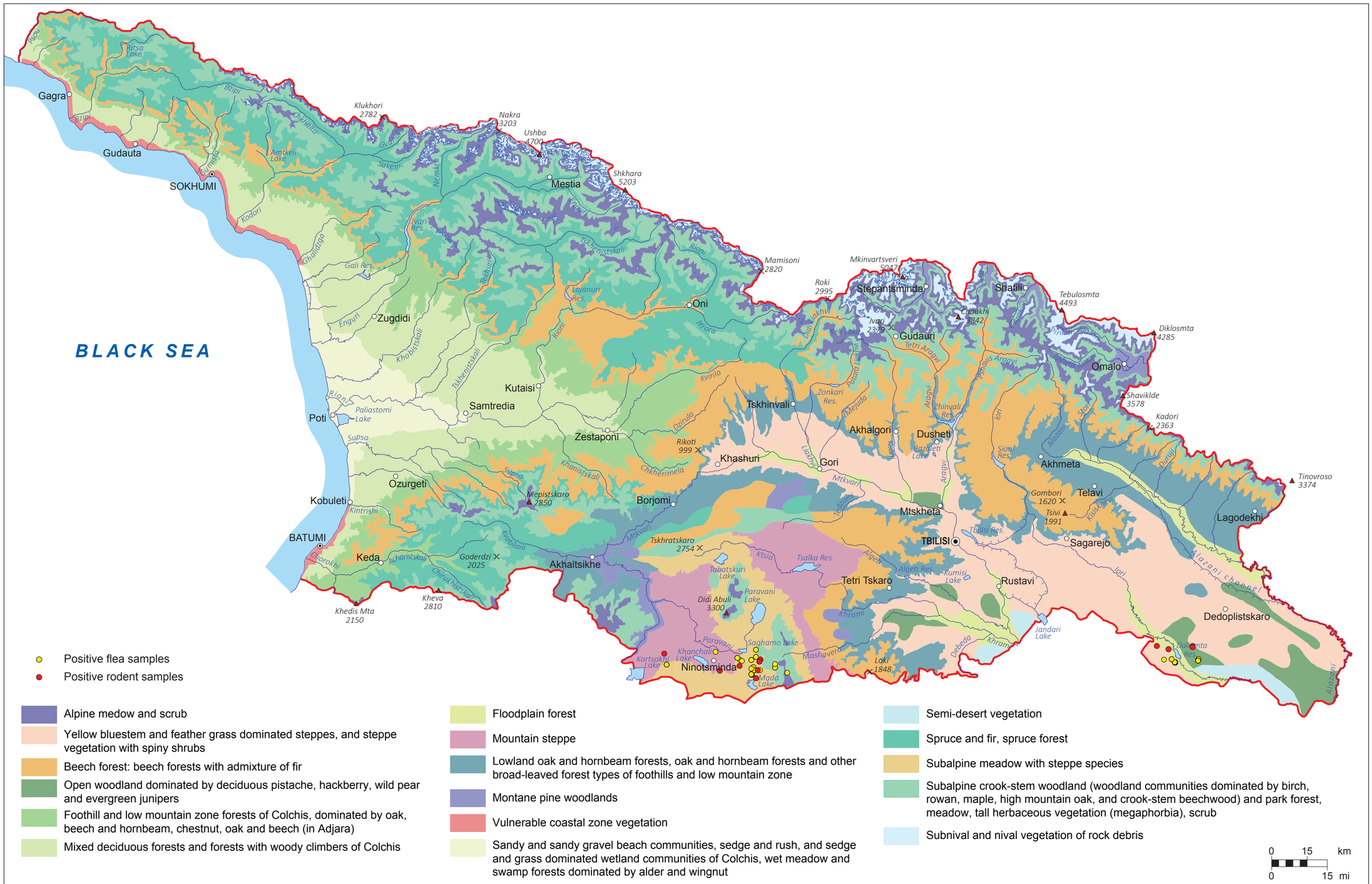
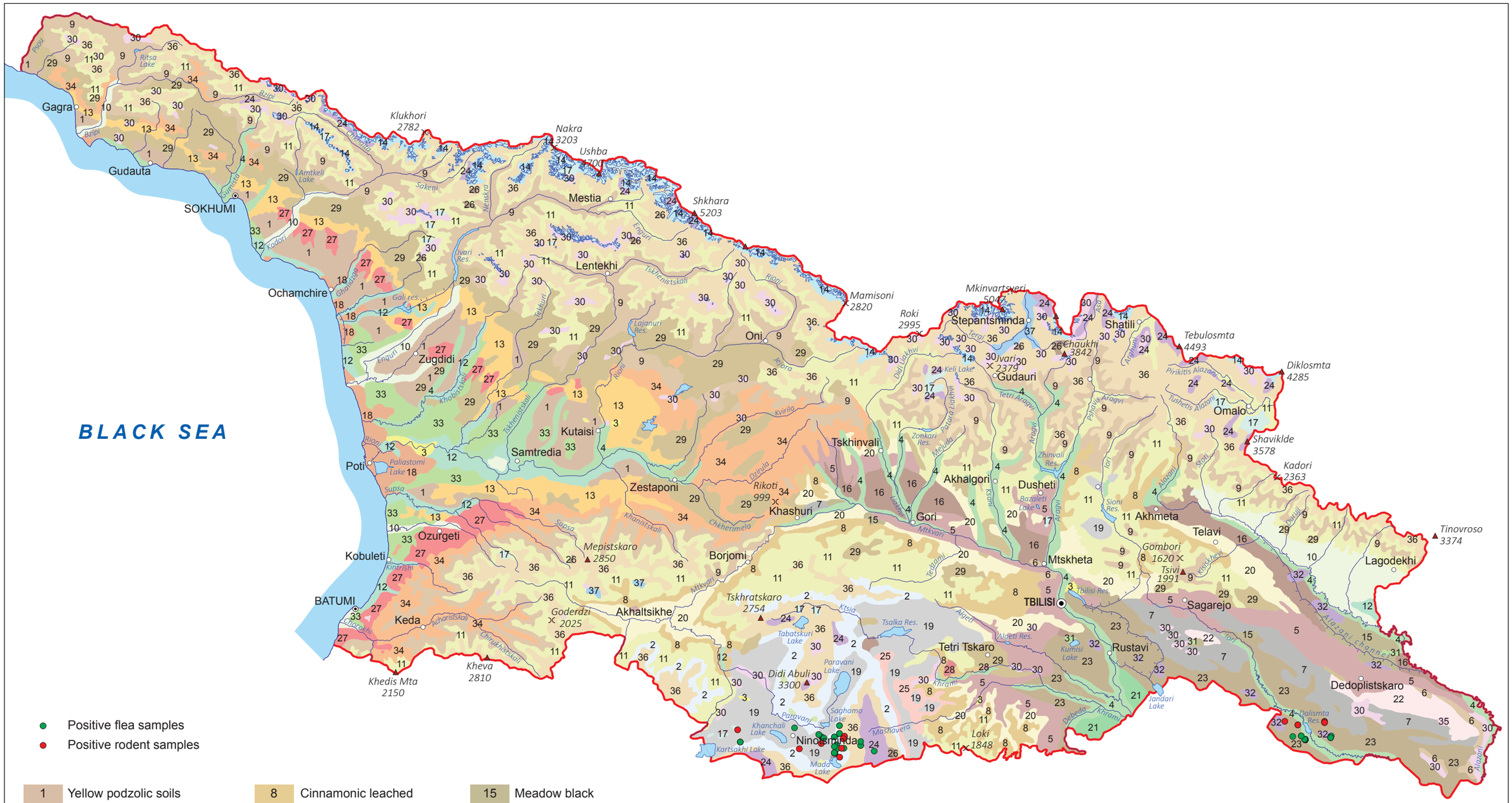
Distribution of Plague Positive Rodent Samples by Landscape in the South Caucasus, 1950-2019



Distribution of Plague Positive Flea and Rodent Samples by Vegetation in Georgia, 1950-2019

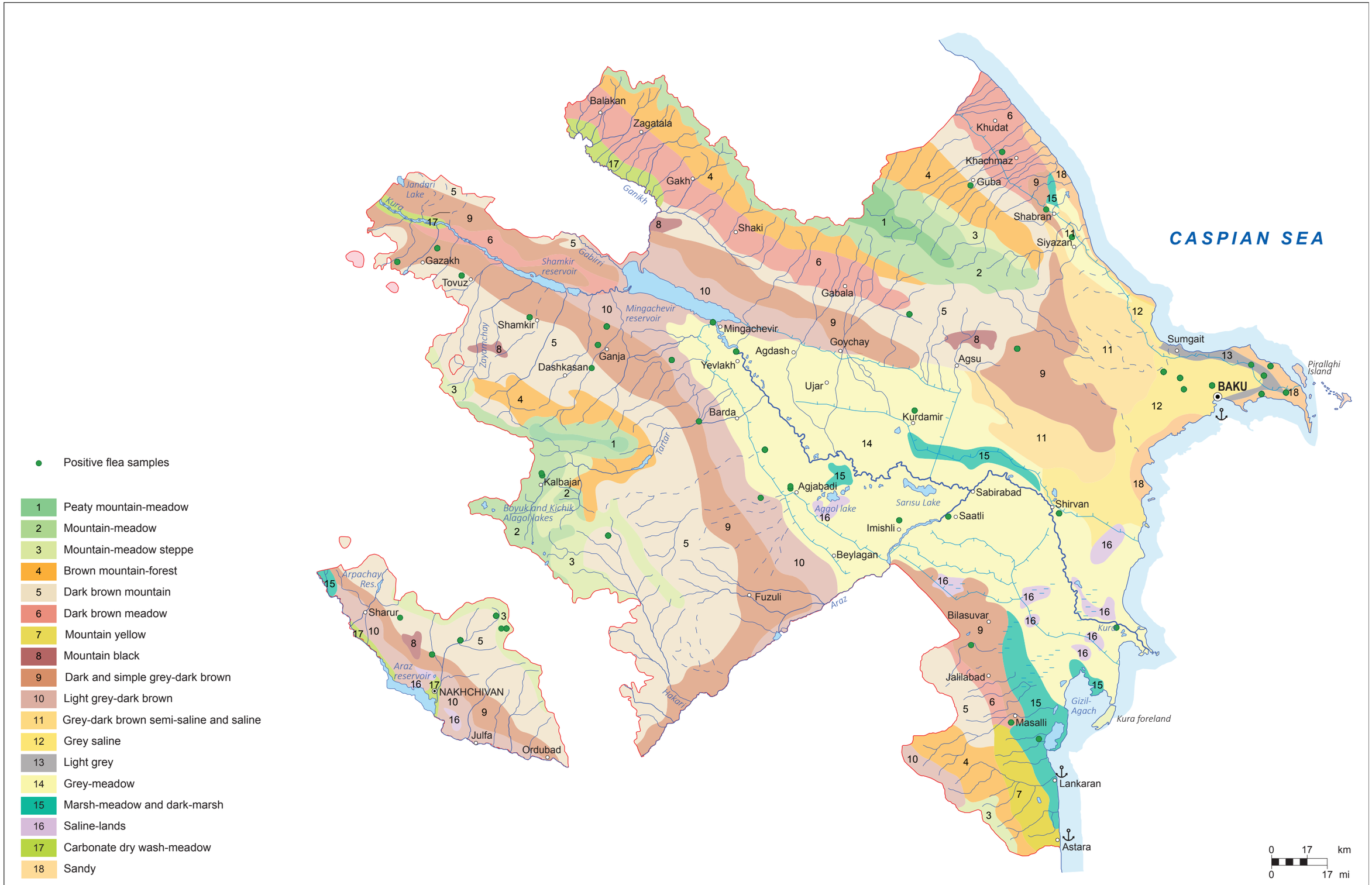


Distribution of Plague Positive Flea and Rodent Samples by Soil Types in Georgia, 1950-2019

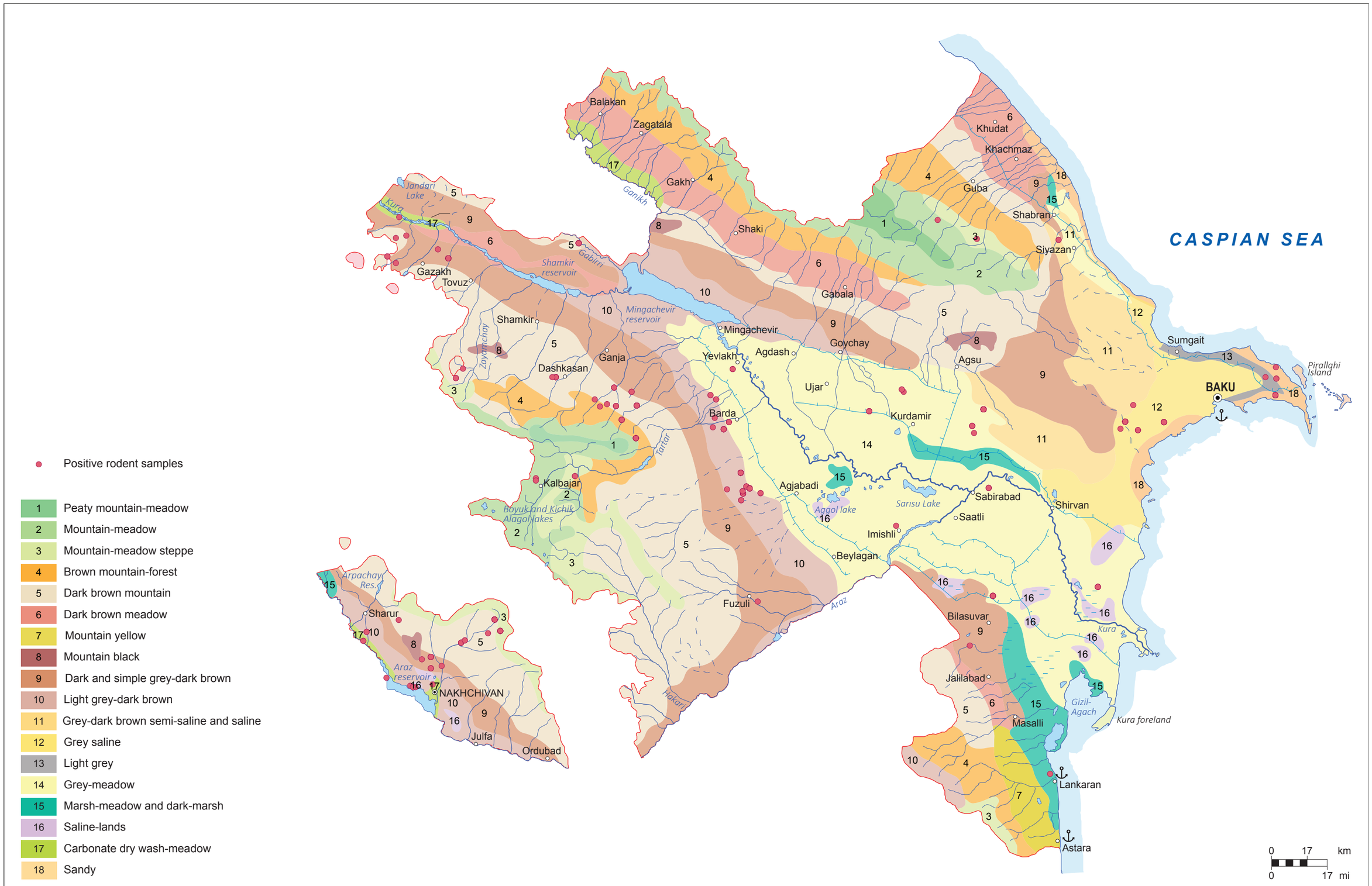


1	Yellow podzolic soils	8	Cinnamonic leached	15	Meadow black						
2	Andosols	9	Dystric cambisols	16	Meadow cinnamonic	22	Black	28	Brown forest black	34	Yellow brown forest
3	Anthropogenic soils	10	Alluvial acid	17	Mountain meadow peat	23	Grey cinnamonic	29	Rendzic leptosols	35	Raw humus sulphate
4	Alluvial calcareous	11	Eutric cambisols	18	Gleysols	24	Primitive mountain meadow	30	Strongly eroded soils and bare rocks	36	Mountain meadow
5	Cinnamonic calcareous	12	Alluvial saturated	19	Chernozems	25	Leached chernozems	31	Solonchak	37	Mountain forest meadow
6	Cinnamonic light	13	Yellow soils	20	Chernozems	26	Mountain meadow chernozem like	32	Solonetz		
7	Black calcareous	14	Glaciers	21	Meadow grey cinnamonic	27	Red soils	33	Yellow podzolic gley soils		

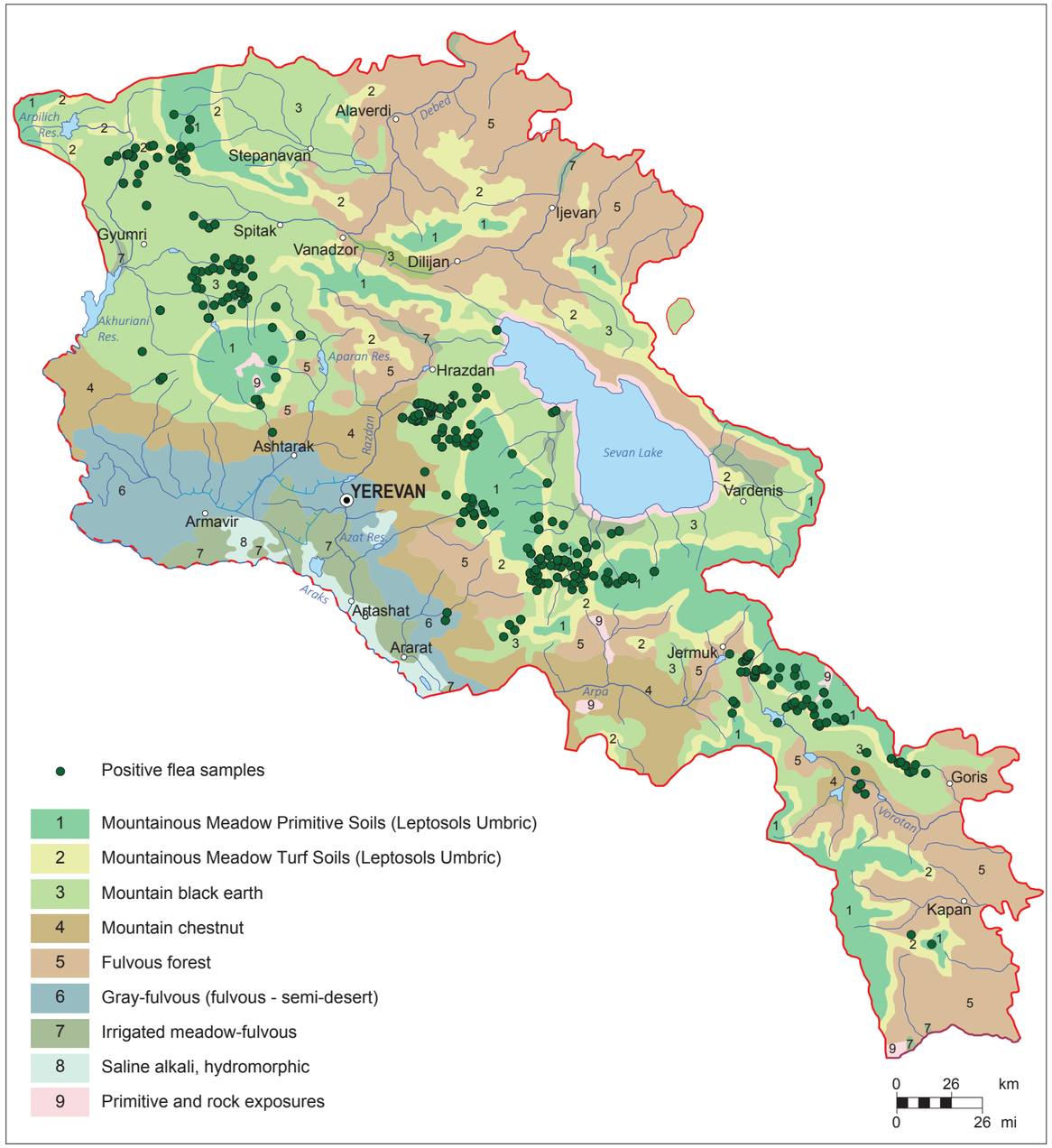
Distribution of Plague Positive Flea Samples by Soil Types in Azerbaijan, 1950-2019



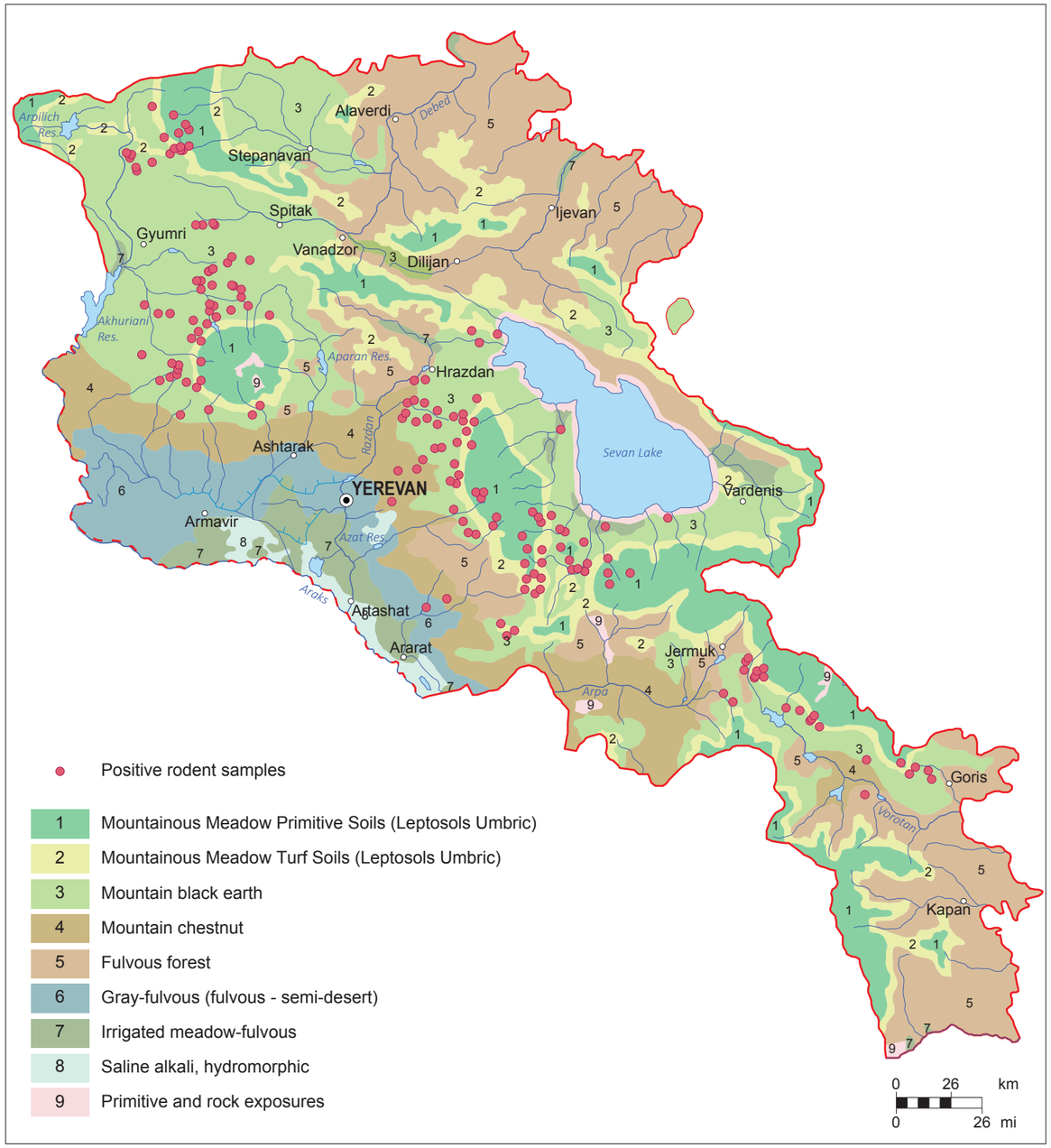
Distribution of Plague Positive Rodent Samples by Soil Types in Azerbaijan, 1950-2019



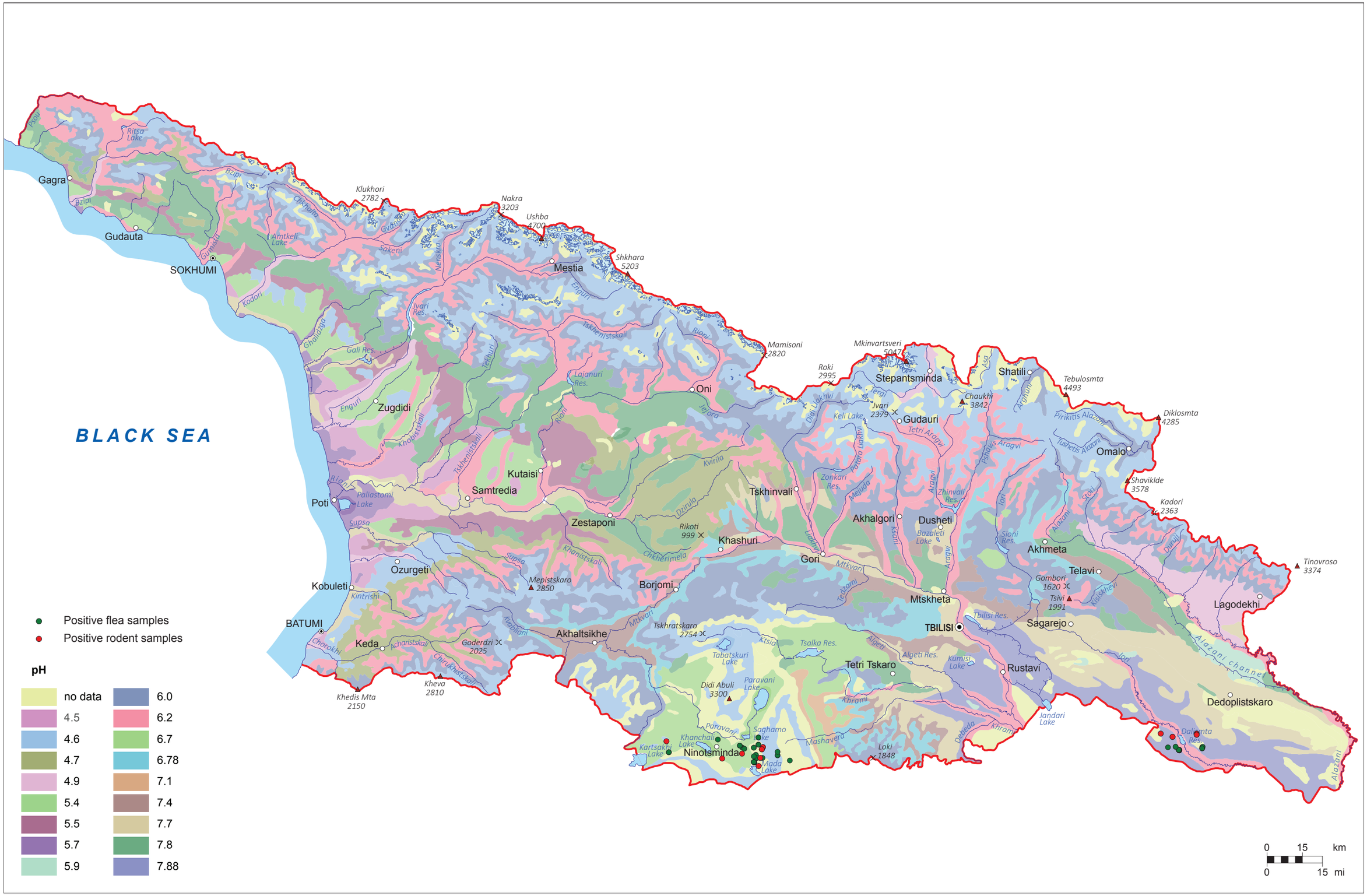
Distribution of Plague Positive Flea Samples by Soil Types in Armenia, 1950-2019



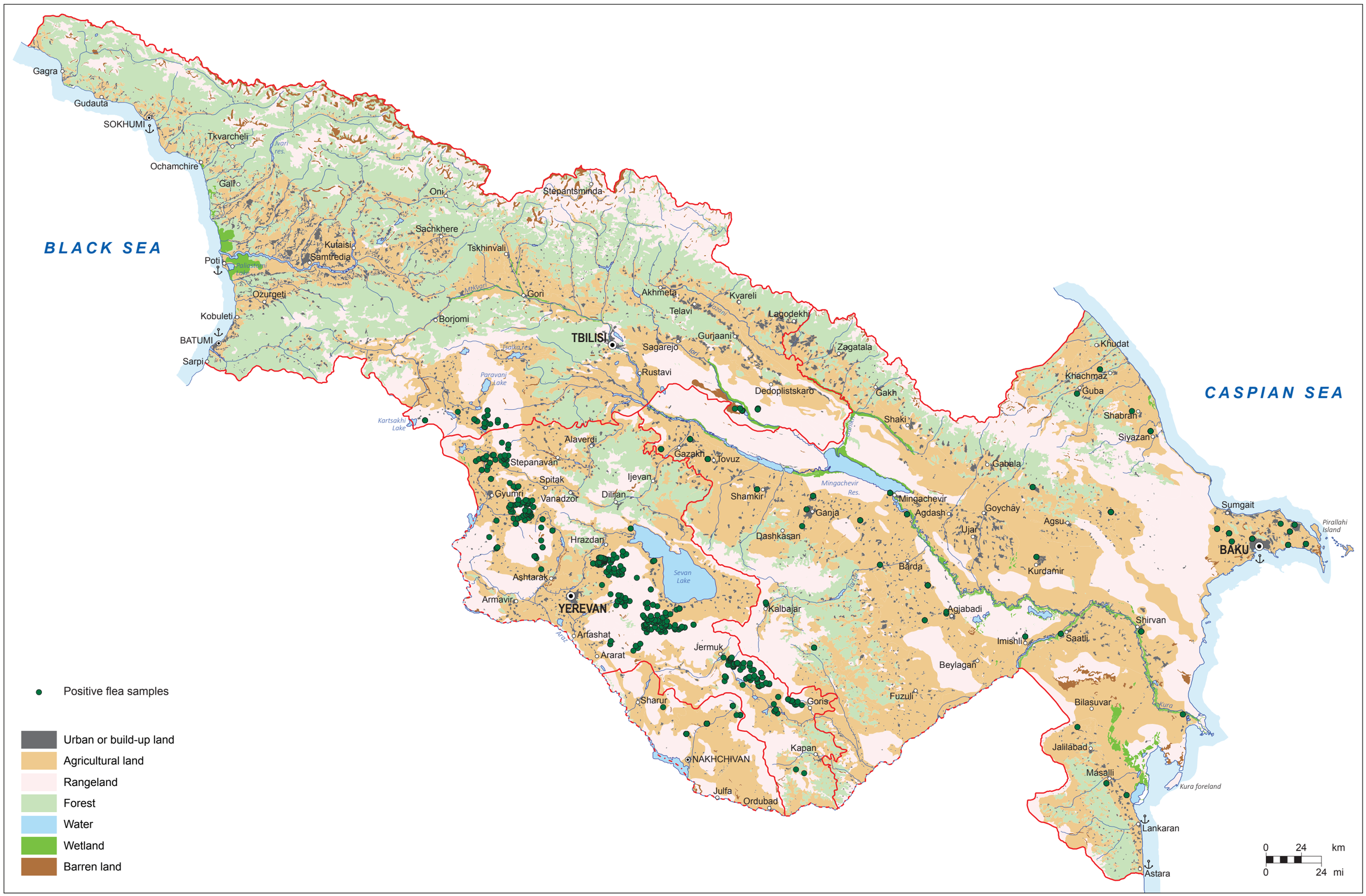
Distribution of Plague Positive Rodent Samples by Soil Types in Armenia, 1950-2019



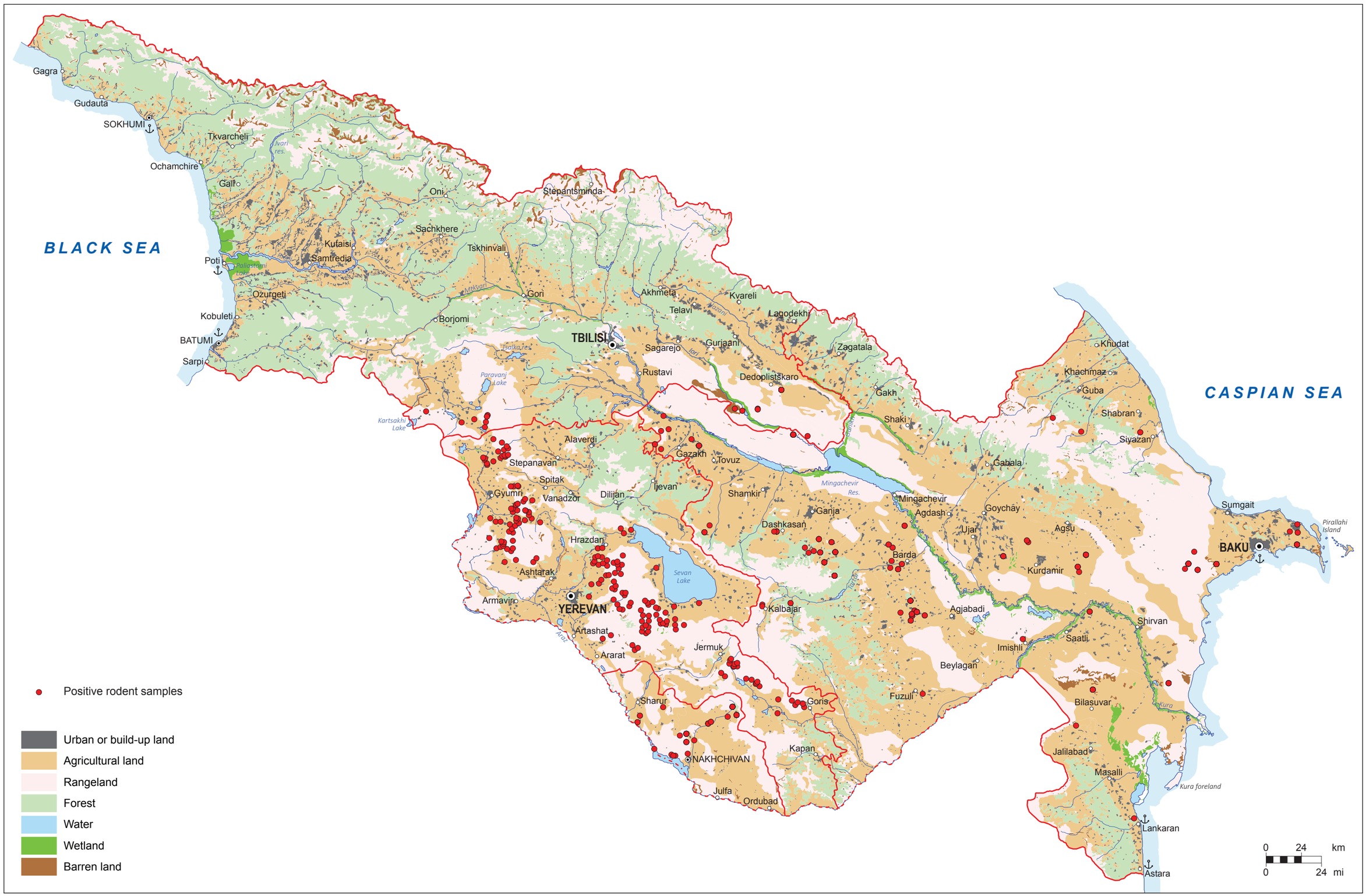
Distribution of Plague Positive Flea and Rodent Samples by Soil pH in Georgia, 1950-2019



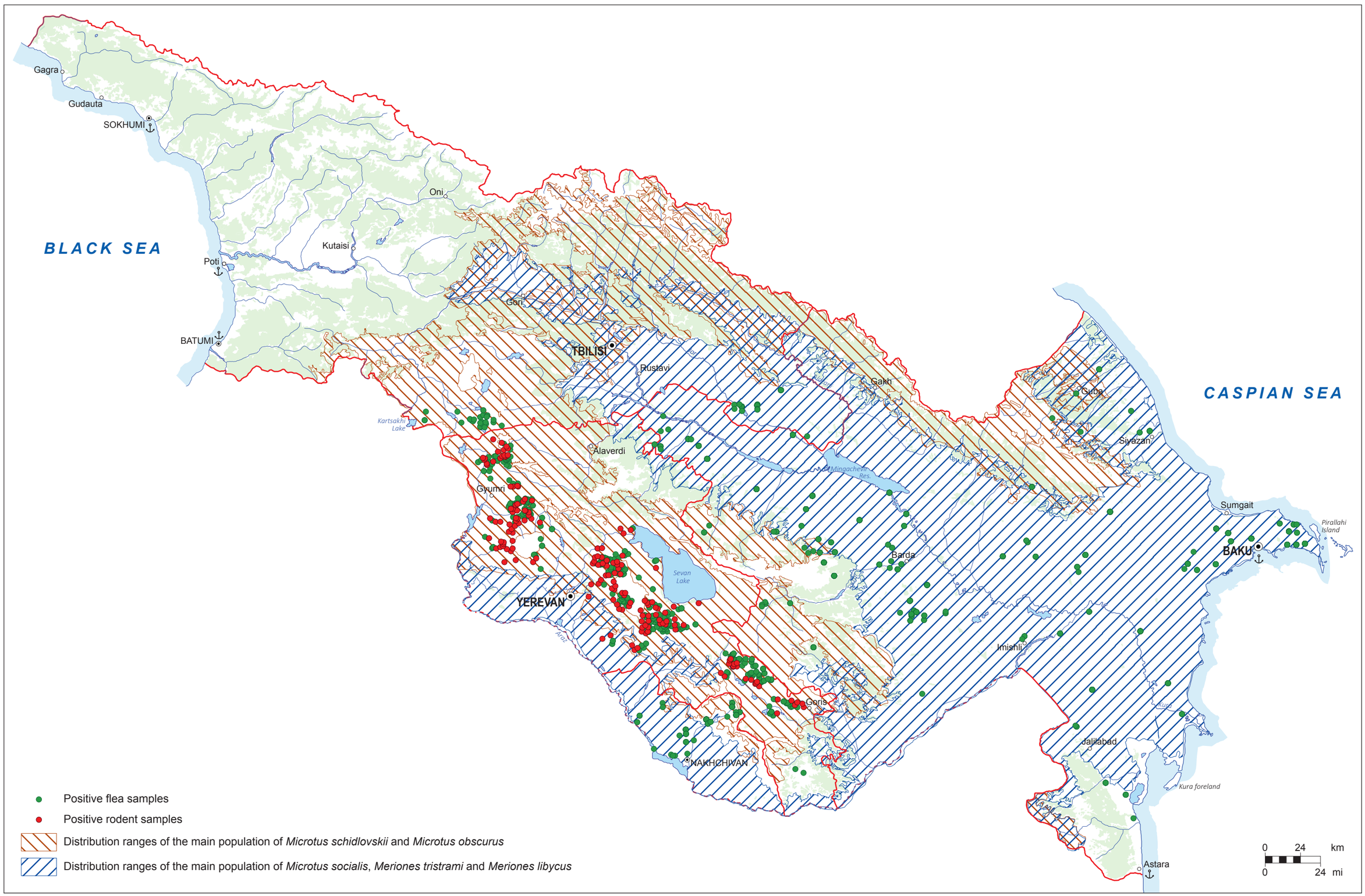
Distribution of Plague Positive Flea Samples by Land Use in the South Caucasus, 1950-2019



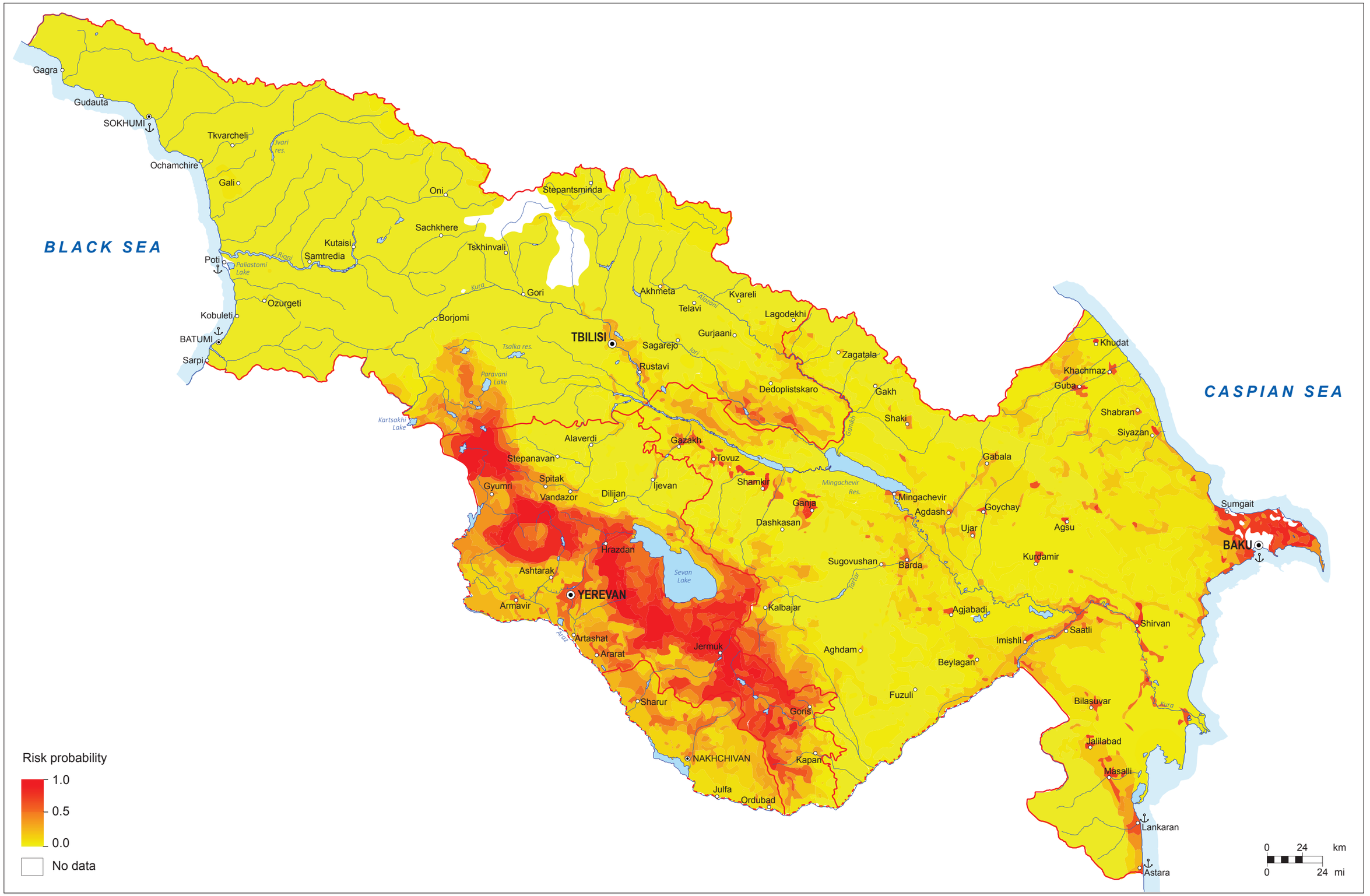
Distribution of Plague Positive Rodent Samples by Land Use in the South Caucasus, 1950-2019



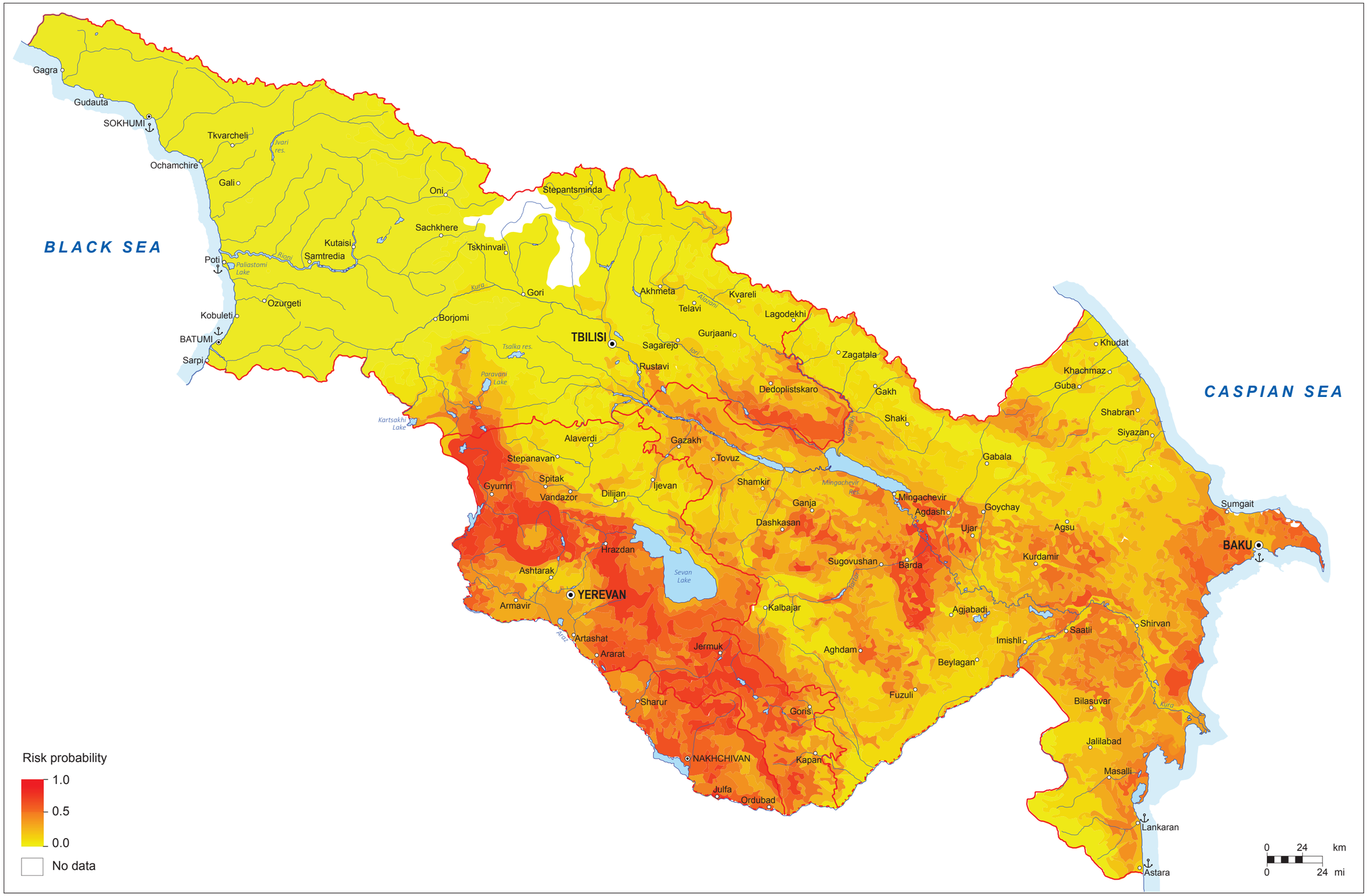
Distribution of Plague Positive Flea and Rodent Samples and Distribution Ranges of the Main Population of Rodents in the South Caucasus, 1950-2019



Plague Positve Flea Samples Risk in the South Caucasus



Plague Positve Rodent Samples Risk in the South Caucasus



Tularemia

Tularemia, also known as rabbit fever or *Francisella tularensis* infection, is a highly virulent bacterial zoonotic disease primarily found in the northern hemisphere. Tularemia poses a significant threat to both humans and various animals such as rodents, hares, and rabbits. The disease can be transmitted to humans through different routes, including arthropod bites, direct contact with infected animals or their tissues/fluids, ingestion of contaminated food or water, or inhalation of infective aerosols. Notably, tularemia does not spread between humans. The occurrence of tularemia varies widely across different regions and countries. Tularemia poses a major public health problem due to its potential for severe illness in humans, the diverse clinical manifestations it presents, and the risk of delayed diagnosis. Furthermore, the high infectivity of *Francisella tularensis*, and its potential as a bioweapon, raises the need for effective surveillance, preparedness, and control measures.

