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DISTRIBUTION OF ALLERGENIC PLANTS ON THE TERRITORY OF RUSSIA AND REPUBLIC OF KAZAKHSTAN: PROBLEMS OF STUDYING AND SOME RESULTS

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Allergenic diseases became very widespread during the last decades in industrialized countries. One of the main causes of allergy is plants pollen. Pollinosis is the disease of every fourth person of the Earth. In this paper we present some approaches to the studying of allergenic plants distribution on the territory of Russia and Kazakhstan. The following methods were applied to the analysis of allergenic plants distribution:

- Cartographic analysis of allergenic plants species per administrative unit of the country, calculation of allergenic danger and cartographic analysis of “allergenic index”;
- Analysis of “hazard indicator” calculated for the population of each administrative unit;
- Calculation of the routes of pollen flight in accordance with the wind rose in the cities;
- Evaluation of allergenic introduced plants impact on public health;
- Evaluation of morphological composition of pollen and its role in allergenic reaction.

In conclusion we give some recommendations for lowering of danger of allergenic reaction.

Keywords: allergenic plants, pollinosis, allergenic index, cross allergy, maps of distribution.

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Allergenic diseases became very widespread during the last decades in industrialized countries. One of the main causes of allergy is plants pollen. Pollinosis is the disease of every fourth person of the Earth. The symptoms of pollinosis manifest themselves when concentration of pollen in the air reaches the threshold values. The dangerous limit is about 10-20 pollen grains per 1 m^3 of air. Pollinosis manifests itself as allergic rhinitis and conjunctivitis, thus causing running nose, cough, sore throat as well as tears, itching and redness of the eyelids. Allergenic reaction may cause bronchospasm and bronchial asthma attack. Maximum pollen concentration in the air is observed during warm sunny weather, while rain and draught slow down the ripening of pollen, so allergic persons feel better during such weather.

More than 700 allergenic plant species are known to date. They are divided into 3 groups in medical literature: trees, cereals and weeds. All those plants bloom during different seasons, so the exacerbation of the disease falls into two periods: spring-summer (from the early April to the middle of June for trees) and summer (June-July for cereals, and from late June to the late August for weed grass). Usually an allergenic person reacts to the blooming of two-three plants only; that is why the seasonal exacerbation of the disease lasts for about month.

In Russian medical literature the principal attention is paid to various aspects of pollen impact on human health. There are calendars of allergenic plants blooming (Pollen Calendar, 2015), but the geographical distribution of these plants has not been analyzed yet.

Foreign allergology gives a lot of attention to this aspect from the end of the XX century (May et al., 2008; Rondón et al., 2011). PollenLibrary (2015) is a website, specifically designed for USA to allow everyone to check the blooming and danger of each of 300 allergenic species in every state and city of the USA. The Russian specialists have started their own researches on this subject, using the materials, specific for Russia (Dikareva, Rumyantsev, 2015).

In this paper we present some approaches to the studying of allergenic plants distribution on the territory of Russia and Kazakhstan. It is a short survey of various methods and approaches to this problem.

Materials and Methods

There is no generally recognized list of allergenic plants in Russia. The guidelines for allergologists (Allergology …, 2009; Method of Health Care …, 2010) list only the most dangerous species and groups of species (mostly, just the plant families). While selecting the allergenic plant species, we used the mentioned sources, internet sources (Allergology, 2015; PollenLibrary, 2015) and some other ones (Esch et al., 2001).

The following methods were applied to the analysis of allergenic plants distribution:

- Cartographic analysis of allergenic plants species per administrative unit of the country, calculation of allergenic danger and cartographic analysis of "allergenic index";
- Analysis of "hazard indicator" calculated for the population of each administrative unit;
- Calculation of the routes of pollen flight in accordance with the wind rose in the cities;
- Evaluation of allergenic introduced plants impact on public health;
- Evaluation of morphological composition of pollen and its role in allergenic reaction.

All the approaches we present in this paper.

Cartographic Analysis of Allergenic Plants Species per Administrative Unit of Russia

We selected 119 species for our analysis. It was a hard task as there is no generally recognized list of allergenic plants in Russia. We selected the widespread species or those producing the large amount of pollen. They are the most dangerous for allergy sufferers during the flowering period. While selecting from the decorative plants, we included only widespread species which have long gone beyond the artificial landings (for example, *Acer negundo*). The allergenic danger of each species was evaluated according to the three-point scale: dangerous (3), medium (2) and weak (1). The estimation was based on the sources mentioned above and on the literature sources about pollen production of those plants. The selected species were divided into 2 groups: flowering during spring (from April-May to the early June) and during summer (from the middle of June to the early September). The numbers of analyzed species by the categories and flowering periods are shown in the table 1.

Table 1. Distribution of number of analyzed allergenic species in Russia according to the categories and terms of flowering.

Flowering period	Category of Allergenic Danger			Total
	Dangerous (1)	Medium (2)	Weak (3)	
Spring	4	24	18	46
Summer	6	33	34	73
Total	10	57	52	119

We must note that we selected only 4 weak species for the spring period. They are either dominant in their vegetation communities (European and Oriental beeches), or widespread (common juniper). The fourth is swamp cypress; it is rare but often mentioned as an allergenic species in many foreign literature sources. For the summer period we selected 6 weak species, widespread on the European Russia (ER).

The data on the areas of allergenic species was taken from the plant guide books (Gubanov et al., 1995; Vascular Plants …, 1996; Flora of Siberia, 1987-2003) and database (Agroecological Atlas …, 2015). The distribution of selected species is attached to the subjects of Russian Federation, which is not well accepted in biogeography for showing of various taxonomic units' distribution. But such classification is clearer to the wide range of people, including allergologists and allergic individuals.

The materials were organized as a database and attached to the map in GIS MapInfo. To construct the database we used the methods that had been created to work with the terrestrial vertebrates of Russia (Rumyantsev, Danilenko, 1998). For each subject of Russian Federation we calculated 2 indices: total number of allergenic species in the region and "allergenic index", which is the sum of points of allergenic danger of allergenic species in the region. For our calculations we used Visual FoxPro and Statistika.

GIS MapInfo allowed us to compile a series of maps of allergenic species distribution for the whole territory of Russia (fig. 1-3). These maps show the numbers of species, flowering during spring and summer, and the total number for the whole flowering period from April to September. We also made the maps of total allergenic danger for spring and autumn periods and for the whole flowering period, on the basis of "allergenic index".

Results and Discussion. Analysis of the maps showed the following. The number of species flowering during spring (fig. 1 a) is maximal in the central regions of the European Russia. It decreases to the north, south and east, reaching its minimum in Chukotka Autonomous District and Magadan Region. This fact can be explained by flowering of allergenic deciduous trees and some coniferous trees, which are widespread mostly in the southern regions of forest zone.

Maximum number of allergenic species flowering during summer (fig. 2 a) is in the southern regions: broad-leaved forests, forest steppe, steppe and Ciscaucasia forests. These are Poaceae and Artemisia species, and some weeds, such as quinoa, nettle, plantain and some others; the tree species is *Tilia cordata.* Their numbers are maximal in the broad-leaved forests zone.

The total number of allergenic species for the whole period of flowering (fig. 3 a) is maximal in the central regions of ER, the Kaliningrad Region, Krasnodar Krai, and Crimea. This can be explained by the fact that allergy is studied and registered mostly in the territory of ER and only local species are considered. The second reason is that the variety of allergenic species reflects the total species diversity in communities, which is the greatest in the broad-leaved forests and forest-steppe zone. Allergenic species include weeds as well, which are the product of anthropogenic impact on vegetation, thus, the impact is maximal in the well-developed regions of ER.

The concentration of allergenic species in the central regions of ER can be associated with the following factor as well. The allergy morbidity rate is higher in the regions with the highest air, water and food pollution indices. The high level of pollution stimulates the so-called cross-allergenic response (Romanyuk, 2010), which makes human organism more vulnerable to pollen. Thus, the allergenic species are concentrated in the most industrially developed and therefore the most polluted regions of Russia.

The highest overall allergy danger during spring (fig. 1 b) is detected in the central regions of ER and the Kaliningrad Region. It decreases to the south and east, but is higher (but not much) in the Far East (Primorsky and Khabarovsk Krai, the Amur Region, and the Jewish Autonomous Region). This fact can be explained by the high allergy danger of almost each willow and oak species in the broad-leaved forests of the Far East. The danger is minimal in the Sakha Republic, the Chukotka Autonomous District, the Magadan Region, and Kamchatka Krai, as well as in the Ciscaucasia republics.

Forest-steppe and steppe regions of ER are the most dangerous for allergy sufferers during summer (fig. 2 b): the Kursk, Voronezh, Saratov, Samara, Lipetsk, and Penza Regions, as well as

Stavropol and Krasnodar Krai, Crimea, and the Republic of Adygea. It can be explained by high allergenic danger of most cereal and wormwood species, abundant in the Russian steppes (Dikareva, 2004).