Tularemia has a global distribution, with varying prevalence in different regions. It is endemic in several parts of the world, including North America, Europe, and Asia. Multiple factors contribute to the prevalence and spread of tularemia worldwide. Animal reservoirs, such as rodents (e.g., voles and *lemmings*) and rabbits, play a significant role in the transmission of the disease. Ticks, including *Dermacentor spp.* and *Ixodes spp.*, are important vectors for transmitting *F. tularensis* to humans. Environmental factors, such as land use changes, climate variations, and agricultural practices, can influence the distribution and abundance of these reservoirs and vectors, thus impacting the epidemiology of tularemia. Two subspecies of *F. tularensis*, type A and type B, are known. Type A is highly virulent to humans and domestic rabbits, mostly in North America, and is primarily transmitted by tick or fly bites or direct contact with infected animals. *Francisella tularensis* type B is found primarily in aquatic rodents and voles in North America, and in rabbits and rodents in Eurasia. It is mainly transmitted by direct contact or by arthropods, primarily ticks and mosquitoes, but can also be transmitted by inhalation or through contaminated water or food. Tularemia is more common in men; possibly related to their increased risk of exposure during hunting and earthworks. It occurs in people of all ages, including children.

Dermacentor marginatus (female) © Julieta Manvelyan

Filed work on Tularemia (Collecting Ticks), © Nikoloz Tsertsvadze

Preventing and controlling tularemia involves a combination of measures. Controlling tularemia in animal reservoirs involves several strategies. Vector control measures, such as tick and flea control, help reduce transmission from animals to humans. Additionally, targeted management of animal populations that serve as reservoirs, such as rodents or rabbits, can help minimize the spread of the disease. In human populations, preventive measures play a crucial role. These include personal protective measures like wearing protective clothing, using insect repellents, and avoiding direct contact with potentially infected animals or carcasses. Public health education campaigns raise awareness about the disease, its transmission, and preventive measures. In summary, controlling tularemia involves measures targeting animal reservoirs and preventive measures in human populations. Vector control, personal protective measures, and public health education play key roles. Development of tularemia vaccines is ongoing, with live attenuated, killed whole-cell, and subunit vaccines being explored. Currently available vaccines have varying effectiveness, limitations, and potential side effects, and further research is needed to improve their efficacy, safety, and duration of protection.

Tularemia can manifest in various clinical forms depending on the route of infection, virulence of the strain, and host factors. The most common clinical presentations include ulceroglandular, glandular, oropharyngeal, pneumonic, and typhoidal tularemia. Several factors influence the severity and outcomes of tularemia. Age plays a role, as children and the elderly are more susceptible to severe disease due to developing or weakened immune systems, respectively. Symptoms usually appear within 3 to 5 days of exposure to the bacteria, but can range between 1 to 14 days. Global travel and trade play a role in the international spread of tularemia. Infected individuals or contaminated animal products can contribute to the introduction of the disease into new regions. Implementation of effective control strategies pose challenges in different socioeconomic settings due to variations in healthcare infrastructure, access to diagnostics and treatment, public health resources, and awareness levels. Coordinated international efforts and collaboration are crucial for managing and controlling tularemia globally.

Various factors influence the occurrence, transmission, and severity of tularemia. Host-related factors include age, gender, underlying health conditions, and immune status, which can affect susceptibility and disease outcomes. Environmental factors such as climate, land use, wildlife populations, and tick vectors contribute to the epidemiology of tularemia by influencing reservoir and vector populations and their interactions with humans. Tularemia is a complex disease, requiring interdisciplinary approaches to understand and manage it effectively. The interaction between host, pathogen, and environment makes it challenging to predict its dynamics. Comprehensive research involving epidemiology, microbiology, ecology, and immunology is necessary to unravel the complexities and develop effective control strategies.

Tularemia was first recognized in Georgia in 1946 during an outbreak at a military garrison in South Georgia. Three waterborne outbreaks of oropharyngeal tularemia have been reported in Georgia: in 1946 and 1984 in the south, and in 2007 in the middle of the country. The largest outbreak occurred in January 2007 in Zemo Rene, a village in the Kaspi Region, where 26 human cases were confirmed, and four isolates were obtained from the village's drinking water. Over a period of 60 years, a total of 465 environmental isolates of *F. tularensis* were obtained from the two main tularemia foci in Georgia. The main foci identified in East Georgia are Kartl-Kakheti and Meskhet-Javakheti. These regions are predominantly located in valley and foothill

Tularemia human positive case (glandular form, 2007)
© Nikoloz Tsertsvadze

Gamasoidea © Julieta Manvelyan

areas with elevations around 2000 m above sea level. The main rodent reservoirs/amplifiers in these foci are *Microtus socialis* and *Apodemus sp. (*recorded as *Apodemus sylvaticus*), while the main tick reservoirs/vectors include *Ixodes sp.*, *Haemaphysalis sp.*, *Gamasoidea* ticks, and fleas. Dmanisi region in Kvemo Kartli focus, located at an elevation above 1200m, differs in its rodent reservoirs and echtoparasite vectors. Meskhet-Javakheti natural foci encompass Meskheti and Javakheti regions, as well as Erusheti Upland near the Turkish border. Rodents such as *Microtus arvalis*, *Apodemus sp.* (recorded as *Apodemus sylvaticus*), and *Arvicola terrestris* (in Javakheti) play a significant role in disease transmission, along with *Gamasoidea* ticks and fleas. *Ixodes sp.* is found only in Meskheti and Erusheti area. Routine monitoring and investigation of tularemia in Georgia began in the mid-1940s. Since then, several autonomous, naturally-occurring foci of tularemia have been identified there: one in the mountainous Meskhet-Javakheti region and another in the Kartl-Kakheti Valley. The Meskhet-Javakheti focus covers the Ninotsminda, Akhalkalaki, Akhaltsikhe and Aspindza regions (many of which overlap with endemic foci of plague in Georgia). The Kartl-Kakheti focus covers central Georgia and a large part of Kakheti (in eastern Georgia). Epizootics of tularemia in the Meskhet-Javakheti focus were established during 1963, 1977, 1979, and 1980, and they were identified in the Kartl-Kakheti focus during 1956. Cultures of *F. tularensis* were isolated from *Microtus arvalis* (common vole) as well as from its fleas and *Ixodes* ticks.).

The Armenian landscape is composed of a complex mountainous relief (400 to 4095 m above the sea level) with several landscape-ecological zones. Fauna diversity is conditioned by ecological factors, and 13 families of rodents, 12 types of insectivores. Because of these complex ecological features, many diseases remain endemic in the country. For examples, approximately 95% of Armenia is a natural focus for tularemia. Voles play the most important role in the epizotoology of tularemia. Voles inhabit all the landscape-ecological zones on 1400 to 3300 m. above the sea level. In addition, 80 species of ticks and fleas are found in all ecological zones of Armenia. There are foci of tularemia on the steppe and mountain-stream regions of Armenia, which are located in the same areas as the plague foci. Single human cases and outbreaks are registered every year in Armenia. The bacterium was first isolated in 1949 from different sources: a patient, rodents, and ticks. This began the epidemiology of tularemia in Armenia, which has since concentrated on identifying the natural foci of infection. Last three outbreaks were Kotayq (2003, Fantan village, 158 cases) in Gegharquniq (2007, Tsovagyux village, 17 cases) and in Tavsuh (2017, Artsvaberd, 32 cases) regions (A. Manuchary - 2018).

Data on tularemia was collected from 1946 to 2019 from Georgia and from 1950 to 2019 from Armenia and Azerbaijan from publications, annual reports, unpublished data of the public health centers, former anti-plague stations and veterinary centers as well as from different finished and/or ongoing scientific projects reports.

Tularemia animal positive cases are registered among *Microtus obscurus* and *Microtus socialis* in Georgia; in Azerbaijan, tularemia animal positive cases are registered among *Meriones libycus* and *Oryctolagus cuniculus*. And, in Armenia the majority of tularemia animal positive samples are registered among *Microtus obscurus*. Tularemia positive tick samples are obtained from *Haemaphysalis otophila*, *Haemaphysalis punctata*, *Dermacentor marginatus* species in Georgia. In Azerbaijan tularemia tick positive samples are registered among *Dermacentor marginatus*, *Hyalomma asiaticum*, *Ixodes laguri*, *Ornithodoros allactagalis*, and *Rhipicephalus annulatus*. In Armenia tick and flea positive samples are registered among *Gamasoidea* and *Ixoided* species (species level in the records were not identified).

The majority of tularemia human cases are between 10 to 30 years of age in Georgia and Armenia; while in Azerbaijan, cases are equally distributed among all age groups. Distribution by gender are almost equal in Georgia between male and female while more than 80% of human cases are female in Azerbaijan, and almost 70% of registered cases are male in Armenia. By clinical manifestation, almost all clinical forms are reported from Georgia, although the majority of cases are oropharyngeal, oculoglandular and typhoidal. Most cases in Azerbaijan are glandular and oculoglandular, and, in Armenia, cases are ulceroglandular, glandular and oculoglandular.

In Georgia, most of the tularemia human cases and environmental (rodent and tick) positive samples are reported in areas where the annual sum of precipitation is 800 to 1,200 mm (p. 214-215). In Armenia and Azerbaijan, cases are registered where the annual sum of precipitation is 500 to 800 mm (p. 214-215). Tularemia cases mainly observe during the hot months, when the average maximum temperature is 14 to 20 degrees Celcius. (pp. 218). Overall, tularemia cases in humans and animals are mostly found in agricultural and forest territories within the South Caucasus (pp. 233-234).

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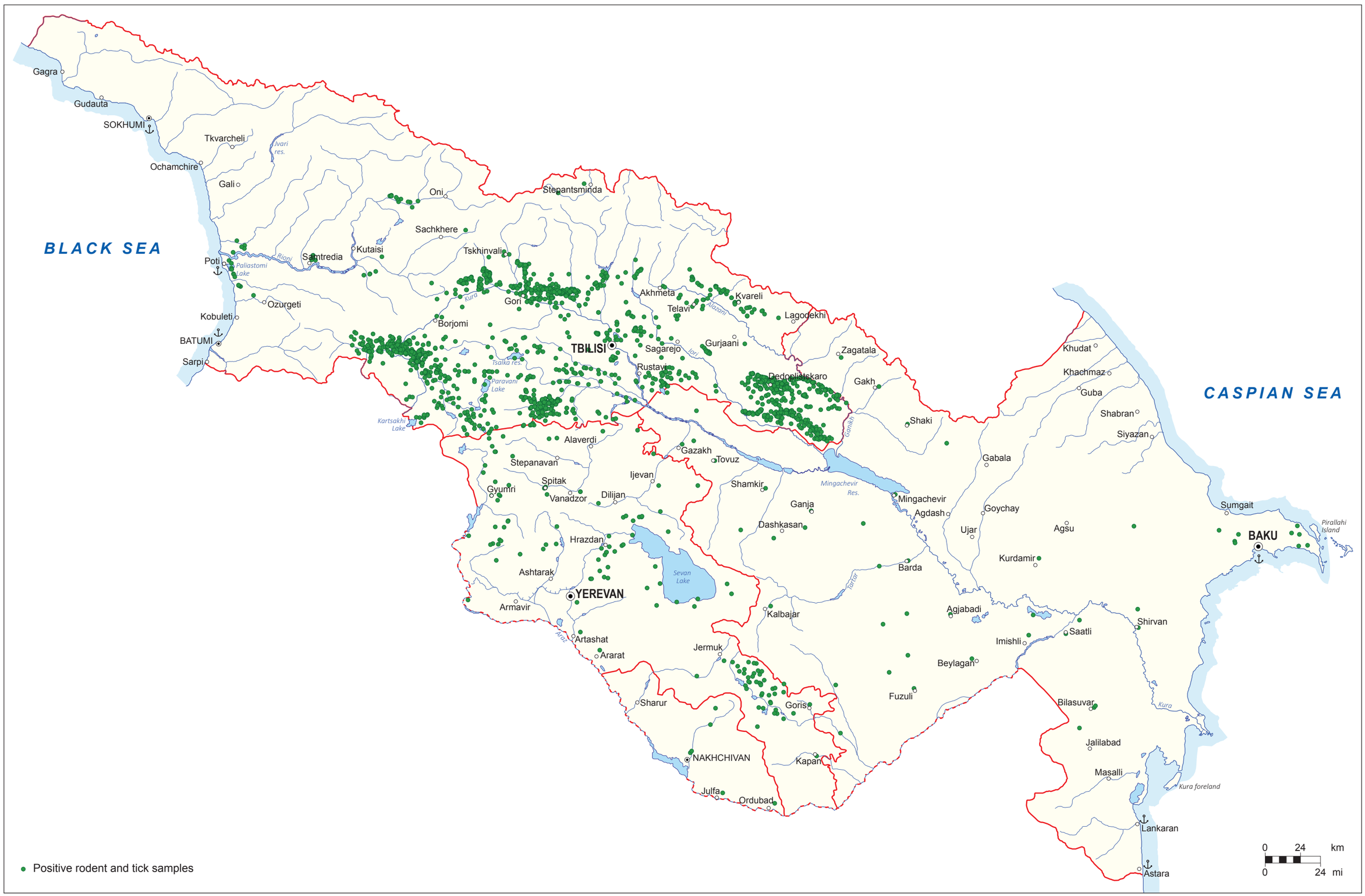
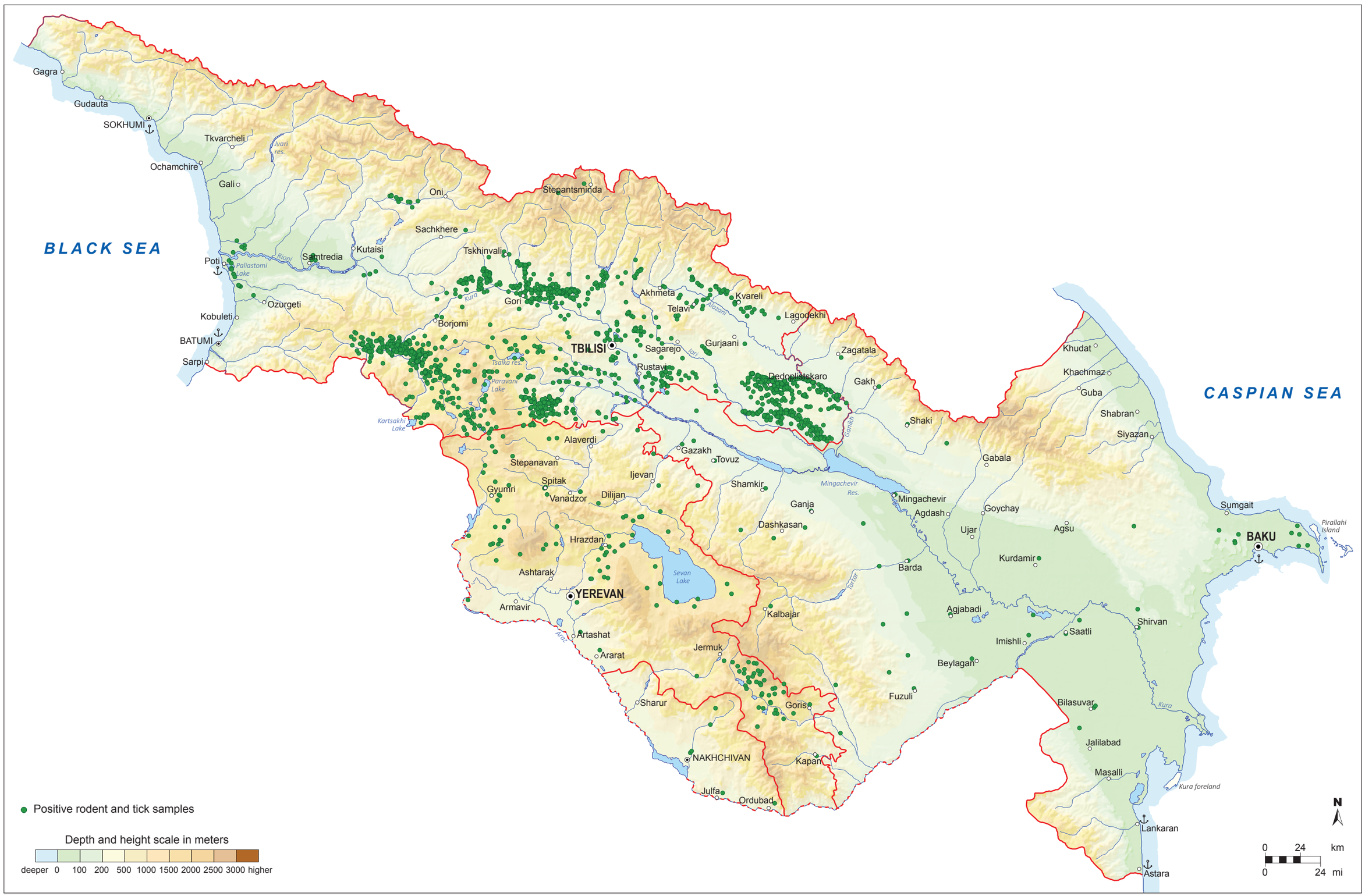
Distribution of Tularemia Human Cases in the South Caucasus, 1946-2019

Distribution of Tularemia Positive Rodent and Tick Samples in the South Caucasus, 1946-2019

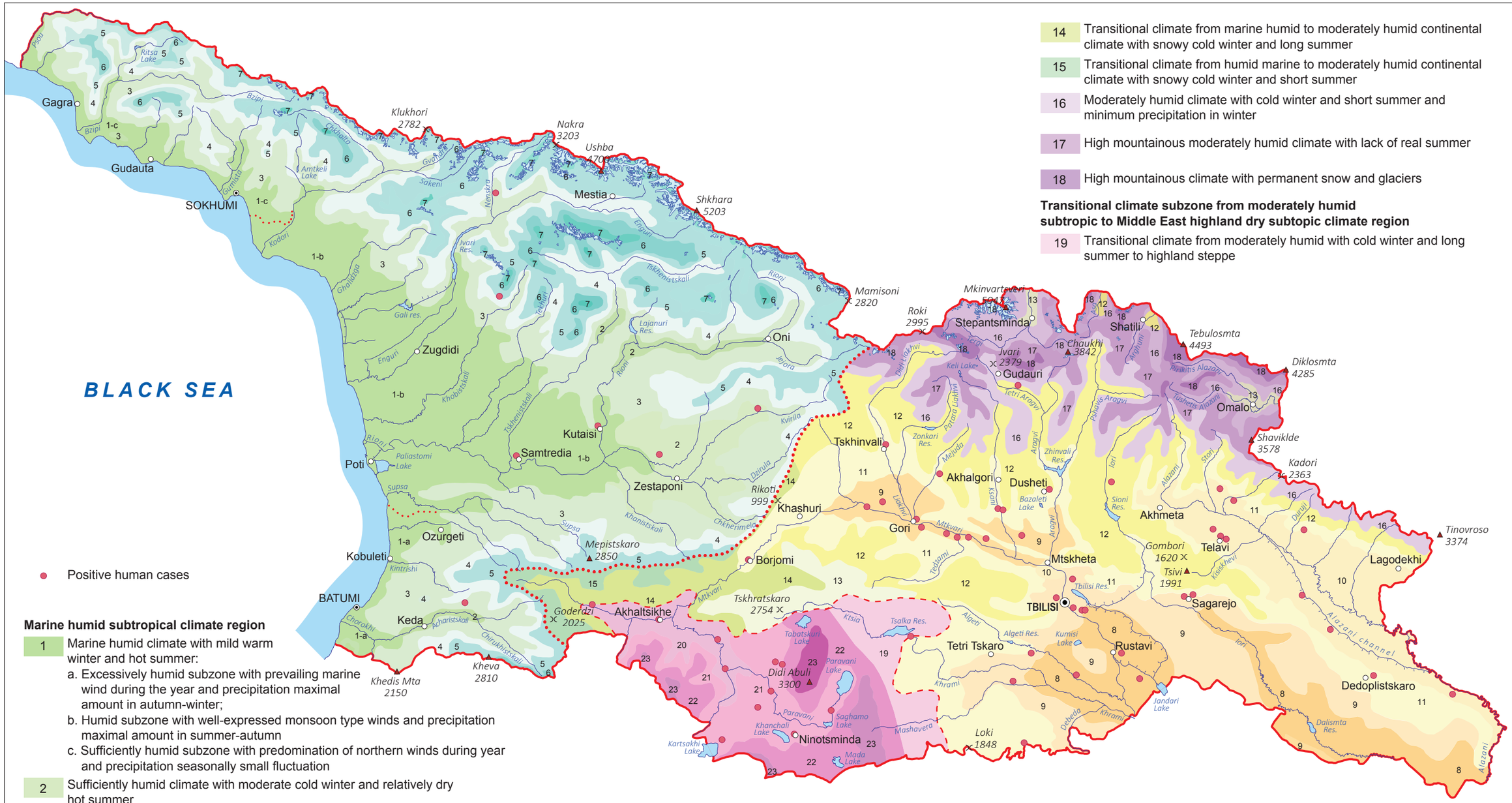


Distribution of Tularemia Human Cases by Elevation in the South Caucasus, 1946-2019

Distribution of Tularemia Positive Rodent and Tick Samples by Elevation in the South Caucasus, 1946-2019



Distribution of Tularemia Human Cases by Climate Types in Georgia, 1946-2019



- Positive human cases

Marine humid subtropical climate region

1 Marine humid climate with mild warm winter and hot summer:
- a. Excessively humid subzone with prevailing marine wind during the year and precipitation maximal amount in autumn-winter;
- b. Humid subzone with well-expressed monsoon type winds and precipitation maximal amount in summer-autumn
- c. Sufficiently humid subzone with predomination of northern winds during year and precipitation seasonally small fluctuation

2 Sufficiently humid climate with moderate cold winter and relatively dry hot summer

3 Humid climate with moderate cold winter and long warm summer

4 Humid climate with cold winter and long cool summer

5 Humid climate with cold winter and short summer

6 High mountainous humid climate with lack of real summer

7 High mountainous humid climate with year-round abundant snow and glaciers

Moderately humid subtropical climate region

8 Moderately warm steppe with hot summer and minimum precipitation twice a year

9 Transitional climate from a moderate warm steppe to a moderate humid one, with hot summer and minimum precipitation twice a year

10 Moderate humid climate with moderately cold Winter and hot summer and minimum precipitation twice a year

11 Moderate humid climate with moderately cold Winter and long warm summer and minimum precipitation twice a year

12 Moderate humid climate with cold Winter and long cold summer, minimum precipitation twice a year

13 Moderate humid climate with cold winter and long cool summer and minimum precipitation in winter

14 Transitional climate from marine humid to moderately humid continental climate with snowy cold winter and long summer

15 Transitional climate from humid marine to moderately humid continental climate with snowy cold winter and short summer

16 Moderately humid climate with cold winter and short summer and minimum precipitation in winter

17 High mountainous moderately humid climate with lack of real summer

18 High mountainous climate with permanent snow and glaciers

Transitional climate subzone from moderately humid subtropic to Middle East highland dry subtopic climate region

19 Transitional climate from moderately humid with cold winter and long summer to highland steppe

20 Highland steppe climate with less snowy, cold winter and long, warm summer

21 Highland steppe climate with less snowy, cold winter and long cool summer

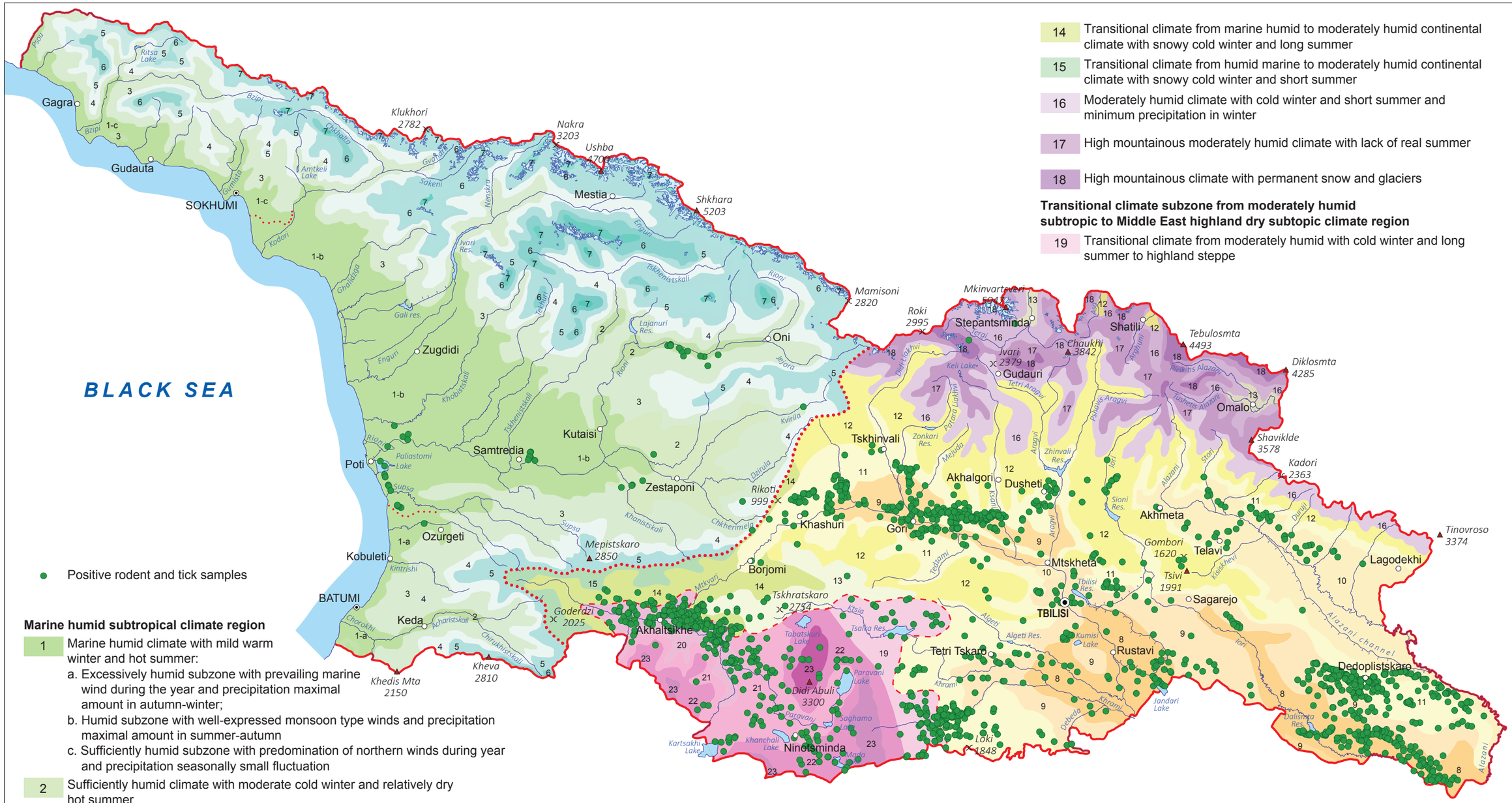
22 Highland steppe climate with short summer and cold, less snowy winter

23 Highland moderately dry climate with lack of real summer

- Climate region's border
- Climate subzone's border
- Subregion border

0 15 km
0 15 mi

Distribution of Tularemia Positive Rodent and Tick Samples by Climate Types in Georgia, 1946-2019



- Positive rodent and tick samples

Marine humid subtropical climate region

1 Marine humid climate with mild warm winter and hot summer:
- a. Excessively humid subzone with prevailing marine wind during the year and precipitation maximal amount in autumn-winter;
- b. Humid subzone with well-expressed monsoon type winds and precipitation maximal amount in summer-autumn
- c. Sufficiently humid subzone with predomination of northern winds during year and precipitation seasonally small fluctuation

2 Sufficiently humid climate with moderate cold winter and relatively dry hot summer

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4 Humid climate with cold winter and long cool summer

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6 High mountainous humid climate with lack of real summer

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12 Moderate humid climate with cold Winter and long cold summer, minimum precipitation twice a year

13 Moderate humid climate with cold winter and long cool summer and minimum precipitation in winter

14 Transitional climate from marine humid to moderately humid continental climate with snowy cold winter and long summer

15 Transitional climate from humid marine to moderately humid continental climate with snowy cold winter and short summer

16 Moderately humid climate with cold winter and short summer and minimum precipitation in winter

17 High mountainous moderately humid climate with lack of real summer

18 High mountainous climate with permanent snow and glaciers

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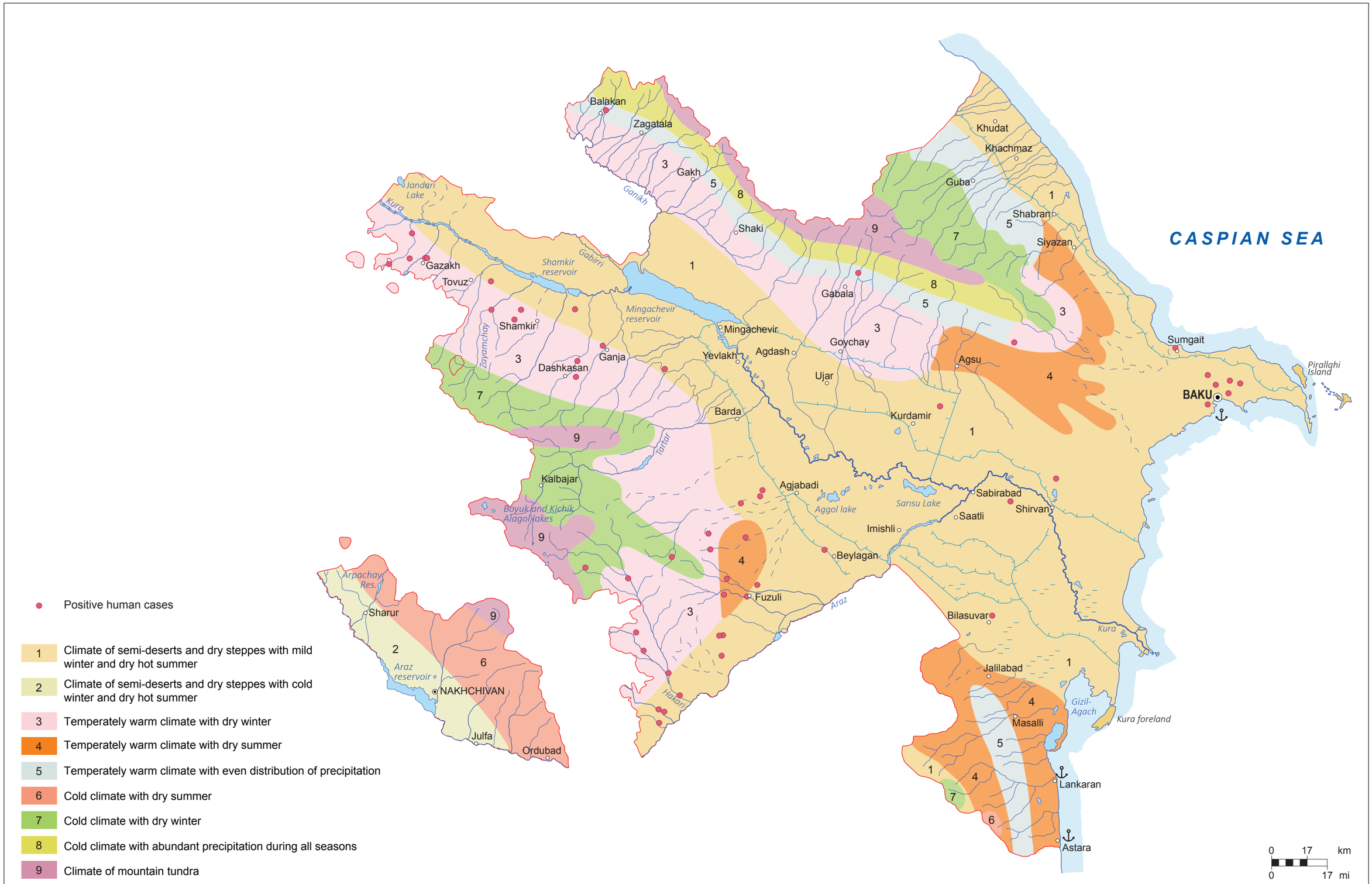
22 Highland steppe climate with short summer and cold, less snowy winter

23 Highland moderately dry climate with lack of real summer

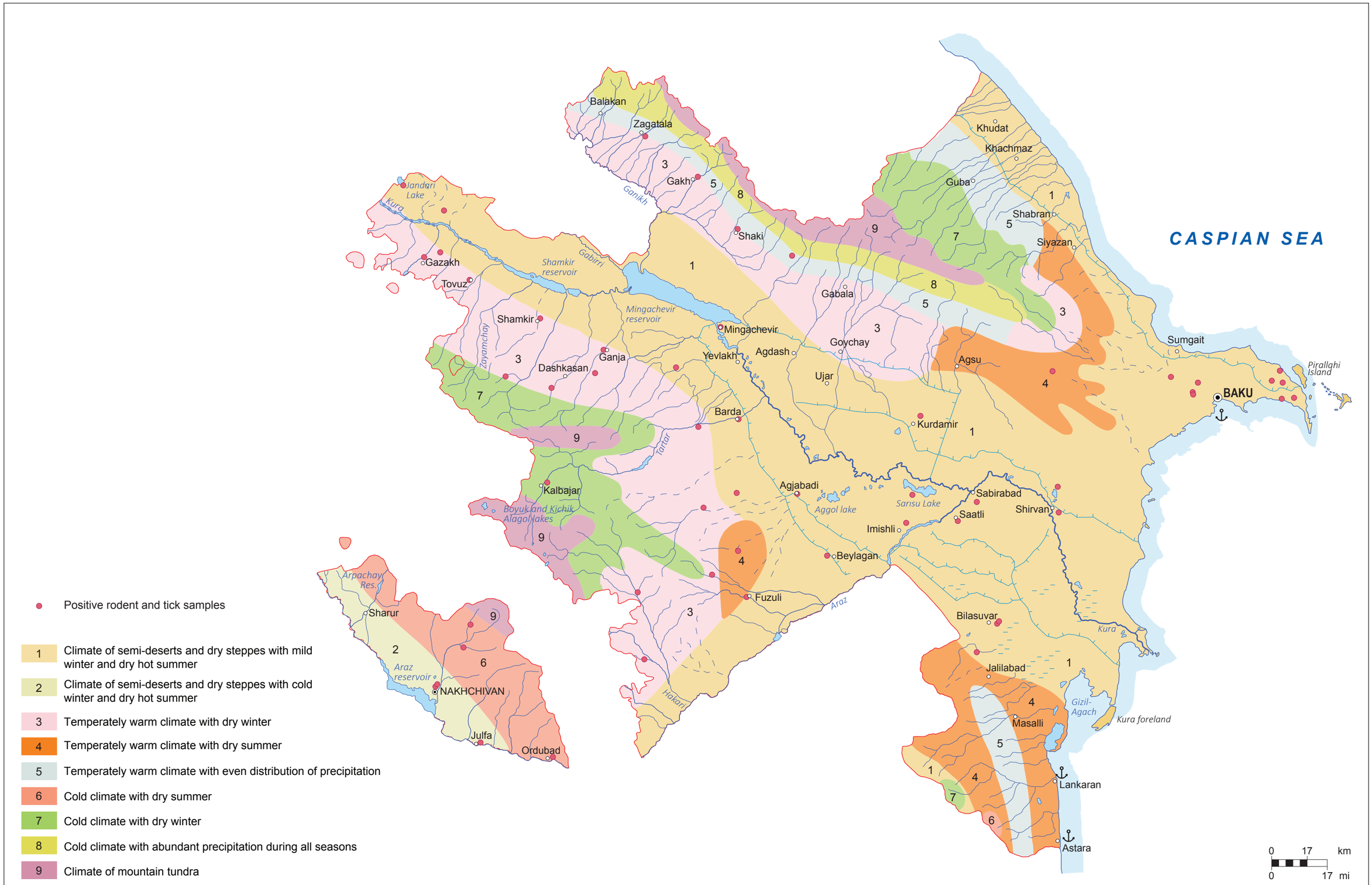
Climate region's border · Climate subzone's border · Subregion border

0 15 km
0 15 mi

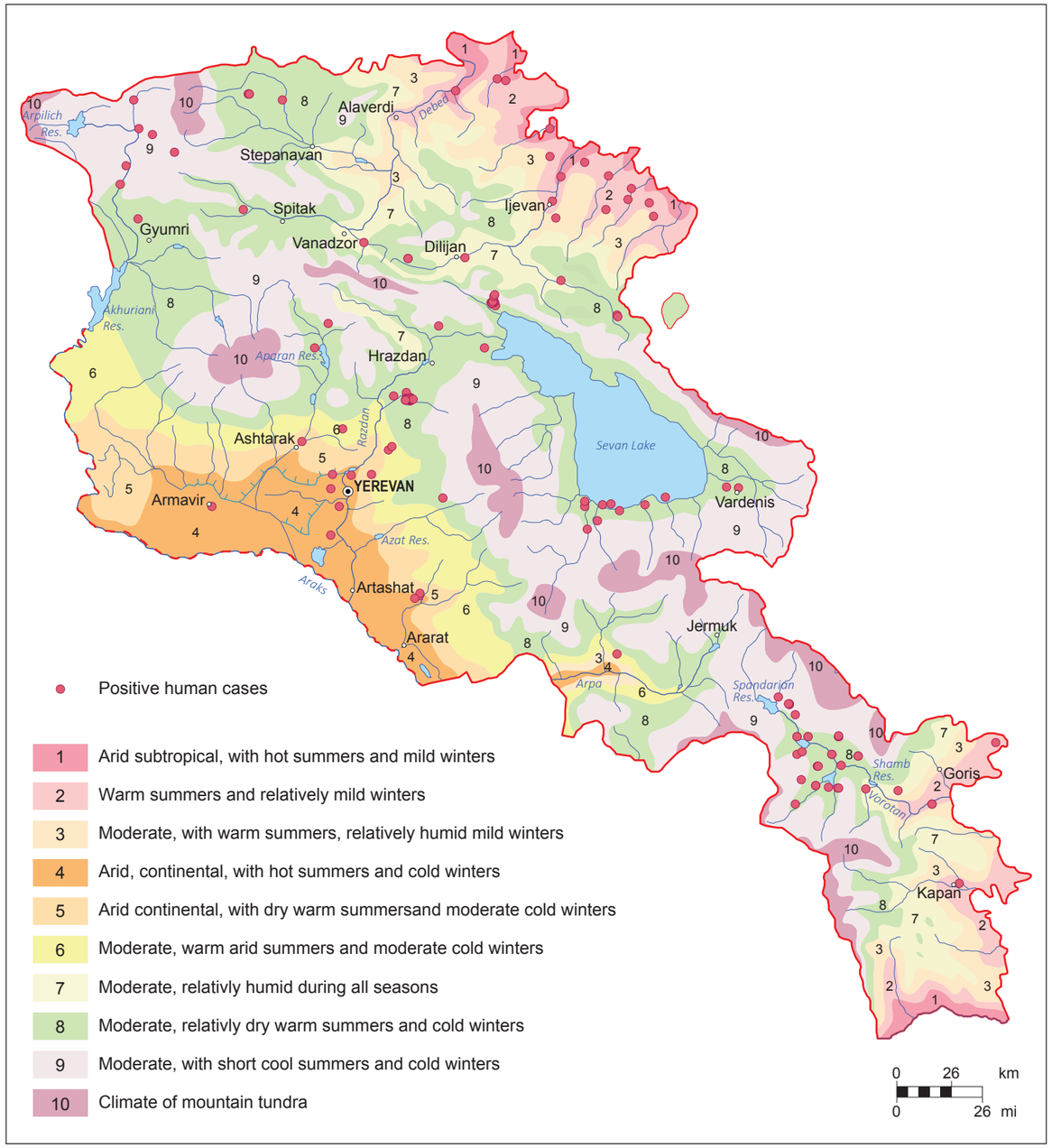
Distribution of Tularemia Human Cases by Climate Types in Azerbaijan, 1964-2019



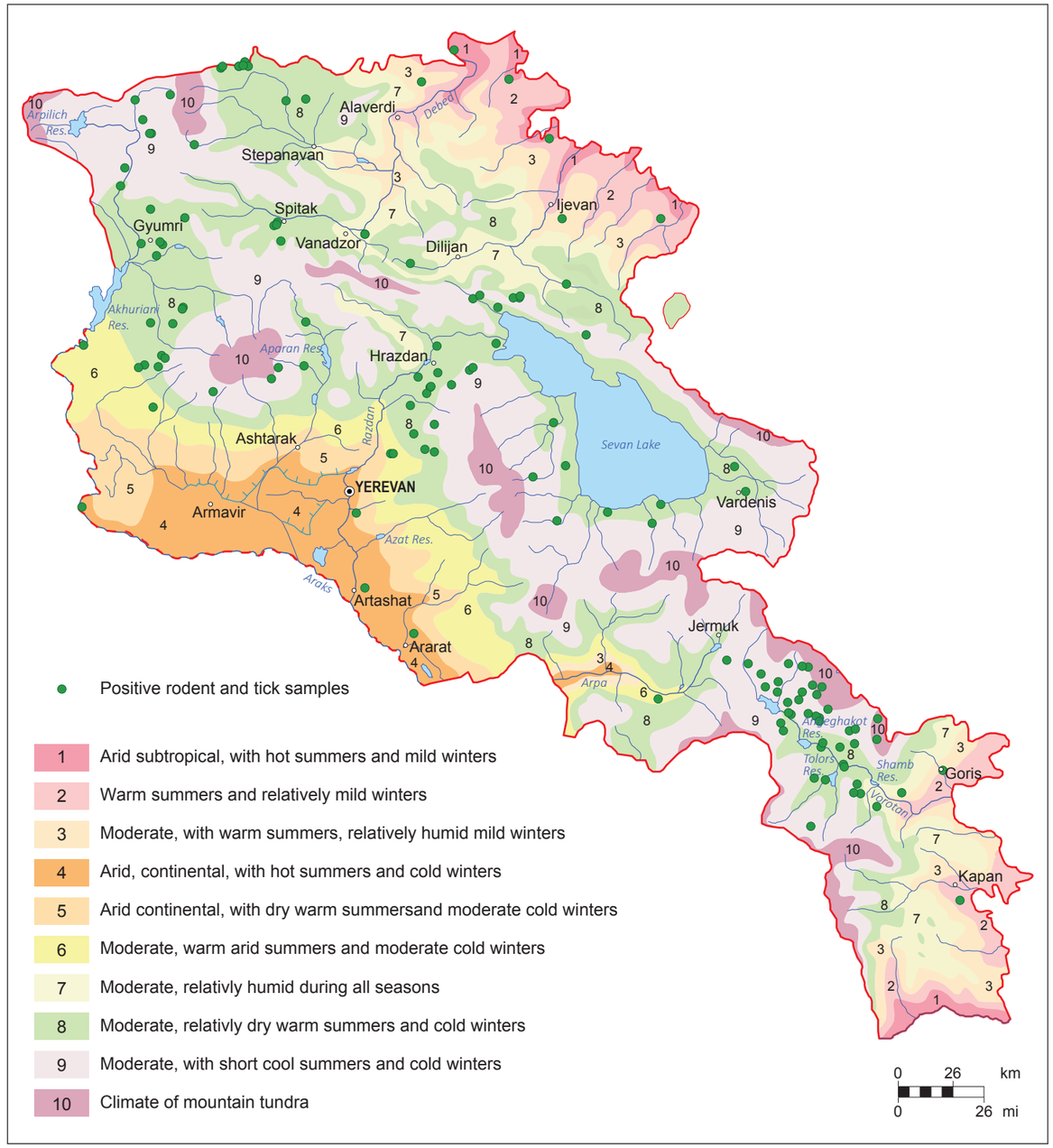
Distribution of Tularemia Positive Rodent and Tick Samples by Climate Type in Azerbaijan, 1958-2019



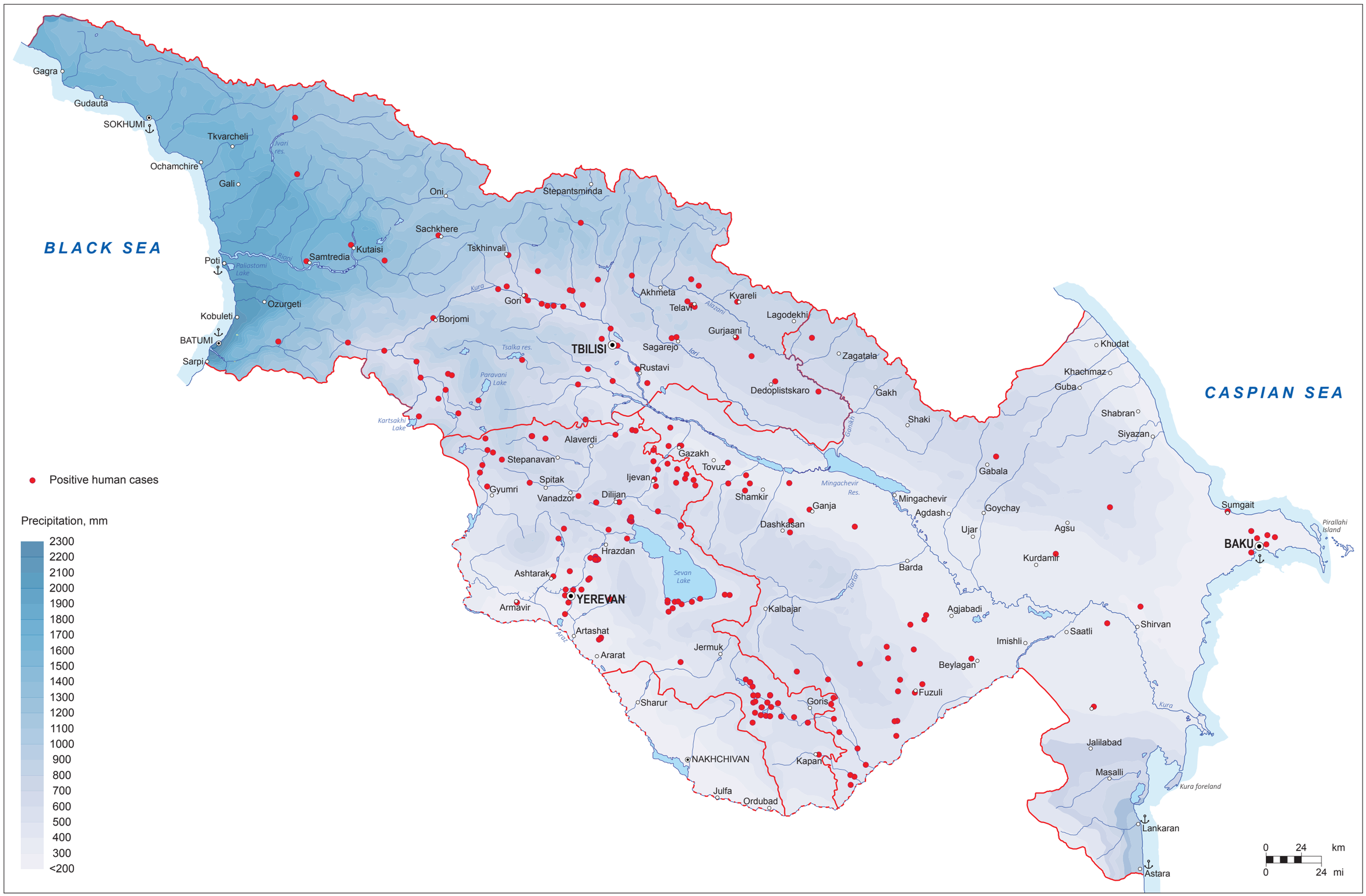
Distribution of Tularemia Human Cases by Climate Types in Armenia, 1954-2019



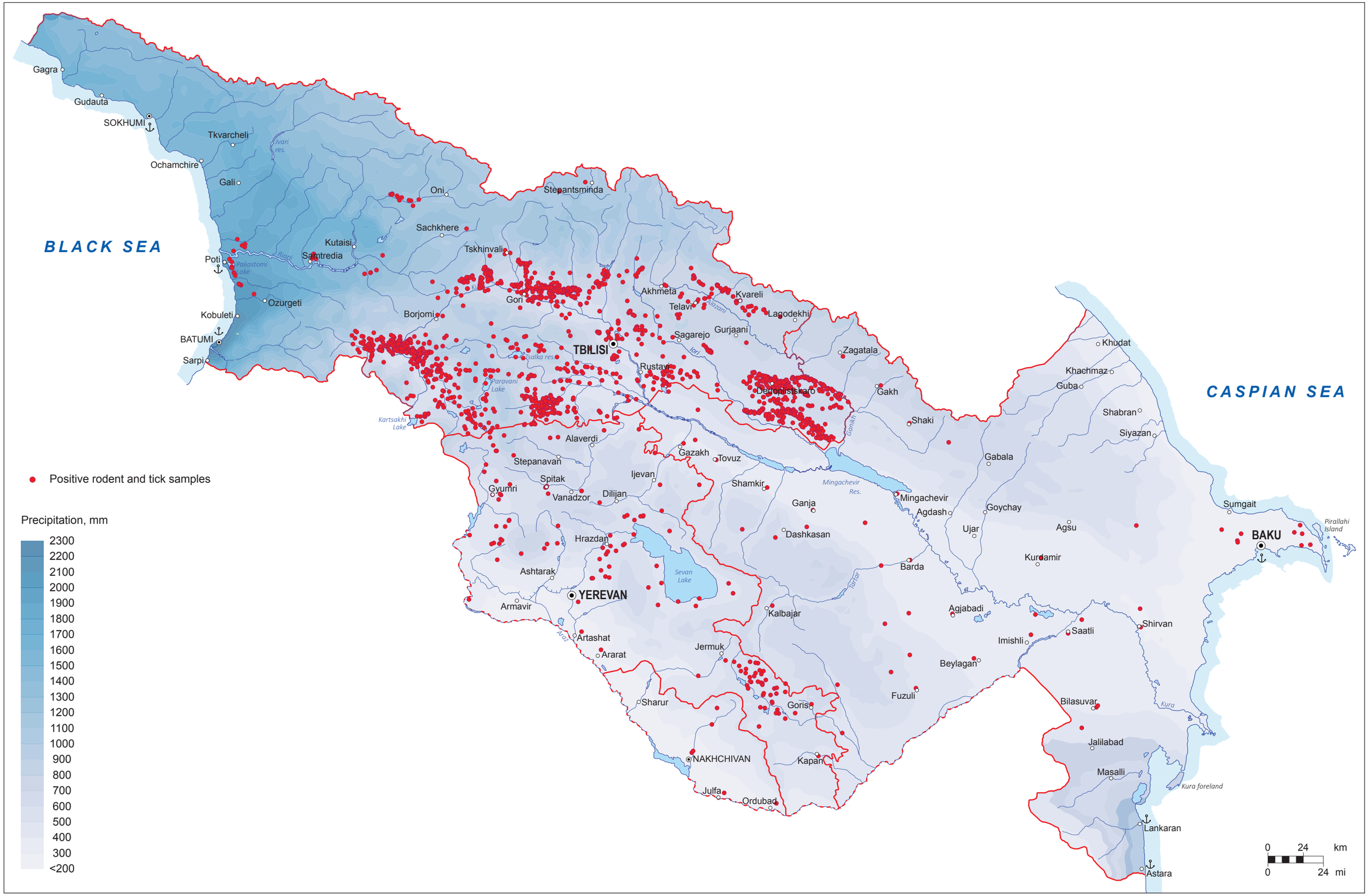
Distribution of Tularemia Positive Rodent and Tick Samples by Climate Types in Armenia, 1950-2019



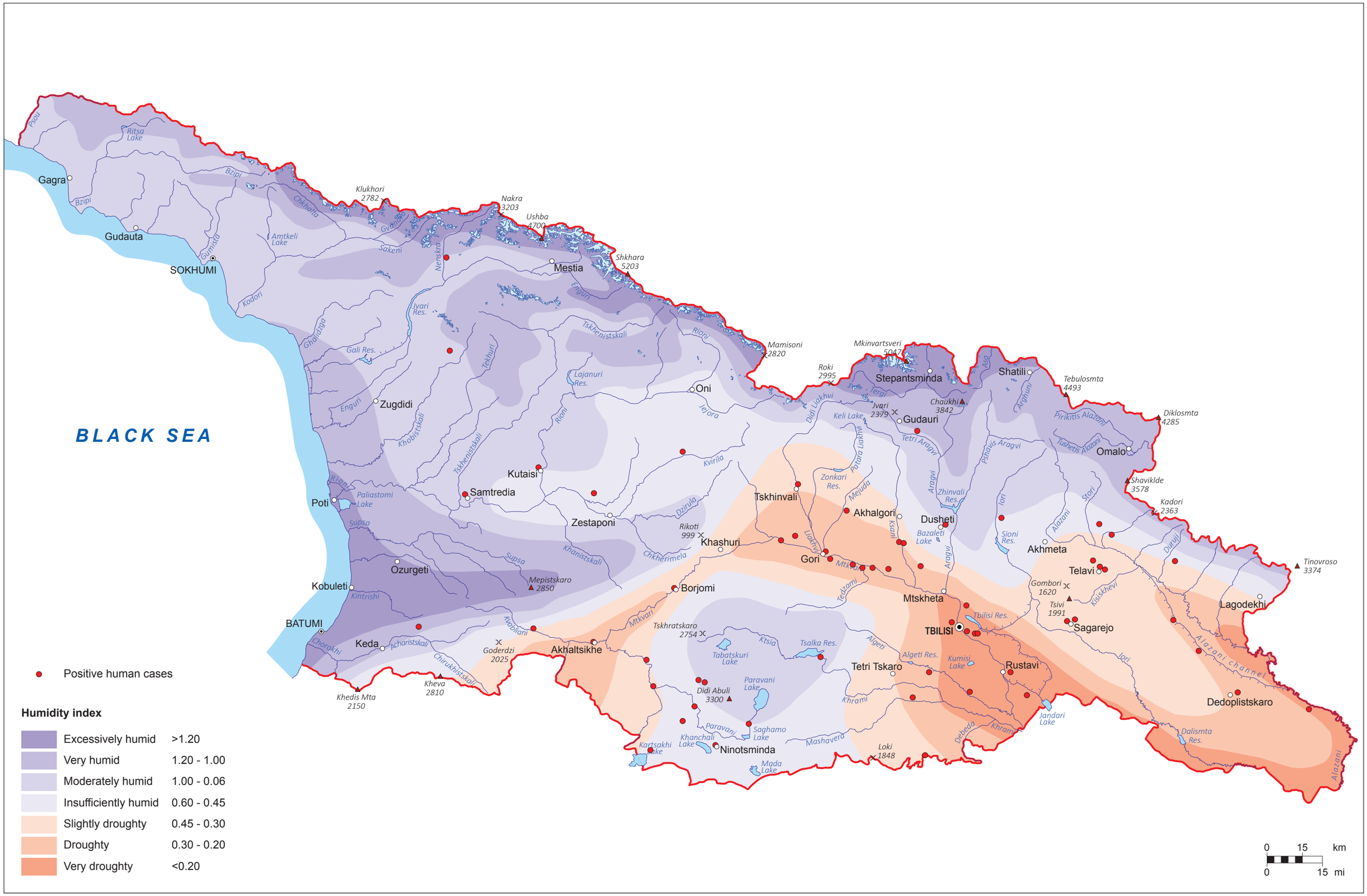
Distribution of Tularemia Human Cases by Precipitation in the South Caucasus, 1946-2019



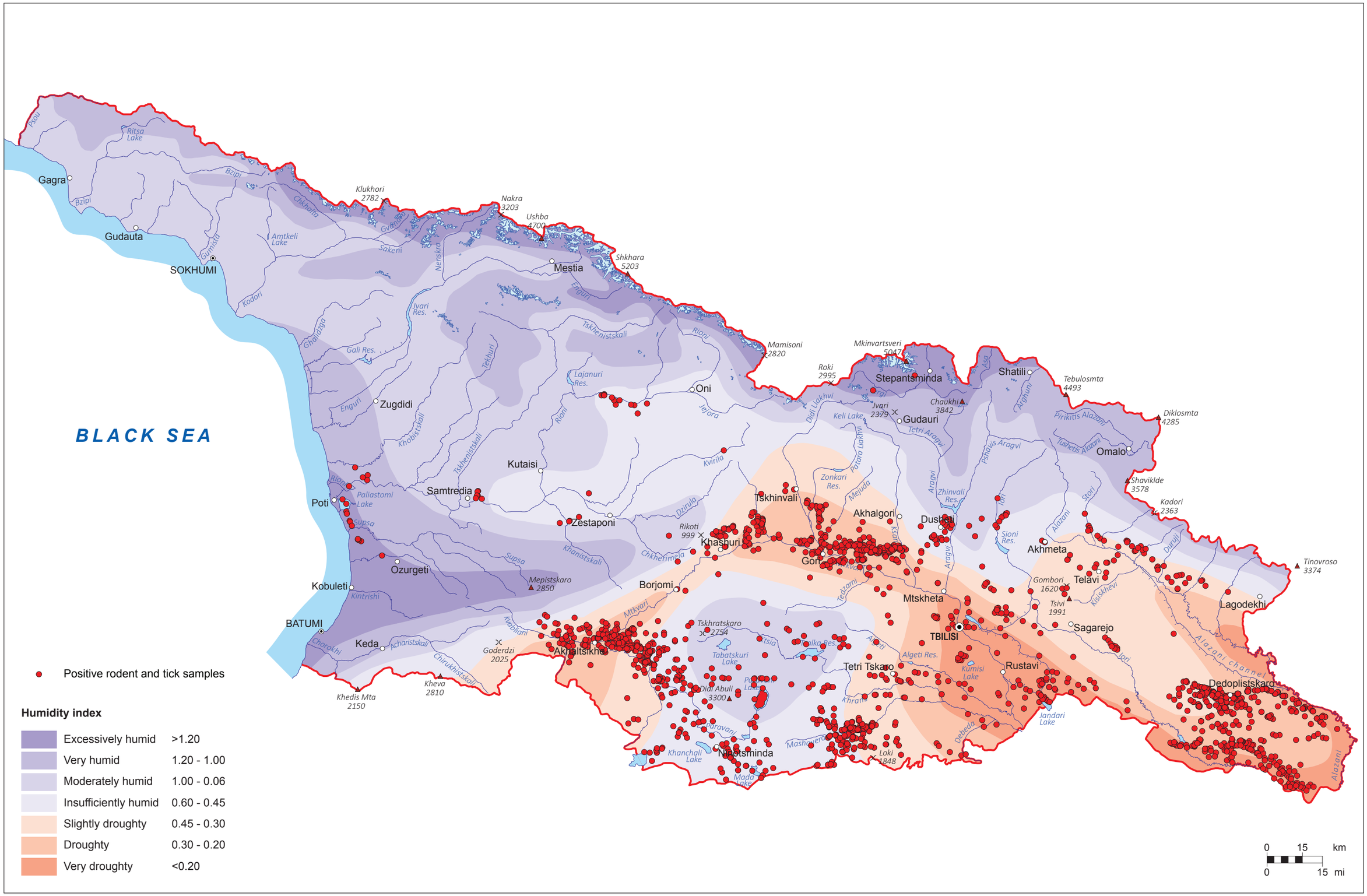
Distribution of Tularemia Positive Rodent and Tick Samples by Precipitation in the South Caucasus, 1946-2019



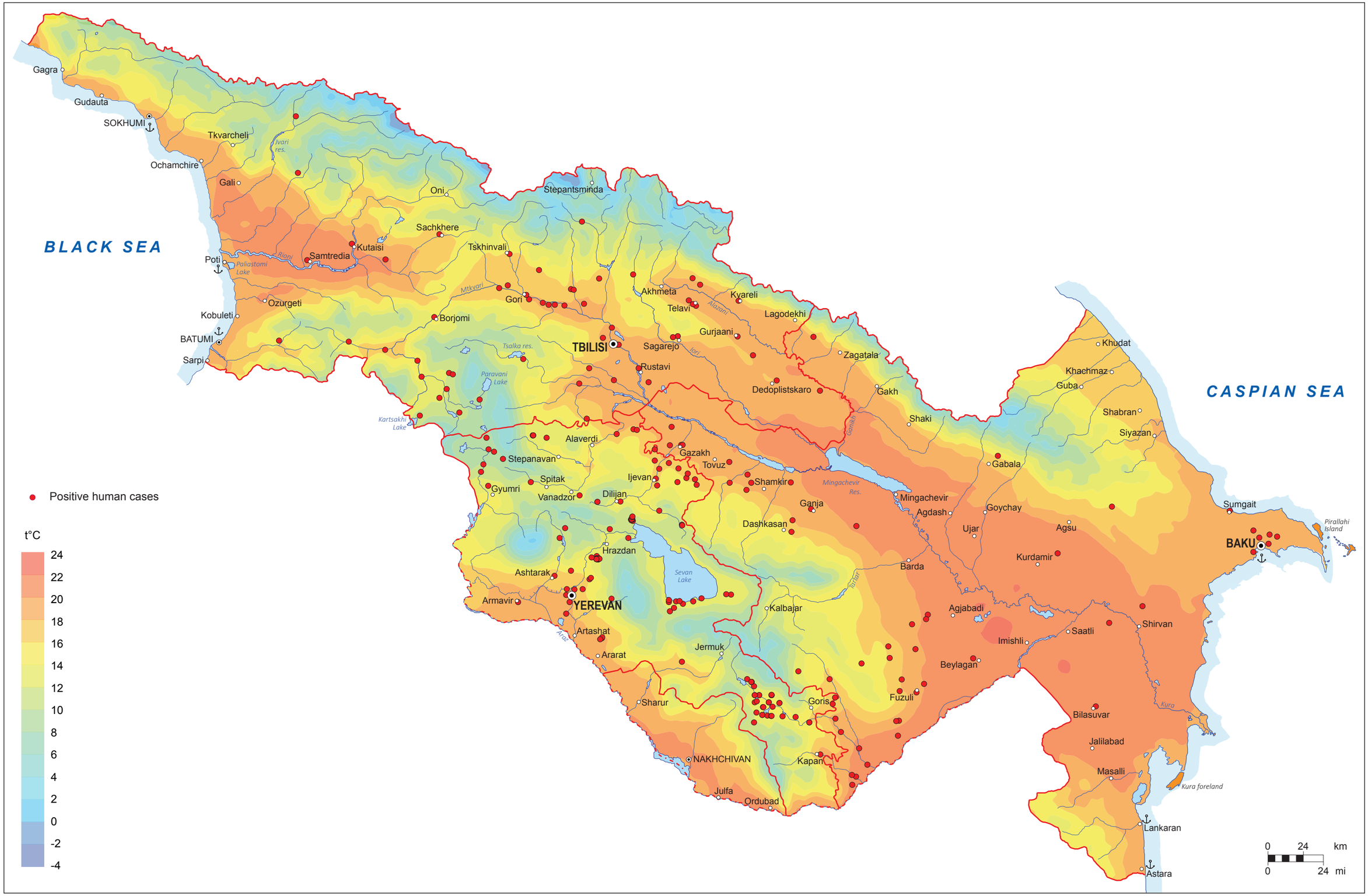
Distribution of Tularemia Human Cases by Humidity Index in Georgia, 1946-2020



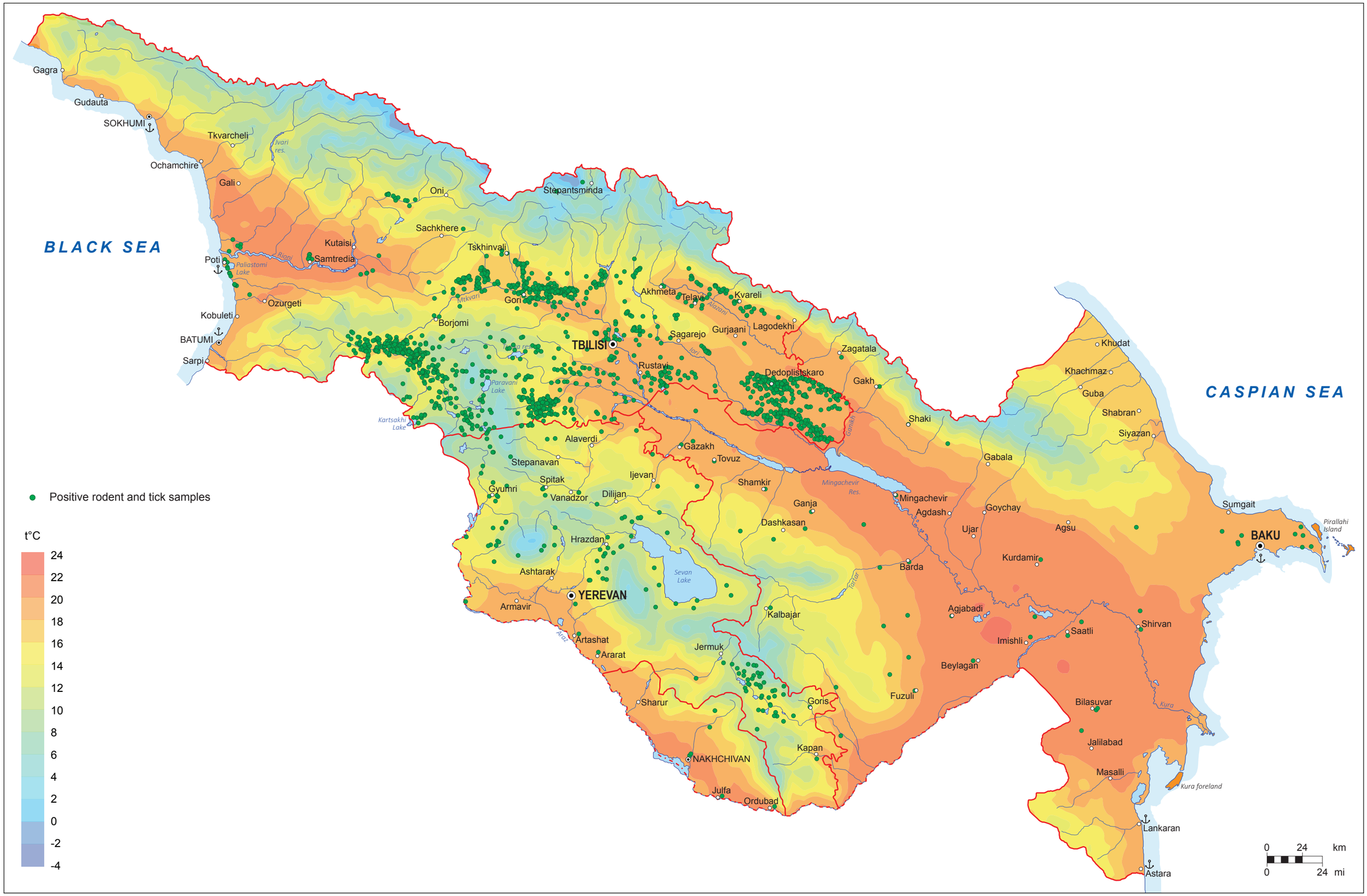
Distribution of Tularemia Positive Rodent and Tick Samples by Humidity Index in Georgia, 1946-2019



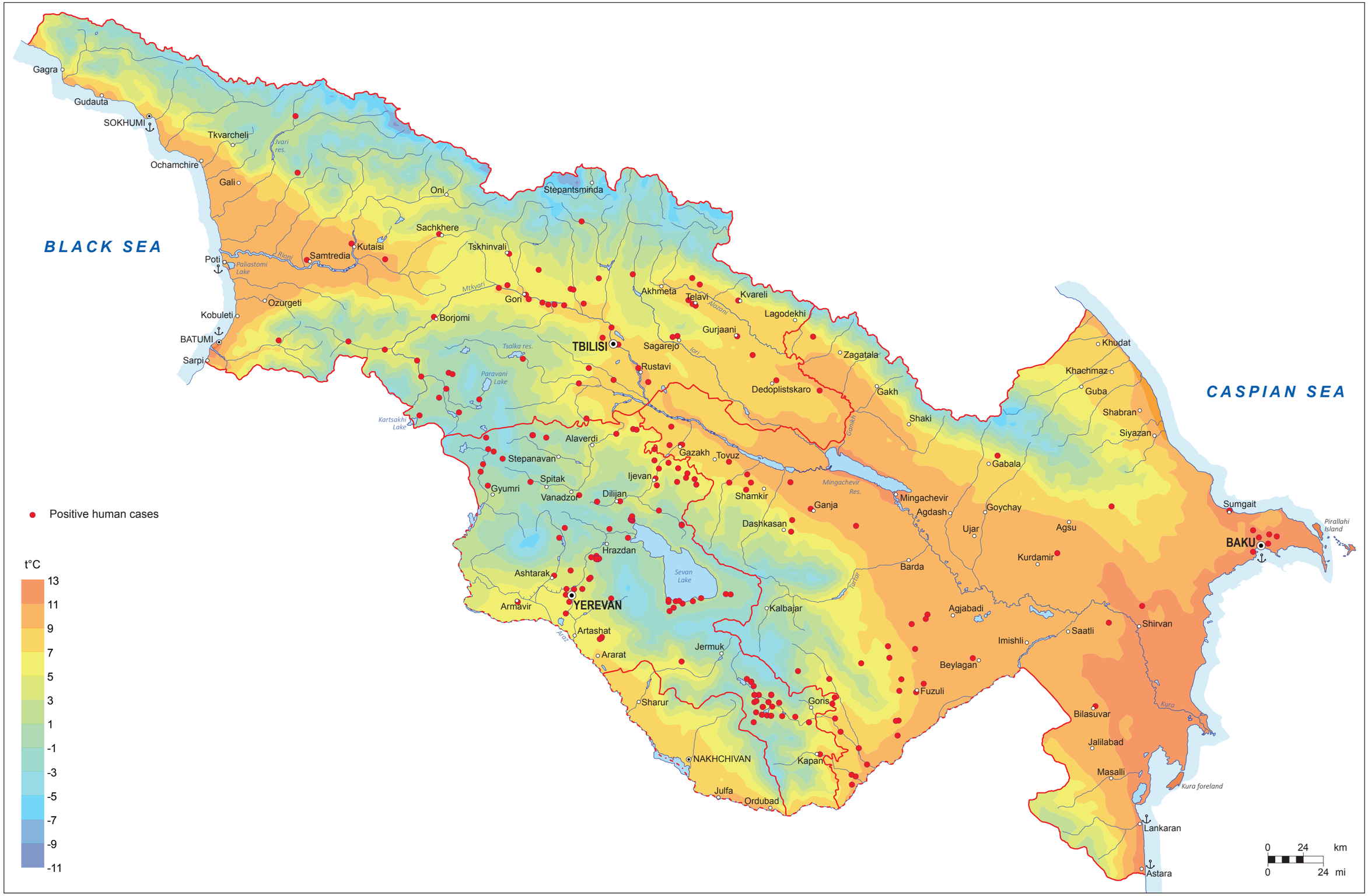
Distribution of Tularemia Human Cases by Maximum Temperature in the South Caucasus, 1946-2019



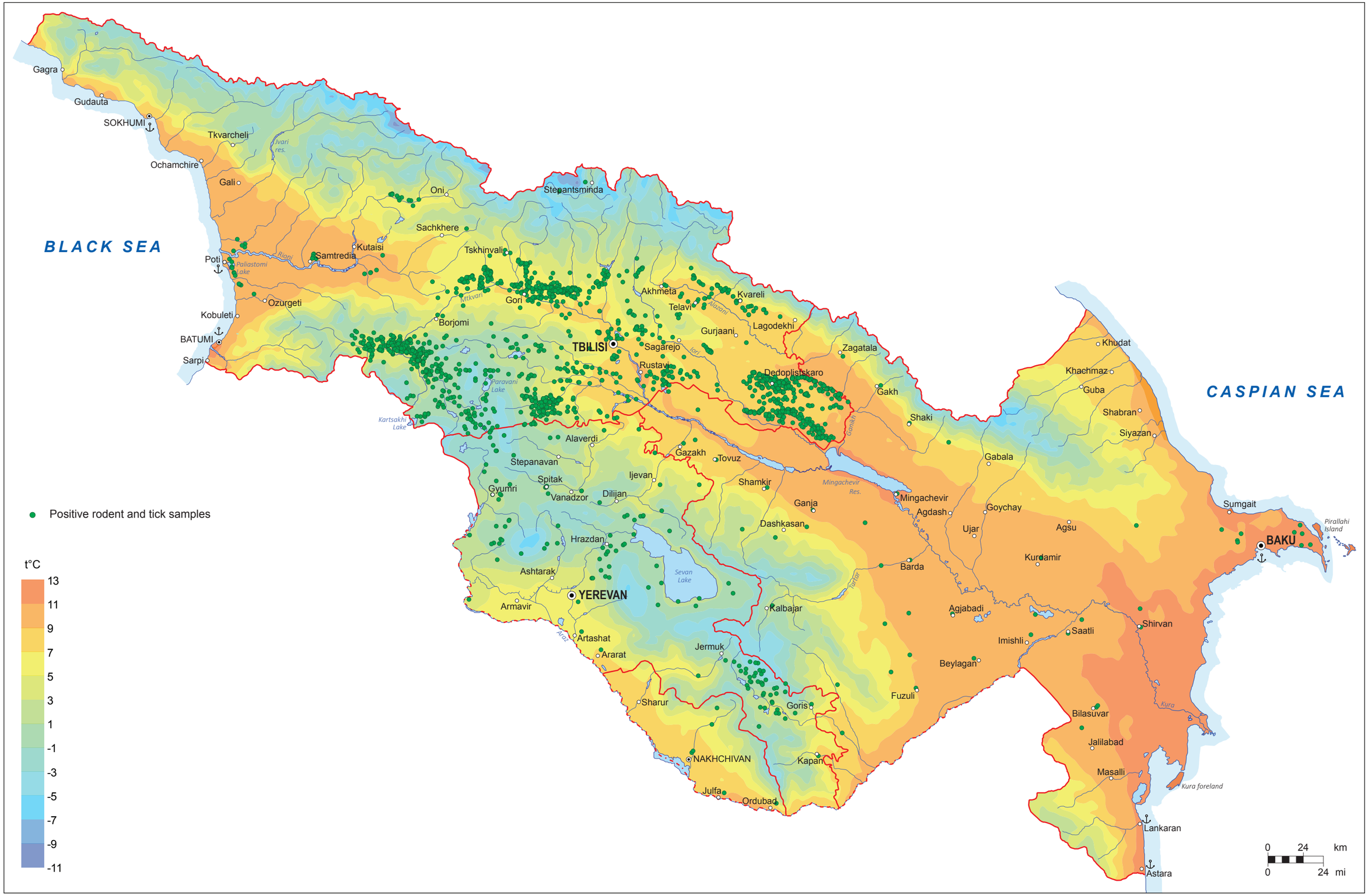
Distribution of Tularemia Positive Rodent and Tick Samples by Maximum Temperature in the South Caucasus, 1946-2019



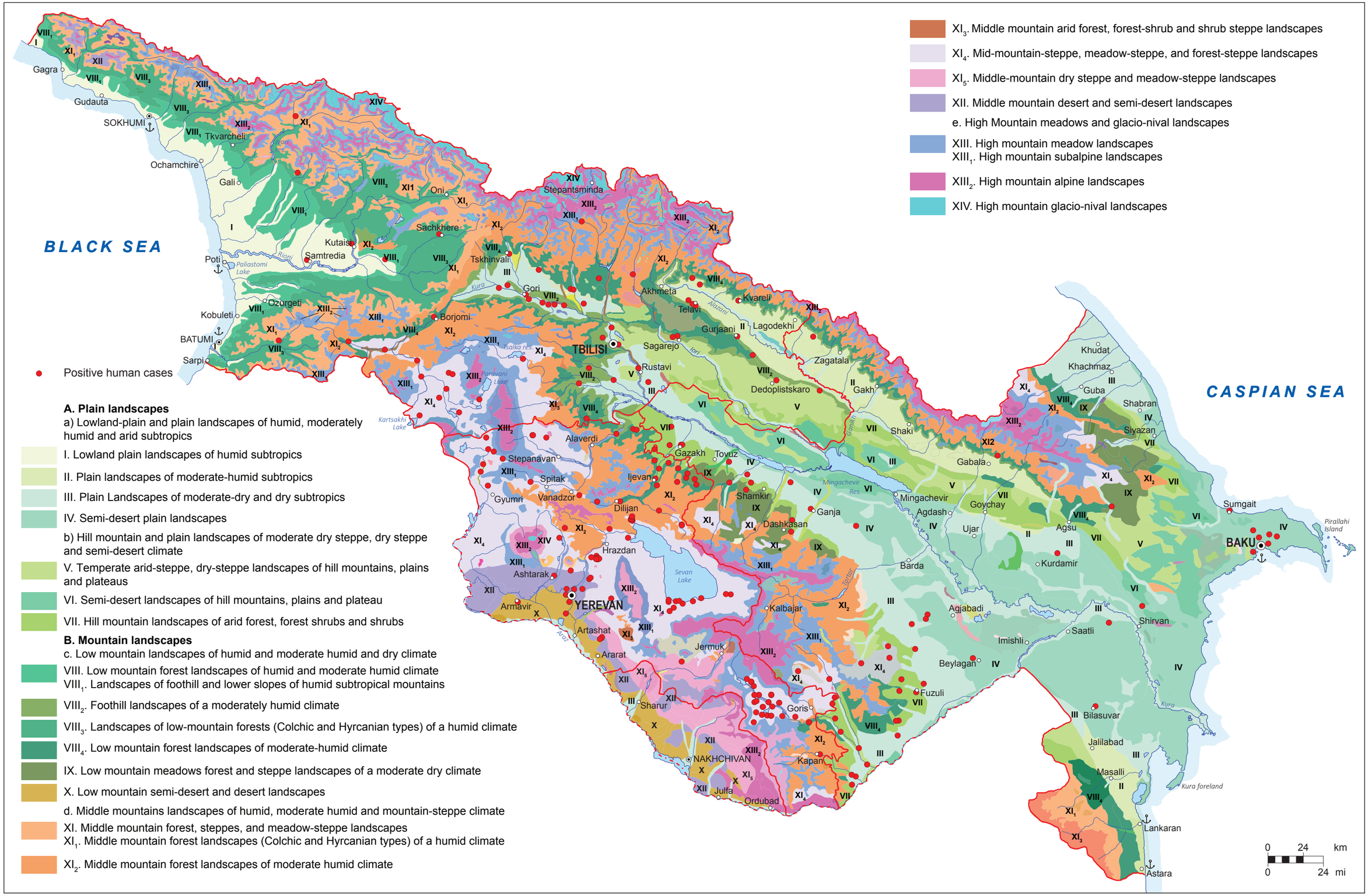
Distribution of Tularemia Human Cases by Minimum Temperature in the South Caucasus, 1946-2019



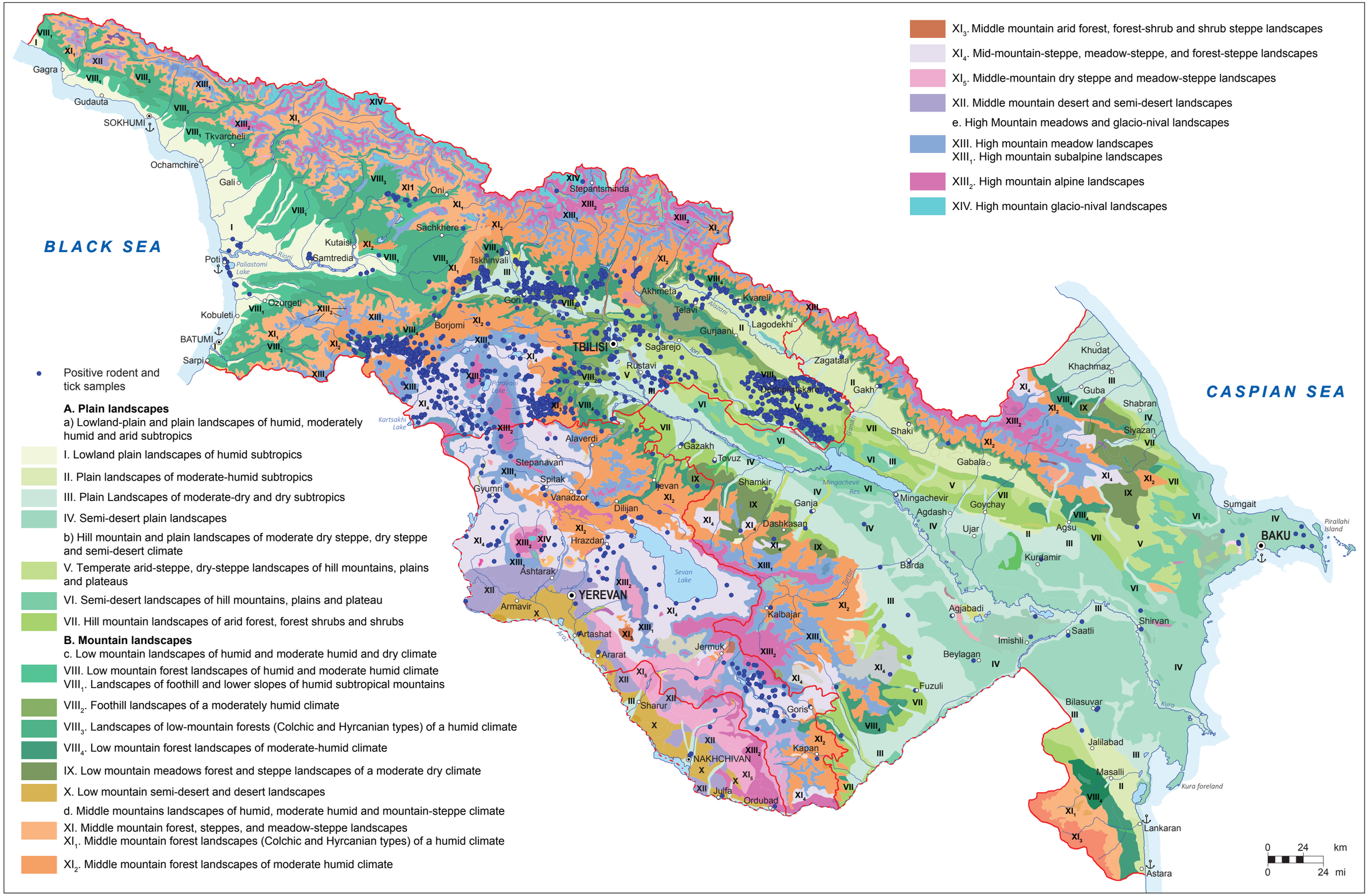
Distribution of Tularemia Positive Rodent and Tick Samples by Minimum Temperature in the South Caucasus, 1946-2019



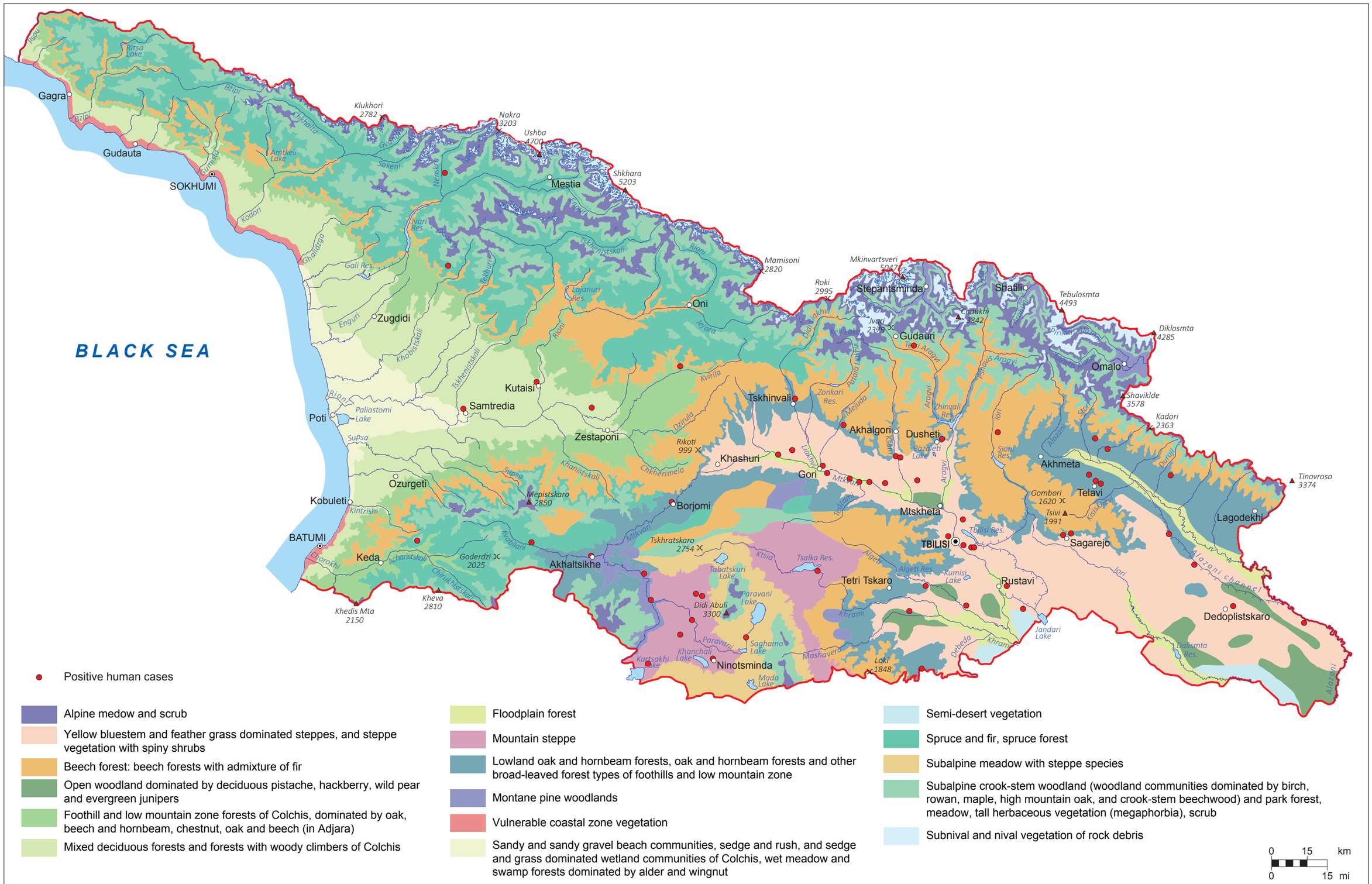
Distribution of Tularemia Human Cases by Landscape in the South Caucasus, 1946-2019



Distribution of Tularemia Positive Rodent and Tick Samples by Landscape in the South Caucasus, 1946-2019



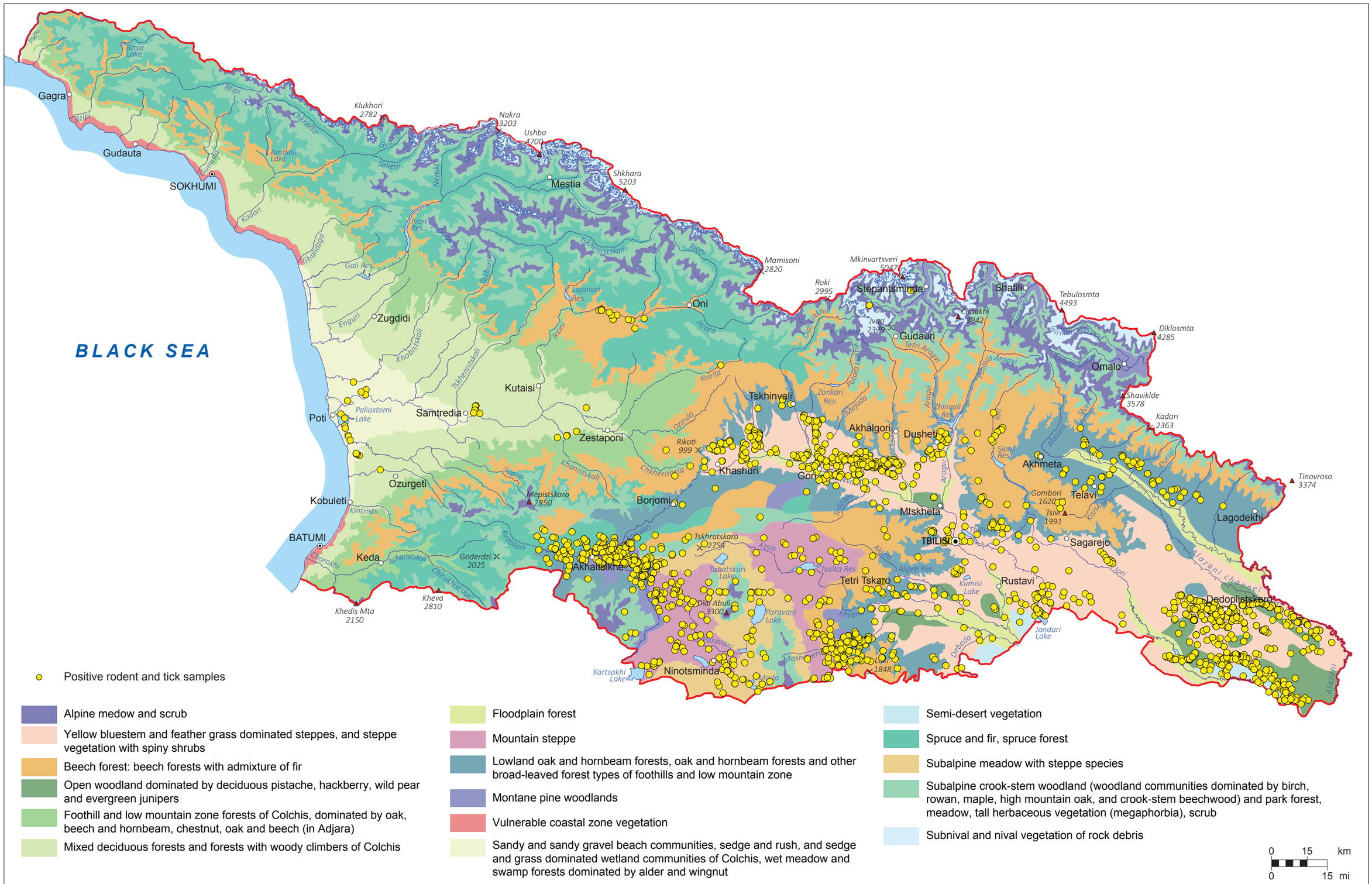
Distribution of Tularemia Human Cases by Vegetation in Georgia, 1946-2019



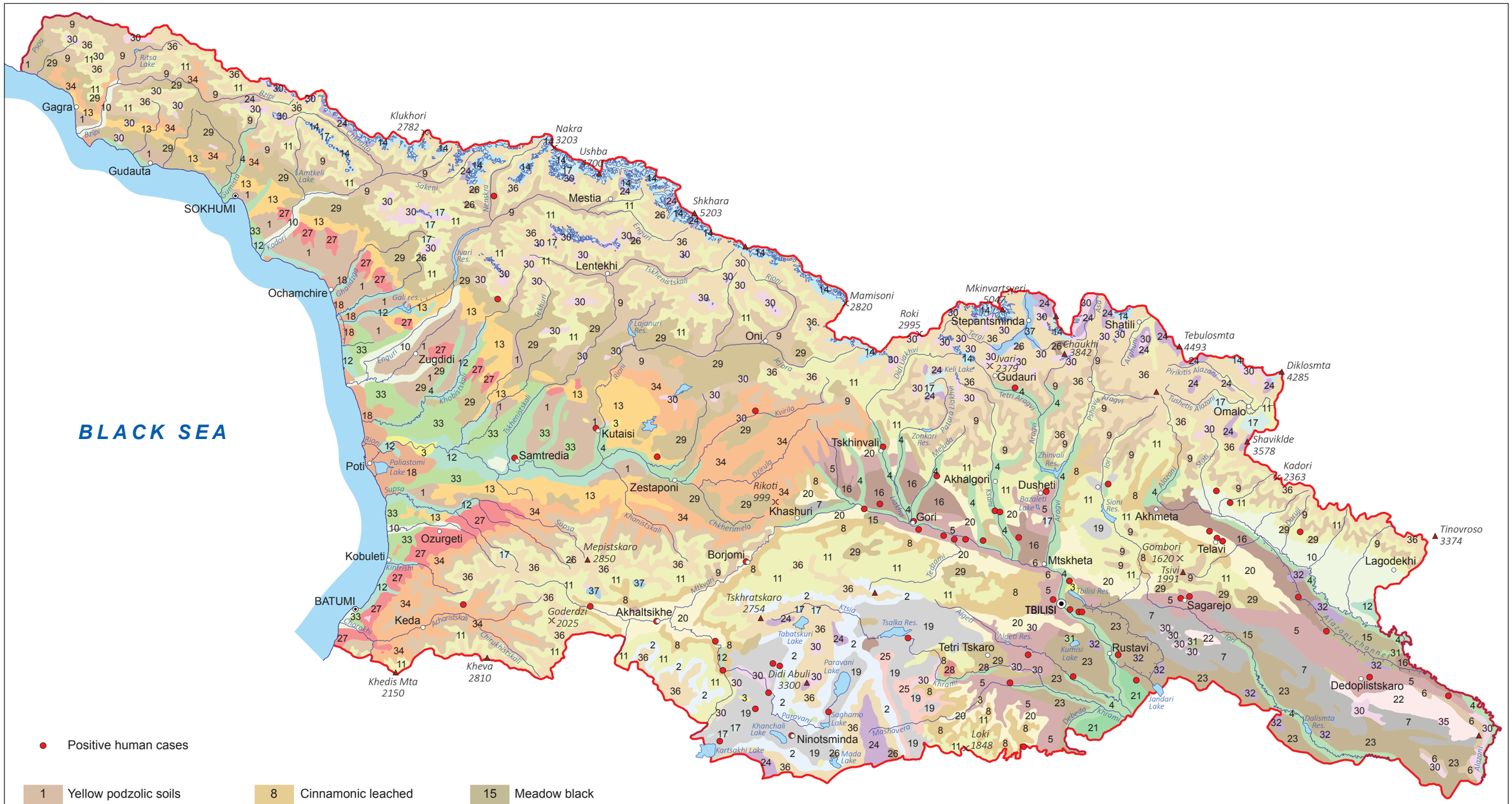
Positive human cases

- Alpine medow and scrub
- Yellow bluestem and feather grass dominated steppes, and steppe vegetation with spiny shrubs
- Beech forest: beech forests with admixture of fir
- Open woodland dominated by deciduous pistache, hackberry, wild pear and evergreen junipers
- Foothill and low mountain zone forests of Colchis, dominated by oak, beech and hornbeam, chestnut, oak and beech (in Adjara)
- Mixed deciduous forests and forests with woody climbers of Colchis
- Floodplain forest
- Mountain steppe
- Lowland oak and hornbeam forests, oak and hornbeam forests and other broad-leaved forest types of foothills and low mountain zone
- Montane pine woodlands
- Vulnerable coastal zone vegetation
- Sandy and sandy gravel beach communities, sedge and rush, and sedge and grass dominated wetland communities of Colchis, wet meadow and swamp forests dominated by alder and wingnut
- Semi-desert vegetation
- Spruce and fir, spruce forest
- Subalpine meadow with steppe species
- Subalpine crook-stem woodland (woodland communities dominated by birch, rowan, maple, high mountain oak, and crook-stem beechwood) and park forest, meadow, tall herbaceous vegetation (megaphorbia), scrub
- Subnival and nival vegetation of rock debris