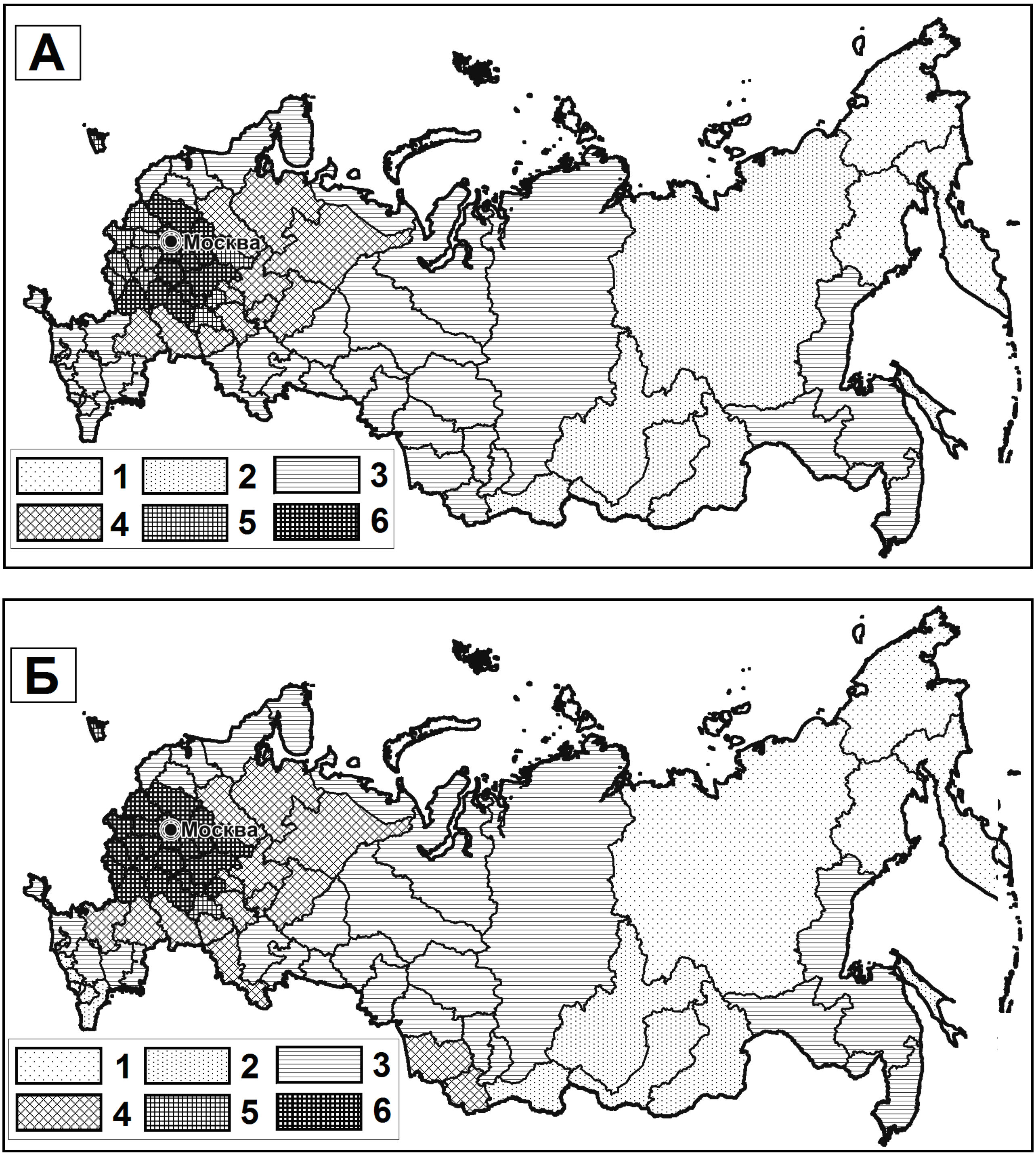


Fig. 1. Distribution of allergenic plant species, flowering during spring. *Notes.* A – number of plant species: 1 – 10 and less (3), 2 – 11-15 (6), 3 – 16-20 (39), 4 – 21-25 (11), 5 – 26-30 (12), 6 – 31 and more (11); Б – representation of summarized “allergenic index”: 1 – 30 and less (4), 2 – 31-40 (11), 3 – 41-50 (29), 4 – 51-60 (15), 5 – 61-70 (2), 6 – 71 and more (21); in brackets – number of Russian Federation subjects within the given range.

A relatively high danger is typical for broad-leaved, small-leaved, and mixed forests, mostly because of the cereal species flowering. The minimum danger is typical for the northern and the Far East regions (the Sakha Republic, the Chukotka, Nenets and Yamalo-Nenets Autonomous Districts, the Magadan and Sakhalin Regions, Kamchatka and Khabarovsk Krai during the same period).

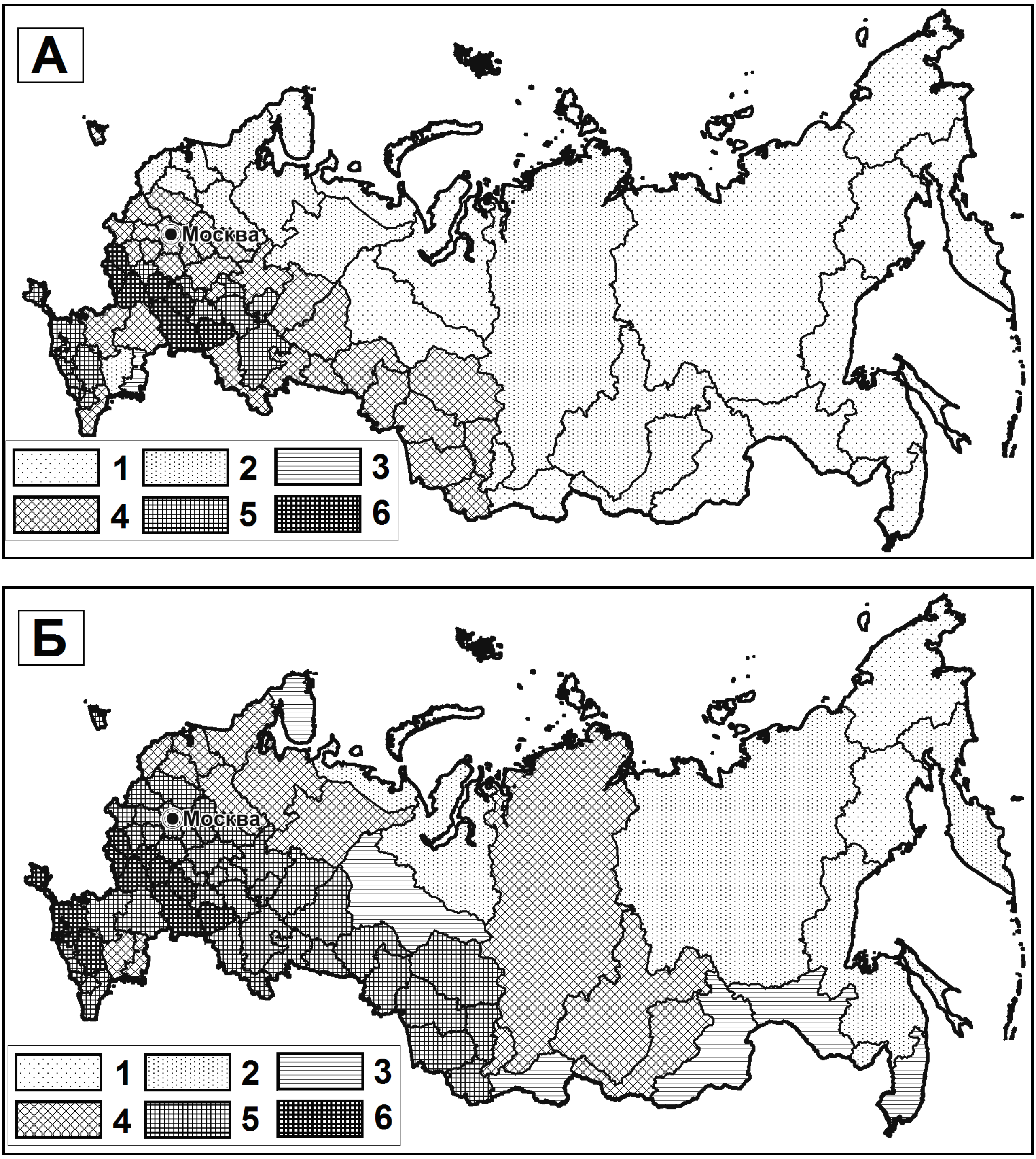


Fig. 2. Distribution of allergenic plant species flowering during summer. *Notes.* A – number of plant species: 1 – 34 and less (15), 2 – 35-39 (12), 3 – 40-44 (1), 4 – 45-49 (31), 5 – 50-54 (16), 6 – 55 and more (7); Б – representation of summarized “allergenic index”: 1 – 40 and less (2), 2 – 41-60 (7), 3 – 61-80 (6), 4 – 81-100 (13), 5 – 101-120 (42), 6 – 121 and more (12); in brackets – number of Russian Federation subjects within the given range.

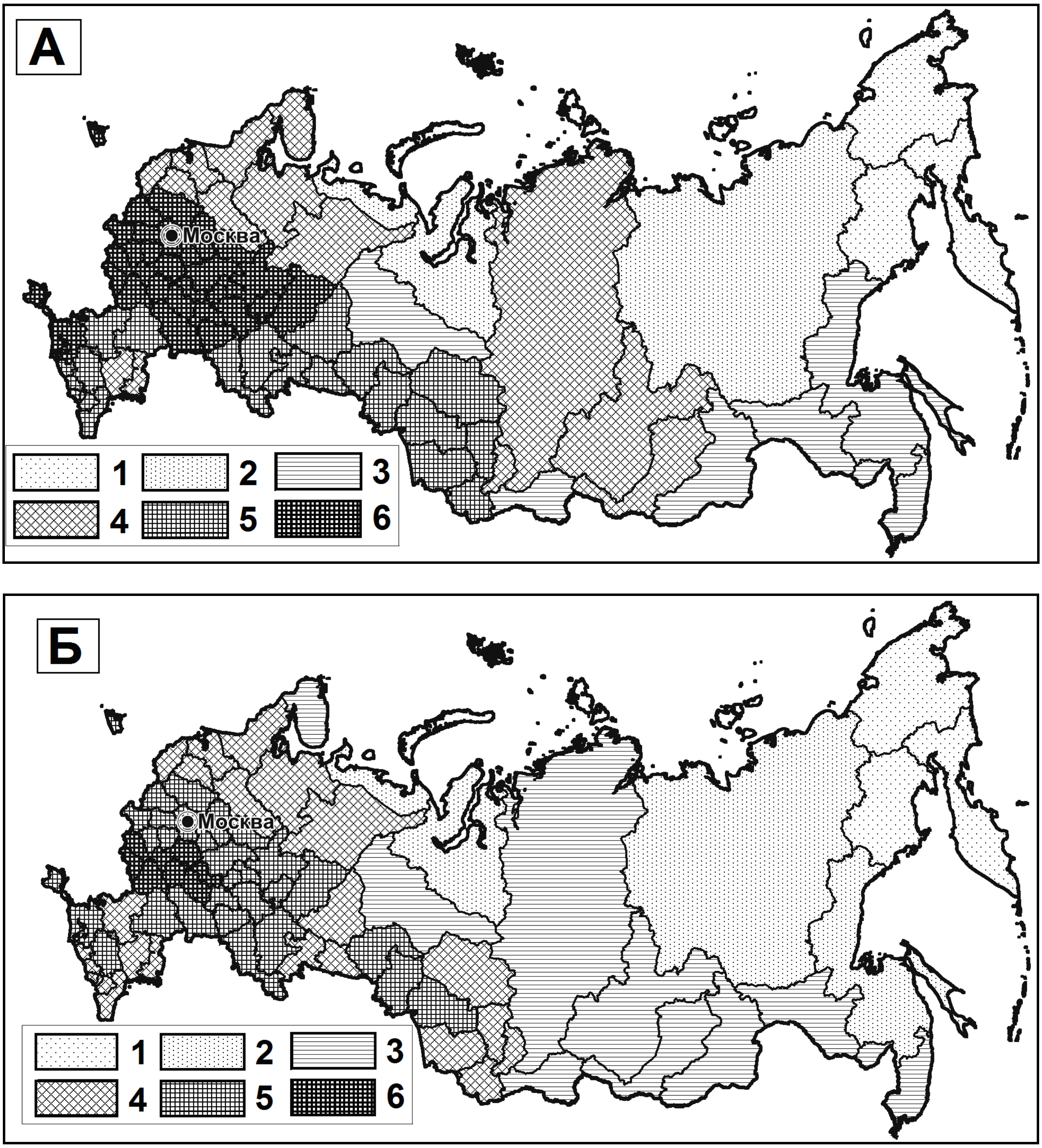


Fig. 3. Distribution of allergenic plant species flowering during the whole vegetation period. *Notes.* A – number of plant species: 1 – 30 and less (3), 2 – 31-40 (3), 3 – 41-50 (8), 4 – 51-60 (14), 5 – 61-70 (21), 6 – 71 and more (33); Б – summarized "allergenic index": 1 – 70 and less (3), 2 – 71-100 (5), 3 – 101-130 (10), 4 – 131-160 (24), 5 – 161-190 (32), 6 – 191 and more (8); in brackets – number of Russian Federation subjects within the given range.