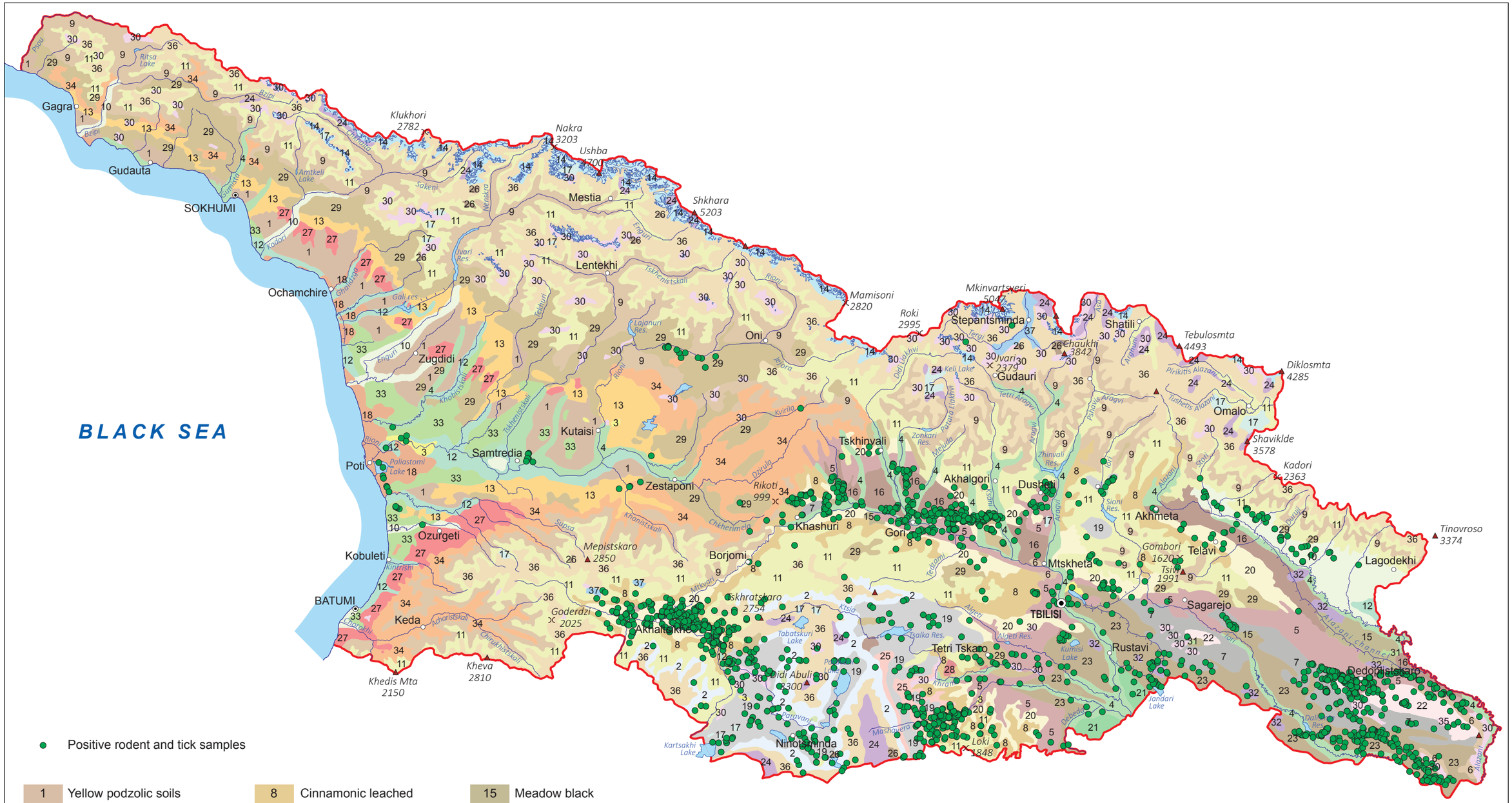
Distribution of Tularemia Positive Rodent and Tick Samples by Vegetation in Georgia, 1946-2019



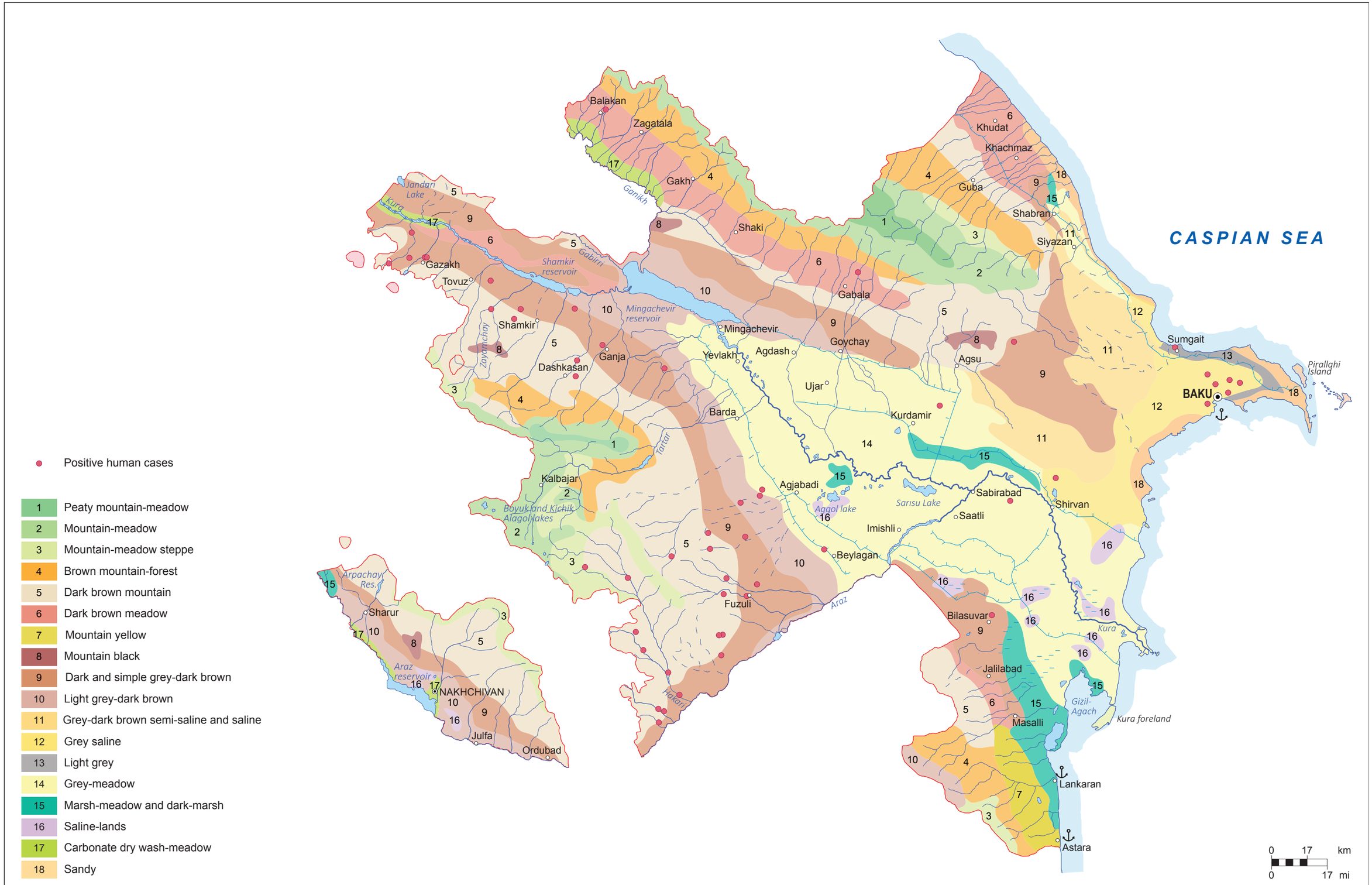
Distribution of Tularemia Human Cases by Soil Types in Georgia, 1946-2019



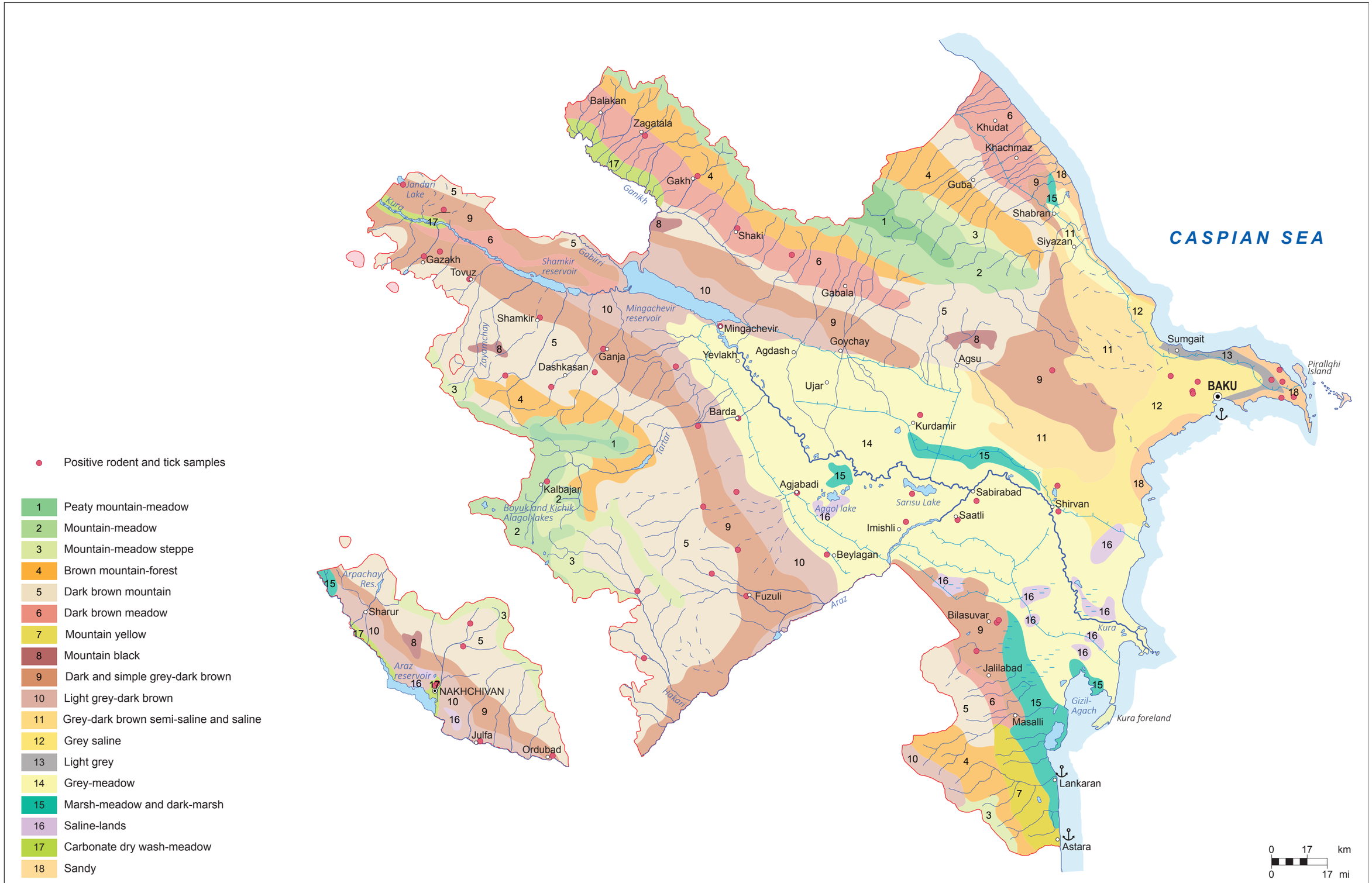
Distribution of Tularemia Positive Rodent and Tick Samples by Soil Types in Georgia, 1946-2019



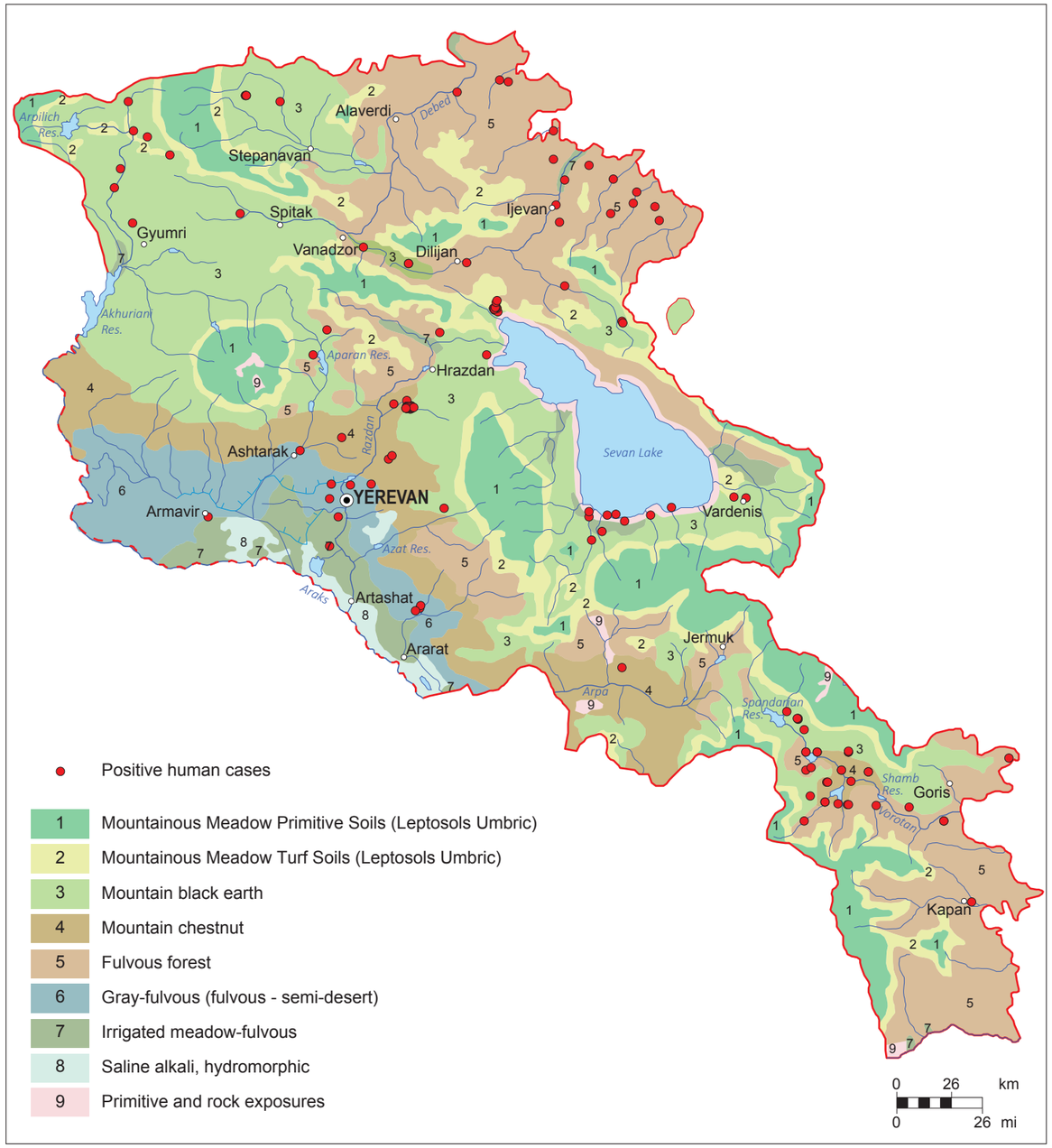
Distribution of Tularemia Human Cases by Soil Types in Azerbaijan, 1964-2019



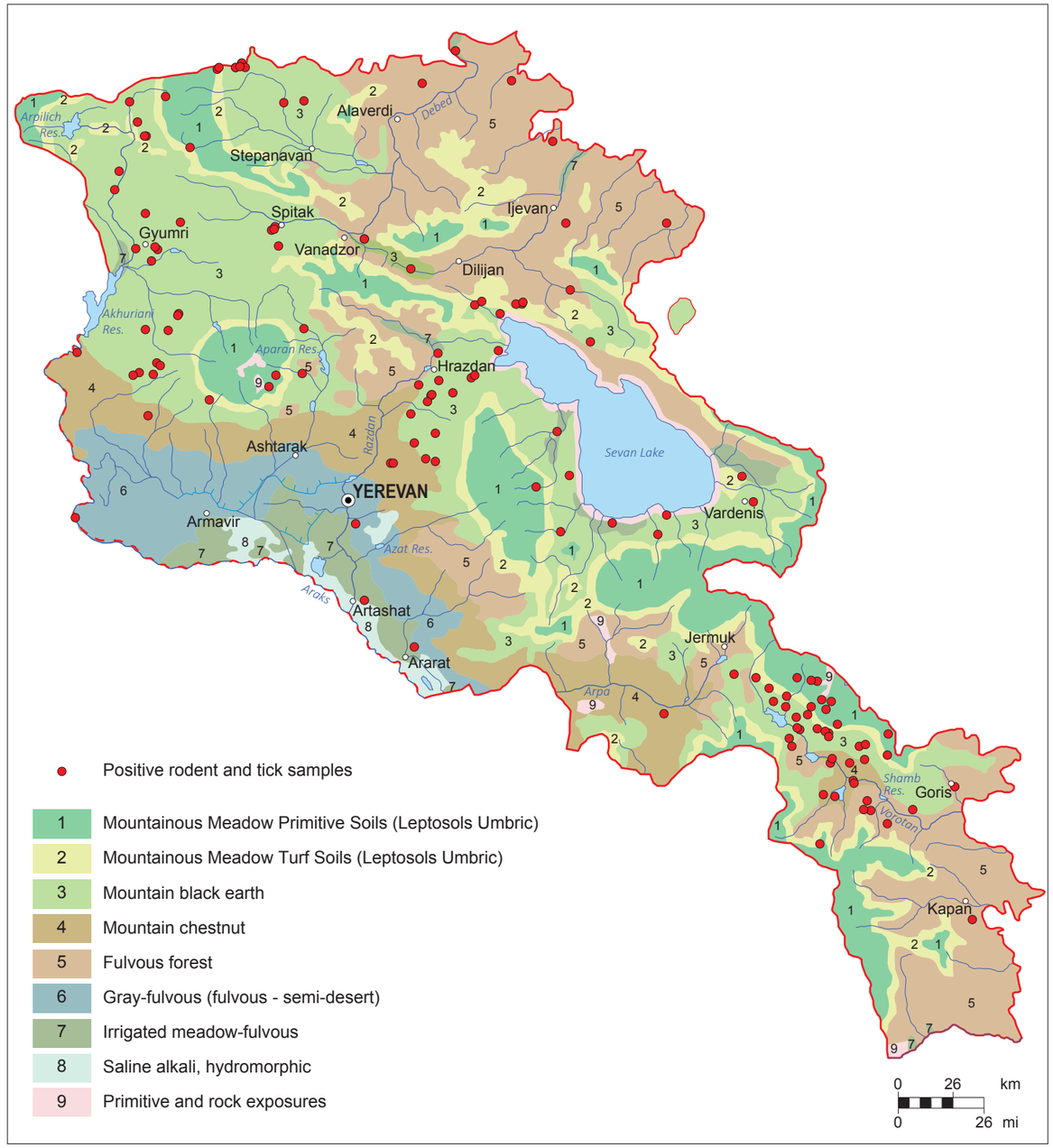
Distribution of Tularemia Positive Rodent and Tick Samples by Soil Types in Azerbaijan, 1958-2019



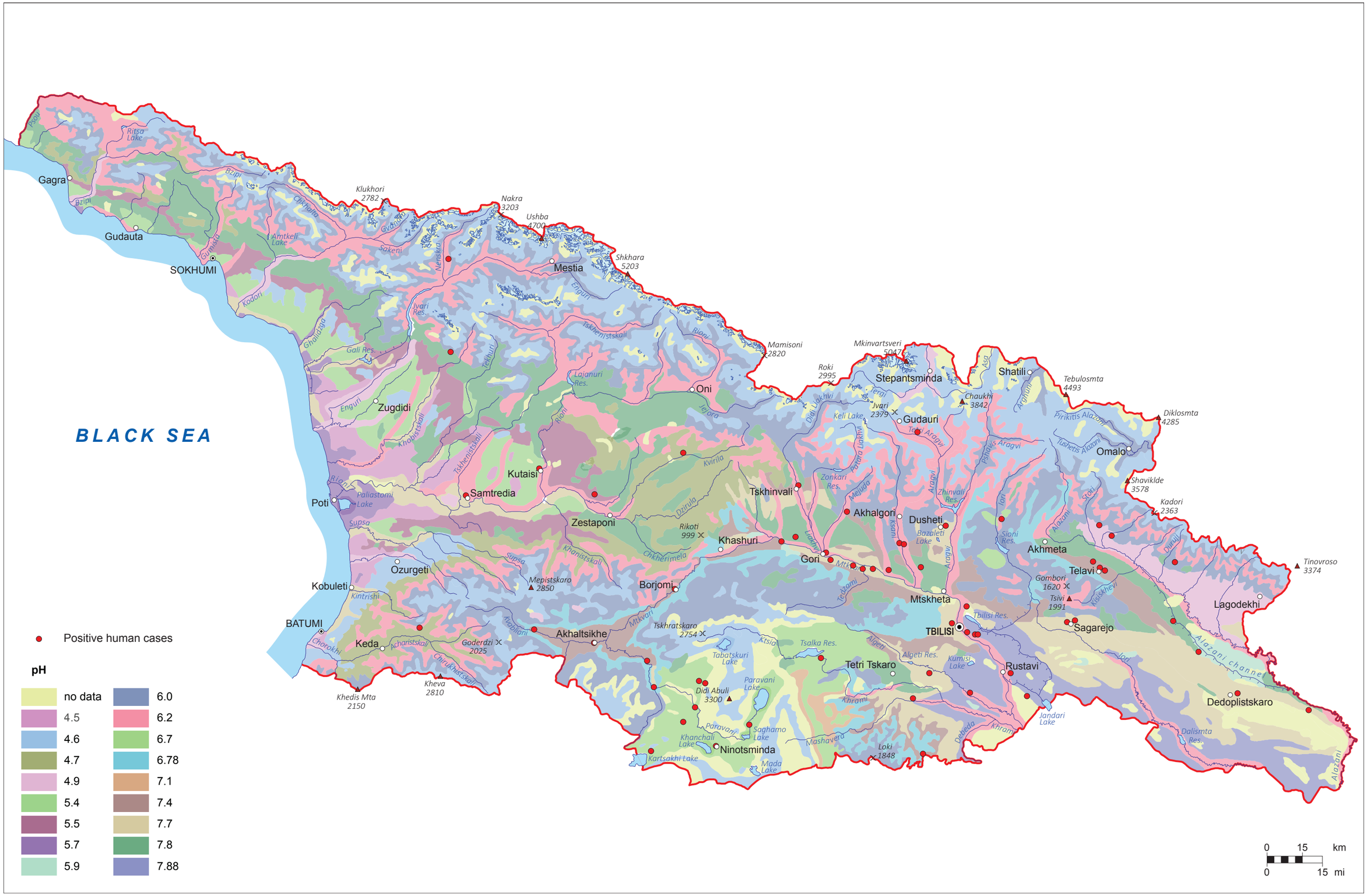
Distribution of Tularemia Human Cases by Soil Types in Armenia, 1954-2019



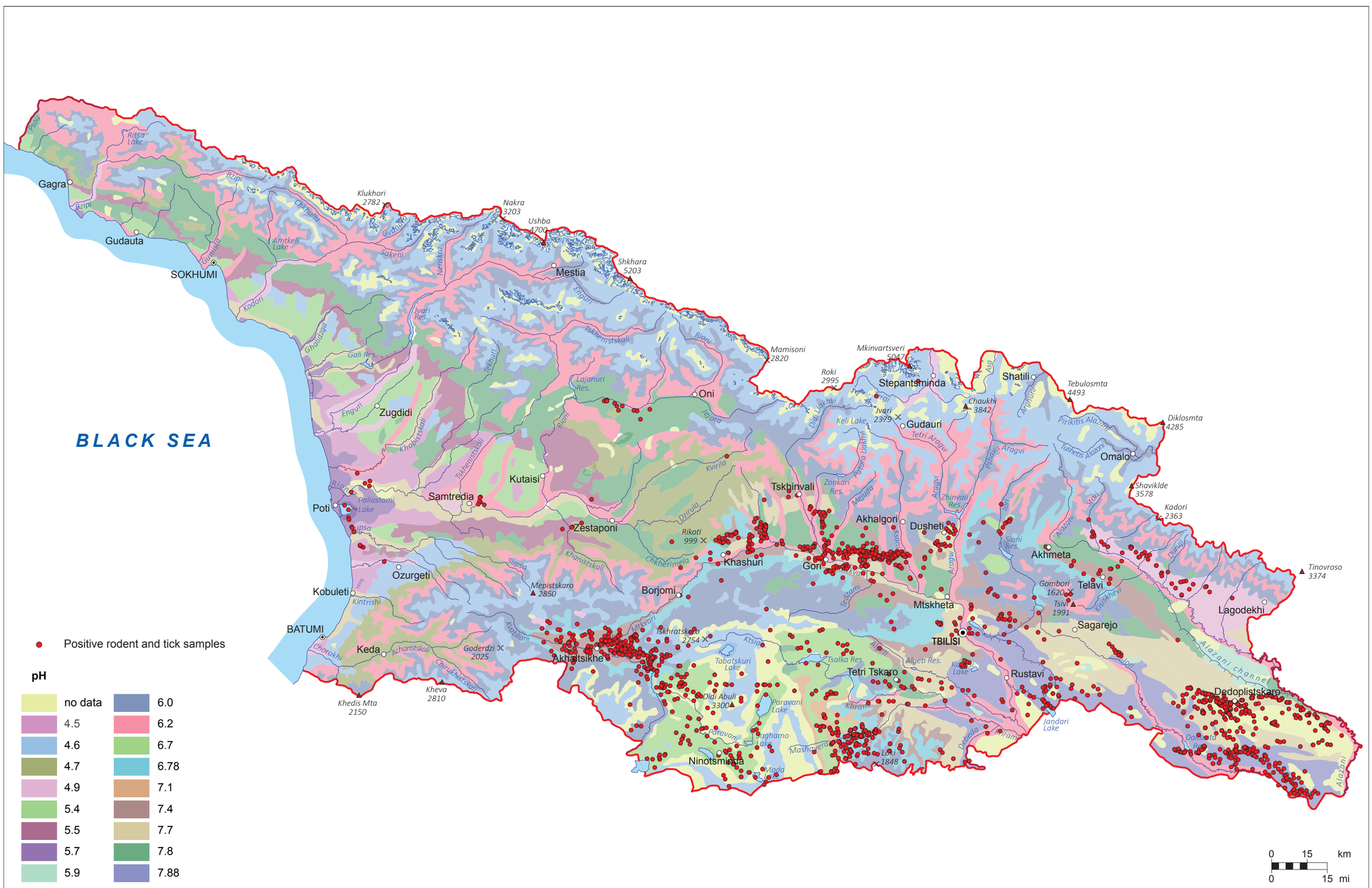
Distribution of Tularemia Positive Rodent and Tick Samples by Soil Types in Armenia, 1950-2019



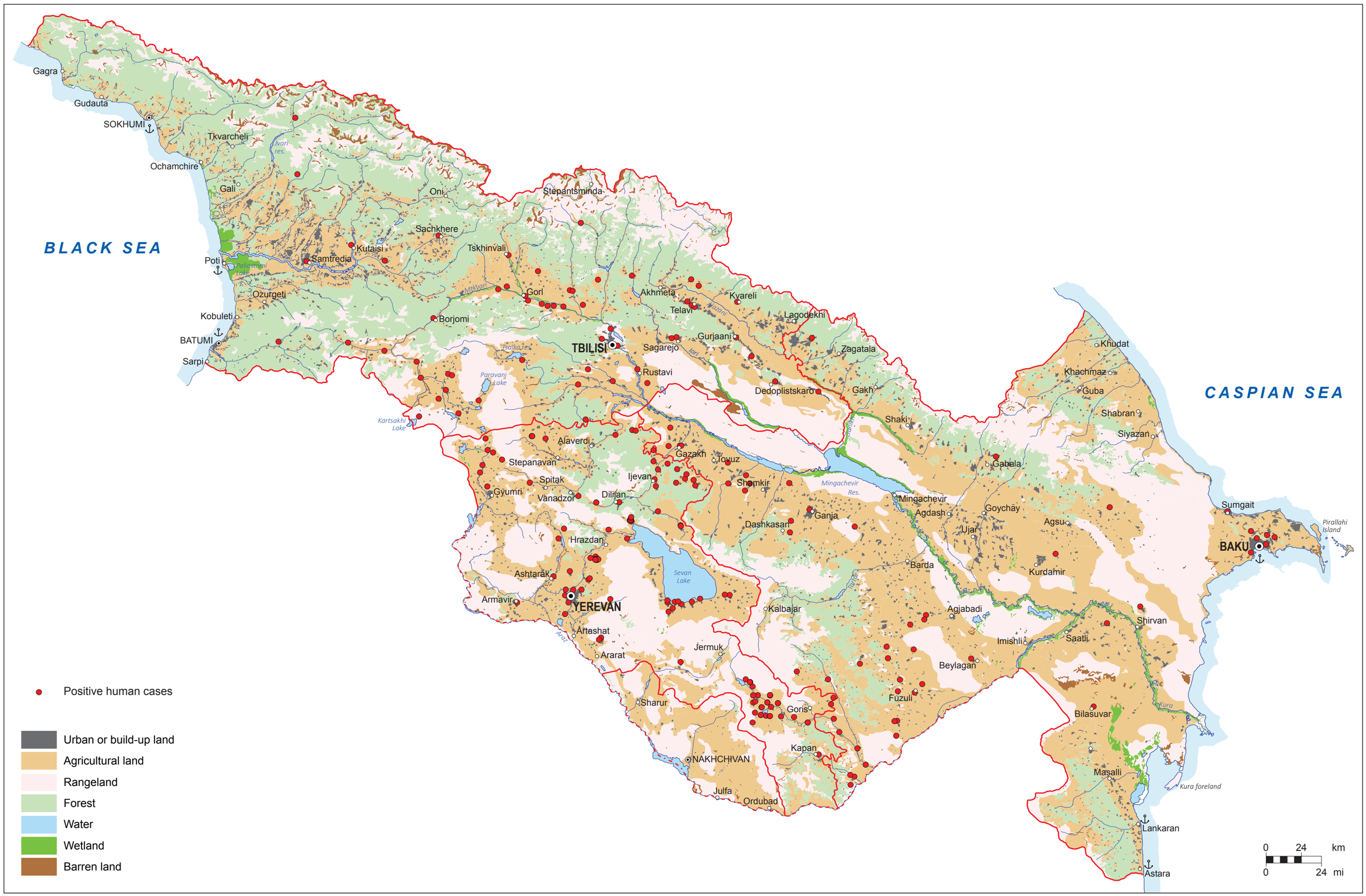
Distribution of Tularemia Human Cases by Soil pH in Georgia, 1946-2019



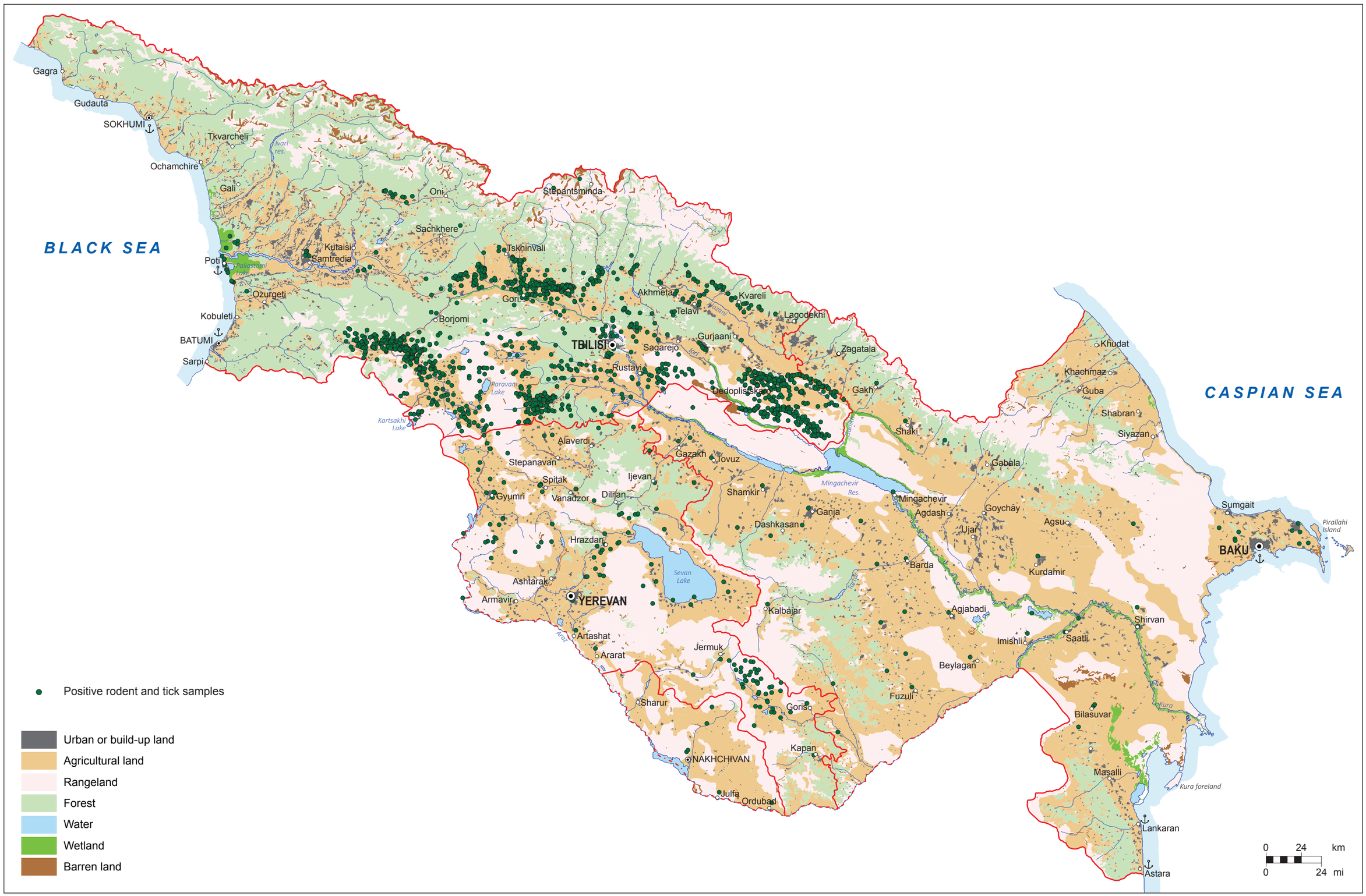
Distribution of Tularemia Positive Rodent and Tick Samples by Soil pH in Georgia, 1946-2019



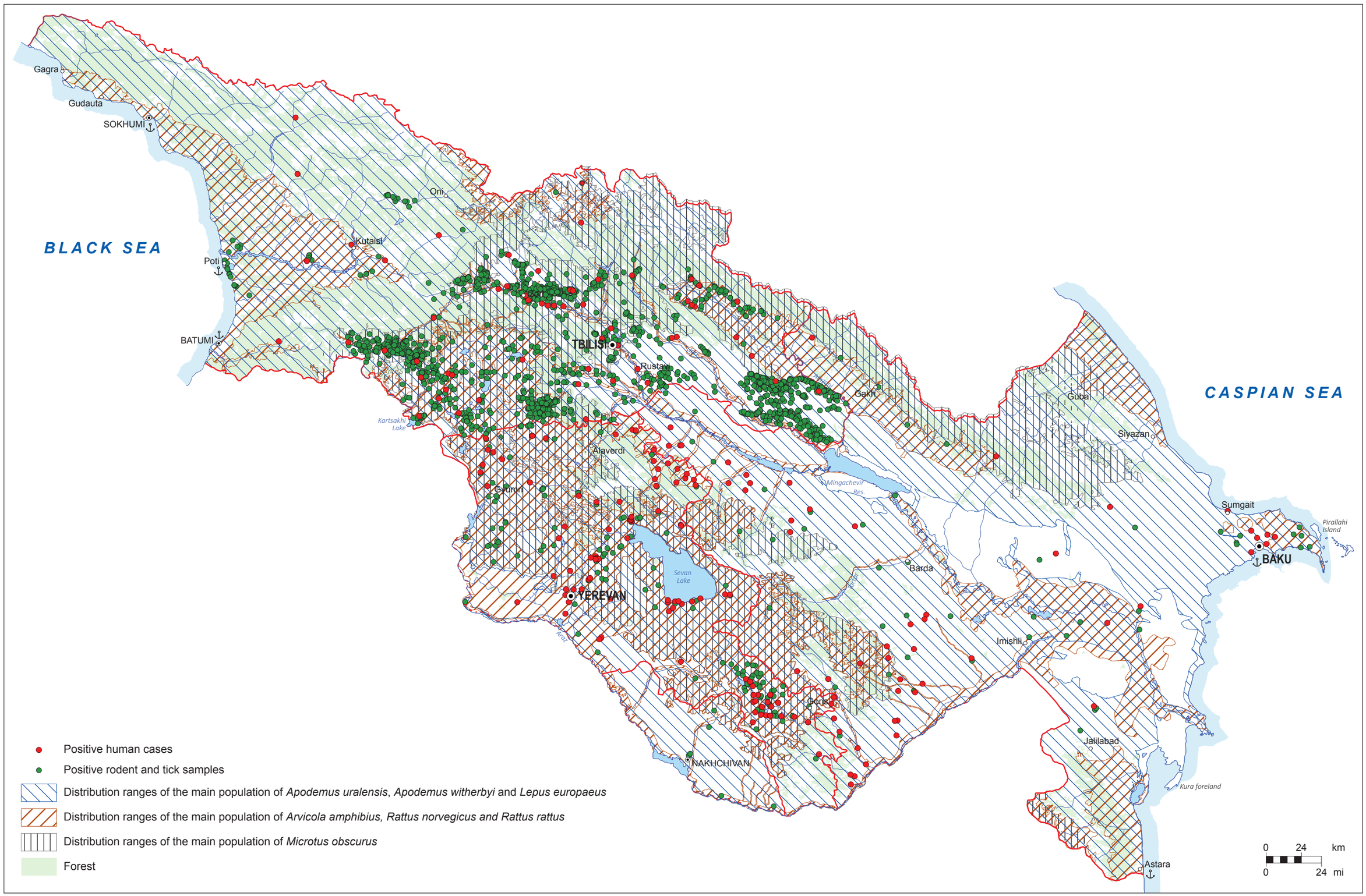
Distribution of Tularemia Human Cases by Land Use in the South Caucasus, 1946-2019



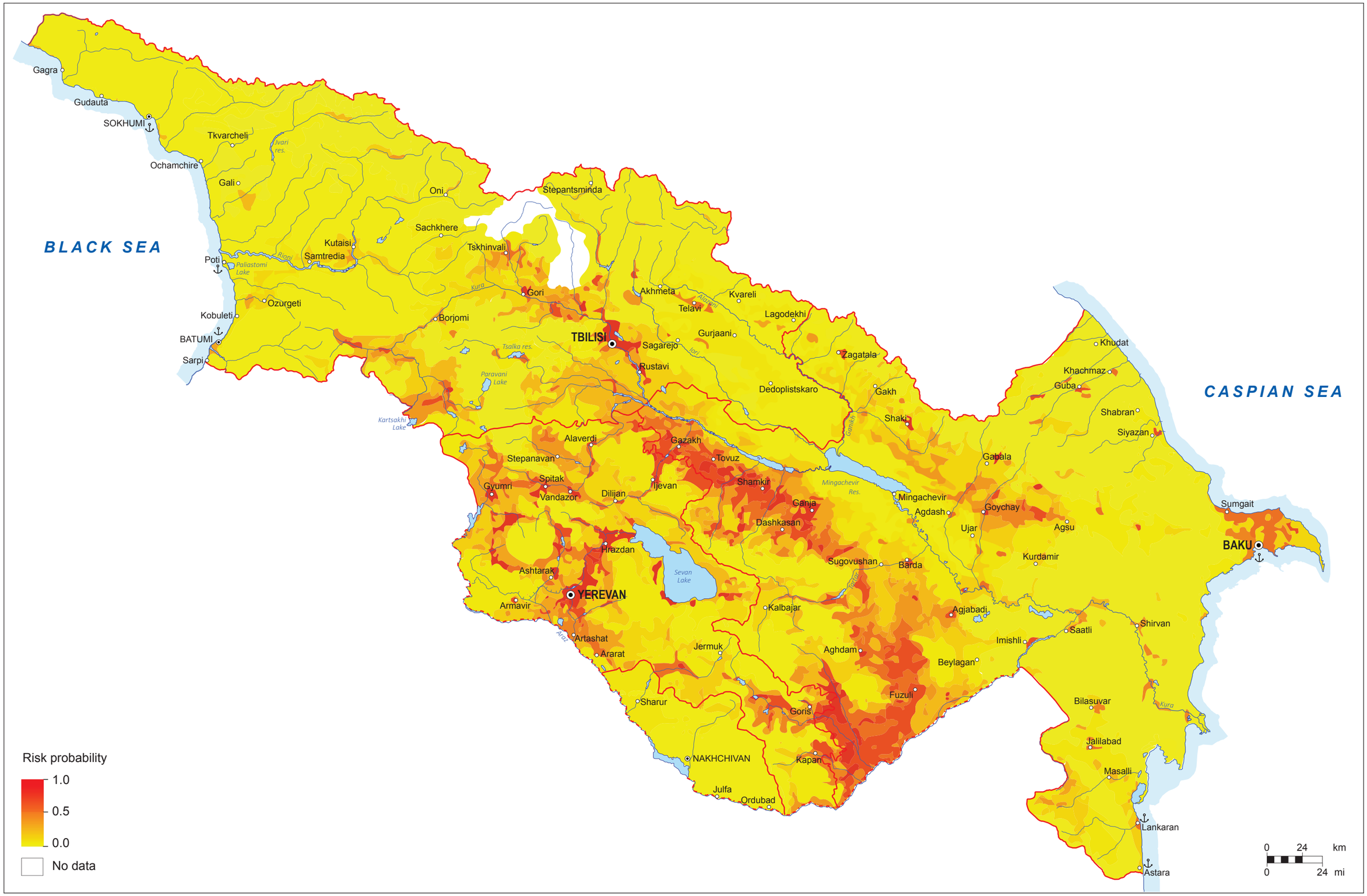
Distribution of Tularemia Positive Rodent and Tick Samples by Land Use in the South Caucasus, 1946-2019



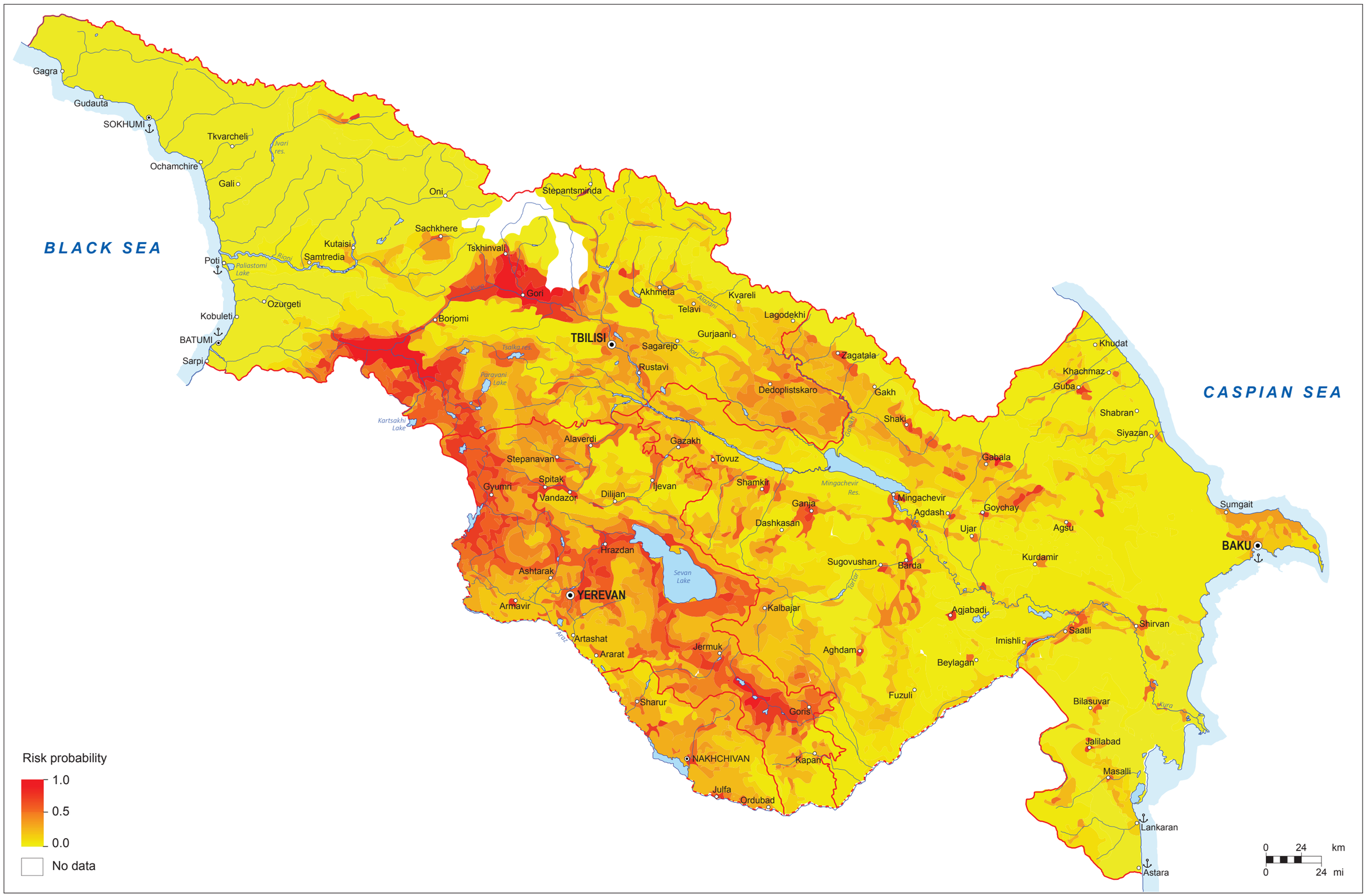
Distribution of Tularemia Human Cases, Rodent and Tick Positive Samples and Distribution Ranges of the Main Population of Rodents in the South Caucasus, 1950-2020



Tularemia Human Cases Risk in the South Caucasus



Tularemia Positive Rodent and Tick Samples Risk in the South Caucasus



Crimean-Congo Hemorrhagic Fever (CCHF)

Crimean-Congo hemorrhagic fever (CCHF) is a widespread zoonotic disease. Its causative virus belongs to the genus Orthonairovirus and the family Nairoviridae, formerly Bunyaviridae. CCHF was first described in Crimea in 1944 among soldiers and agricultural workers, and in 1969 it was recognized that the virus causing the disease was identical to the virus isolated from a child in the Congo in 1956. The hosts are cattle, sheep and goats. Animals are infected by the bites of infected ticks, and ticks of genus Hyalomma are the main vector. In humans, CCHF causes severe disease, and is mainly transmissible through the bite or shedding of infected ticks. It can also be transmitted by contact with the tissues of a sick domestic or wild animal, immediately during and after the animal is slaughtered. Infection is transmitted from human to human via contact with blood or biological fluids, especially during medical treatment. The risk group includes agricultural workers, herdsmen, animal slaughterhouse workers, veterinarians, military personnel, and travelers to CCHF endemic regions. Medical workers are at especially high risk. Hospital-acquired infections may develop through improper sterilization of medical equipment, reuse of needles, and use of contaminated medical supplies. The spread of CCHF is a threat to public health services, as outbreaks often occur in hospitals and healthcare facilities.