For the whole period of flowering (fig. 3 b), the most dangerous are the Kursk, Belgorod, Voronezh, Ryazan, Lipetsk, Tambov and Penza Regions and the Republic of Mordovia. As it was mentioned above, due to the extensively developed industry these regions have a high level of environment pollution.

Generally, according to the numbers of allergenic species and the “allergenic index,” the most dangerous are the Ryazan and Voronezh Regions, while the least dangerous are the Chukotka Autonomous District and the Magadan Region.

Results to the Chapter 1

Thus, our analysis revealed the principal patterns of allergenic plants distribution in Russia.

The most dangerous for allergy sufferers are the regions of Central Russia. During spring it is the Ryazan Region, during summer it is the Voronezh Region, but both are equally dangerous during the entire vegetation period. The least dangerous during spring are Chukotka Autonomous District and the Magadan Region, during summer it is the Magadan Region only, and both are equal for the entire vegetation period.

Further research on the hypothetic connection between pollinosis and environment pollution in the region is necessary. We also plan to compare our results with data on the pollinosis morbidity rate.

The compiled maps may serve as reference material for allergologists and allergy sufferers. In prospect, these maps and the database they were based on may be used for development of an interactive information system.

2. Cartographic Analysis of Allergenic Plants Species per Administrative Unit of Kazakhstan

For cartographic analysis of allergenic species in the Kazakhstan Republic we used the same methods as for the analysis of the Russian species. The only difference was the number of species. The database of allergenic plants includes the widespread species or those which produce the largest amount of pollen, i.e. the most dangerous for allergy sufferers during the flowering period. The allergenic danger of 59 species was evaluated according to the three-point scale: dangerous (3), medium (2) and weak (1). The selected species were divided into 2 groups: flowering during spring (from April-May to the early June) and summer (from the middle of June to the early September; Dikareva, Rumiantsev, 2015). The number of analyzed species by the categories and flowering periods is shown in the table 2.

Table 2. Distribution of number of analyzed allergenic species in the Kazakhstan according to the categories and terms of flowering.

Flowering period	Category of allergenic danger			
	Dangerous (1)	Medium (2)	Weak (3)	Total
Spring	1	13	7	21
Summer	5	15	18	38
Total	6	28	25	59

Thus, the spring period is characterized only by one weak species, which is *Millium effusum*[1] of Poaceae family. It is not very dangerous for allergy sufferers as its distribution is limited: it grows only in the forest belt and subalpine meadows in the Eastern and Southern Kazakhstan. The number of allergenic species grows during summer and includes 3 weak species of Chenopodiaceae family (*Salsola arbuscula*, *Halocnemum strobilaceum* and *Anabasis salsa*), and 2 weak ones of Poaceae family (*Puccinellia dolicholepis* and *Trisetum sibiricum*). Their pollen is slightly allergenic.

The category of medium danger includes 13 species, flowering in spring, and 15 species,

[1] The Latin species are provided by the “Botanical Geography of Kazakhstan and Middle Asia (Deserts Only)” (2003).

flowering in summer. The main flora individuals that flower during spring are of Poacea family (*Stipa hohenackeriana, S. zalesskii, Bromopsis inermis, Poa angustifolia*, *Helictotrichon pubescens*), and Pinaceae family (*Pinus sylvestris*), while Salicaceae includes only 5 species from *Populus* genus (*Populus alba, P. laurifolia, P. diversifolia, P. nigra, P. tremula*) and one from *Salix* genus (*Salix viminalis*). The summer is characterized mostly by Poacea family (genera *Poa*, *Stipa* and *Festuca*), and lesser by Chenopodiaceae (*Chenopodium album*) and Urticaceae families (*Urtica dioica*). In total, these species are widespread in all landscapes and can be encountered in every administrative region of Kazakhstan.

The category of dangerous allergenic species is wider during summer than spring due to the flowering of Asteraceae family, which includes maximum number of allergenic species for the territory under concern, about 13 species: *Artemisia austriaca, A. leucodes, A. absinthium, A. transiliense, A. lessingiana, A. vulgaris, A. rutifolia, Ambrosia artemisiifolia* and others; and Chenopodiaceae family (*Halimione verrucifera, Atriplex nitens, A. cana* and others), as well as some species of Poaceae family (*Festuca gigantea, F. kryloviana* and others). All scientific-medical sources note that *Artemisia* genus is very dangerous as they are widespread in all settlements, diverse and their pollen covers big distances, which greatly deteriorates ecology of the regions. The category of dangerous spring plants includes a little amount of species: *Salix* genus (*Salix cinerea, S. trianda*), Poaceae family (*Poa pratense, P. bulbosa, Festuca valesiaca, Alopecurus pratensis*) and Chenopodiaceae family (*Atriplex tatarica*).

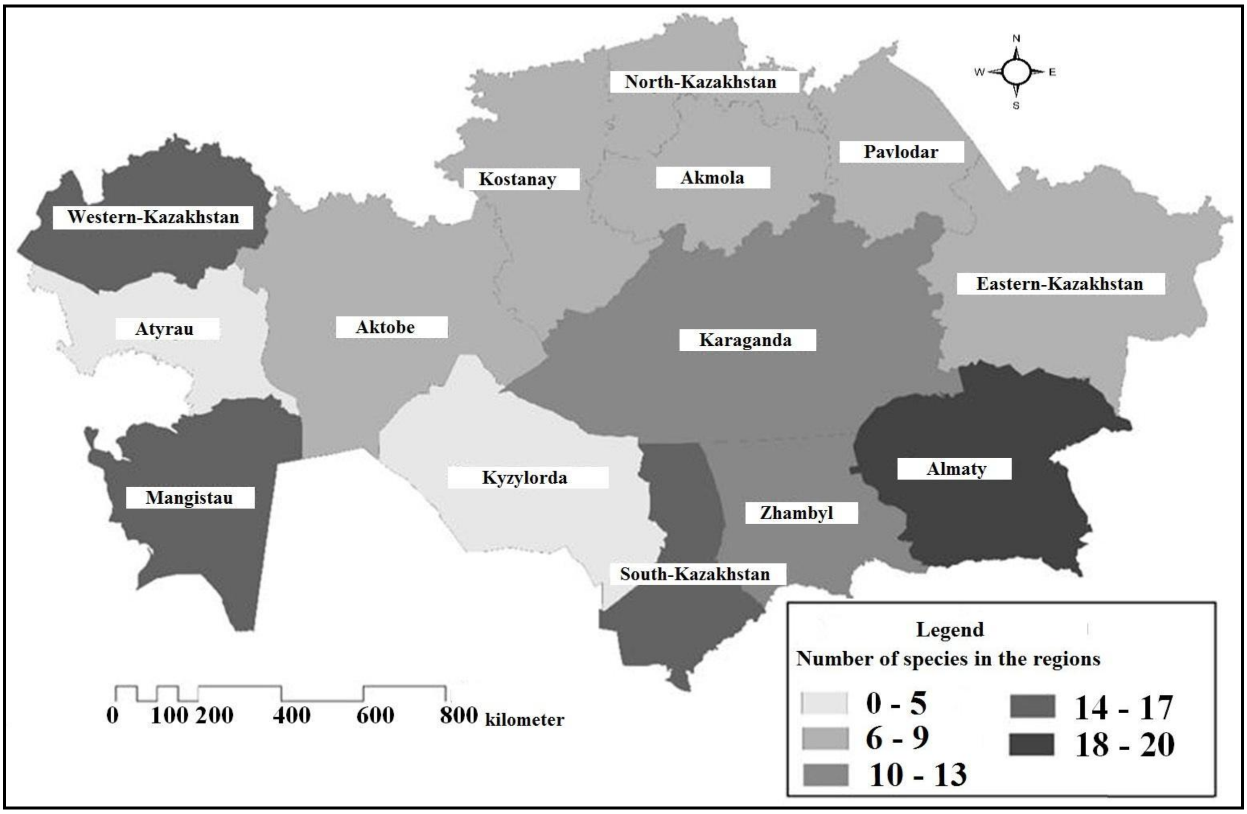
For each subject of the Republic of Kazakhstan we calculated 2 indices: total number of allergenic species in the region and “allergenic index”, which is the sum of points of allergenic danger of allergenic species in the region.

GIS MapInfo allowed us to compile a series of maps of allergenic species distribution for the whole territory of Kazakhstan (fig. 4-6). These maps show the numbers of species, flowering during spring and summer, and the total number for the whole flowering period from April to September. We also made the maps of total allergenic danger for spring and autumn periods and for the whole flowering period, on the basis of “allergenic index”.

As a result, the maximal number of allergenic species flowering during spring was found in the Eastern-Kazakhstan region: 19 species in total. The Northern regions of Kazakhstan also have big number, varying from 13 to 16 (fig. 4 a). From north to south these numbers become smaller; the minimal ones were registered for Atyrau, Mangistau and Kyzylorda Regions, with only 6 species in each. The predominance of allergenic species in the northern and eastern regions of Kazakhstan can be explained by flowering of deciduous (poplar, willow, aspen) and coniferous (pine) trees.