The CCHF virus can cause severe viral hemorrhagic fever outbreaks with a high mortality rate (10 to 40%), and is difficult to prevent and treat. It is found in Eastern Europe, especially the former Soviet Union, throughout the Mediterranean, northwestern China, Central Asia, southern Europe, Africa, the Middle East, and the Indian subcontinent. Anyone who comes into contact with an infected reservoir (ticks, animals, humans) can become ill. All ages and both genders are susceptible to the disease; however, most cases occur in adults, which is related to their involvement in agricultural activities. After contracting the disease, a person develops strong immunity, probably for life. Cases are more frequent from June to September. The incubation period of the disease is 1 to 3 days, the maximum incubation period is 13-14 days, and however, a 30-day incubation period is also described in Turkey.

Prevention and control of CCHF in animals and ticks is difficult because infection in domestic animals is usually not obvious. Furthermore, because tick vectors are numerous and widely distributed, control of ticks with acaricides is difficult. In order to prevent CCHF, attention should be focused on key aspects of public health, such as reducing the risk of tick-to-human transmission as well as reducing the risk of animal-to-human and human-to-human transmission. Healthcare workers who care for or collect specimens from suspected or confirmed cases of CCHF should implement standard infection control measures. This includes hand hygiene, use of personal protective equipment, safe injection practices as well as safe funeral arrangements. An inactivated mouse brain-derived vaccine against CCHF has been developed, but is of limited use in Eastern Europe. There is currently no safe and effective vaccine for human and animal use.

CCFH human positive case, 2010 © Nikoloz Tsertsvadze

The main approach to managing CCHF in humans is supportive care combined with symptomatic treatment, including correction of fluid balance and electrolyte abnormalities, oxygenation and hemodynamic support. Appropriate treatment of secondary infections is also important. Ribavirin, an antiviral drug, has been used as an effective treatment for CCHF infection both orally and intravenously. Death with CCHF occurs in the second week of illness. In patients who recover, improvement usually begins on the ninth or tenth day after the onset of illness.

Data on CCHF cases was collected from 1950 to 2020 from all three countries from publications, annual reports, public health centers, former anti-plague stations, veterinary centers, and finished and/or ongoing scientific projects.

The first confirmed human case in Georgia was in 2009. Since then, surveillance of the disease became part of routine and case investigation. About 65% of human cases are male in Georgia and 35% of reported cases are female. The majority of human cases (42%) are between 40 to 60 years old in Georgia. Field work is conducted regularly, and sporadic cases occur almost every year. Surveillance in Armenia and Azerbaijan is weak and lacks diagnostic capacity and clinical diagnosis and awareness among medical personnel. In Azerbaijan, human cases were confirmed in a few neighboring rayons in 2017; no human cases have been reported since. A single human case was reported in Armenia in the late 1990th.

CCFH human positive case, 2012 © Nikoloz Tsertsvadze

Positive tick samples are reported among *Dermacentor marginatus*, *Haemaphysalis parva*, *Haemaphysalis punctata*, *Rhipicephalus bursa*, *Rhipicephalus Boophilus annulatus* and *Rhipicephalus sanguineus* in Georgia between 2009 and 2020. Tick samples were not reported in Azerbaijan from the study period. In Armenia, positive tick samples were found among *Dermacentor marginatus*, *Rhipicephalus bursa*, *Rhipicephalus annulatus* and *Rhipicephalus sanguineus*.

The data from Armenia and Azerbaijan does not necessarily indicate that the disease is rare in the region; lack of identified cases may be due to the absence of case definitions and laboratory diagnostics. CCHF human cases in Georgia are mostly concentrated in the central part of the country. In Azerbaijan, the human cases were in the northern part of the country. In Armenia, positive tick samples are located in the north and eastern part of the country (pp. 240-241).

Most cases in eastern Georgia have been reported across territories with moderate humid climate with moderately cold winter and prolonged warm summer, with minimum precipitation twice a year, and transitional climate from maritime humid to moderately humid continental climate with snowy cold winter and prolonged summer. In this part of the country have been reported at the territories with sufficiently humid climate with moderate cold winter and comparatively dry hot summer; maritime humid climate with mild winter and hot summer (pp. 244-245). In Azerbaijan, positive samples are reported from the territories with temperately warm climate with even distribution of precipitation throughout the year, climate of semi-deserts and dry steppes with mild winter and dry hot summer, and climate of semi-deserts and dry steppes with cold winter and dry hot summer (p. 246). In Armenia, the majority of CCHF cases have been reported across the territories with moderate, warm arid summers and moderate cold winters, and moderate, warm summers, relatively humid mild winters (p. 247).

In Georgia, most of the cases of CCHF are reported in areas where the annual sum of precipitation is 800 mm to 2,000 mm (pp. 248-249). In Armenia and Azerbaijan, cases are registered where the annual sum of precipitation is 600 mm to 1000 mm (pp. 248-249).

CCHF cases is characterized by seasonality and the majority of cases are reported during the hot season of the year, when average maximum temperatures are between 14 to 20 degrees Celsius in the South Caucasus (pp. 252-253).

Animal samples collection for laboratory investigation
© Tengiz Chaligava

Filed laboratory work on CCHF © Nikoloz Tsertsvadze

CCHF cases are mostly registered in agricultural and forest territories within the South Caucasus (pp. 266-267).

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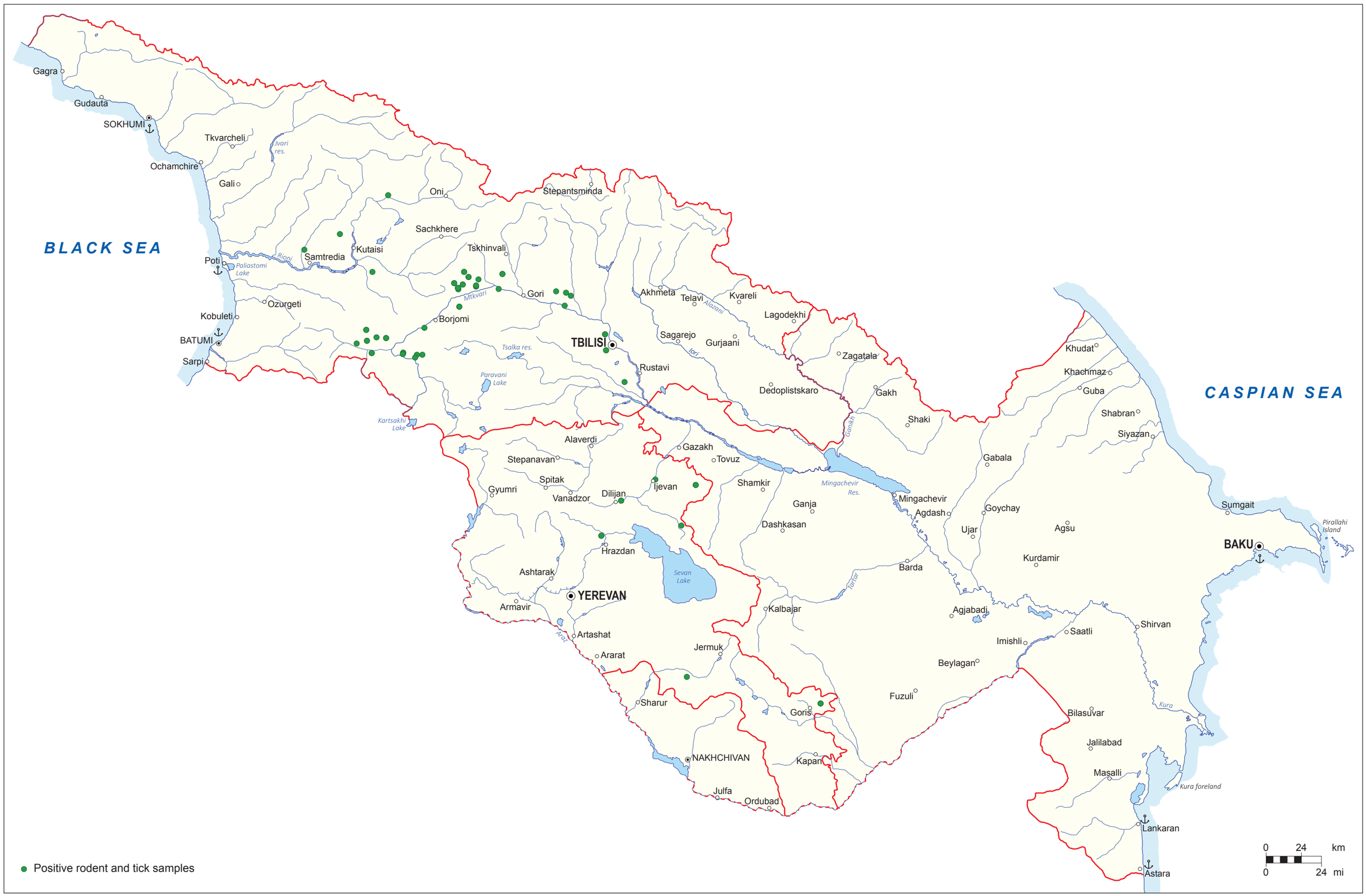
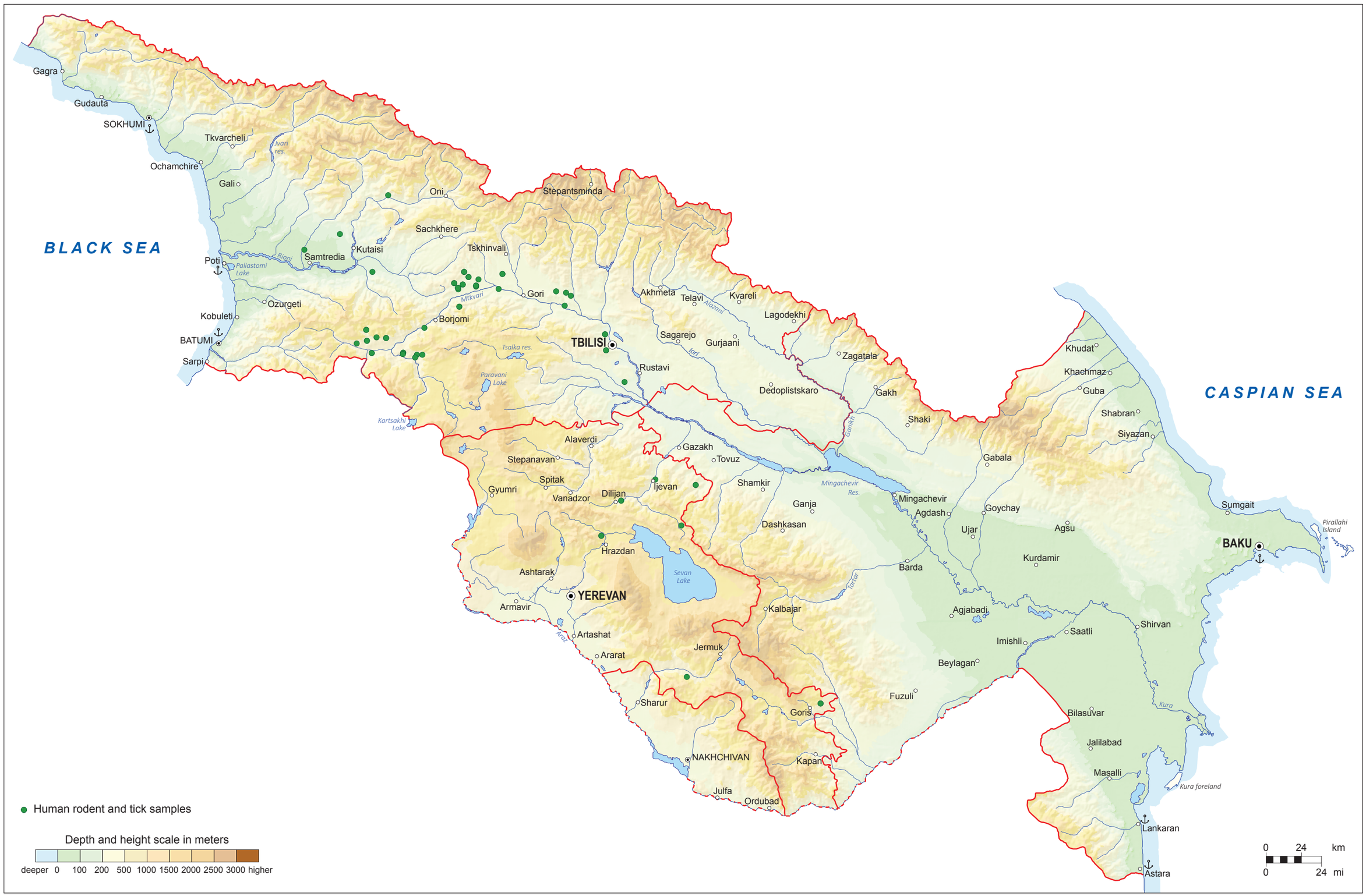
Distribution of CCHF Human Cases in the South Caucasus, 1997-2019

Distribution of CCHF Positive Rodent and Tick Samples in the South Caucasus, 1997-2019

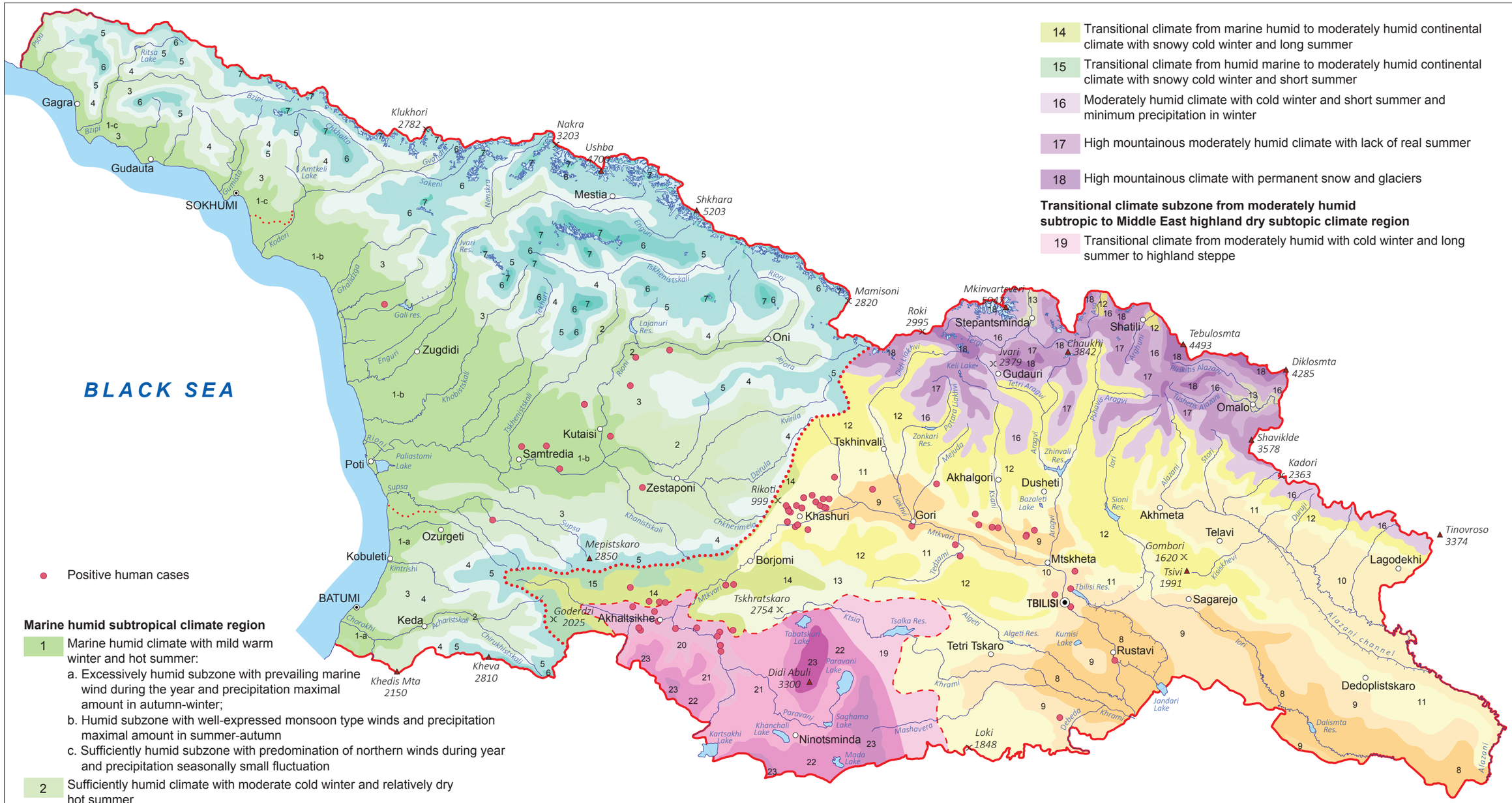


Distribution of CCHF Human Cases by Elevation in the South Caucasus, 1997-2019

Distribution of CCHF Positive Rodent and Tick Samples by Elevation in the South Caucasus, 1997-2019



Distribution of CCHF Human Cases by Climate Types in Georgia, 2009-2019



- Positive human cases

Marine humid subtropical climate region

1 Marine humid climate with mild warm winter and hot summer:
- a. Excessively humid subzone with prevailing marine wind during the year and precipitation maximal amount in autumn-winter;
- b. Humid subzone with well-expressed monsoon type winds and precipitation maximal amount in summer-autumn
- c. Sufficiently humid subzone with predomination of northern winds during year and precipitation seasonally small fluctuation

2 Sufficiently humid climate with moderate cold winter and relatively dry hot summer

3 Humid climate with moderate cold winter and long warm summer

4 Humid climate with cold winter and long cool summer

5 Humid climate with cold winter and short summer

6 High mountainous humid climate with lack of real summer

7 High mountainous humid climate with year-round abundant snow and glaciers

Moderately humid subtropical climate region

8 Moderately warm steppe with hot summer and minimum precipitation twice a year

9 Transitional climate from a moderate warm steppe to a moderate humid one, with hot summer and minimum precipitation twice a year

10 Moderate humid climate with moderately cold Winter and hot summer and minimum precipitation twice a year

11 Moderate humid climate with moderately cold Winter and long warm summer and minimum precipitation twice a year

12 Moderate humid climate with cold Winter and long cold summer, minimum precipitation twice a year

13 Moderate humid climate with cold winter and long cool summer and minimum precipitation in winter

14 Transitional climate from marine humid to moderately humid continental climate with snowy cold winter and long summer

15 Transitional climate from humid marine to moderately humid continental climate with snowy cold winter and short summer

16 Moderately humid climate with cold winter and short summer and minimum precipitation in winter

17 High mountainous moderately humid climate with lack of real summer

18 High mountainous climate with permanent snow and glaciers

Transitional climate subzone from moderately humid subtropic to Middle East highland dry subtopic climate region

19 Transitional climate from moderately humid with cold winter and long summer to highland steppe

20 Highland steppe climate with less snowy, cold winter and long, warm summer

21 Highland steppe climate with less snowy, cold winter and long cool summer

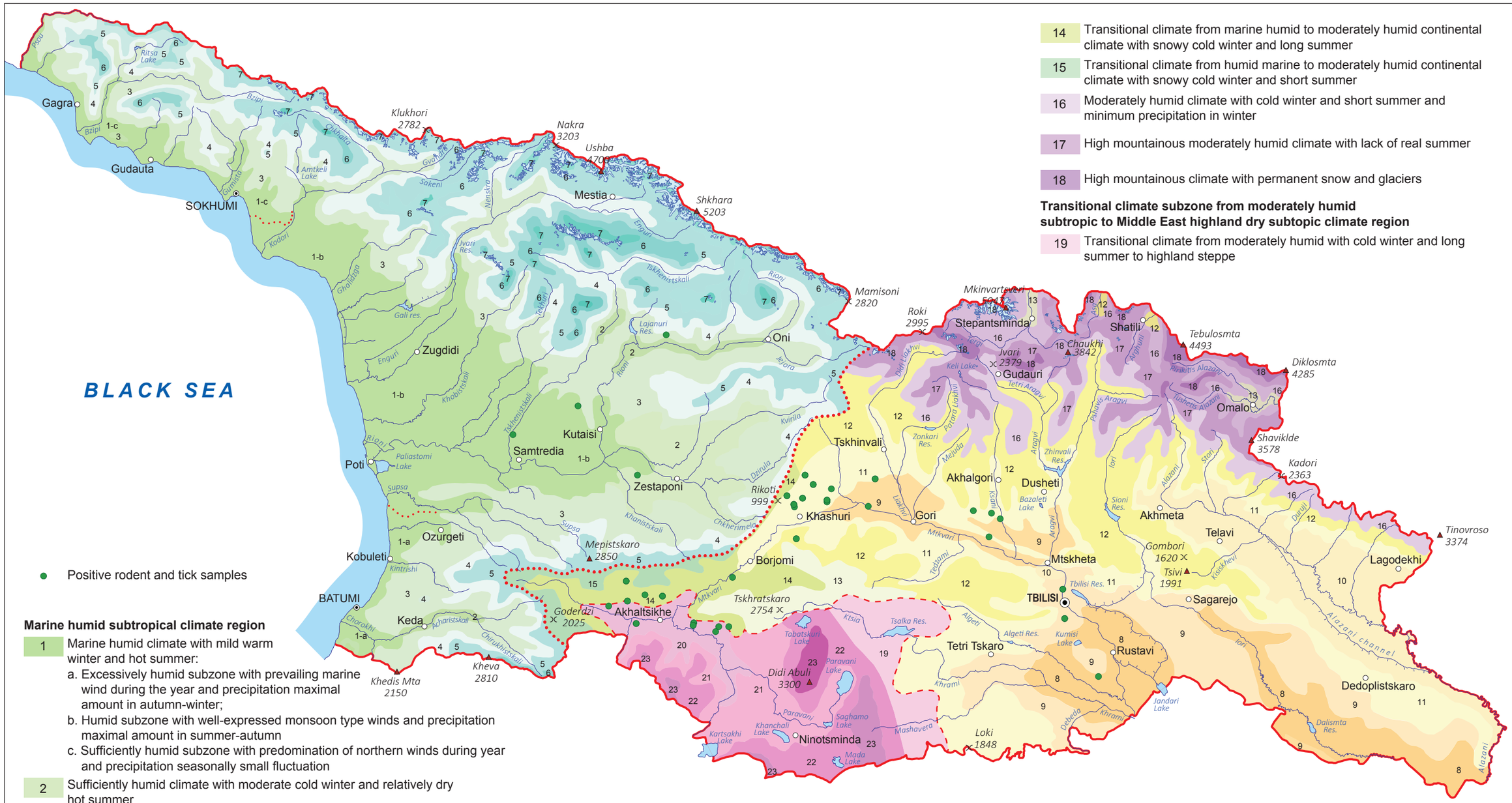
22 Highland steppe climate with short summer and cold, less snowy winter

23 Highland moderately dry climate with lack of real summer

Climate region's border · Climate subzone's border · Subregion border

0 15 km
0 15 mi

Distribution of CCHF Positive Rodent and Tick Samples by Climate Types in Georgia, 2009-2019



- 14 Transitional climate from marine humid to moderately humid continental climate with snowy cold winter and long summer
- 15 Transitional climate from humid marine to moderately humid continental climate with snowy cold winter and short summer
- 16 Moderately humid climate with cold winter and short summer and minimum precipitation in winter
- 17 High mountainous moderately humid climate with lack of real summer
- 18 High mountainous climate with permanent snow and glaciers

Transitional climate subzone from moderately humid subtropic to Middle East highland dry subtopic climate region

- 19 Transitional climate from moderately humid with cold winter and long summer to highland steppe

- Positive rodent and tick samples

Marine humid subtropical climate region

- 1 Marine humid climate with mild warm winter and hot summer:
  - a. Excessively humid subzone with prevailing marine wind during the year and precipitation maximal amount in autumn-winter;
  - b. Humid subzone with well-expressed monsoon type winds and precipitation maximal amount in summer-autumn
  - c. Sufficiently humid subzone with predomination of northern winds during year and precipitation seasonally small fluctuation
- 2 Sufficiently humid climate with moderate cold winter and relatively dry hot summer
- 3 Humid climate with moderate cold winter and long warm summer
- 4 Humid climate with cold winter and long cool summer
- 5 Humid climate with cold winter and short summer
- 6 High mountainous humid climate with lack of real summer
- 7 High mountainous humid climate with year-round abundant snow and glaciers

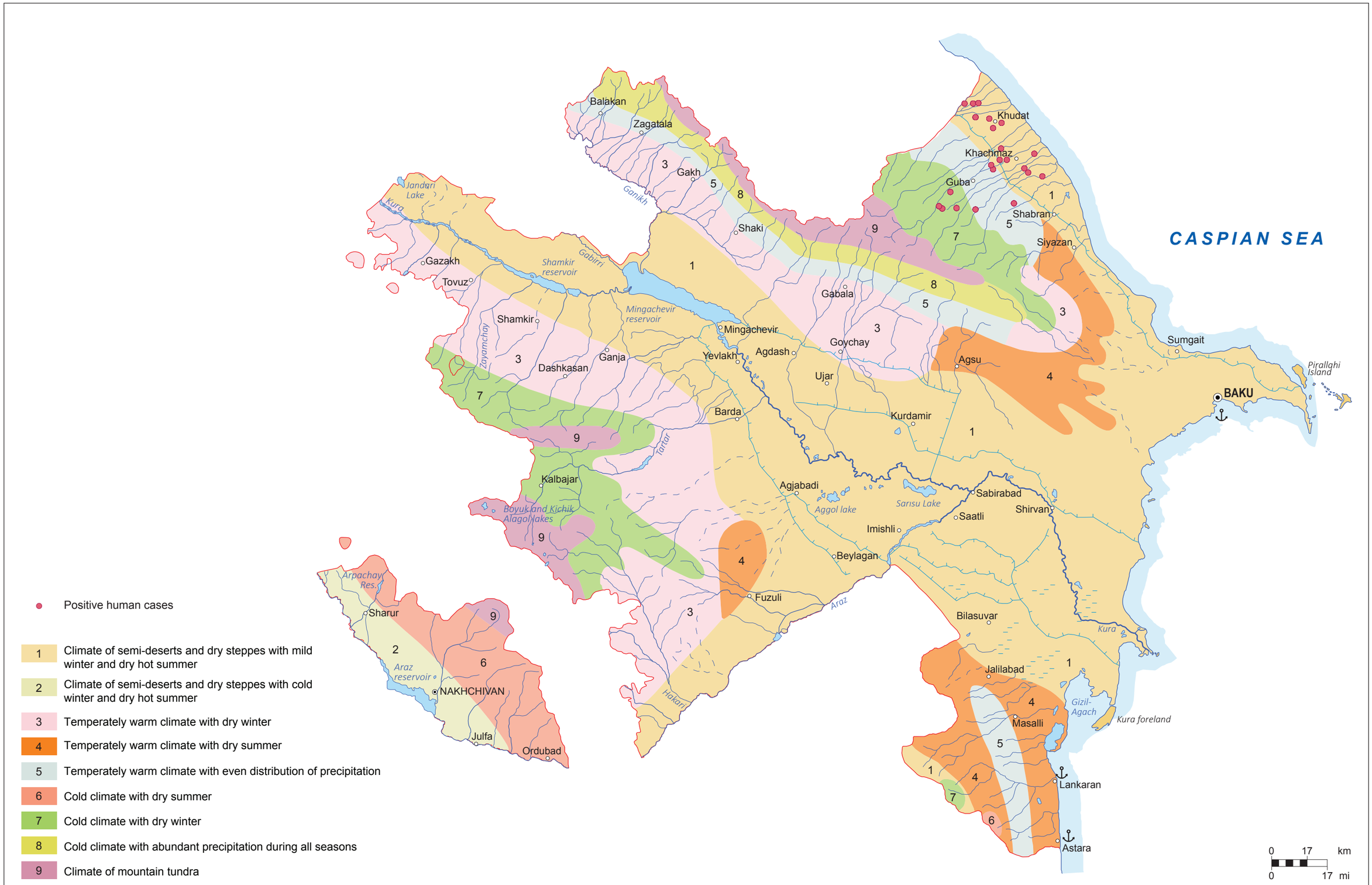
Moderately humid subtropical climate region

- 8 Moderately warm steppe with hot summer and minimum precipitation twice a year
- 9 Transitional climate from a moderate warm steppe to a moderate humid one, with hot summer and minimum precipitation twice a year
- 10 Moderate humid climate with moderately cold Winter and hot summer and minimum precipitation twice a year
- 11 Moderate humid climate with moderately cold Winter and long warm summer and minimum precipitation twice a year
- 12 Moderate humid climate with cold Winter and long cold summer, minimum precipitation twice a year
- 13 Moderate humid climate with cold winter and long cool summer and minimum precipitation in winter
- 20 Highland steppe climate with less snowy, cold winter and long, warm summer
- 21 Highland steppe climate with less snowy, cold winter and long cool summer
- 22 Highland steppe climate with short summer and cold, less snowy winter
- 23 Highland moderately dry climate with lack of real summer

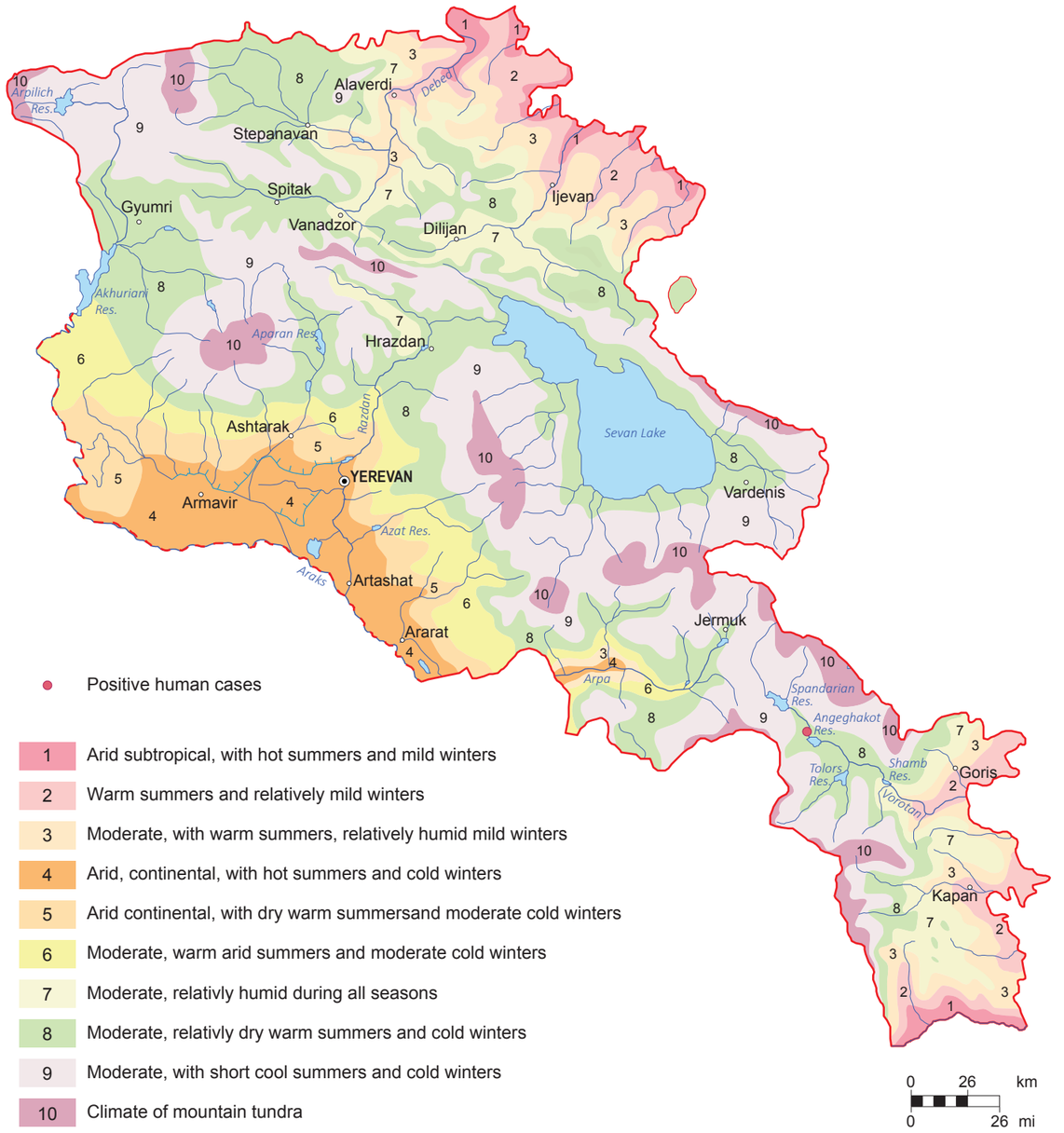
Climate region's border · Climate subzone's border · Subregion border

0 15 km
0 15 mi

Distribution of CCHF Human Cases by Climate Types in Azerbaijan, 2010

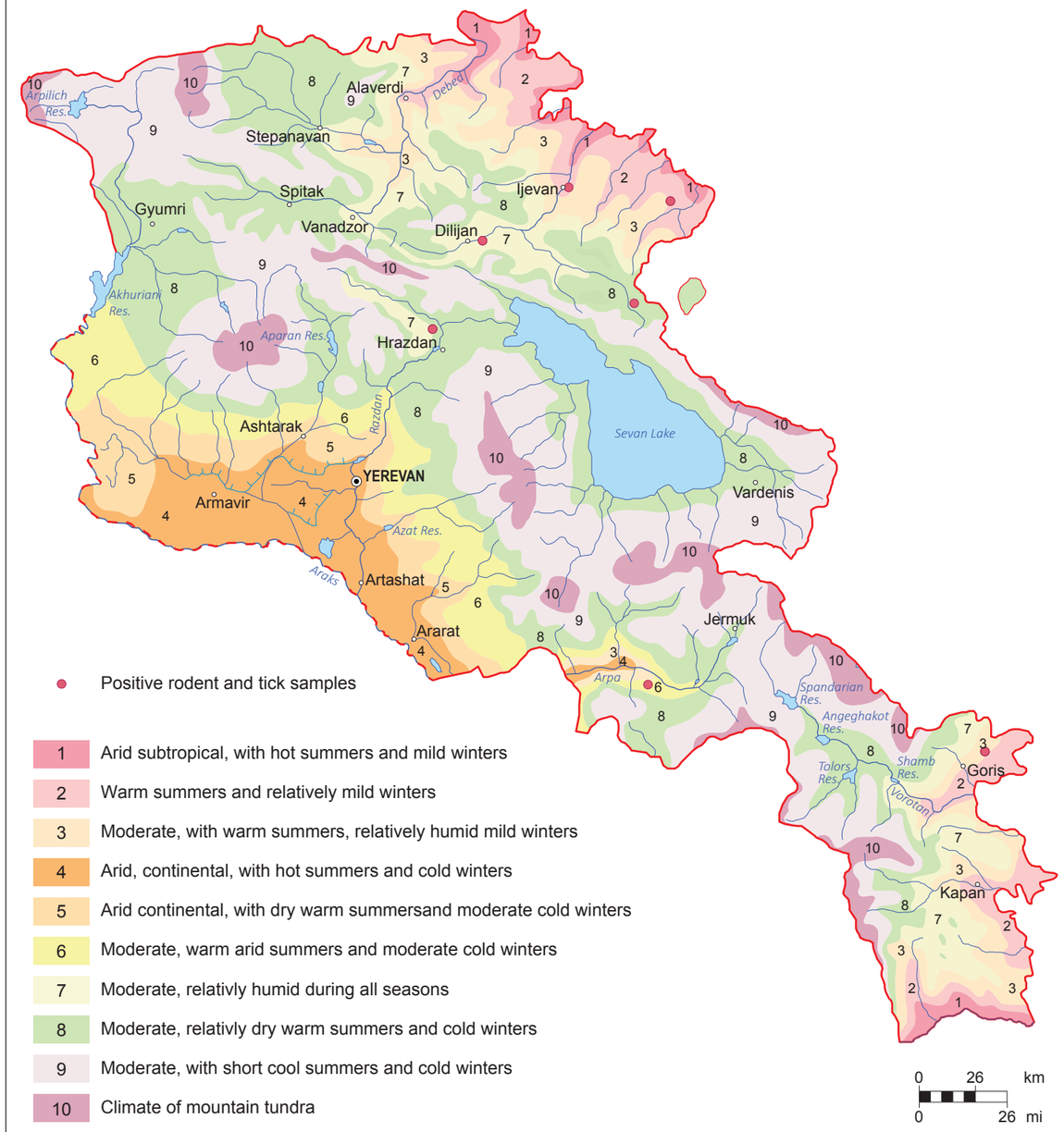


Distribution of CCHF Human Cases by Climate Types in Armenia, 1997



1 Arid subtropical, with hot summers and mild winters
2 Warm summers and relatively mild winters
3 Moderate, with warm summers, relatively humid mild winters
4 Arid, continental, with hot summers and cold winters
5 Arid continental, with dry warm summersand moderate cold winters
6 Moderate, warm arid summers and moderate cold winters
7 Moderate, relativly humid during all seasons
8 Moderate, relativly dry warm summers and cold winters
9 Moderate, with short cool summers and cold winters
10 Climate of mountain tundra

Distribution of CCHF Positive Rodent and Tick Samples by Climate Types in Armenia, 1997-2019



1 Arid subtropical, with hot summers and mild winters
2 Warm summers and relatively mild winters
3 Moderate, with warm summers, relatively humid mild winters
4 Arid, continental, with hot summers and cold winters
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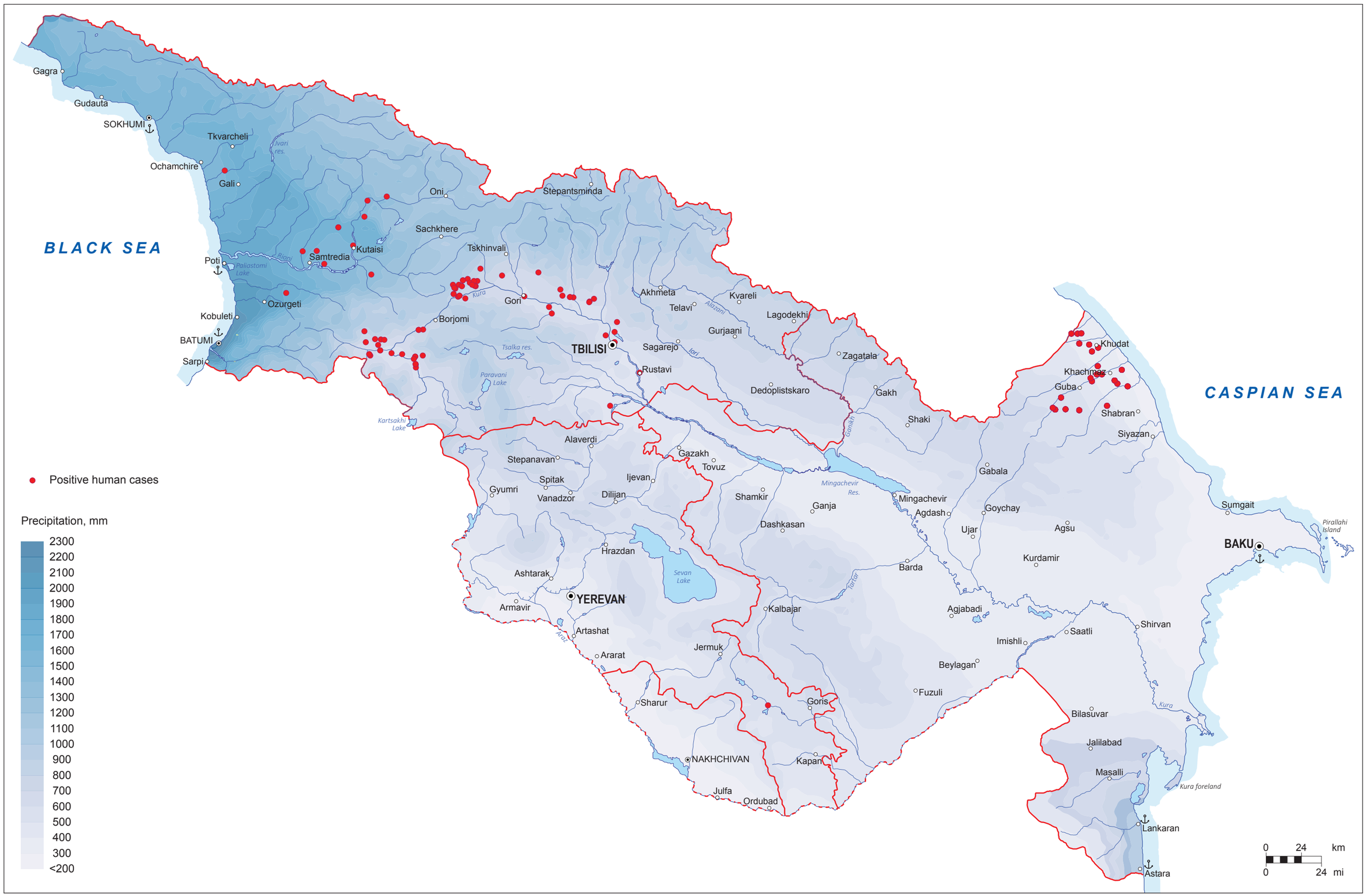
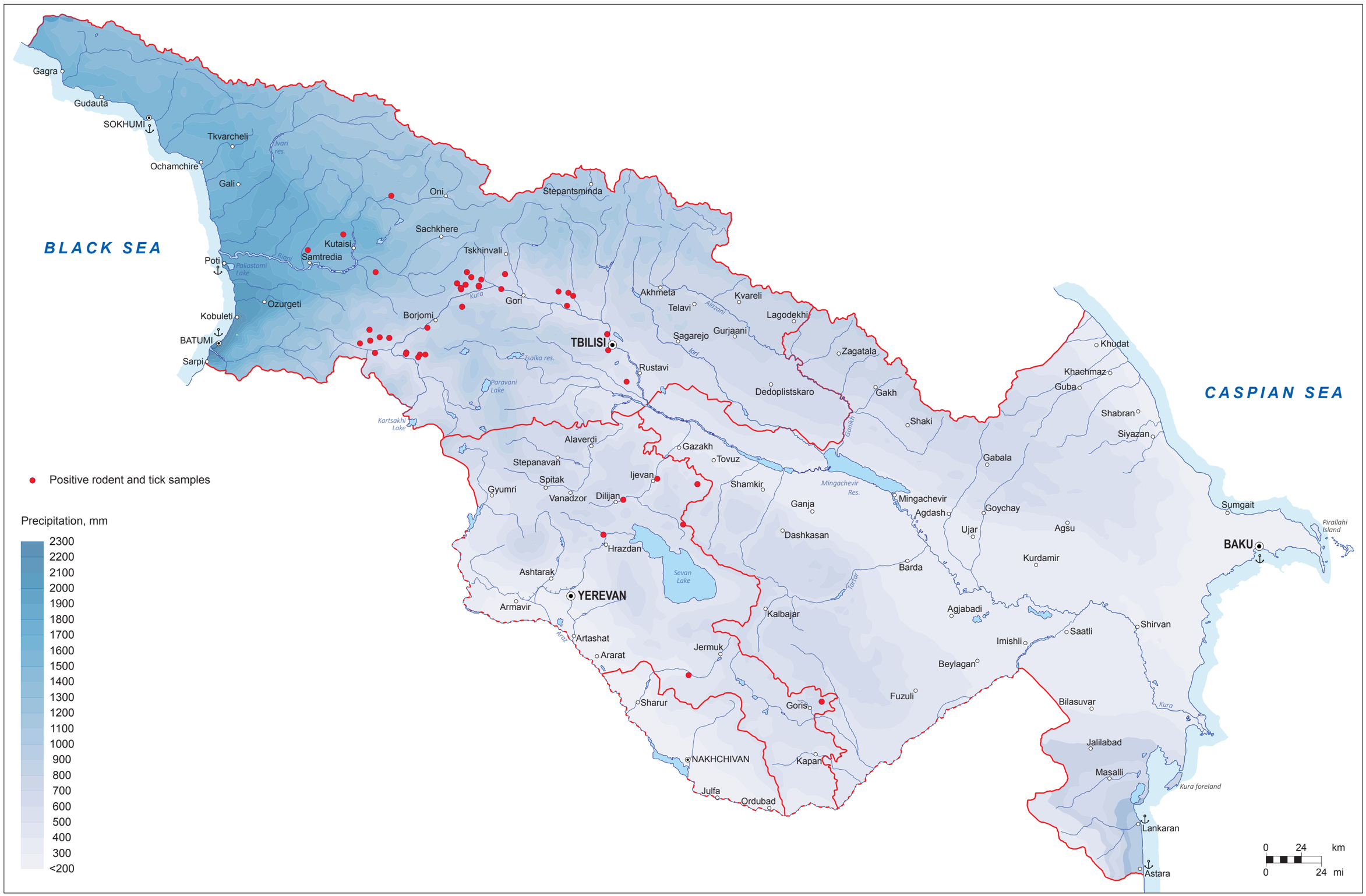
7 Moderate, relativly humid during all seasons
8 Moderate, relativly dry warm summers and cold winters
9 Moderate, with short cool summers and cold winters
10 Climate of mountain tundra

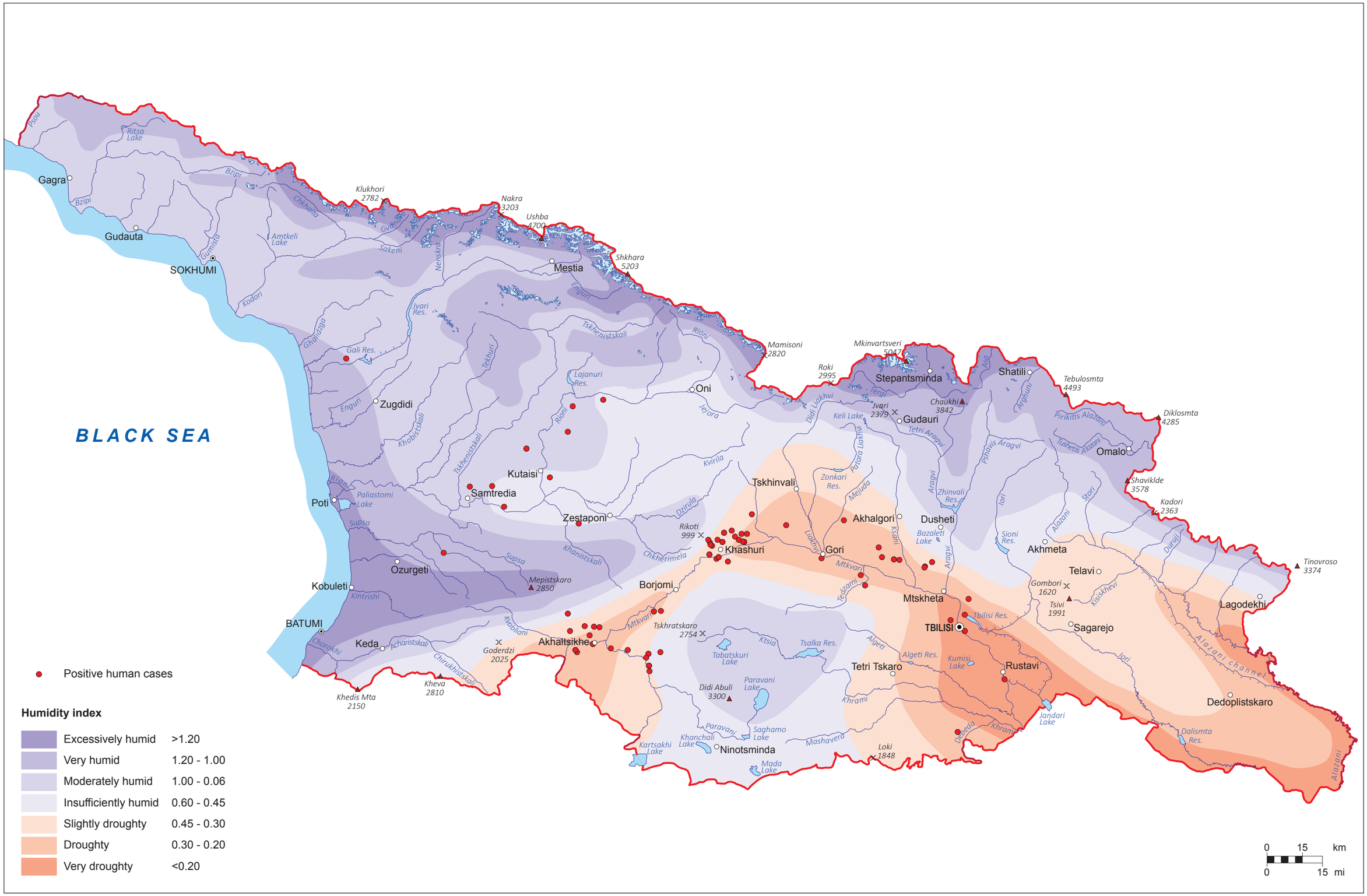
Distribution of CCHF Human Cases by Precipitation in the South Caucasus, 1997-2019



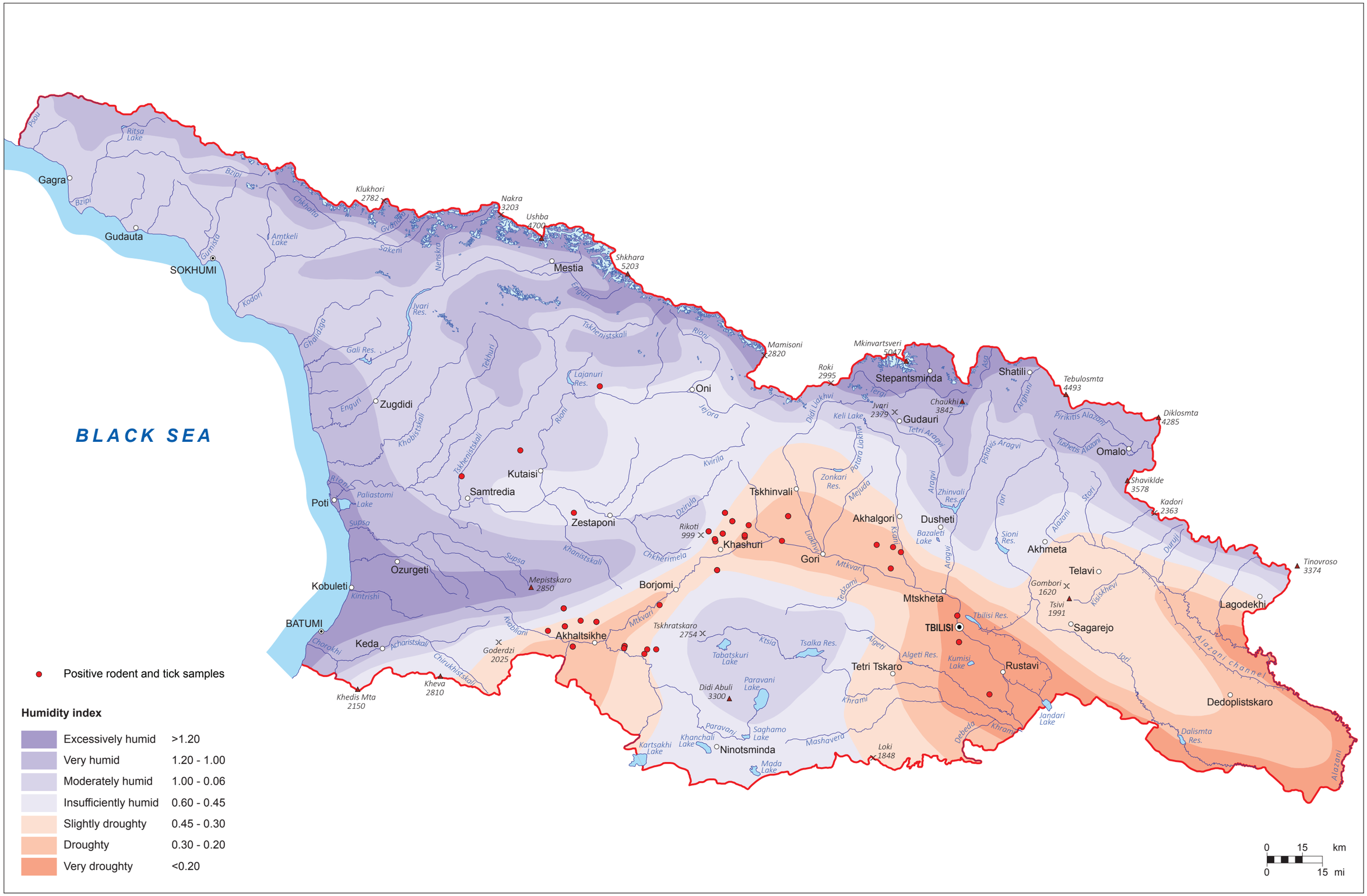
Distribution of CCHF Positive Rodent and Tick Samples by Precipitation in the South Caucasus, 1997-2019



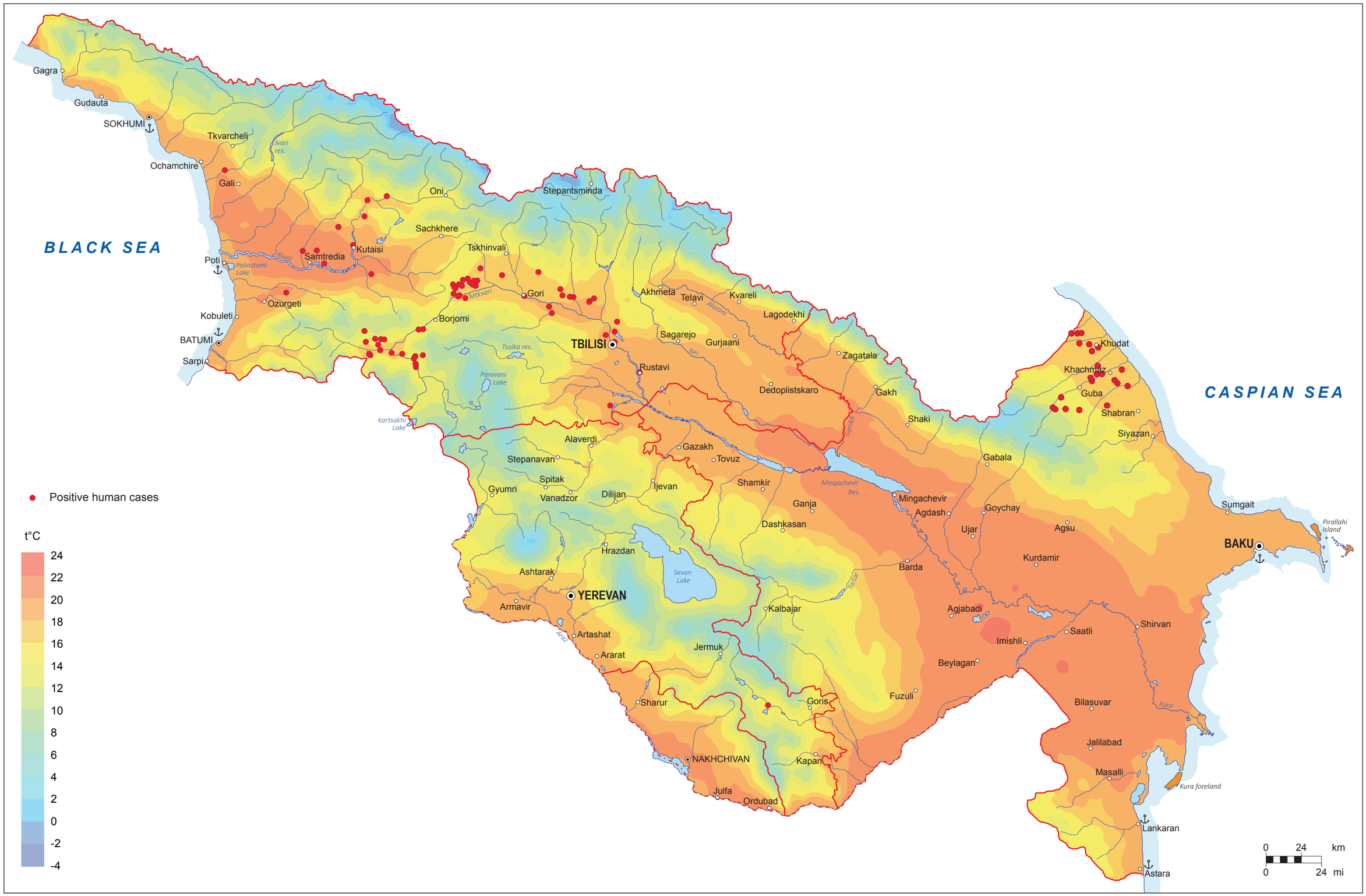
Distribution of CCHF Human Cases by Humidity Index in Georgia, 2009-2019



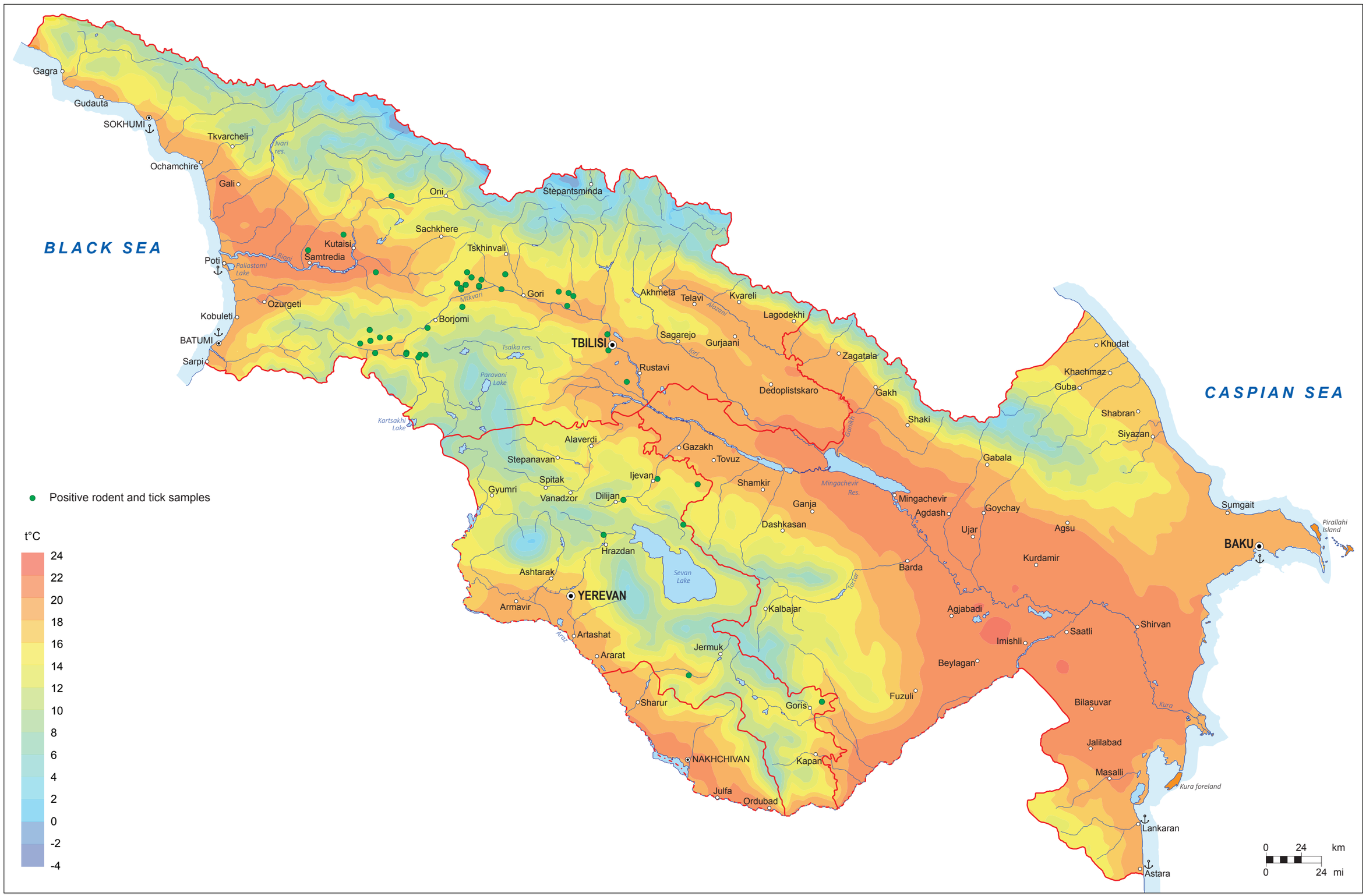
Distribution of CCHF Positive Rodent and Tick Samples by Humidity Index in Georgia, 2009-2019



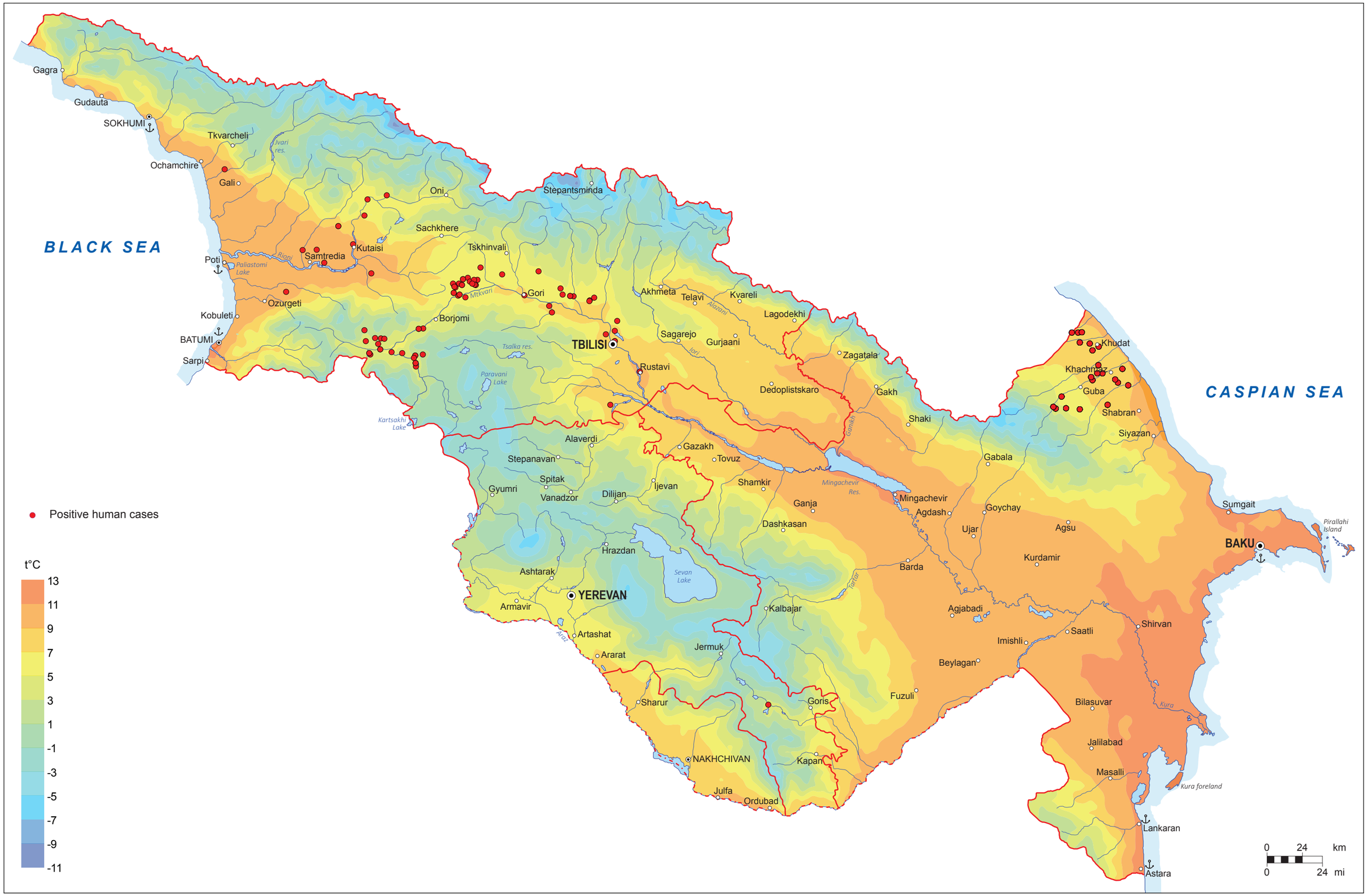
Distribution of CCHF Human Cases by Maximum Temperature in the South Caucasus, 1997-2019



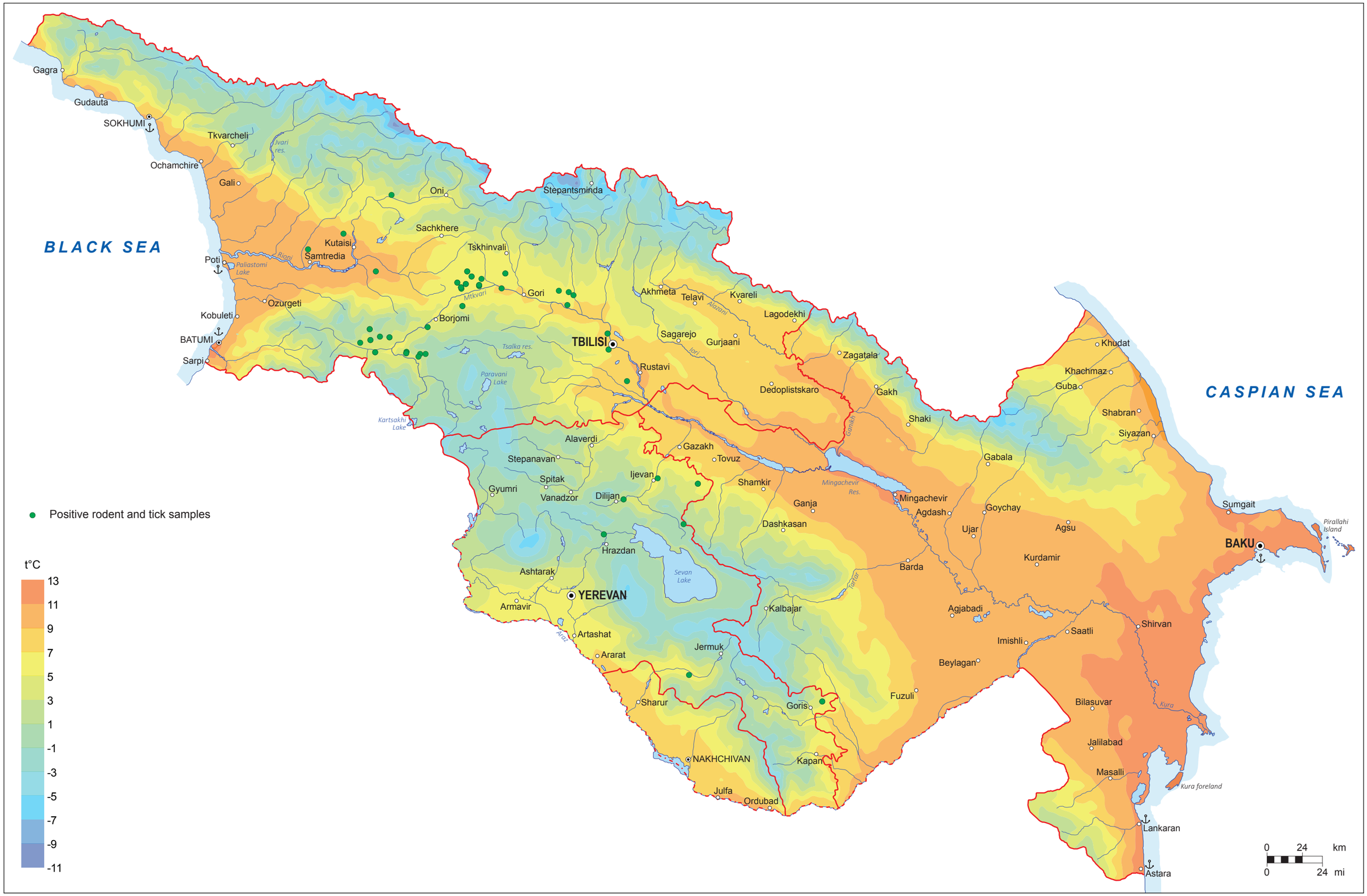
Distribution of CCHF Positive Rodent and Tick Samples by Maximum Temperature in the South Caucasus, 1997-2019



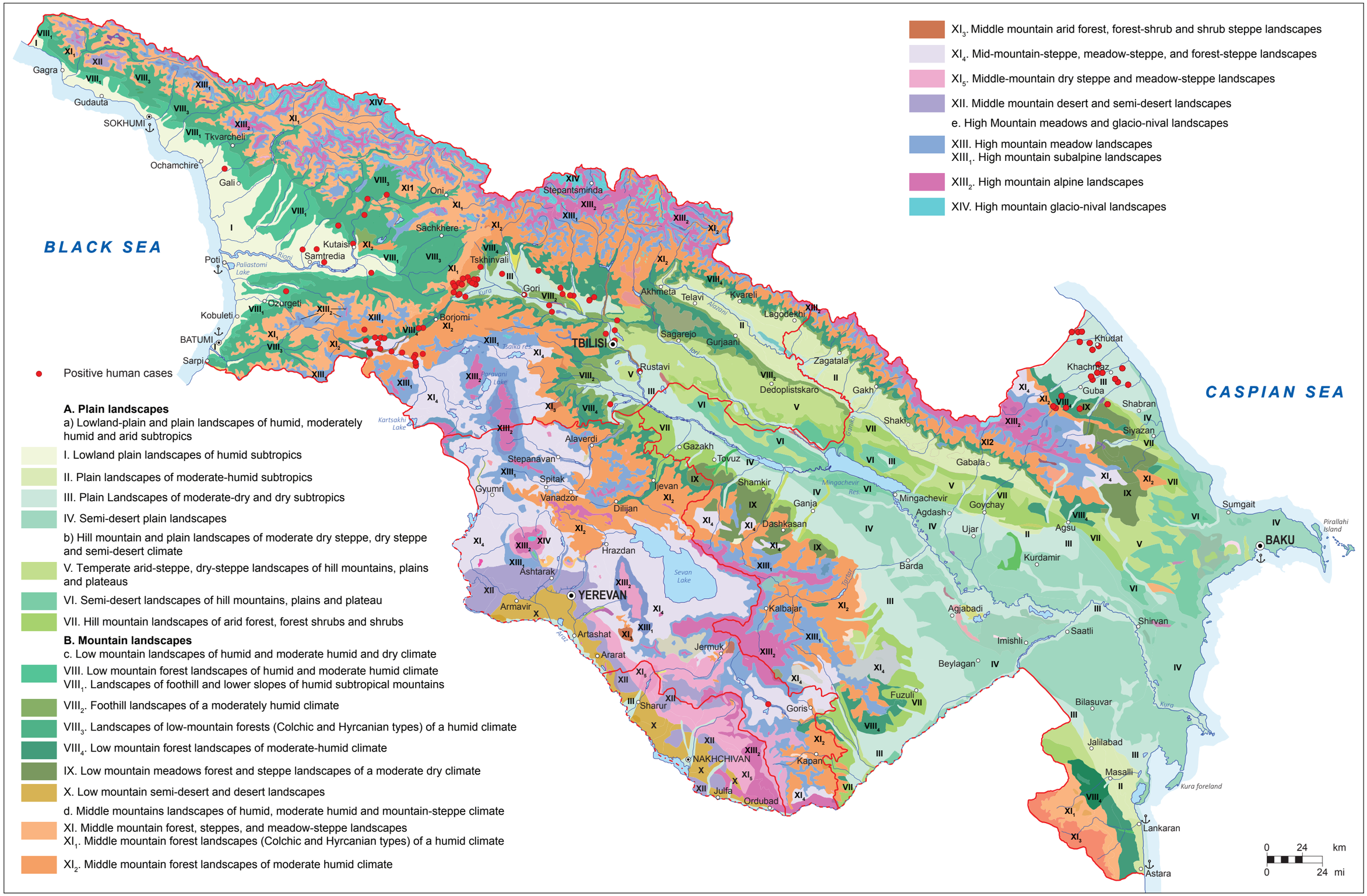
Distribution of CCHF Human Cases by Minimum Temperature in the South Caucasus, 1997-2019



Distribution of CCHF Positive Rodent and Tick Samples by Minimum Temperature in the South Caucasus, 1997-2019



Distribution of CCHF Human Cases by Landscape in the South Caucasus, 2009-2019



- Positive human cases

A. Plain landscapes

a) Lowland-plain and plain landscapes of humid, moderately humid and arid subtropics

- I. Lowland plain landscapes of humid subtropics
- II. Plain landscapes of moderate-humid subtropics
- III. Plain Landscapes of moderate-dry and dry subtropics
- IV. Semi-desert plain landscapes

b) Hill mountain and plain landscapes of moderate dry steppe, dry steppe and semi-desert climate

- V. Temperate arid-steppe, dry-steppe landscapes of hill mountains, plains and plateaus
- VI. Semi-desert landscapes of hill mountains, plains and plateau
- VII. Hill mountain landscapes of arid forest, forest shrubs and shrubs

B. Mountain landscapes

c. Low mountain landscapes of humid and moderate humid and dry climate

- VIII. Low mountain forest landscapes of humid and moderate humid climate
- $VIII_1$. Landscapes of foothill and lower slopes of humid subtropical mountains
- $VIII_2$. Foothill landscapes of a moderately humid climate
- $VIII_3$. Landscapes of low-mountain forests (Colchic and Hyrcanian types) of a humid climate
- $VIII_4$. Low mountain forest landscapes of moderate-humid climate
- IX. Low mountain meadows forest and steppe landscapes of a moderate dry climate
- X. Low mountain semi-desert and desert landscapes

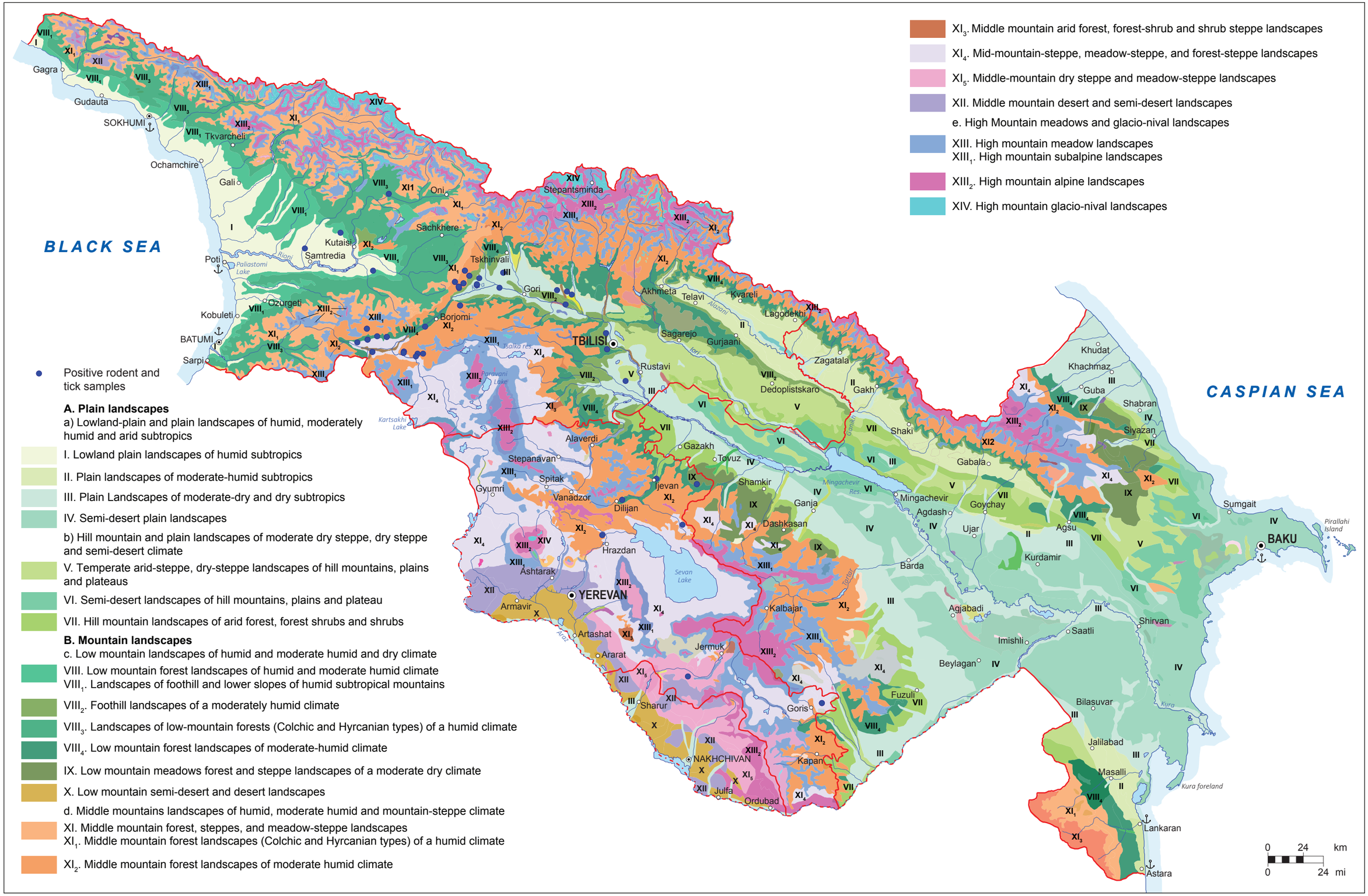
d. Middle mountains landscapes of humid, moderate humid and mountain-steppe climate

- XI. Middle mountain forest, steppes, and meadow-steppe landscapes
- XI_1. Middle mountain forest landscapes (Colchic and Hyrcanian types) of a humid climate
- XI_2. Middle mountain forest landscapes of moderate humid climate
- XI_3. Middle mountain arid forest, forest-shrub and shrub steppe landscapes
- XI_4. Mid-mountain-steppe, meadow-steppe, and forest-steppe landscapes
- XI_5. Middle-mountain dry steppe and meadow-steppe landscapes
- XII. Middle mountain desert and semi-desert landscapes

e. High Mountain meadows and glacio-nival landscapes

- XIII. High mountain meadow landscapes
- $XIII_1$. High mountain subalpine landscapes
- $XIII_2$. High mountain alpine landscapes
- XIV. High mountain glacio-nival landscapes

Distribution of CCHF Positive Rodent and Tick Samples by Landscape in the South Caucasus, 1997-2019



- Positive rodent and tick samples

A. Plain landscapes

a) Lowland-plain and plain landscapes of humid, moderately humid and arid subtropics

- I. Lowland plain landscapes of humid subtropics
- II. Plain landscapes of moderate-humid subtropics
- III. Plain Landscapes of moderate-dry and dry subtropics
- IV. Semi-desert plain landscapes

b) Hill mountain and plain landscapes of moderate dry steppe, dry steppe and semi-desert climate

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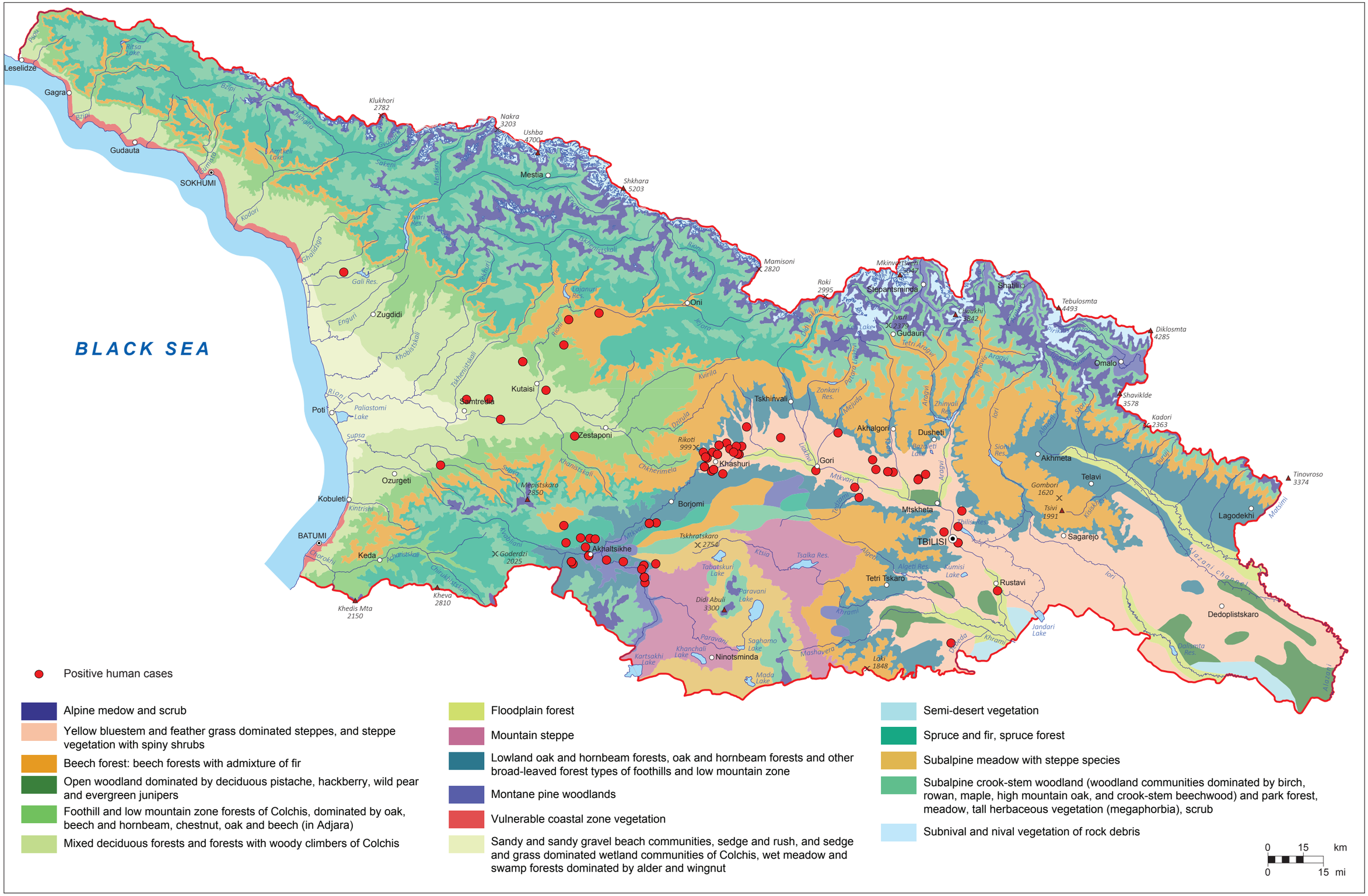
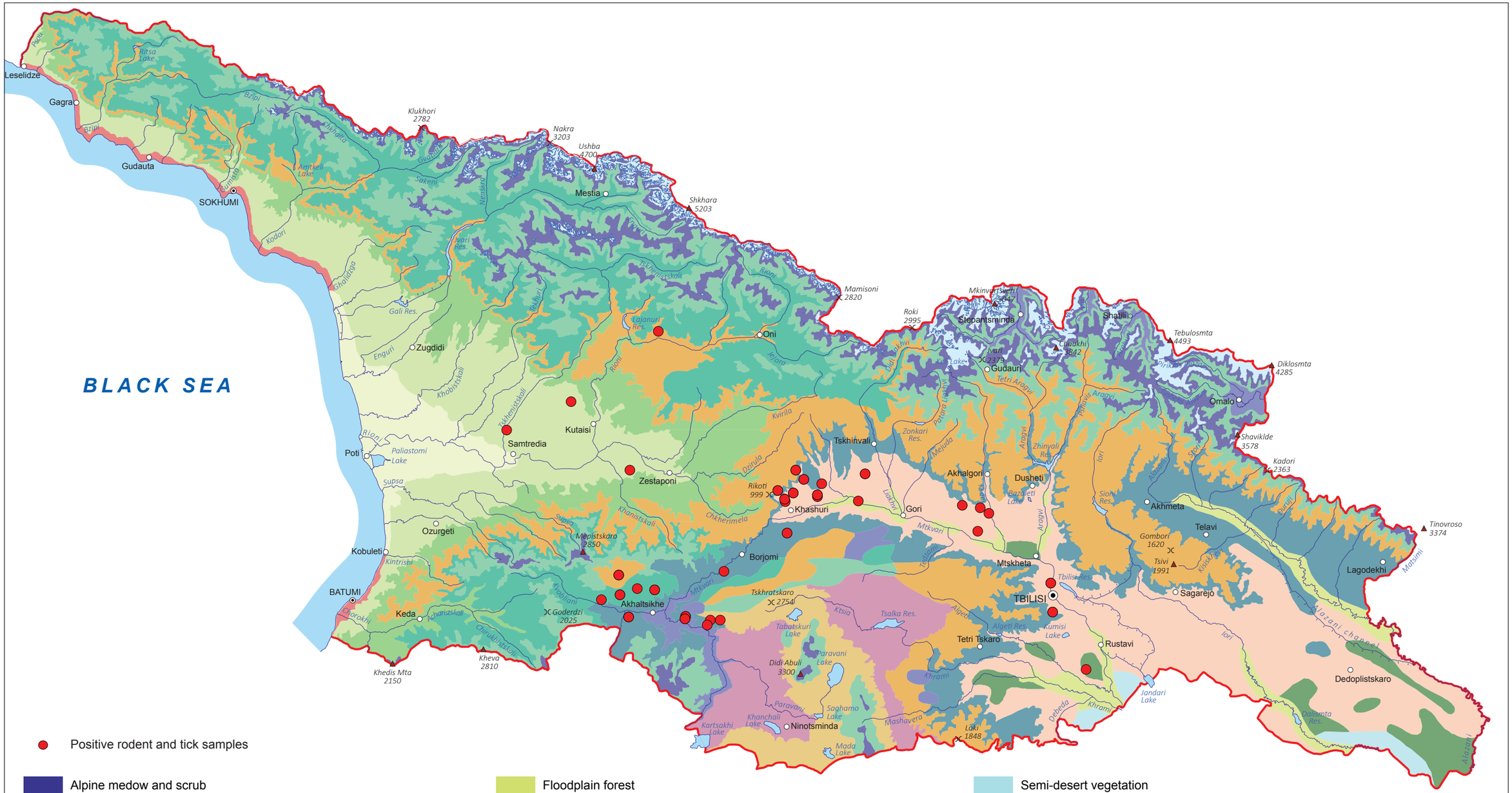
Distribution of CCHF Human Cases by Vegetation in Georgia, 2009-2019



Distribution of CCHF Positive Rodent and Tick Samples by Vegetation in Georgia, 2009-2019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Gagra
Gudauta
SOKHUMI
Ritsa Lake
Bzipi
Klukhori 2782
Nakra 3203
Ushba 4700
Mestia
Shkhara 5203
Amtkeli Lake
Nenskra
Svaneti
Kodori
Ghalidzga
Ivari Res.
Gali Res.
Zugdidi
Enguri
Khobistskali
Tskhenistskali
Rioni
Lajanuri Res.
Oni
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Roki 2995
Mkinvartsveri 4047
Stepantsminda
Shatili
Tebulosmta 4493
Chaukhi 3842
Ivari Lake 2379
Gudauri
Tetri Aragvi
Pshavis Aragvi
Diklosmta 4285
Omalo
Shaviklde 3578
Kadori 2363
Kutaisi
Samtredia
Poti
Paliastomi Lake
Supsa
Zestaponi
Tskhinvali
Zonkari Res.
Akhalgori
Dusheti
Aragvi
Zhinvali Res.
Iori
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Stori
Rikoti 999
Khashuri
Gori
Liakhvi
Bazaleti Lake
Sioni Res.
Akhmeta
Telavi
Tinovroso 3374
Gombori 1620
Tsivi 1991
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Alazani channel
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Chirukhistskali
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Khedis Mta 2150
Saghamo Lake
Kartsakhi Lake
Khanchali Lake
Ninotsminda
Mashavera
Laki 1848
Mada Lake
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Paravani
Kvirila
Dairula
Meljuda
Patara Liakhvi
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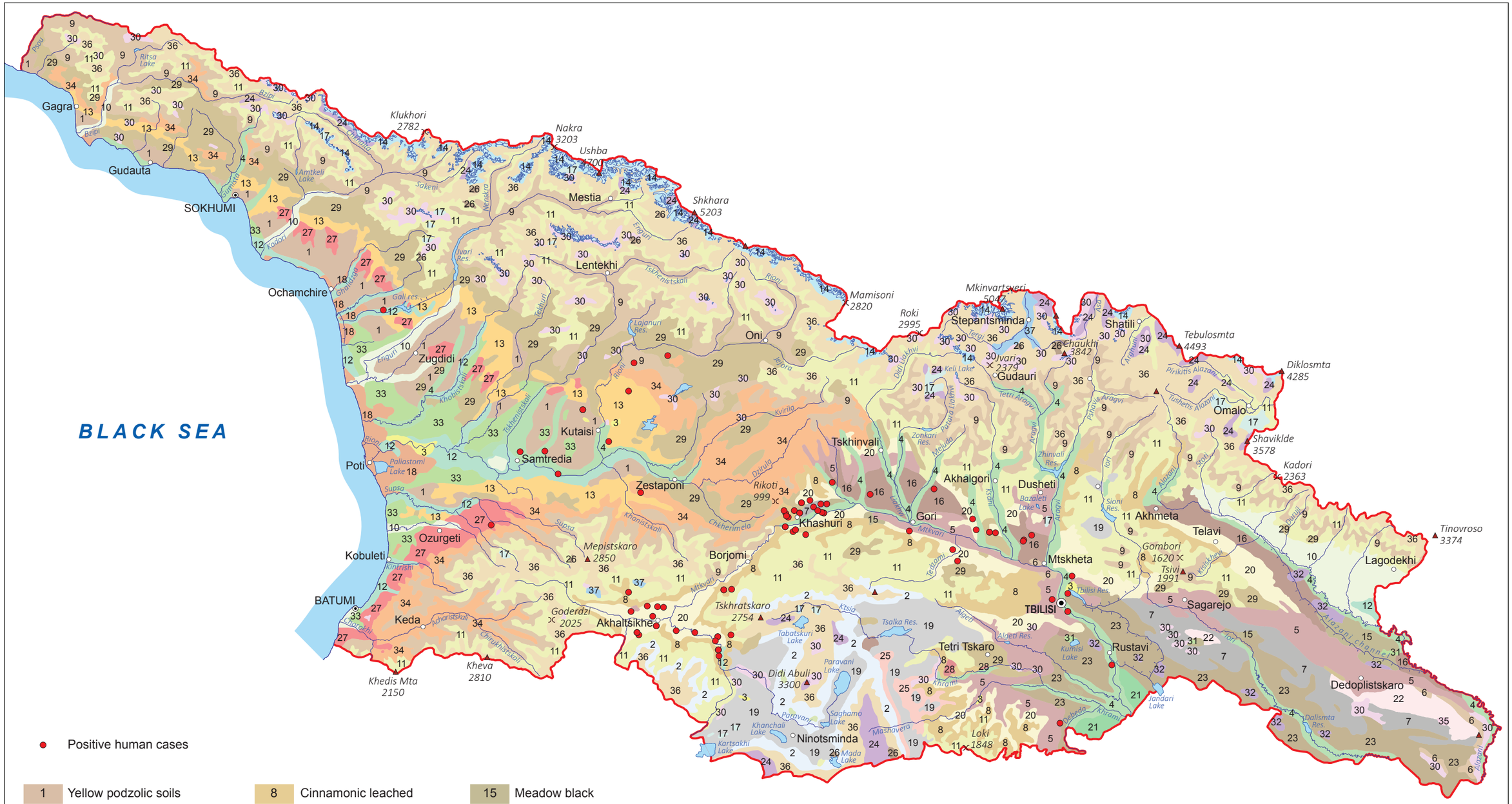
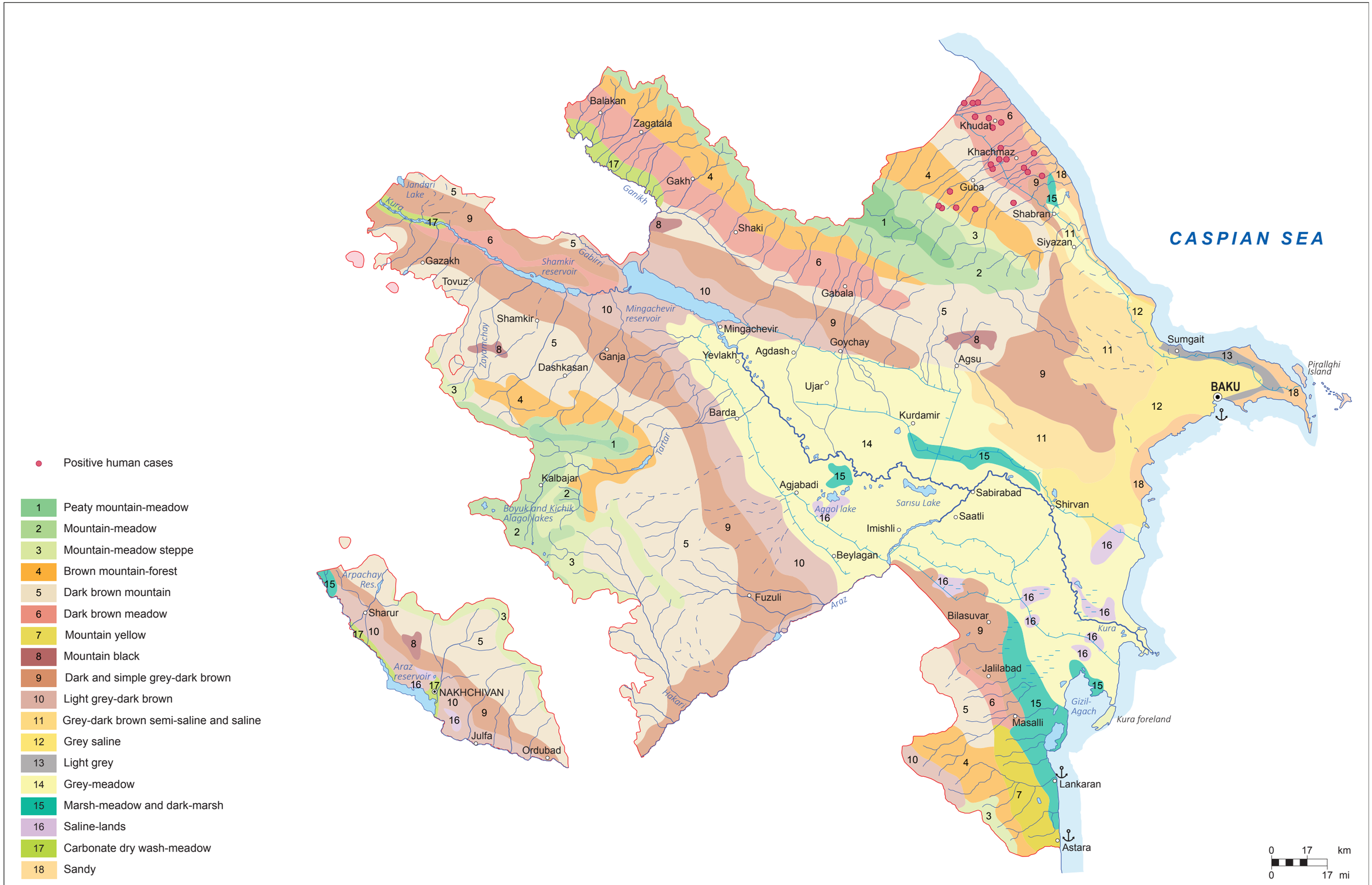
Khobistskali