The total allergenic danger during spring months is higher in the Eastern-Kazakhstan and Kostanay Regions (fig. 4 b). We must mention as well the high number of allergenic species in Akmola, Karaganda, North-Kazakhstan and Pavlodar Regions. It can be explained by the big number of tree species, some of which are allergenic: *Salix cinerea* and *S. triandra*, that grow in the steppe regions of the North-Kazakhstan and Central parts of the country. The danger from allergenic species decreases to the south and south-west. It can be explained be transformation from semi-desert to desert zone, climatic changes, hydrologic and soil conditions. There the salt tolerant allergenic species can be found; they are not very dangerous as allergenic, for example, *Salsola arbuscula*. So, Atyrau, Aktobe and Kyzylorda Regions have the least “allergenic index” and are not dangerous for allergenic persons.

Maximal number (30) of allergenic species flowering during summer was found in Almaty Region, as well as in Aktobe, Karaganda and the Eastern-Kazakhstan Regions, with 24 to 27 species (fig. 5 a). This phenomenon is related to the beginning of plentiful flowering of Poaceae and Chenopodiaceae families and *Artemisia* genus. Minimal number was registered in the western and south-western regions: the Western-Kazakhstan, Atyrau, Mangistau, Kyzylorda and South-Kazakhstan Regions.



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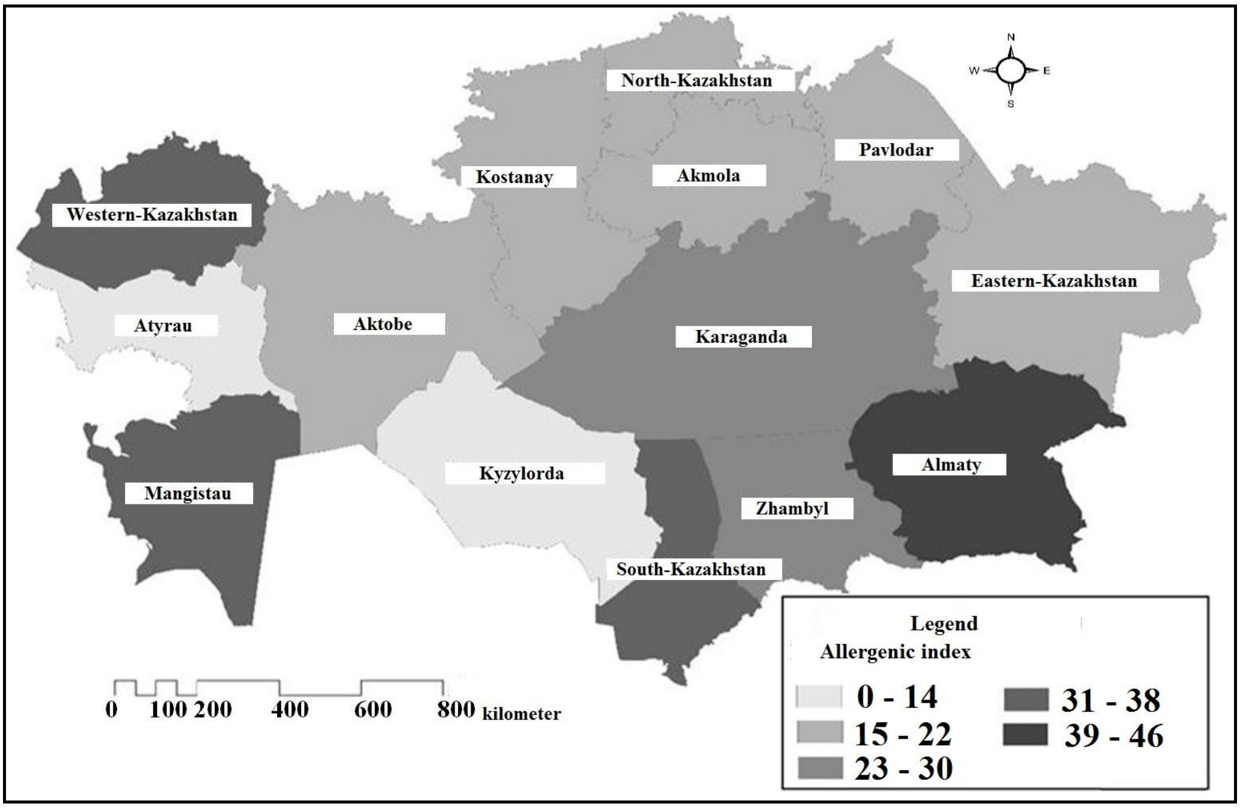
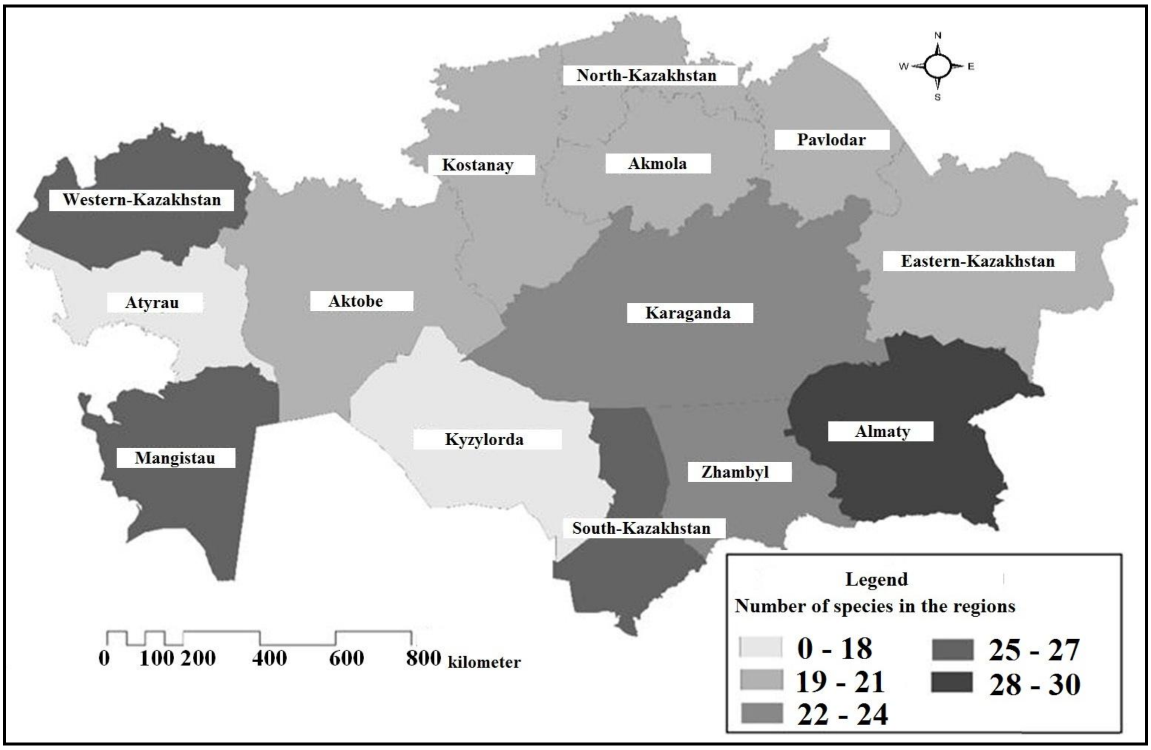


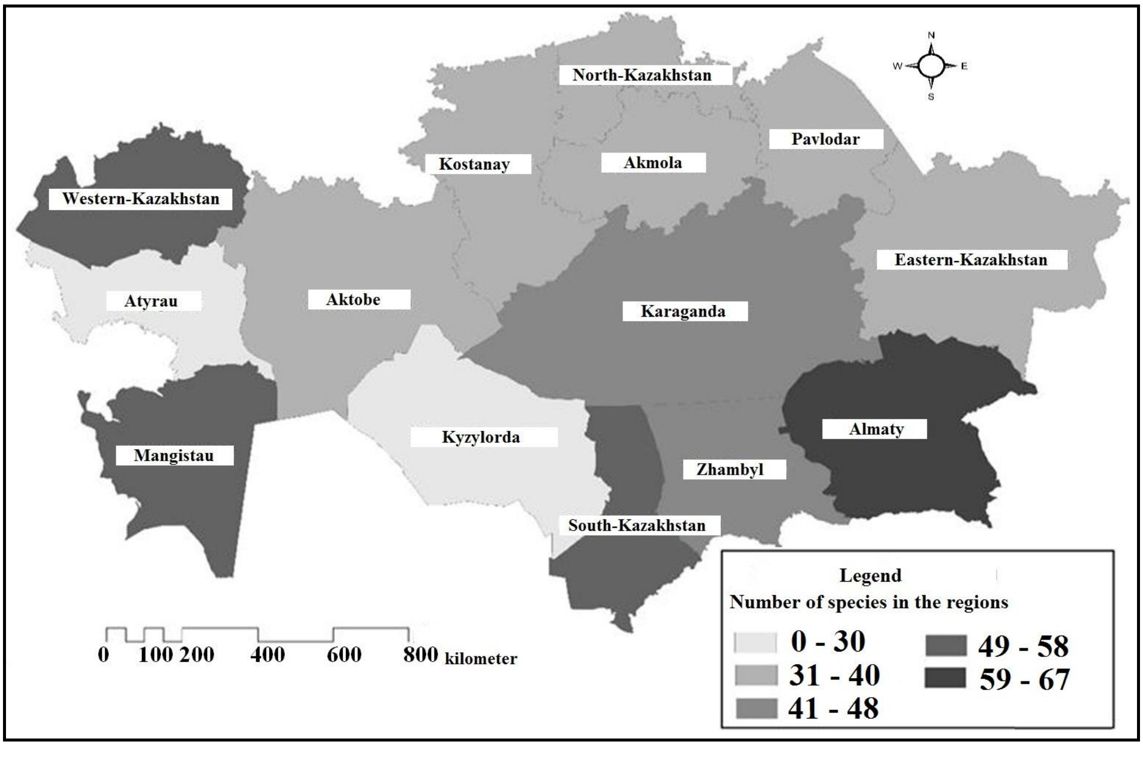
b)

Fig. 4. Schematic map of a) distribution of allergenic plant species, flowering during spring, b) total value of “allergenic index” during spring.

During summer time the most dangerous regions are Eastern-Kazakhstan and Almaty, as well as Zhambyl, Aktobe, Karaganda and Kostanay regions (fig. 5 b). The reason for the high allergenic danger is the wide distribution of sagebrush communities, as well as species from Poaceae and Chenopodiaceae families, and the fact that they flower for a long period, starting from June to the middle of September. The minimal danger is caused by Mangistau Region.



a)



б)

Fig. 5. Schematic map of a) distribution of allergenic plant species, flowering during summer, б) total value of "allergenic index" during summer.