Distribution of CCHF Human Cases by Soil Types in Georgia, 2009-2019

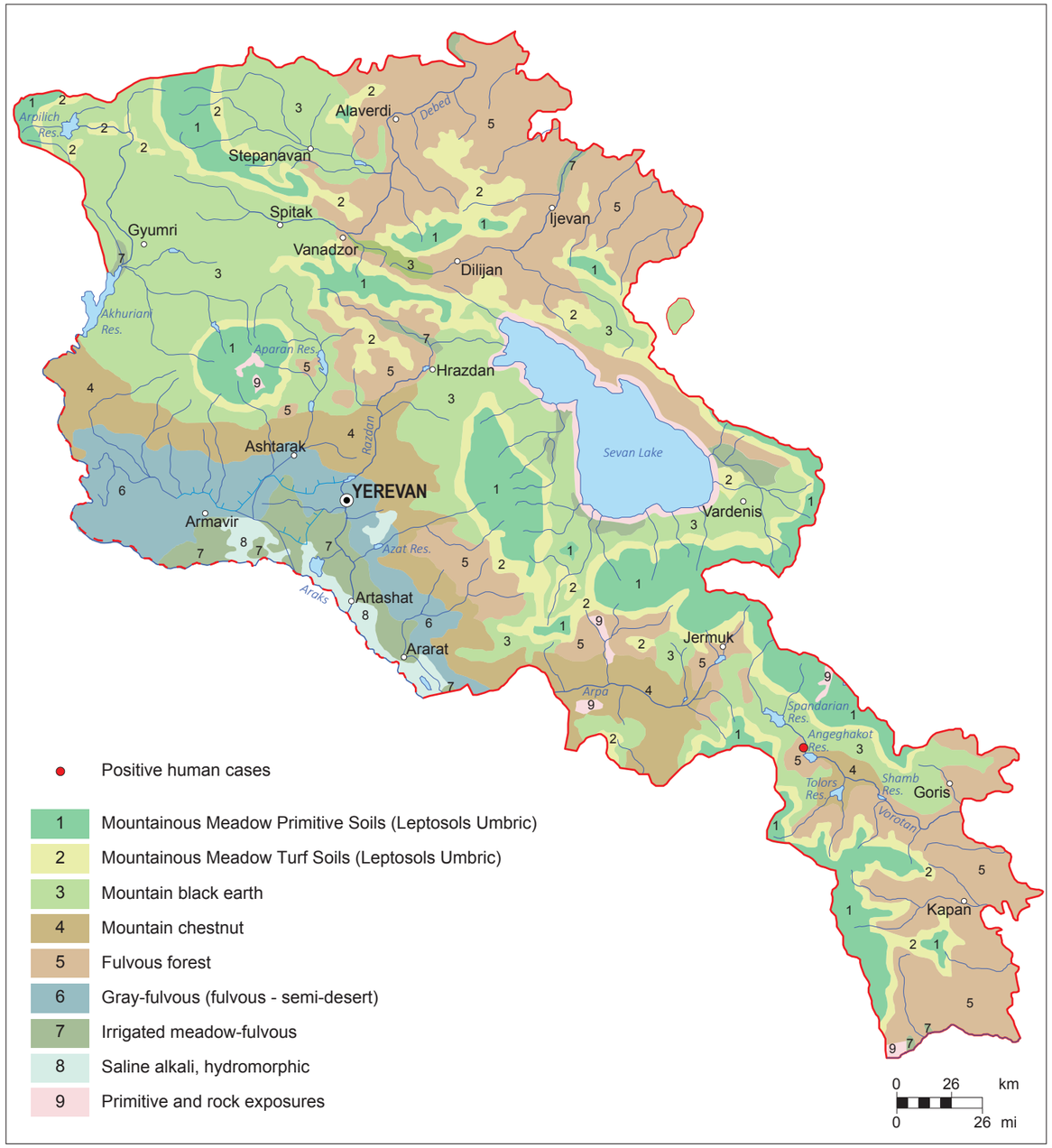


Distribution of CCHF Positive Rodent and Tick Samples by Soil Types in Georgia, 2009-2019

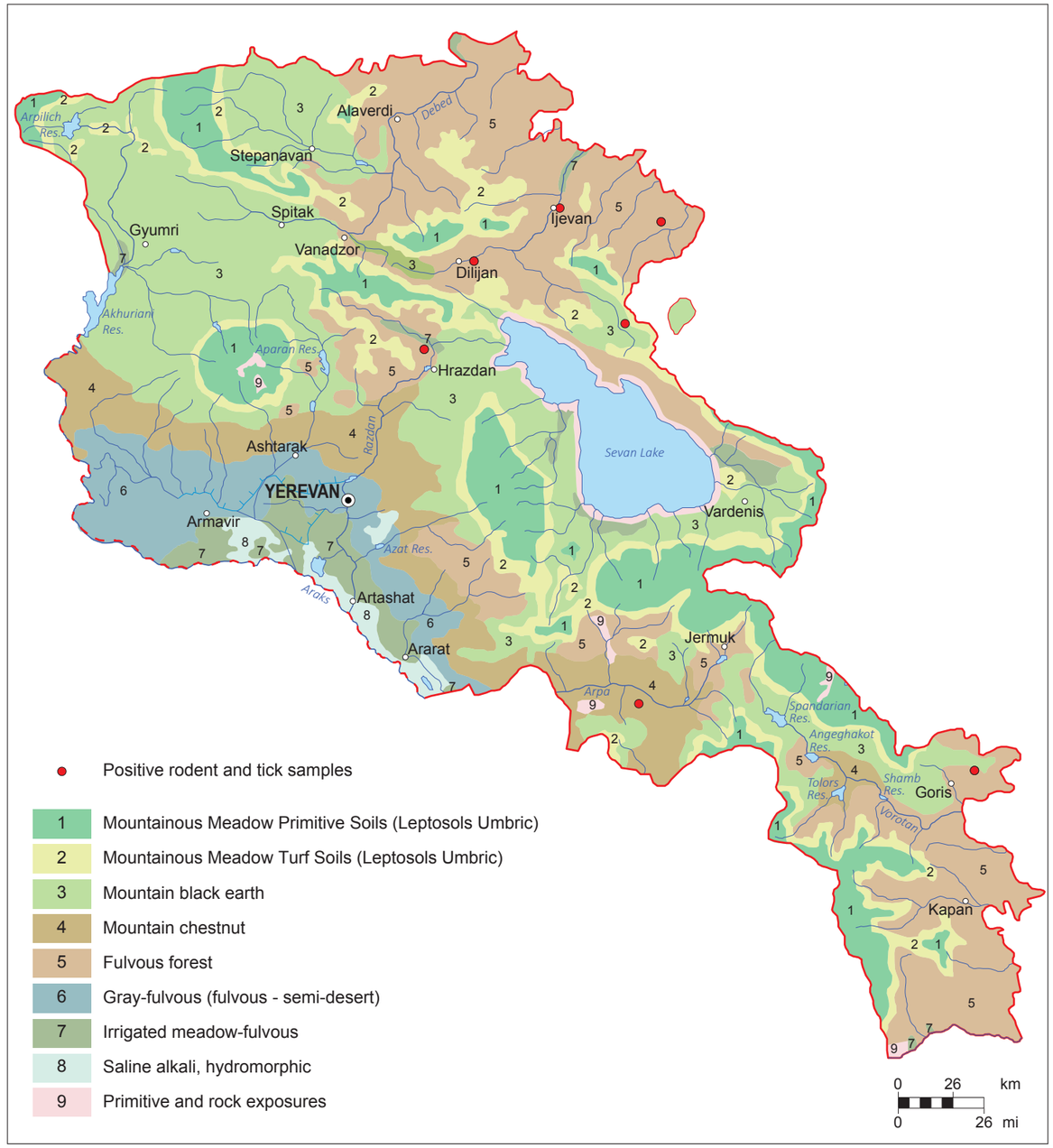
Distribution of CCHF Human Cases by Soil Types in Azerbaijan, 2010



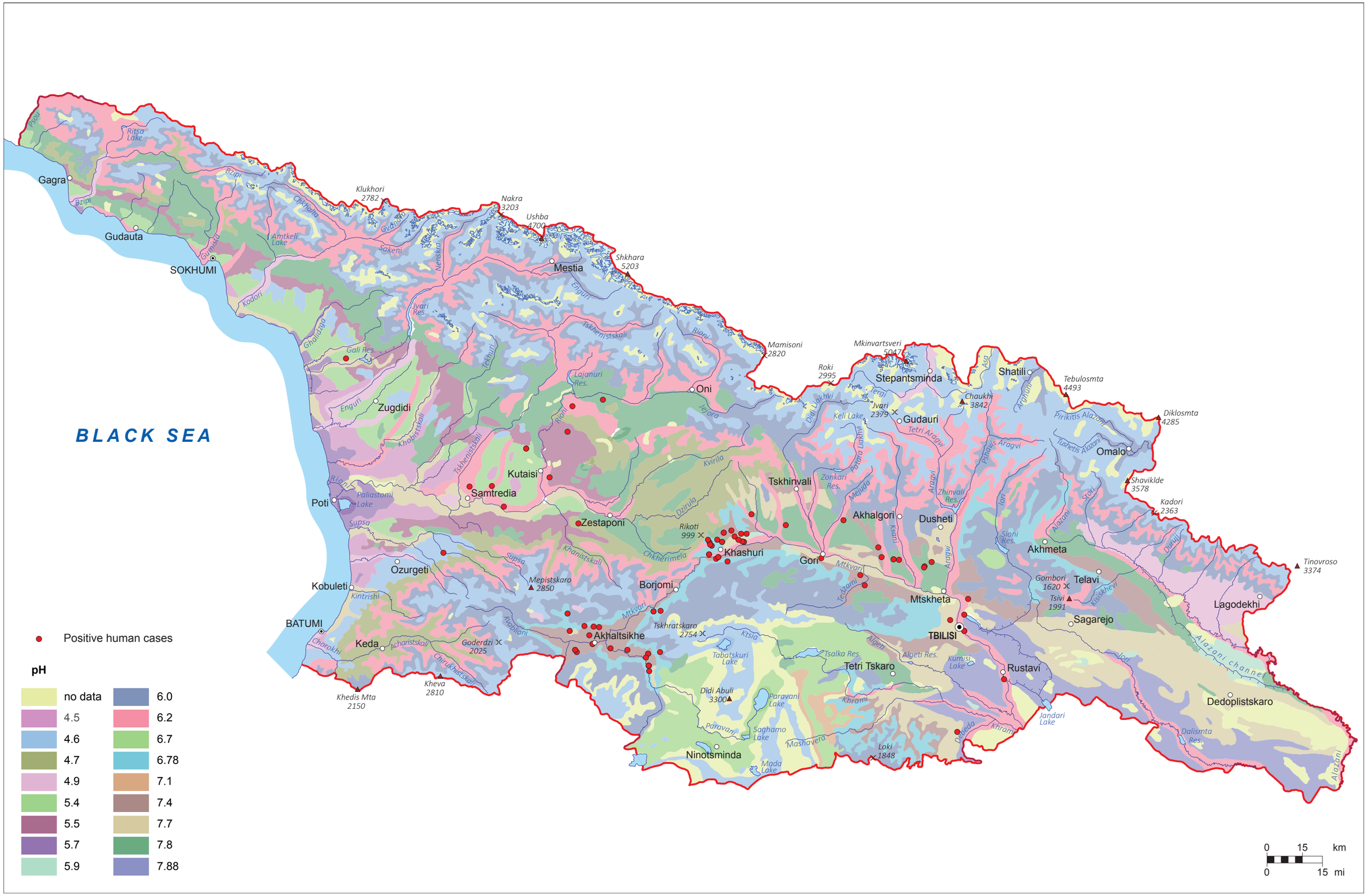
Distribution of CCHF Human Cases by Soil Types in Armenia, 1997



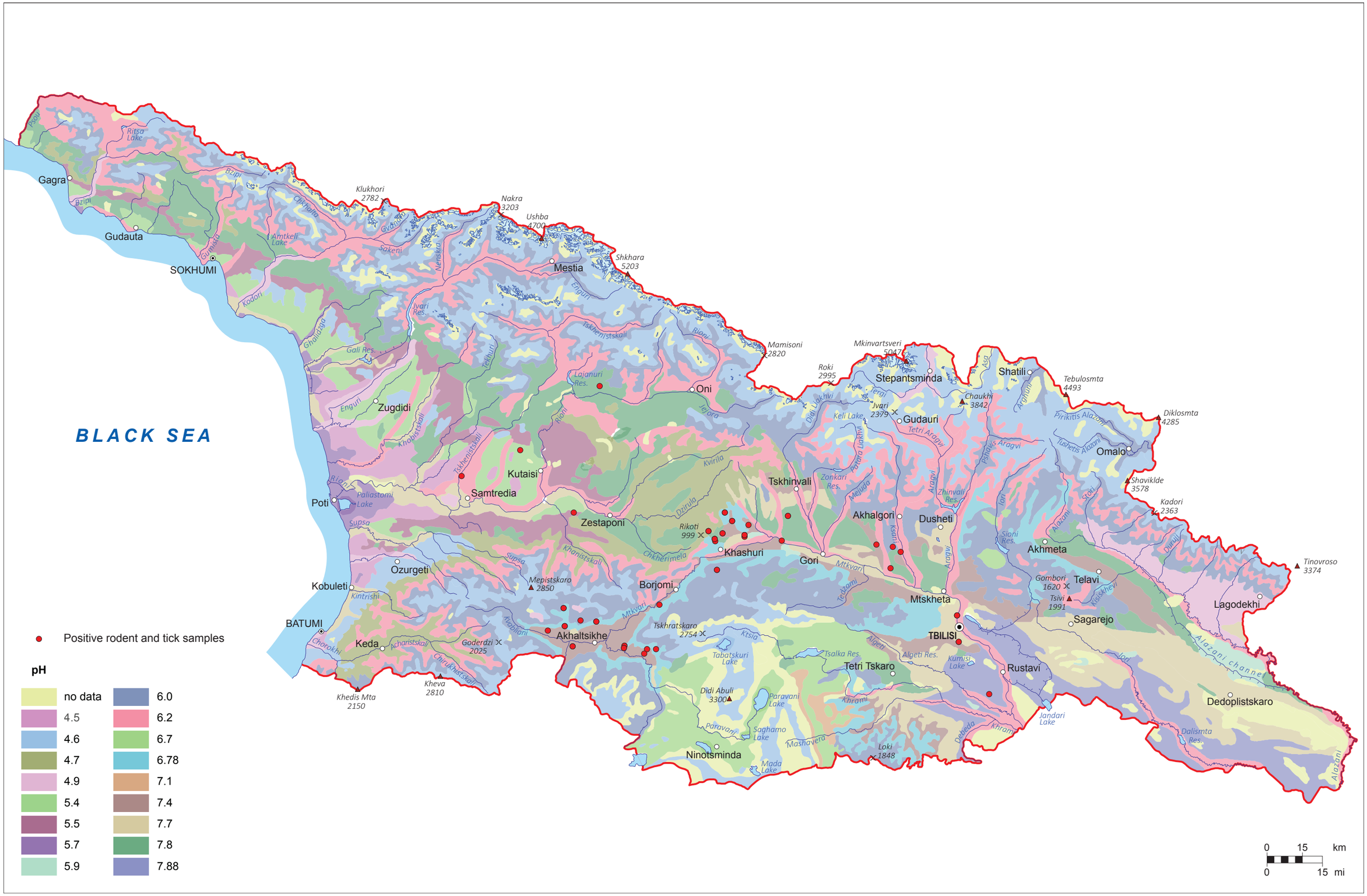
Distribution of CCHF Positive Rodent and Tick Samples by Soil Types in Armenia, 1997-2019



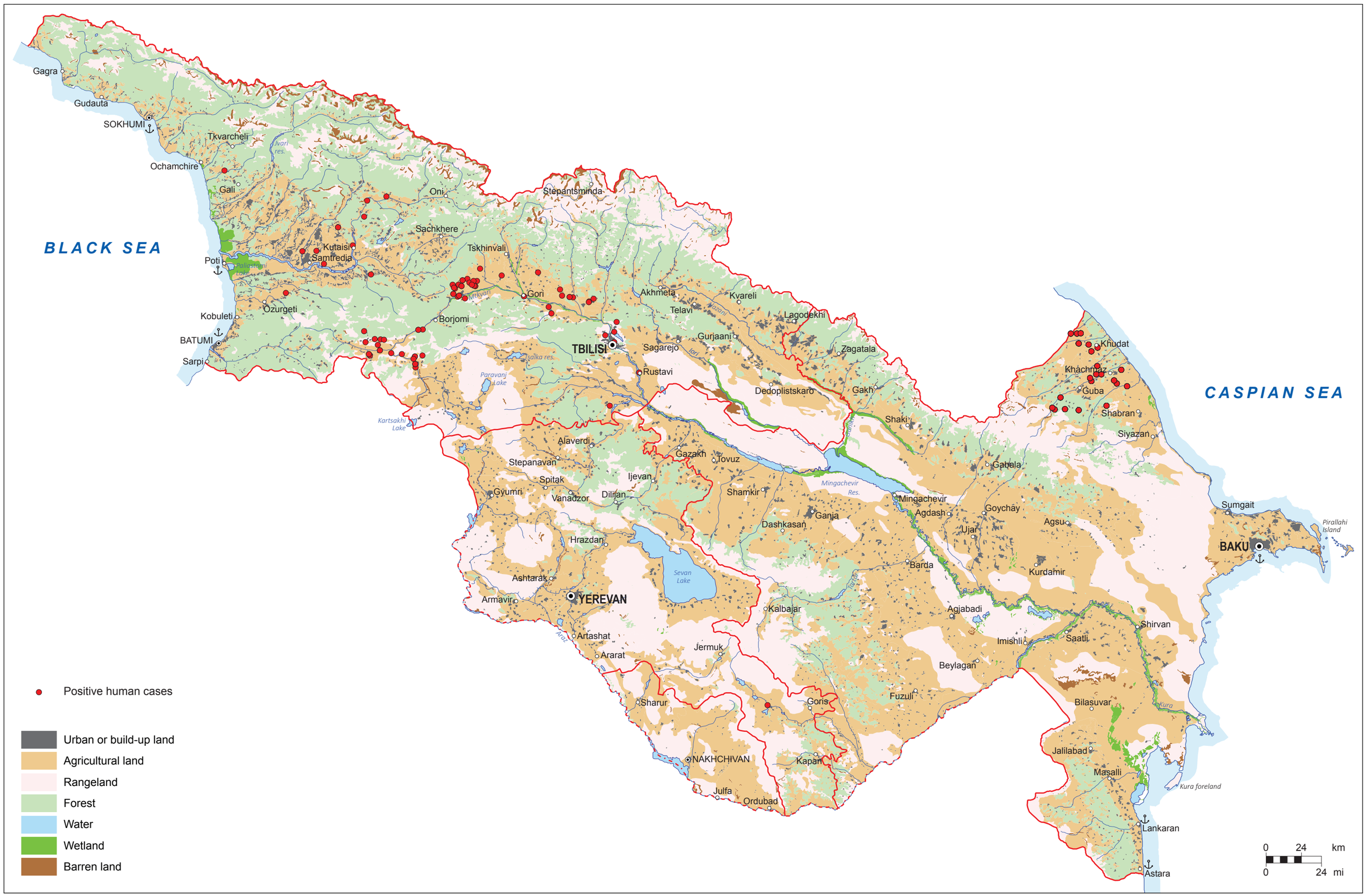
Distribution of CCHF Human Cases by Soil pH in Georgia, 2009-2019



Distribution of CCHF Positive Rodent and Tick Samples by Soil pH in Georgia, 2009-2019

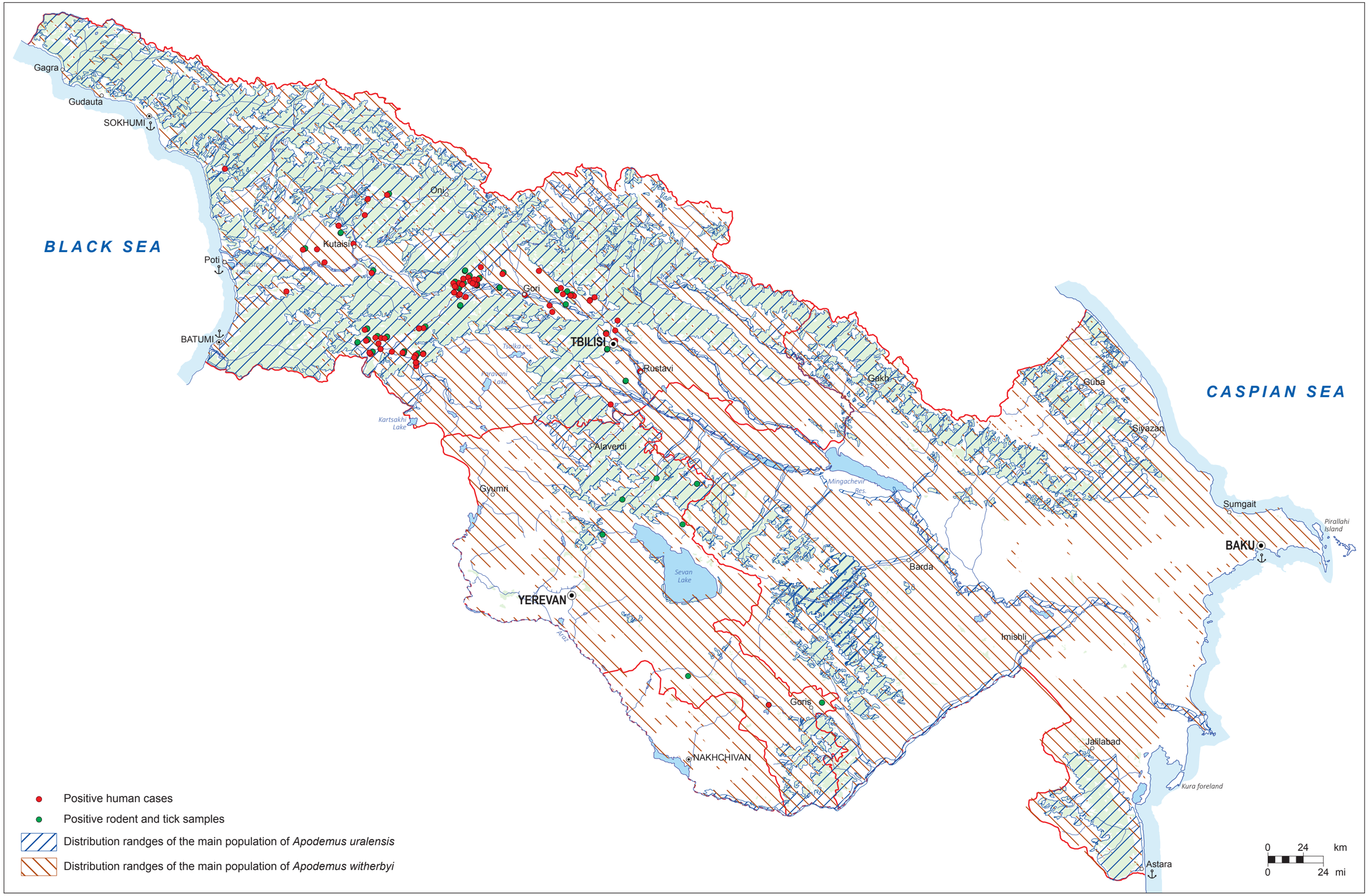


Distribution of CCHF Human Cases by Land Use in the South Caucasus, 1997-2019

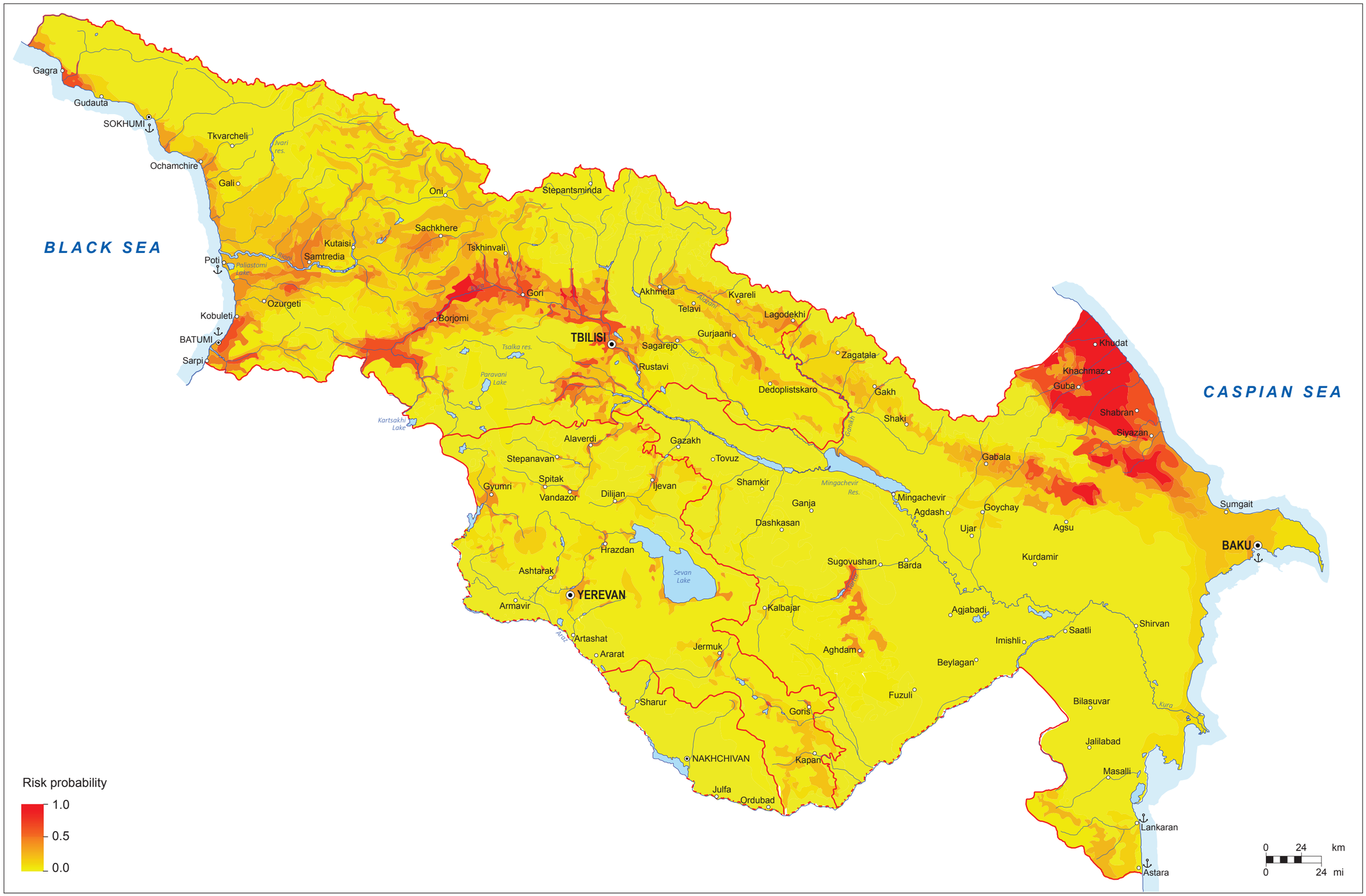


Distribution of CCHF Positive Rodent and Tick Samples by Land Use in the South Caucasus, 1997-2019

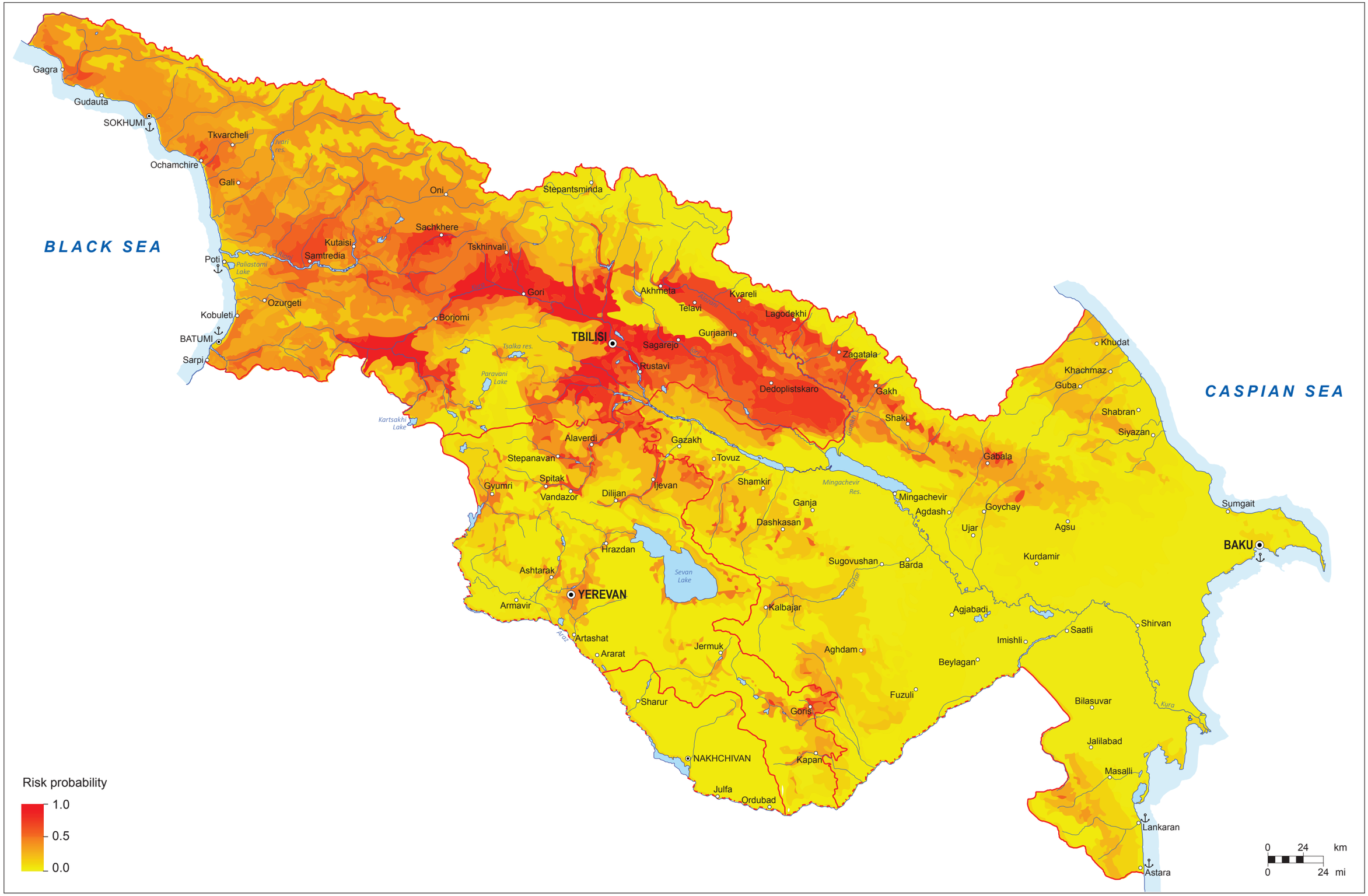
Distribution of CCHF Human Cases, Rodent and Tick Positive Samples and Distribution Ranges of the Main Population of Rodents in the South Caucasus, 1997-2019



CCHF Human Cases Risk in the South Caucasus



CCHF Positive Rodent and Tick Samples Risk in the South Caucasus



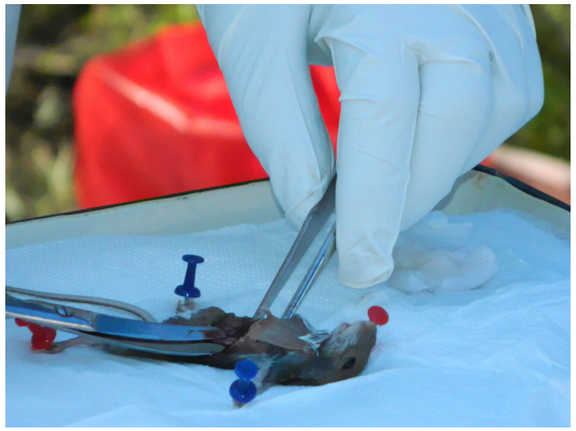
Tick Borne Encephalitis (TBE)

Tick-borne encephalitis (TBE) is caused by a virus that causes severe damage to the central nervous system. Humans are often infected by tick bites, but the virus can be transmitted to a person in other ways, like drinking raw milk or cheese from infected goats, sheep, or cows. TBE virus is found in parts of the world from western and northern Europe to northern and eastern Asia. The ticks that transmit the TBE virus are most active during the warm months, and people who spend time outdoors, or near forests, have an increased risk of being bitten by an infected tick. Approximately 10,000 to 12,000 TBE cases are reported annually, but the number of clinical cases is believed to be much higher. The disease develops from 4 to 28 days after the bite of an infected tick, and four days after ingesting infected. It is very rare for the TBE virus to be spread directly from human to human. The disease is preventable by vaccination.

The number of cases of tick-borne encephalitis has increased significantly since the second half of the 20th century. In TBE-endemic countries, the annual incidence ranges from 1 to 20 cases per 100,000 population per year. The increase in cases is largely due to environmental changes and better diagnostic systems. In the European Union, TBE is mostly found in the 45 to 64 age group, where the male to female ratio is 1.5:1. TBE is characterized by seasonality. A notable increase in cases occurs from April, when temperatures approach 6 degrees Celsius to November, when temperatures drop. This period also coincides with heavy tick activity in Europe. Depending on the geographical location, this period may change. The main TBE virus reservoirs are small rodents. Ticks become infected when they feed on the blood of infected vertebrate hosts, especially small rodents, and can transmit the virus to the next blood meal. The first case of TBE virus was isolated in 1937. There are three subtypes of TBE virus: Western/European, Siberian, Far-Eastern subtype. The subtypes are genetically similar but cause different disease severities. TBE virus main vectors are Ixodes ticks.

Due to the increase number of travelers to endemic countries, TBE vaccination has become important. Four vaccines are currently considered safe and effective and

Field laboratory work on TBE © Nikoloz Tsertsvadze



Animal samples collection for TBE laboratory investigation
© Nikoloz Tsertsvadze

are used in both adult and pediatric populations. The modern European vaccine that protects against three subtypes consists of two doses and one booster. The first two doses should be given in the winter period so that the person is immune during the activation of ticks in the spring.

Diagnosis is complex, considering immune status, seasonality, geographic location, exposure to animals and arthropods, and clinical and radiographic findings. In most patients, TBE is a biphasic disease. The first, asymptomatic period varies from 1 to 20 days. After that, in up to 15% of cases, patients develop the second phase of the disease. The second phase is characterized by high fever (over 40 degrees Celsius) and central nervous system manifestations such are encephalitis, meningitis, myelitis or sciatica. Most cases remain asymptomatic and patients recover fully without long-term sequelae, but some patients may develop long-term neurological symptoms. Encephalitis developing during this second phase may result in paralysis and about 1% of patients who develop neurological abnormalities die. There is no specific treatment for tick-borne encephalitis which includes patient supportive care and managing complications. Acyclovir is prescribed initially until herpes zoster infection is ruled out. Rest, fluids, and pain relievers can reduce some symptoms. But, patients with severe cases often need hospitalization for breathing support, hydration, or to reduce brain swelling.

Data on TBE cases were collected from 1950 to 2020 from all three countries from publications, annual reports, unpublished data from public health centers, former anti-plague stations, veterinary centers, and scientific projects.

Surveillance on TBE in the South Caucasus is not strong and lacks diagnostic capacity, particularly in Armenia and Azerbaijan. Cases of TBE among humans, rodents, and ticks are not regularly registered in Armenia and Azerbaijan, and there is no ongoing routine surveillance or research project on TBE. Thus, the data we were able to obtain does not necessarily indicate that disease is rare in the region.

Filed work on TBE © Manana Shanidze

TBE positive cases are mostly registered in the central and southern part of Georgia; in Armenia, positive environmental samples were reported from the central part of the country (p. 273). Since 2009 there have been sporadic (single) cases of human TBE in Georgia, as well as positive environmental samples in rodents and ticks. From 1985 until 2000, there were positive samples among rodents and ticks in Armenia (diagnostics mainly were based on serology), and no human cases reported. TBE positive environmental (tick) samples are reported mostly among *Rhipicephalus bursa* in Georgia, and from *Dermacentor marginatus*, *Hyalomma asiaticum*, *Rhipicephalus bursa*, *Rhipicephalus sanquineus*, and *Boophilus annulatus* in Armenia.

Most cases in western Georgia were reported across territories with transitional climates from moderate warm steppe to moderate humid climate with hot summer and with minimum precipitation twice a year, and moderate humid climate with moderately cold winter and hot summer, with minimum precipitation twice a year. Southern Georgia cases are mostly occur in highland steppe climates with less snowy cold winters and prolonged warm summers (p. 275). In Armenia, TBE positive environmental samples have been reported across the territories with warm summers and relatively calm winters, moderate, relatively dry warm summers and cold winters, arid continental, with dry warm summers and moderate cold winters, and moderate, warm arid summers and moderate cold winters (p. 276).

In Georgia, most of the cases of TBE are reported in the areas where the annual sum of precipitation is 800 mm to 1,000 mm (p. 277). In Armenia, cases are registered where the annual sum of precipitation is 500 mm to 700 mm (p. 277); TBE cases are reported during the hot season of the year, when average maximum temperatures are between 14-18 degrees Celsius (p. 279).

TBE cases are mostly found in agricultural territories within the South Caucasus, as well as the forested areas of Georgia (p. 285).

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4. Süss J. Epidemiology and ecology of TBE relevant to the production of effective vaccines. Vaccine 2003;21(Supl. 1):S19–35.
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6. Kaiser R. The clinical and epidemiological profile of tick-borne encephalitis in southern Germany 1994-98: a prospective study of 656 patients. Brain. 1999;122(Pt 11):2067-78.
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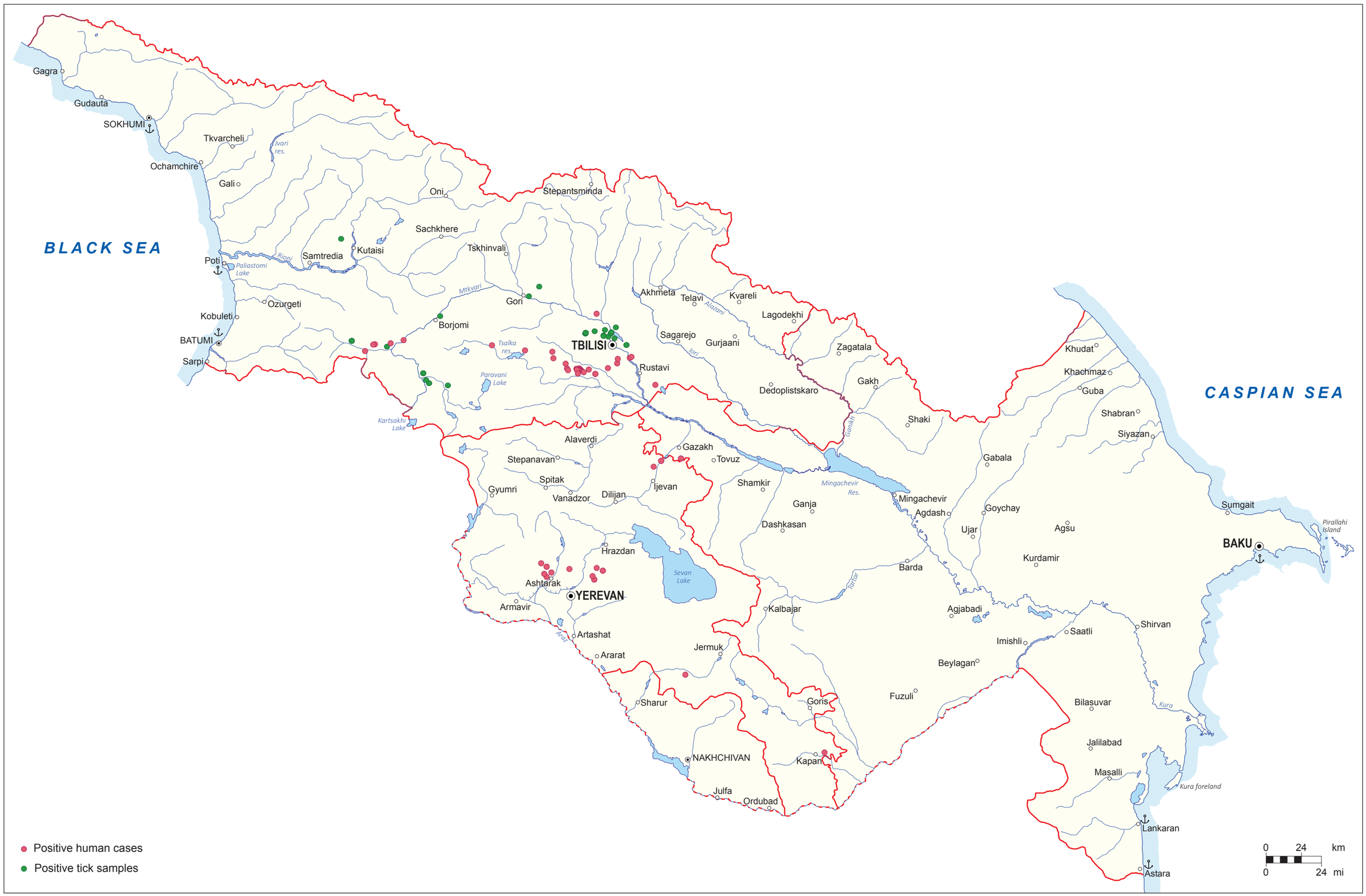
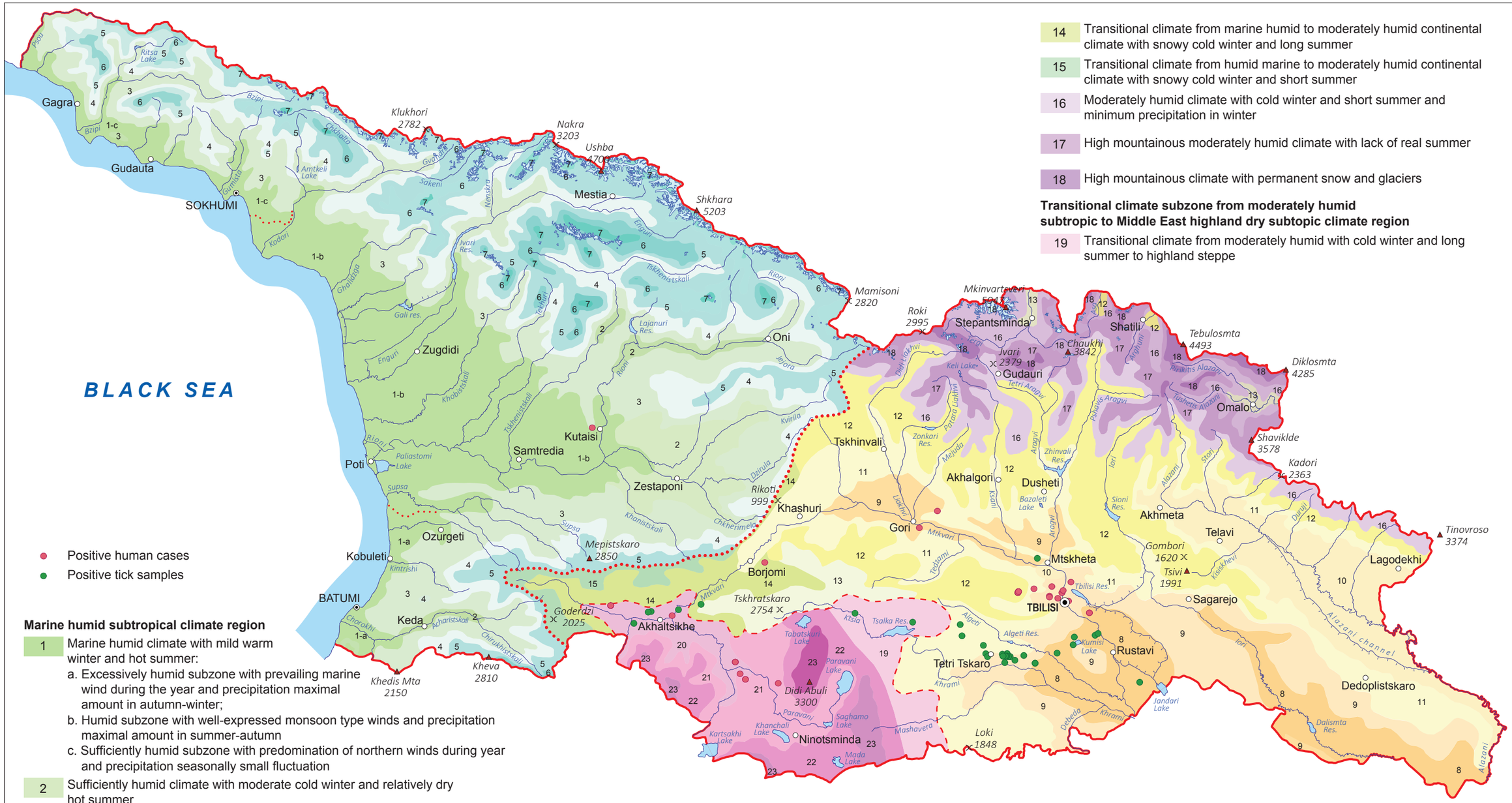
Distribution of TBE Human Cases and TBE Positive Tick Samples in the South Caucasus, 1985-2020