Having analyzed the spring and summer periods separately, we came to a conclusion that maximal concentration of allergenic species during the whole period of flowering is in Eastern-Kazakhstan and Almaty Regions (fig. 6 a). This phenomenon can be explained by altitude belts, which determine the high variety of vegetation types and sharp difference between steppe and desert flora. Big number of allergenic species can be explained by high production potential of the regions. They are highly polluted, and thus the contact of pollen with pollutants is inevitable, with the following deterioration of health and complicated allergenic reactions.

The most dangerous regions during the whole period of flowering are Eastern-Kazakhstan and Almaty, as well as Karaganda and Kostanay (fig. 6 b). The less dangerous are Atyrau, Mangistau and Kyzylorda regions, but this fact is unreliable due to the lack of researches carried out in those regions.

3. Analysis of Allergenic Danger of Administrative Regions of Kazakhstan Republic in Relation to the Number of Population

Increase of allergic diseases and complicated cases of disease's course became the medical-biological problem of high priority. Out of all allergenic diseases of children, the first place belongs to bronchial asthma (Balabolkin, 1985).

The base for allergenic bronchial asthma is formed by the developing vulnerability of human organism to the substances and compounds of exogenous and endogenous origin, with antigenic properties. Impact of allergen on the organism of a human may cause bronchial asthma. By their origin the allergens are divided into 2 types: exogenous, coming from the environment, and endogenous, forming in the human organs and tissues (Balabolkin, 1985). In our case, the environmental allergens and their influence on the human is of the higher interest, especially the impact of allergenic plants on the occurrence of bronchial asthma.

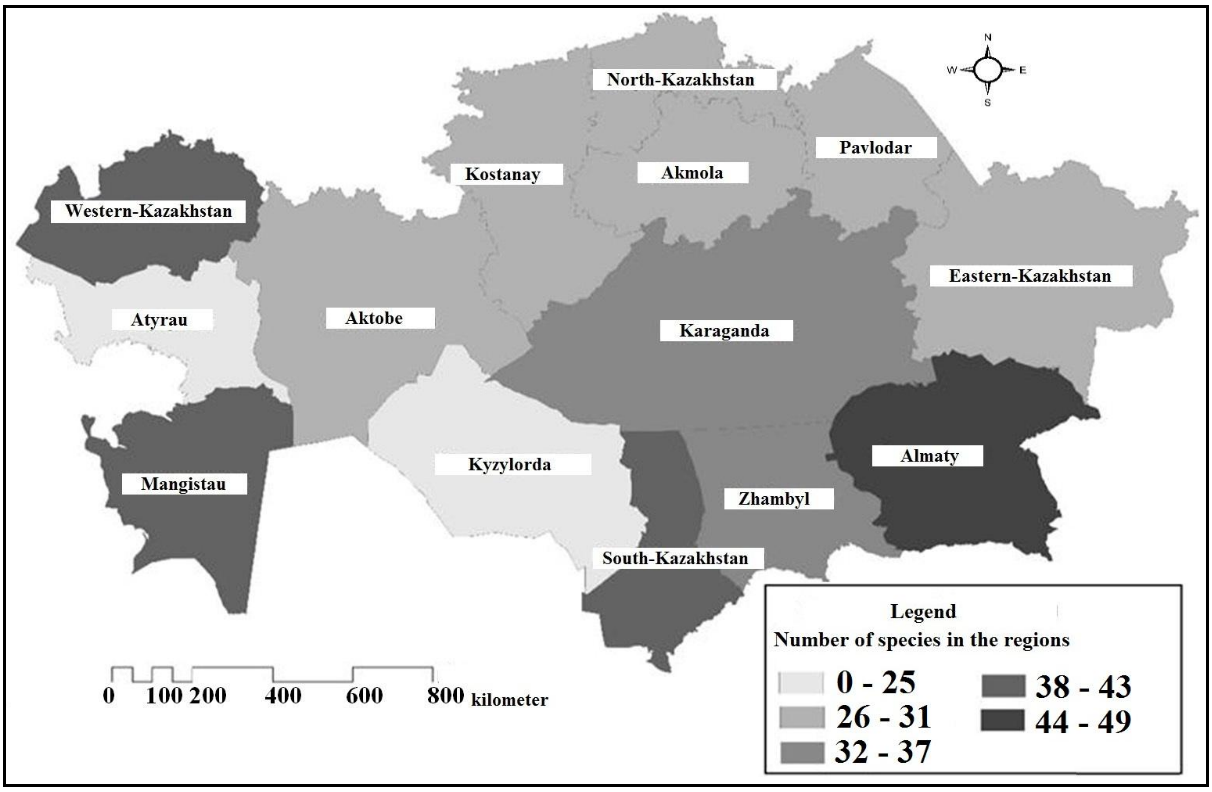
The researches of physicians showed that the greatest amount of allergens, causing bronchial asthma attacks, comes from the air. The principal pathogens are plant pollen, micro fungus, house dust and many other substances of plant or animal origin. Allergens of 3 main groups of plants can also cause bronchial asthma. These are trees and bushes; in our case, it is willow, poplar and pine; plants from Poaceae family (fescue, meadow foxtail, bluegrass, bonfire grass, feather grass, etc.), as well as weeds, such as sagebrush, ragweed, quinoa, nettle and some others (Chuchalin, 1985).

Due to the phenology of allergen flora blooming, we can select several periods of allergy attacks: spring (April-May), caused by tree pollen; summer (June-August), caused by grass pollen; autumn (August-October), caused by weeds pollen. The terms of blooming and range of allergen species may vary depending on the vegetation zone.

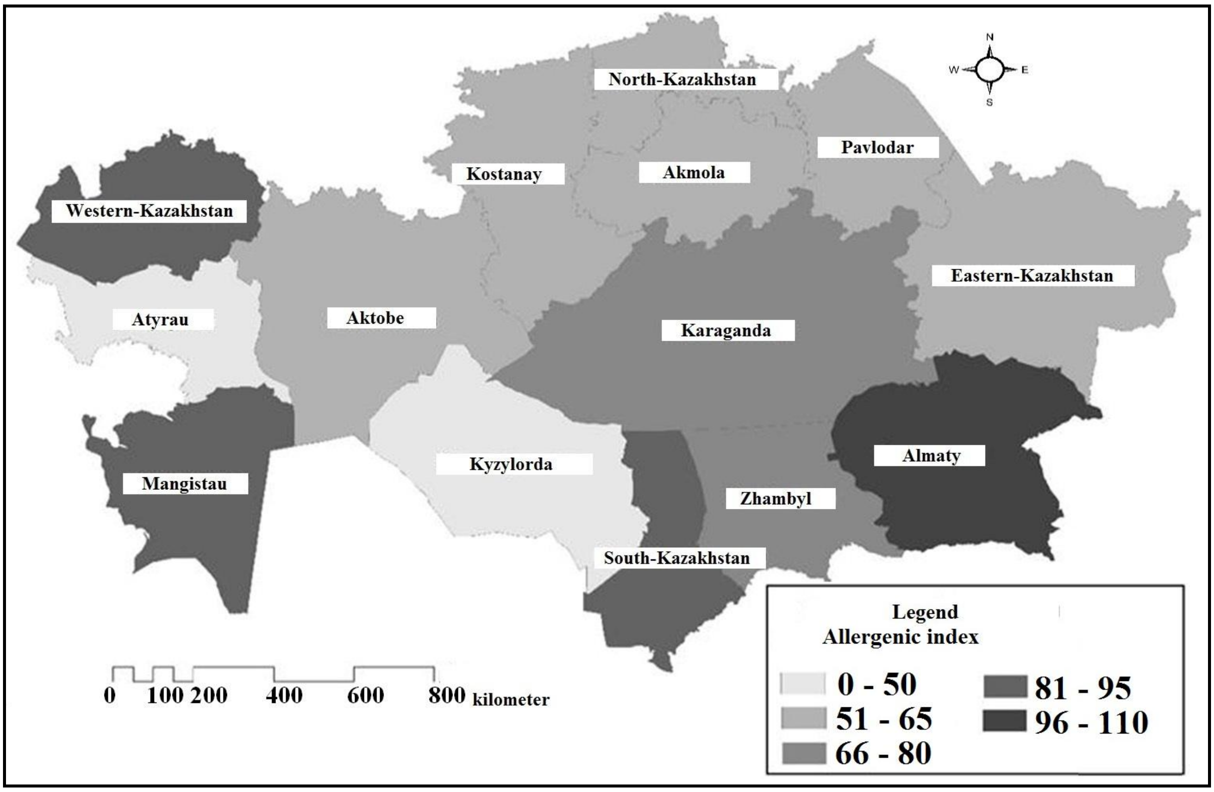
Bronchial asthma is very frequent among children. According to several authors, the values of asthma's distribution vary from 1 to 20 cases per 1000 people. In the Republic of Kazakhstan the value is 106 per 100000 children (Syrbaeva, 2014).

Results and Discussion. We calculated the "hazard indicator" for population of each administrative unit of the country by giving each unit a point, determined by dividing the total number of region population by 100000 people. Then it was multiplied by "allergenic danger index". Thus, we received the "hazard indicator" that gave us the chance to analyze maximal and minimal influence of allergenic plants on humans in every region, calculated per 100000 people (Dikareva, Rumyantsev, 2015).

Analyzing the maps, we can see that maximal allergenic danger is in Almaty Region with 1600 sick people per 100000. This phenomenon is connected with the maximal allergenic danger index in this region and high number of population (about 1 million 800 thousand), as well as with high industrial development and high density of transport. As we showed above, the aggravation of the allergenic reaction is conditioned by environmental pollution.



a)



b)

Fig. 6. Schematic map of a) distribution of allergenic plant species, flowering during the entire vegetation period, b) total value of “allergenic index” during the entire vegetation period.

In Western-Kazakhstan, Mangistau, Southern-Kazakhstan, Karaganda and Zhambyl Regions there are 650-1100 allergic individuals per each 100 thousand of people (fig. 7). In spite of the low index of allergenic danger for some of these regions (47 for Mangistau Region), the index grows due to the high concentration of population there (more than 2 million).