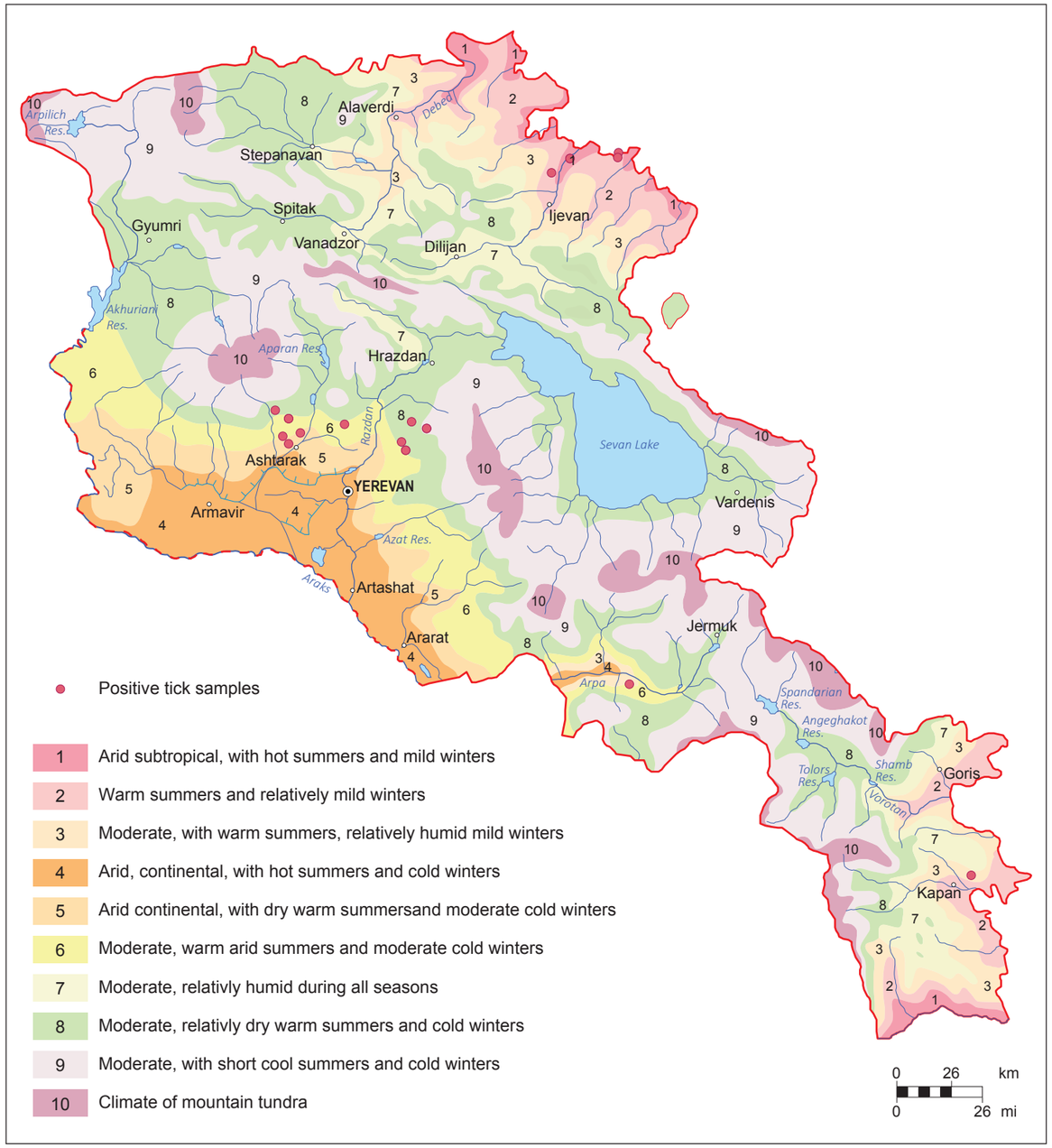


Distribution of TBE Human Cases and TBE Positive Tick Samples by Elevation in the South Caucasus, 1985-2020

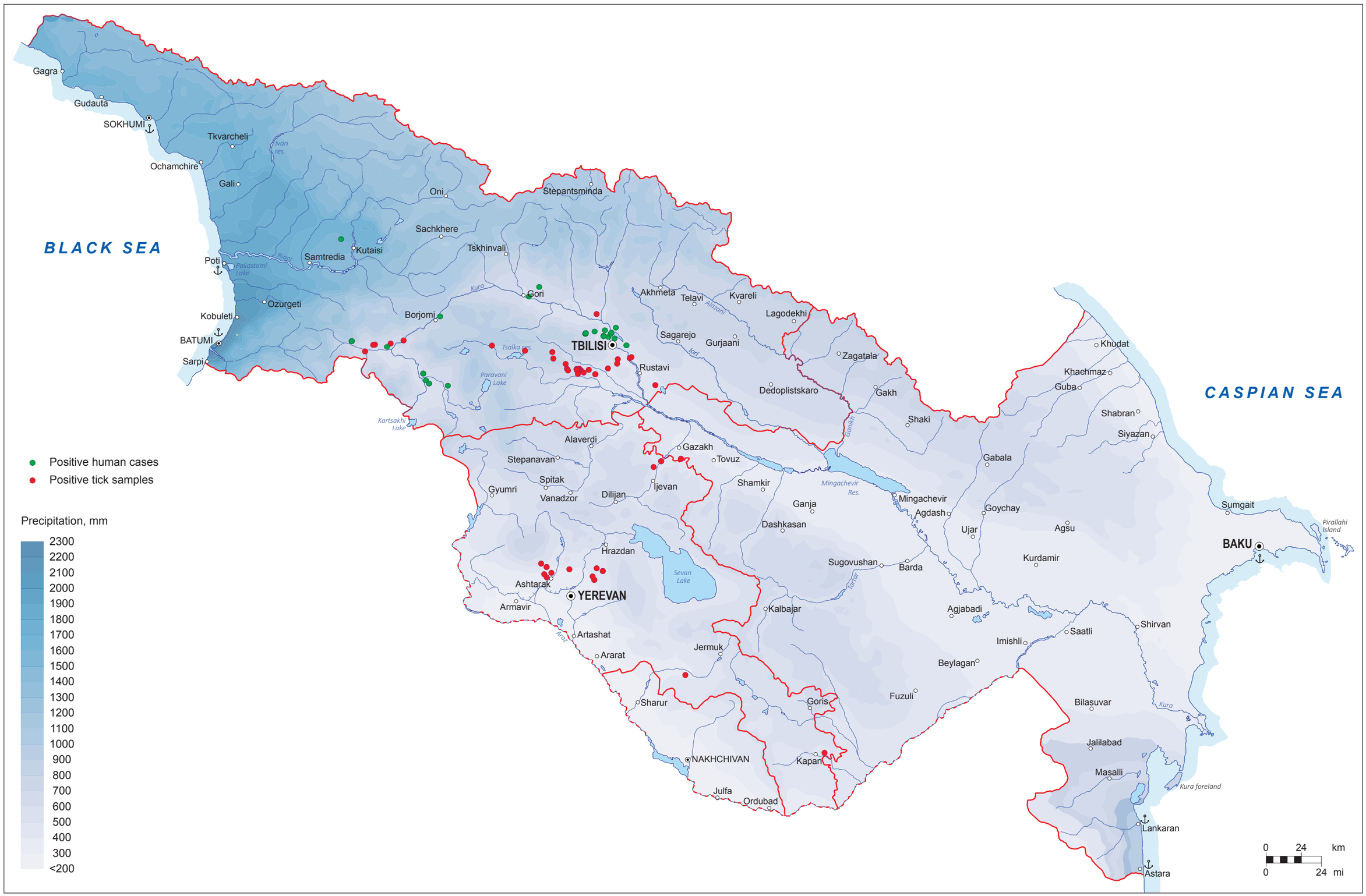
Distribution of TBE Human Cases and TBE Positive Tick Samples by Climate Types in Georgia, 2009-2020



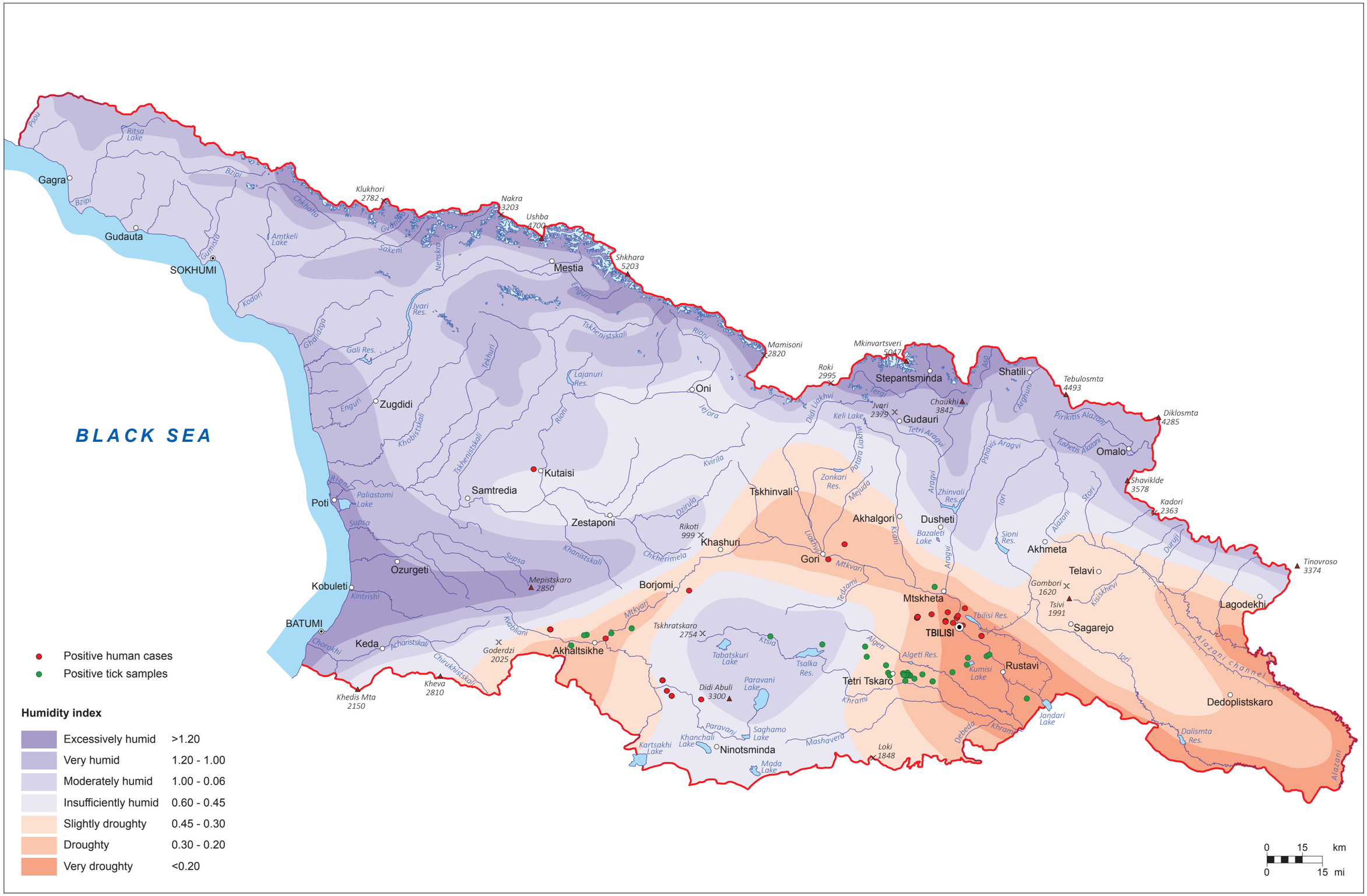
Distribution of TBE Tick Positive Samples by Climate Types in Armenia, 1985-2019



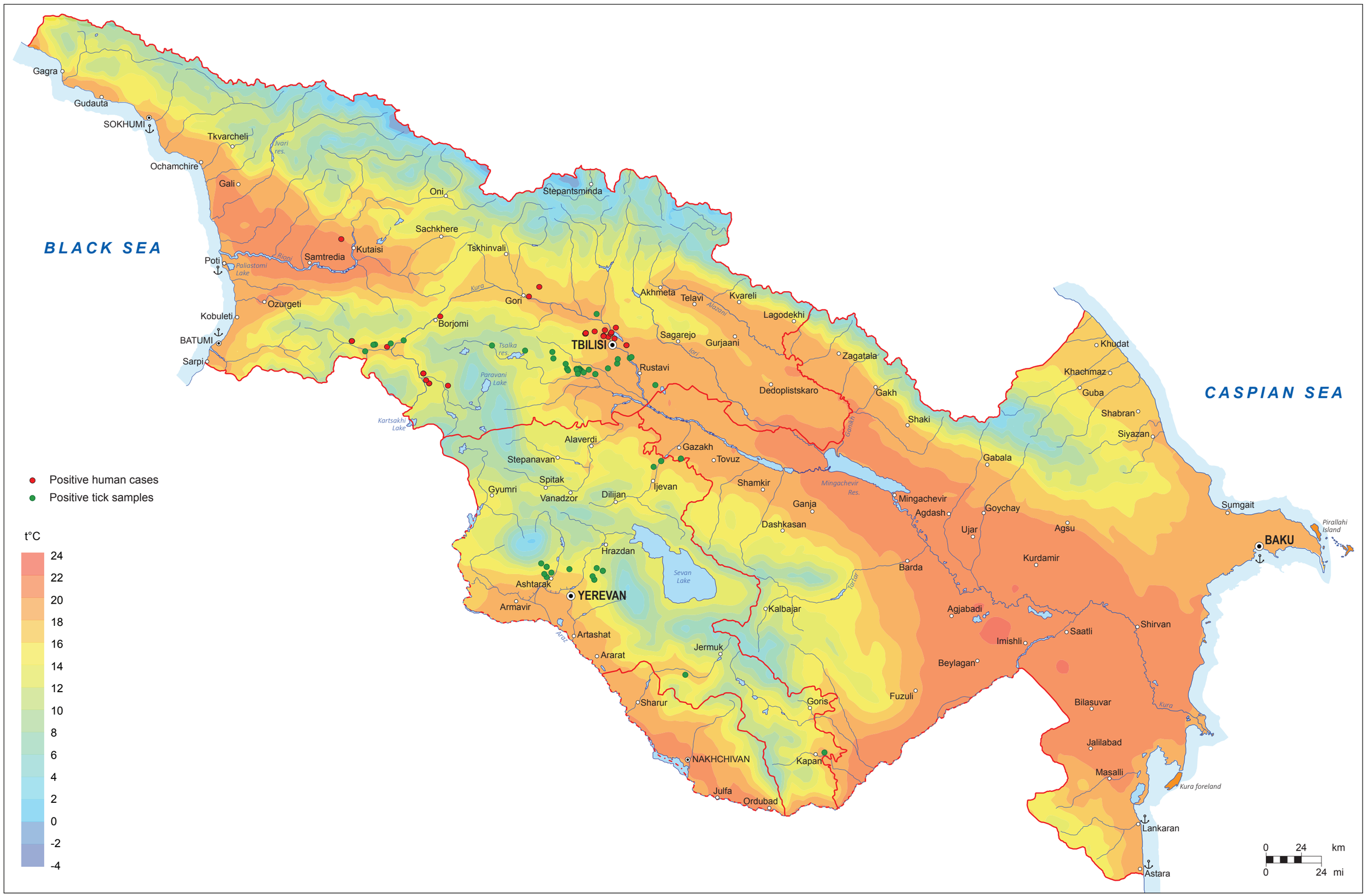
Distribution of TBE Human Cases and TBE Positive Tick Samples by Precipitation in the South Caucasus, 1985-2020



Distribution of TBE Human Cases and TBE Positive Tick Samples by Humidity Index in Georgia, 1985-2020



Distribution of TBE Human Cases and TBE Positive Tick Samples by Maximum Temperatures in the South Caucasus, 1985-2020



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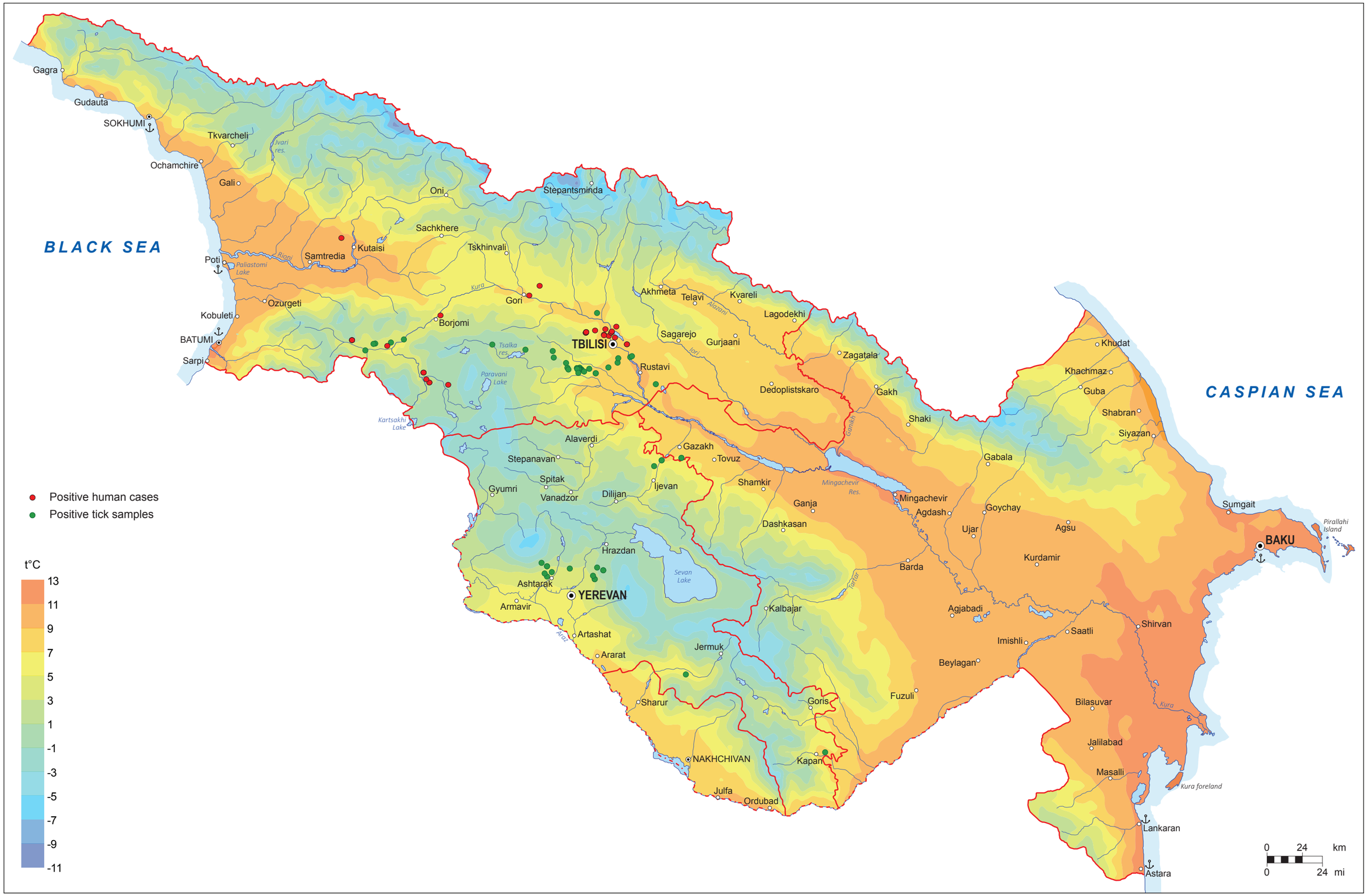
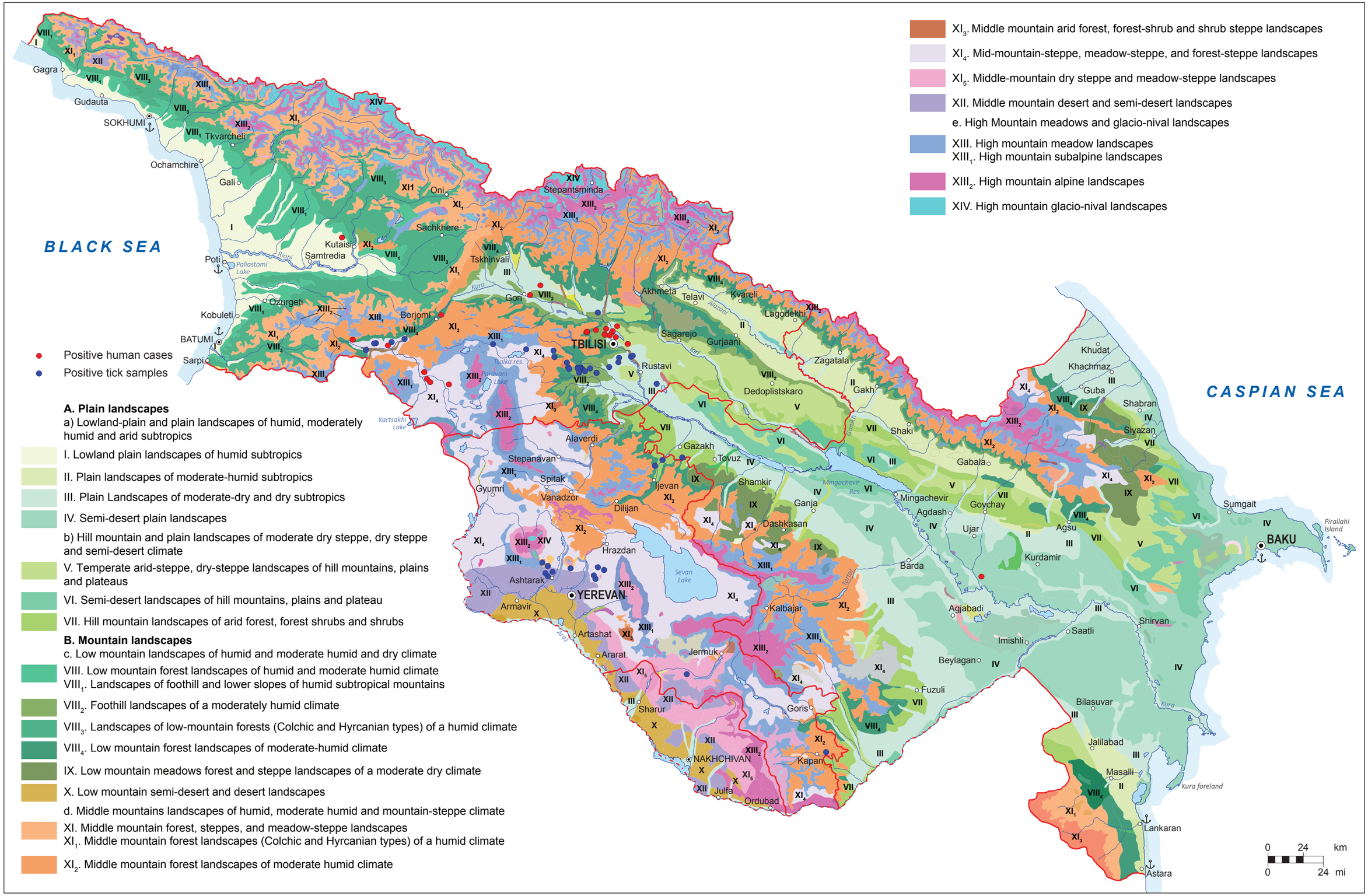
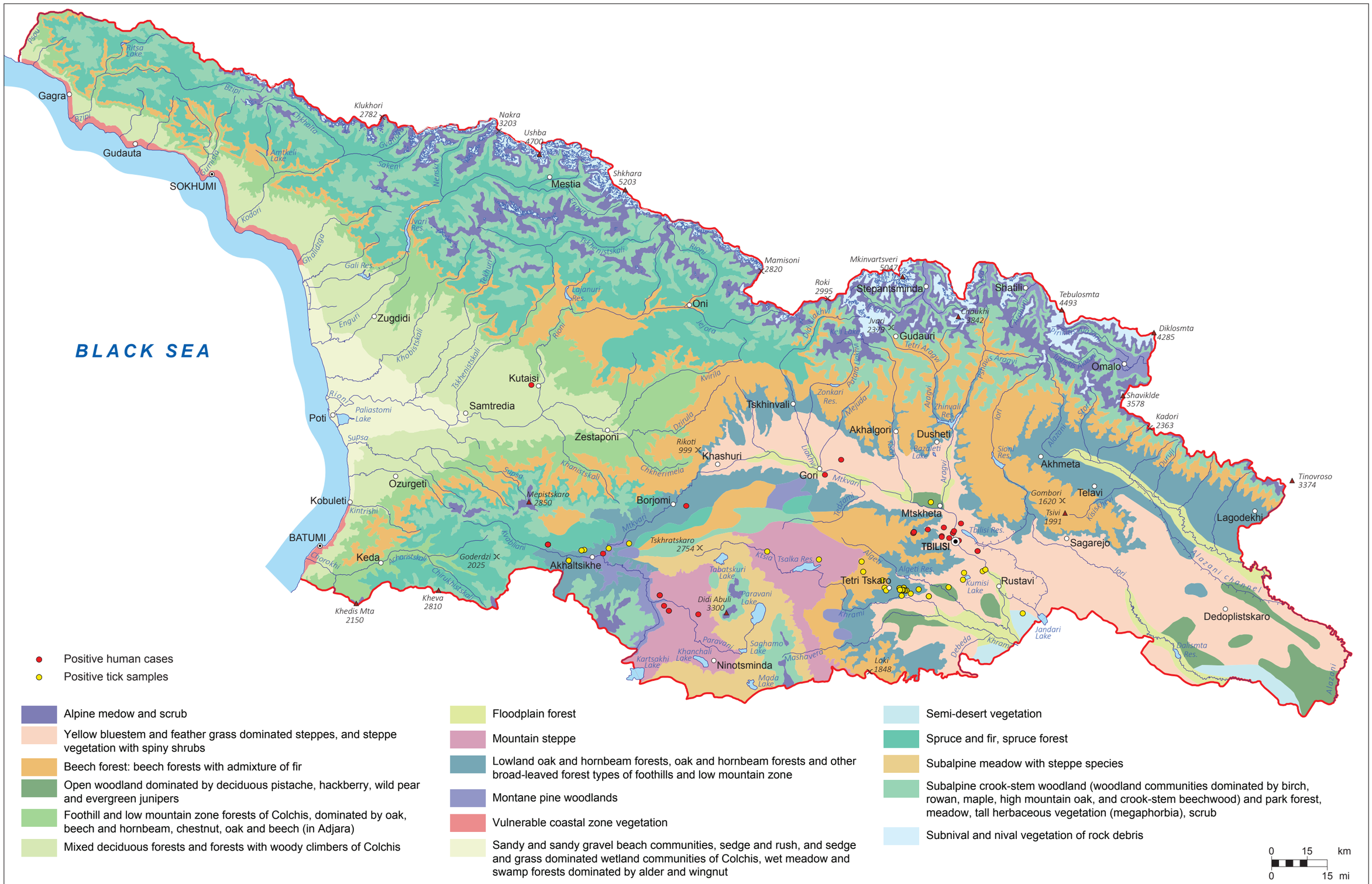


Distribution of TBE Human Cases and TBE Positive Tick Samples by Landscapes in the South Caucasus, 1985-2020

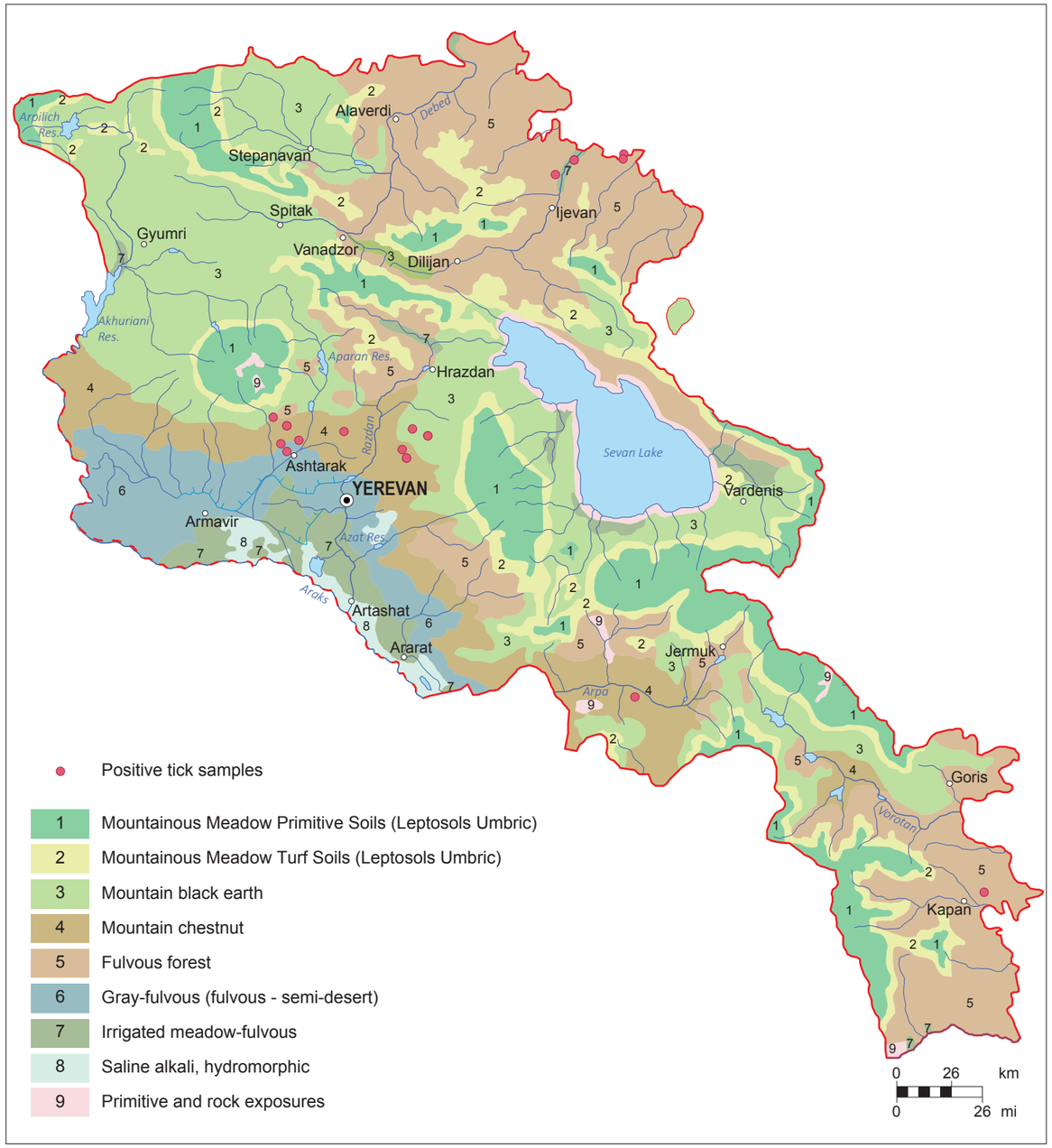


Distribution of TBE Human Cases and TBE Positive Tick Samples by Vegetation in Georgia, 2009-2020

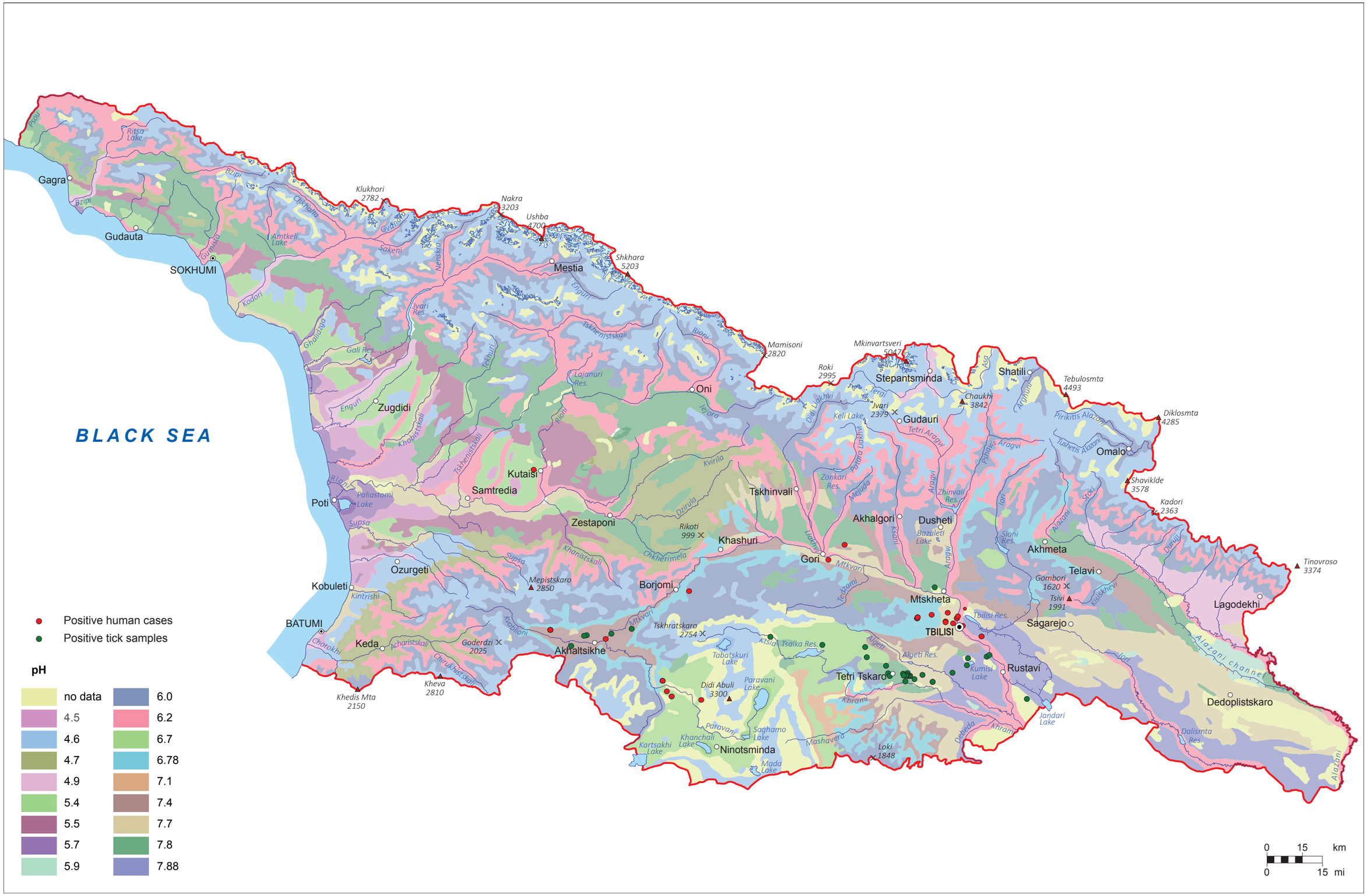


Distribution of TBE Human Cases and TBE Positive Tick Samples by Soil Types in Georgia, 2009-2020

Distribution of TBE Positive Tick Samples by Soil Types in Armenia, 1985-2019

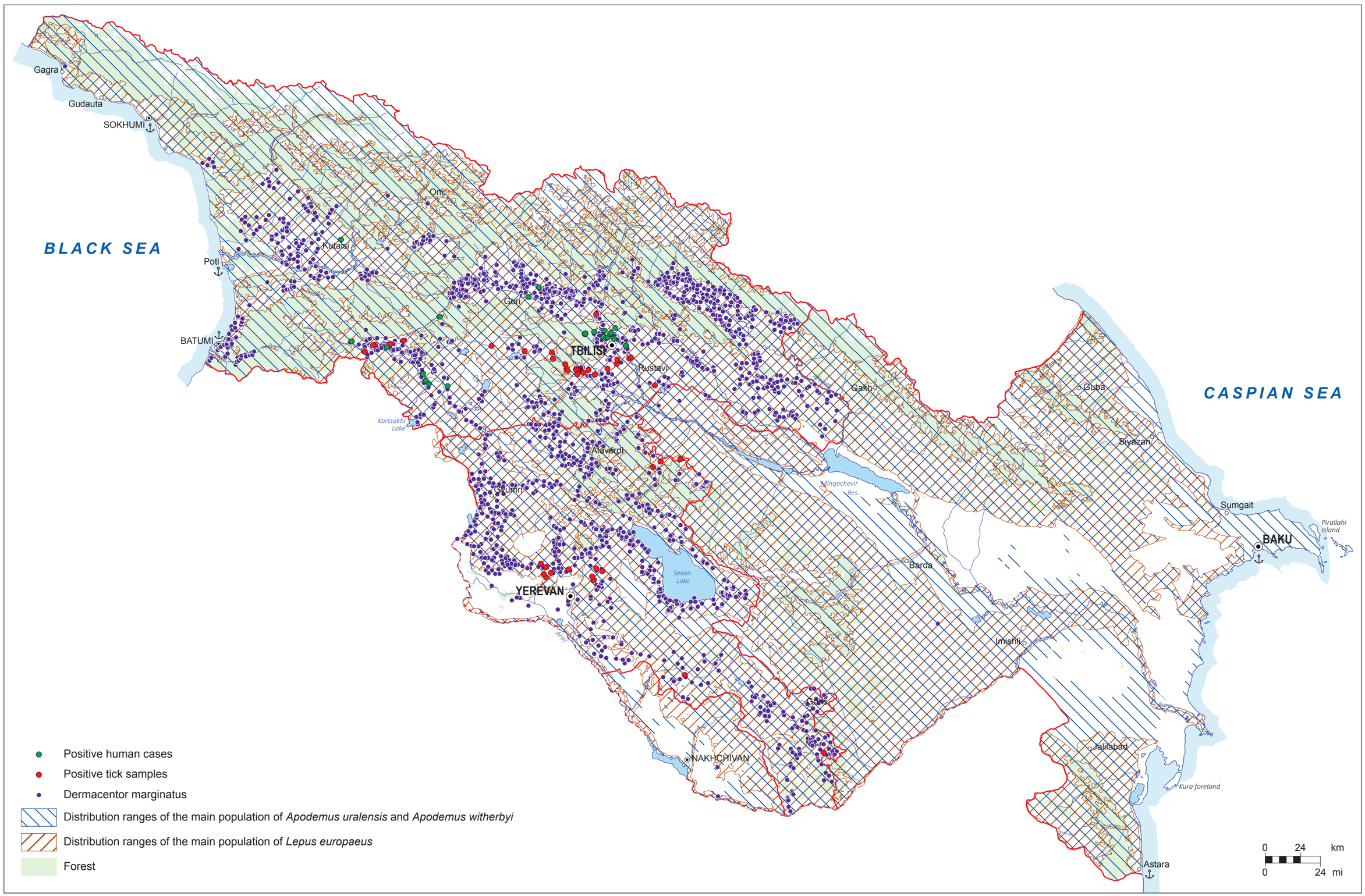


Distribution of TBE Human Cases and TBE Positive Tick Samples by Soil pH in Georgia, 2009-2020

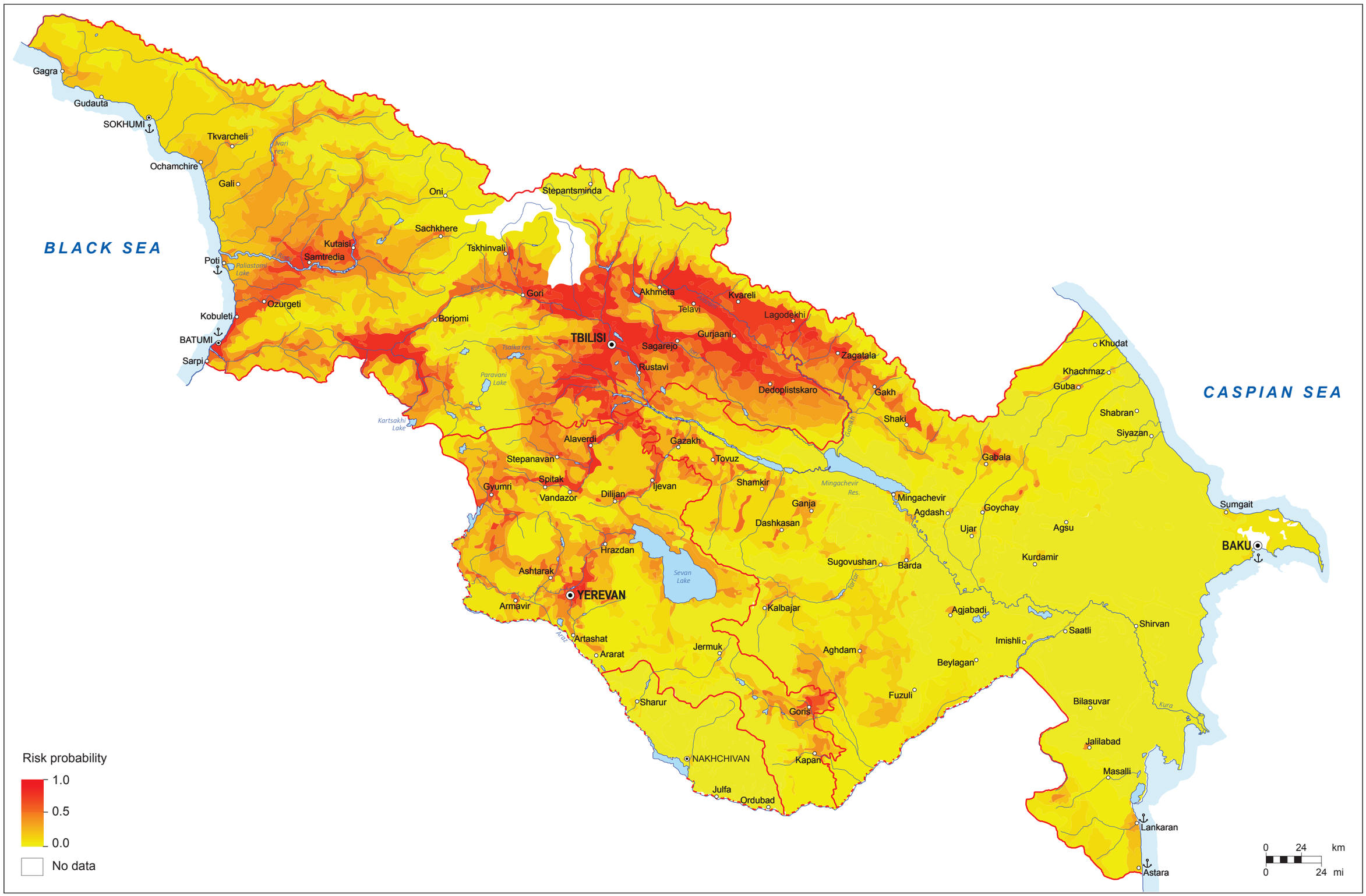


Distribution of TBE Human Cases and TBE Positive Tick Samples by Land Use in the South Caucasus, 1985-2020

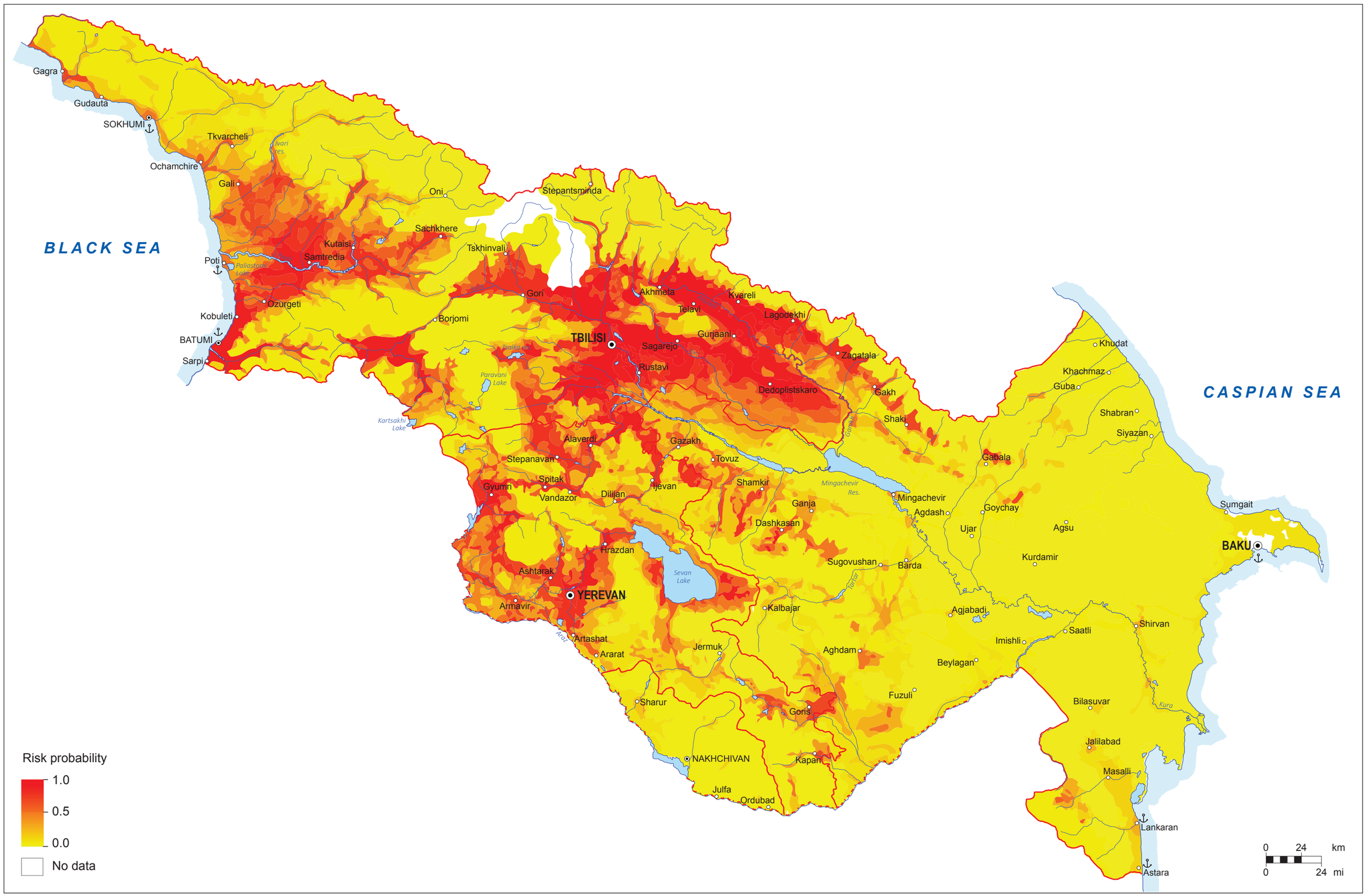
Distribution of TBE Human Cases and Tick Positive Samples and Distribution Ranges of the Main Population of Rodents in the South Caucasus, 1950-2020



TBE Human Cases Risk in the South Caucasus



TBE Positive Tick Samples Risk in the South Caucasus



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