All northern regions of Republic of Kazakhstan (Kostanay, Northern-Kazakhstan, Pavlodar and Akmola), Eastern-Kazakhstan and Aktobe Regions have the allergenic danger index from 400 to 650 per 100 thousand of people. The minimal value lesser than 400 was registered in 2 regions: Atyrau and Kyzylorda. The number of allergenic species is low there, and "allergenic index" is relatively small (54) in comparison to the other regions of the country.

Generally, the most dangerous region is Almaty, while the less dangerous is Kyzylorda and Atyrau, but this result is not accurate, due to the lack of researches carried out in those regions, while Almaty Region has a large database on the pollen complexes being the cause of pollinosis.

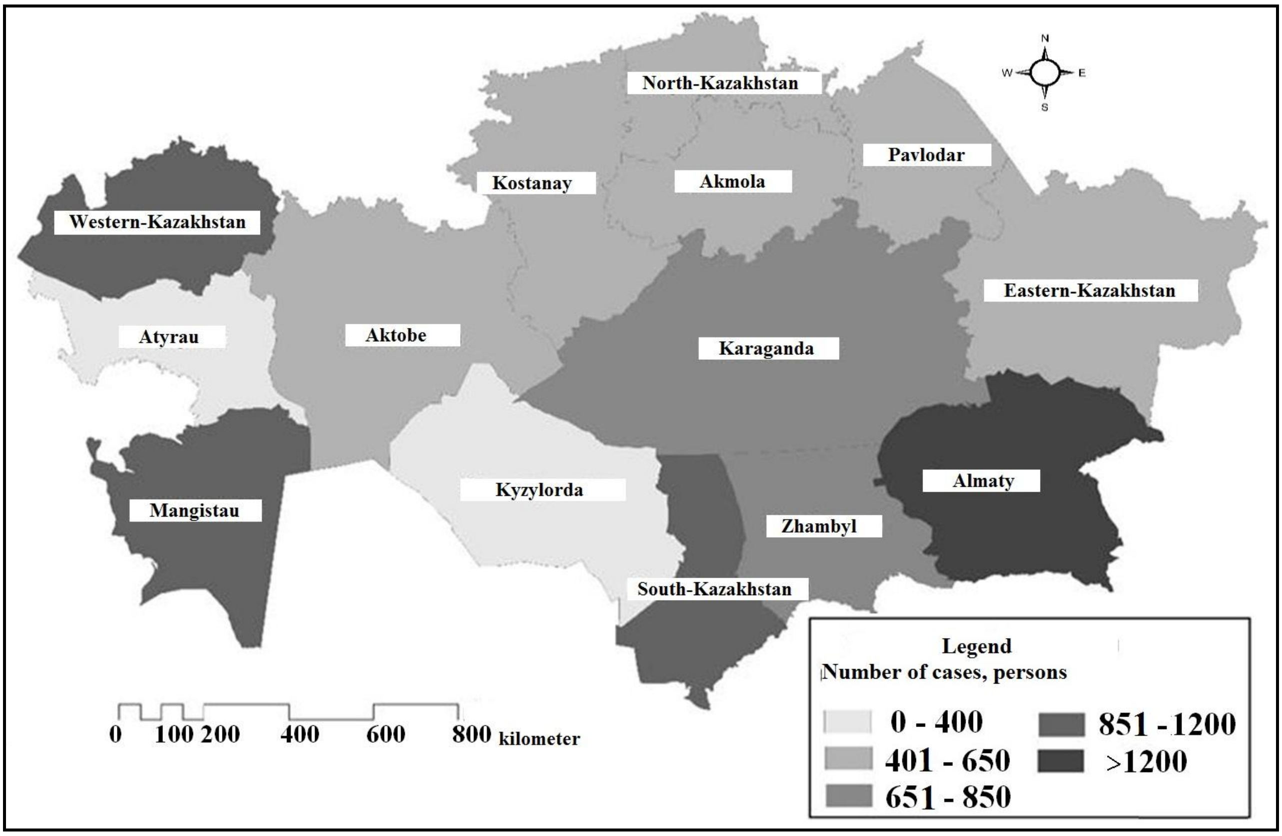


Fig. 7. Schematic map of "hazard indicator", calculated for the population of each administrative unit of Kazakhstan Republic (per every 100 thousand persons).

Results to the Chapters 2 and 3

The Republic of Kazakhstan has a big variety of allergenic plants. We selected 59 species from 32 genera and 6 families. Allergens, which pollen can cause pollinosis, are widespread over various regions of the country. While studying the distribution of allergenic flora, we revealed the dominance of arid complex flora, such as Poaceae (*Poa, Stipa, Festuca* genuses) and Asteraceae (*Artemisia*) families.

Allergenic species are taxonomically and ecologically diverse. They can be found in all natural zones and mountain belts of Kazakhstan, while every zone and belt has its specific allergenic species. Big numbers of arid complex species are typical for the lowland regions of Kazakhstan, the dominant families are Poaceae (*Poa, Stipa, Festuca*) and Asteraceae (*Artemisia*). The mountain regions have a big diversity of allergenic species; the main dominants are *Artemisia rutifolia,* *A. dracunculus, Festuca kryloviana, F. gigantea, F. valesiaca, Helictotrichon pubescens*, and *P. alpina, P. bulbosa, P. angustifolia* of Poa genus, as well as *Pinus sylvestris* as a tree species.

Vegetation in the river valleys develops under special ecological conditions, which are different from lowland and mountain. The most important among them is water supply. The following species are spread along the river valleys: *Populus diversifolia, P. alba, P. nigra, P. laurifolia, Salix cinerea, S. trianda, S. viminalis* and *Phragmites australis.*

Analyzing the phenology of allergen flora blooming, we can select several periods of flowering: 1) spring (April-May) for trees and shrubs; 2) summer, dividing into 2 stages: a) June-July for Poacea family; b) July-August (September) for weeds of *Artemisia* genus and Chenopodiaceae family.

The most allergically dangerous species are representatives of Artemisia genus, Poacea and Chenopodiaceae families, which are very frequent and dominant in steppe, semidesert and desert ecosystems. There is a few of less dangerous species from Poacea and Chenopodiaceae families. They are rare and, according to some scientific-medical literature sources, their pollen is not very dangerous.

The highest indices of allergenic species are typical for the Eastern-Kazakhstan and Almaty Regions: the Eastern-Kazakhstan has the higher number of allergenic species during spring – about 19 species; Almaty reaches its maximum during summer – 30 species. In total for the whole period of flowering, these regions also prevail: the Eastern-Kazakhstan region with 46 species, and Almaty with 42. We can also mention Kostanay and Karaganda Regions with a high index of allergenic species – 39 for each. According to the results of researches, the least dangerous are Atyrau, Mangistau and Kyzylorda Regions with only 22-25 allergenic species for the entire period of flowering, which is two times less than in the Eastern-Kazakhstan and Almaty Regions. For the whole period of flowering and for spring and summer separately, those regions have minimal indices: 16-18 species in summer, and 5-6 in spring.

Calculation of "allergenic danger" index revealed the regions with the higher (lower) favorable conditions for the allergy sufferers during various seasons. In summer the highest index was registered for the Eastern-Kazakhstan Region, with the value of 62, and Almaty with 60. We must also mention the high "allergenic index" in Aktobe, Karaganda and Zhambyl Regions with 58. The lowest index is in Mangistau region – 31. In spring the most dangerous are Kostanay with 39 and the Eastern-Kazakhstan Region with 41, as well as all regions of the northern Kazakhstan, where index varies from 32 to 38. The less dangerous during spring are Altobe, Atyrau and Kyzylorda Regions with the index varying from 12 to 15.

In total the most dangerous regions, according to the number of allergenic species and "allergenic index", for the whole period of flowering are the Eastern-Kazakhstan and Almaty Regions, because they are economically developed and have a high level of environmental pollution. The less dangerous are Mangistau, Atyrau and Kyzylorda Regions.

When calculating the index of allergenic danger for the population of each administrative region, we revealed the Almaty to be the most vulnerable one, with 1600 sick individuals per each 100 thousand of people. The least dangerous regions are Atyrau and Kyzylorda, with only 400 potentially sick individuals per 100 thousand.

4. Allergenic Indigenous and Introduced Plant Species of Moscow and Moscow Region

It is practically impossible to find indigenous vegetation in Moscow and Moscow Region. The modern processes of urbanization transformed the natural vegetation communities and floras. Such big cities as Moscow form a specific natural-urbanistic environment, and their local flora gets disturbed by introduced species.

Nevertheless, the diversity of natural and artificial habitats determines flora composition and diversity. Flora of Moscow region has more than 1600 species of vascular plants, while 730 of them are indigenous (Flora of Moscow, 2007).

Green plantations play an important role in city life. Moscow is one of the greenest megalopolises in the world. It includes 17 forest parks, 17 city parks, 58 regional and 9 specialized parks (table 3), 14 gardens, about 700 squares and 100 boulevards, their total area is 35100 ha (Ecological ..., 2000).

Results and Discussion. Indigenous species. The representatives of allergic indigenous flora are several genera of trees: hazel, pine, ash-tree, oak, alder, linden, willow, fir-tree, elm, birch, as well as some weeds and Poaceae species.

Table 3. Forest parks of Moscow city.

Name of Forest Park	Territory, ha
Khimki forest park	277.0
Khlebnikovo forest park	328.2
Forests of the K.A. Timiryazev Agricultural Academy	248.0
National park “Elk Island”	2910.0
Forest park “Sokolniki”	590.0
Forest park “Izmaylovo”	1295.3
Terletsky forest park	141.5
Forest park “Kuskovo”	302.0
Saltykovka forest park	24.0
Forest park “Kuzmiki”	946.4
Vidnoye forest park	23.0
Biryulevo forest park	348.7
Forest park “Tsaritsyno”	175.0
Natural park “Bitsevskiy Forest”	2230.0
Yasenevo forest park	625.0
Olympic forest park	793.0
Butovo forest park	280.4
Troparevo forest park	502.0
Fili-Kuntsevo forest park	284.0
Bakovka forest park	40.0
Serebryanyy Bor Forestry of the Russian Academy of Sciences	533.0
Pokrovsko-Streshnevskiy forest park	238.0
Khoroshovo forest park	197.0
Krasnogorsk forest park	58.0
Kryukovo forest park	875.4
TOTAL	12671.9

Meanwhile, the distribution of species on the territory of Moscow is heterogeneous. This phenomenon is associated with ecological features of species and city landscaping. Thus, according to the norms of trees and shrubs planting in the city dated back to 1988, the main assortment of planted species was *Betula pendula*, *B. pubescens*, *Quercus robur*, *Picea pungens*, *P. abies*, *Tilia cordata*, *T. platyphyllos* and green ash. All of them can cause allergy. According to the data of the Department of Nature Management and Environmental Protection of Moscow, linden is the most abundant (32%) tree in this city.

Invasive species. The estimation of the invasive species' role in flora and analysis of their distribution are very important, because those species may be dangerous for the biodiversity and for public health due to their being very allergenic. In some cases they hybridize with local species, which leads to the growth of new "super-active transformed species" (Mayorov et al., 2012). Their impact on flora and public health is hard to predict. In Russian Federation the control over invasive species is not regulated by law, thus, invasive species occupy more and more territories with each year.

For our analysis we selected the ragweed among all invasive species. In Moscow Region it is represented by 3 American species, but the most abundant is *Ambrosia artemisiifolia* L., while *A. trifida* L. and *A. psylostachya* DC. are known only by single encounters.

The homeland of *A. artemisiifolia* L. is United States of America. It is widespread in eastern and central states. It can be met in other countries as well. It is introduced nowadays to all parts of the world and is included in the list of 100 most aggressive invasive species of Europe. In Russia it is considered as quarantine weed according to the Decree of the Ministry of Agriculture of Russian Federation, 15.12.14, No. 501.

All three species are dangerous for ecosystems, because they dominate plant communities while spreading, naturalize and are hard to eradicate (List ..., 2003).

Ambrosia was detected for the first time in Kolomna in Moscow Region (Oktyabreva et al., 1978). It is found every year on the slopes of the railways, in weedy places and wastelands.

In the XXI century the problem of invasive species distribution and their pollen is acute, because the pollinosis diseases become very widespread. The program of aeropolynological researches in Russia was developed in 2001. In several cities the special stations have been organized for monitoring of pollen emissions. One of those cities is Moscow. Aeropolynological stations work from 15th of April to 15th of September each year (during the period of maximum pollen emission). Data on quantity and quality of pollen is being published in two web sources: Pollen Calendar (2015) and Allergology (2015).

Analysis of this data allows us to study the terms of species flowering, their abundance, state of population isolation, changes in vegetation cover, as well as pollinosis distribution.

Allergenic plants can be divided into 3 groups: flowering during spring (from April-May to the early June), summer (June-August) and from summer to autumn. During the first period of exacerbation of pollinosis the tree species emit pollen: alder, hazel and birch in March-April; willow, poplar, elm, ash and maple in the late April; oak and coniferous trees (pine and fir) in May. The most allergenic is the birch pollen; its content in the air during the spring emission is maximal. During May oak has the maximal content of pollen. Linden has the latest pollinate period – in June.

The mentioned list of allergenic species was registered on every area of the territory under consideration. It may be connected with the severe disturbance of the urban vegetation communities, which makes the weeds spread widely.

The pine tree has the most homogeneous distribution, the number of its trunks is not high, it is not used for landscaping and is not the initiated plant (as birch and aspen). The alder, oak and hazel are not abundant as well. The most widespread species are maple, birch and linden; while linden and maple are actively used for city landscaping. The greenest part of Moscow is the South-Western County; according to the registry, it has 659997 allergenic trees, which is 18% of all allergenic trees in the city. The least green part is North-Western County with 51418 trees (1.4%). For the other administrative districts the figures are: Northern – 428099 (11.7%), North-Eastern – 533557 (14.7%), Eastern – 561927 (15.4%), South-Eastern – 251950 (13.8%), Southern – 398682 (10.9%), Western – 351792 (9.6%), Central – 391659 (10.7%). The total number of trees is 3629081 (fig. 8).

The maple species has largest number of trees due to the features of their registration; the local and introduced species are not distinguished and are planted together in the green zones of the city, causing high population numbers.

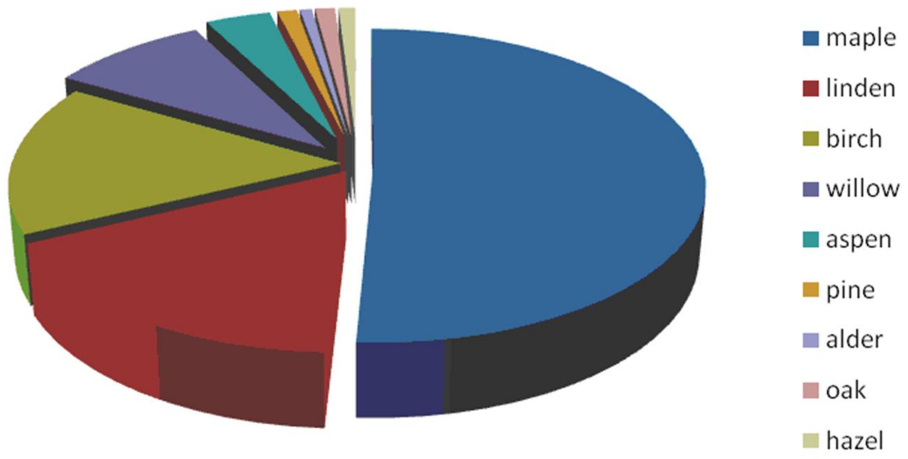


Fig. 8. Various tree species ratio in Moscow.

Introduced allergen species. Ambrosia artemisiifolia is a quarantine weed, which is dangerous for economy and biodiversity, as well as for the public health. This plant provokes allergies during its flowering period from the late summer to the early autumn, causing asthma twice as often as the other allergen species (Dahl et al., 1999). Human vulnerability to the pollen arises when the number of pollen grains reaches 20 units per 1 m^3 of air.

This ambrosia species is wind pollinated. Anthers open when the temperature grows and the humidity is low, i.e. mostly in the morning after sunrise, the emission of pollen lasts only for 6 hours (Martin et al., 2010). Pollen production varies depending on the size and age of the plant from 0.1 up to 3.8 billion of pollen grains per plant (Fumanal et al., 2007). Diameter of pollen grains is 18-22 microns (Taramarcaz et al., 2005).

Living conditions. In the indigenous habitats *A. artemisiifolia* grows under conditions of moderate continental climate (Bassett, Crompton, 1975). In the Europe the optimal conditions for it are high temperatures during the vegetation period (Essl et al., 2009). In the Central Europe the limiting factor is the low summer temperature (Essl et al., 2009). This phenomenon explains the absence of this plant in the mountains of the most territory of Europe.

A. artemisiifolia grows and propagates on the soils with various textures, it is tolerant to trophic conditions, but is vulnerable to high salinity of soils. This plant can endure drought, losing up to 70% of moisture through its leaves without irreversible consequences, and then retain ability of seeds produce. But *A. artemisiifolia* is sensitive to slight frosts, and so the late spring frosts can kill its seedlings (Leiblein-Wild et al., 2014).

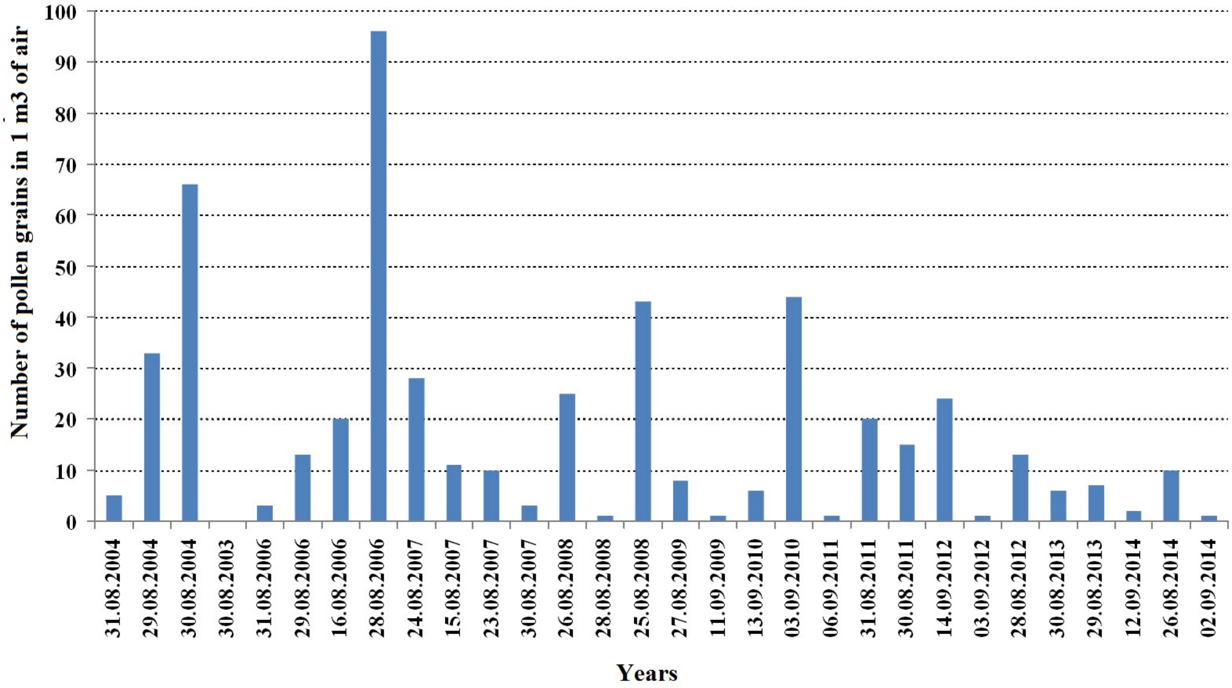
Habitats. In Moscow region *A. artemisiifolia* can be met along the sides of railways, on the weedy places and wastelands. On the territory of its indigenous growing it exists mostly in the disturbed communities, such as arable fields, wastelands, roadsides, but sometimes it can be found in natural communities (Bullok et al., 2012).

Biochemical features. It must be mentioned that *A. artemisiifolia* emits substances which suppress the growth of other plants. The degree of this impact varies depending on the parts of plant (roots, leaves, flowers). The most negative effect is caused by the extract from inflorescence. It was shown in a laboratory research (Vidotto et al., 2013) that the rotting remnants of *A. artemisiifolia* suppress the development of other species seeds. The most sensitive seeds appeared to be *Solanum lycopersicum* seeds, which germination capacity was 50% lower than in the control group.

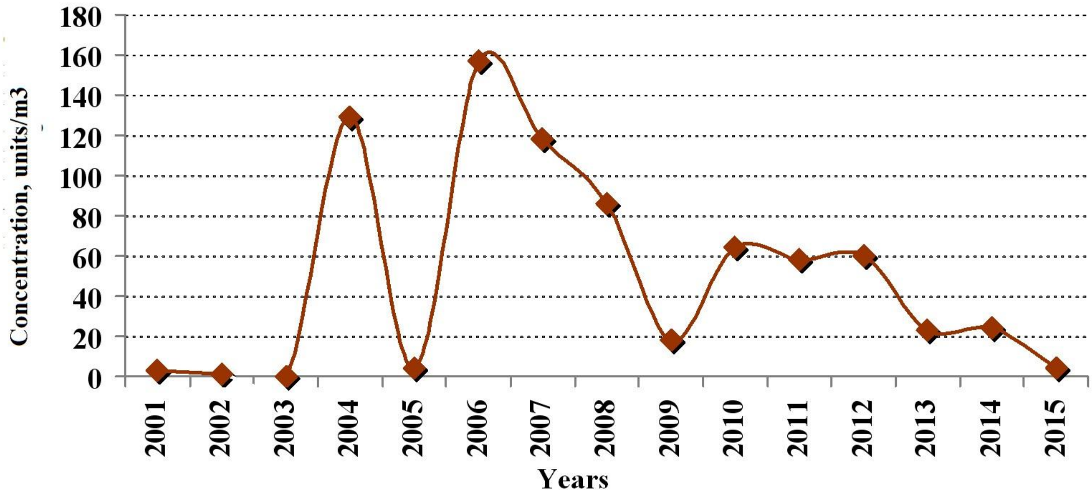
Distribution. The birthplace of the plant is Northern and Central Americas, it is widely distributed in USA, especially in eastern and central states. It can also be found in Canada, Mexico, Peru, Argentina, Bolivia, etc.

Since the early XIX century, *A. artemisiifolia* was introducing into the countries of temperate zone, including Europe, China, Japan, South Korea, South Africa, Australia and New Zealand. The first plants were found on the territory of Russia (former USSR) in 1918 in the suburbs of Stavropol (Maryushkina, 1986). At the end of the XX century *A. artemisiifolia* occupied more than 50 thousand km^2 of Russia and continued its extension in the new century.

The pollen of *A. artemisiifolia* was irregularly detected in aerolynological spectrum in Moscow Region since the beginning of 1994, but not every year. The pollen emission lasts about a week from the late August to the early September, but single grains exist for the whole period from July till November. Number of pollen grains may reach 60-90 units per 1 m^3 of air on some days (fig. 9), reaching the critical level.



a)



b)

Fig. 9. Changes of *Ambrosia artemisiifolia* pollen concentration (units per 1 m^3) in Moscow city (Pollen Calendar, 2015).

Despite the fact that in southern region of Russia *A. artemisiifolia* is widely distributed, it is limited in Moscow Region. Documented findings are shown on the figures 10 and 11. All finding sites are close to the railway stations.

Apparently, the high concentrations of *A. artemisiifolia* pollen are the result of their transportation from the southern regions by the westerlies. Taking into consideration the climatic conditions of the region and the use of herbicides in the agriculture of Moscow region, the further active expansion of *A. artemisiifolia* is unlikely to happen. The plant is unable to compete with local and adventives flora species.

Results to the Chapter 4

At least 17 species of herbaceous allergenic plants are homogeneously distributed throughout the territory of Moscow. The most congeneric distribution and the least abundance among all tree species were registered for pine, which had about 6 thousand trees per district. Alder is also not abundant (from 110 in the Central Administrative District to 9236 in the North-Eastern), oak (from 548 in the North-Western District to 10568 in the Northern) and hazel (from 529 in the Central District to 11629 in the North-Eastern). The highest number and widest distribution were registered for maple (1844815 in the city), birch (564152) and linden (617075).

The highest number of allergenic trees is in the South-Western District, it has 659997 trees or 18% of all allergenic trees in the city. The lowest number is in the North-Western District with 51418 trees (1.4%). For the other administrative districts the figures are: the Northern – 428099 (11.7%), North-Eastern – 533557 (14.7%), Eastern – 561927 (15.4%), South-Eastern – 251950 (13.8%), Southern – 398682 (10.9%), Western – 351792 (9.6%), Central – 391659 (10.7%). The total number of trees is 3629081.

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On the territory of Moscow and Moscow Region *A. artemisiifolia* was detected either as individual plants or as populations. All findings were located close to the railways. In some cases the plants had ripened seeds. Taking into consideration the local climate and the use of herbicides in the agriculture of Moscow region, the further active expansion of *A. artemisiifolia* is unlikely to happen.

5. Relation between the Features of a Wind Rose in the Cities to the Routes of Allergenic Species Pollen

The pollen of wind pollinated plants is the source of pollinosis. Today we know about 700 plants that can provoke allergy. Their pollen has dimensions about 10-50 microns, so it can be easily transported by wind. It is known that the threshold of 10-20 pollen grains in 1 m^3 of air provokes the allergy symptoms.

Results and Discussion. To model the areas of pollen grains, we used methodology that had been used for distribution of pollutants from stationary point-sources. In our case we studied parks and boulevards and modeled the waves of pollination coming from them.

In our work we used the methodology from the Instruction OND1-84, according to Tishchenko (Guide for Consideration …, 1984). The methodology allowed us to simulate the transportation of pollen, taking the wind rose into consideration and using maximum and minimum repeatability. Thus, with this approach as a base, we changed the calculation formula into this:

$$l=L_0P/P_0, \text{ when } P>P_0,$$

where L_0 is the radius in the *i*-direction from the object to the extreme border of pollen complexes distribution without adjustment for the wind rose (km); *P* is an average annual repeatability of wind direction of one rhumb when the circular wind rose is used (for example, the eight-point rhumb wind rose); P_0=100/8=12.5%.

For Astana and Almaty cities we calculated the repeatability of various wind directions in %, the calculations are presented in the table 4.

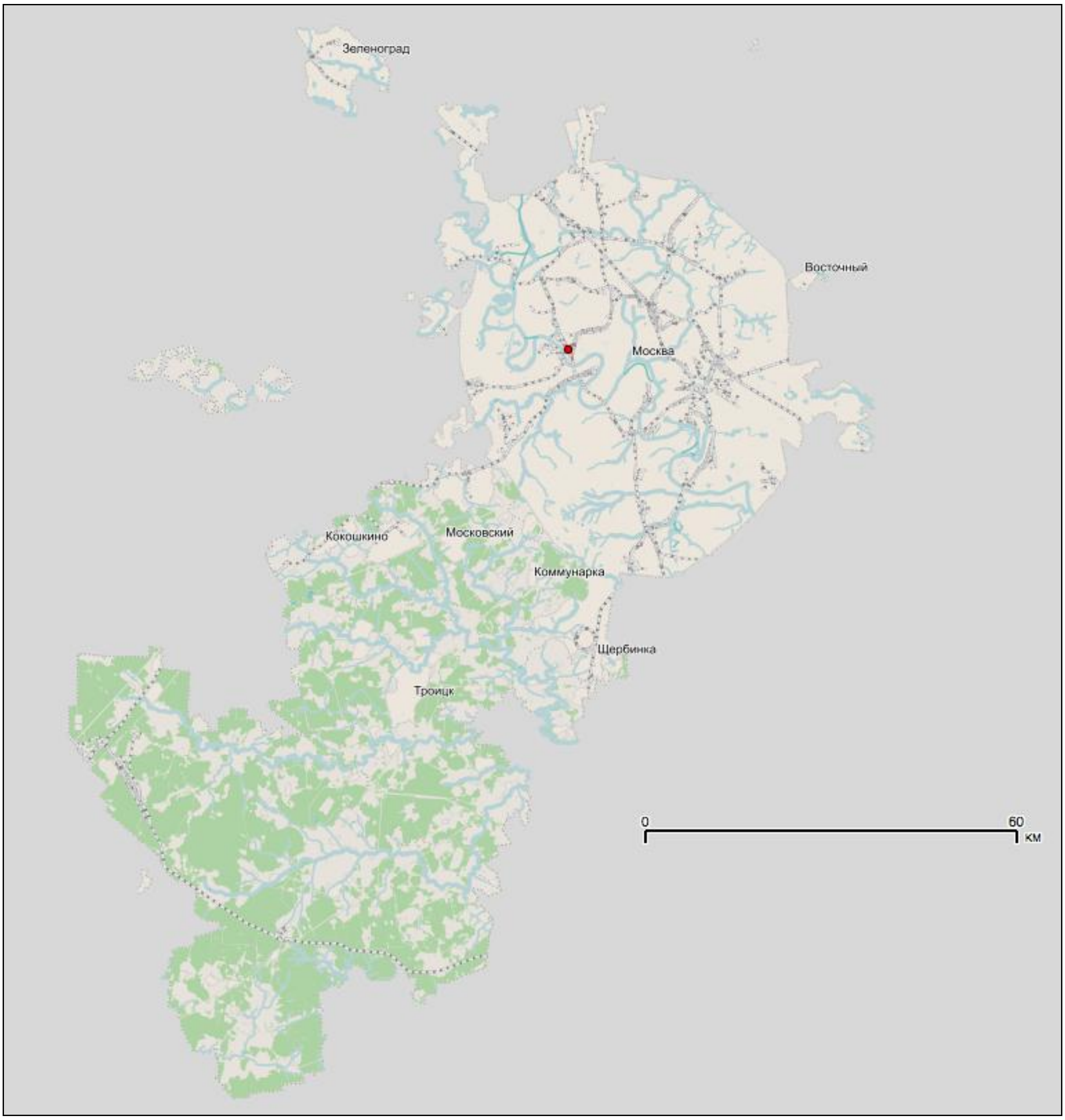

Fig. 10. Findings of *Ambrosia artemisiifolia* on the territory of Moscow city (Presnya Station of the Small Circular Railway where the ripened seeds were found by V.D. Bochkin).

It is worth noting, that for simulation of the pollen grains distribution we chose the spring period of allergenic flora flowering.

The last step of data gathering is identification of the radius of pollen complexes' pollination. We studied some scientific papers, written on the subject of pollen structure and morphology features, and found out that the dimensions of pollen grain affect the distribution range of pollen. Thus, the dimensions of pollen grains of the coniferous plants are respectively small, about 60 μm, and the range of their flight is up to 800 m, which is not much. It is quite the opposite for the allergenic species of small-leaved trees. The dimensions of their pollen is up to 30 μm, and the radius of distribution is up to 2500 m (for example, the sizes of birch pollen, which is the widespread species of the city gardening, are 20-30 μm). The radius values were assigned according to the scientific works in pollen complexes aeropalynology (Statistics of Population …, 2015).

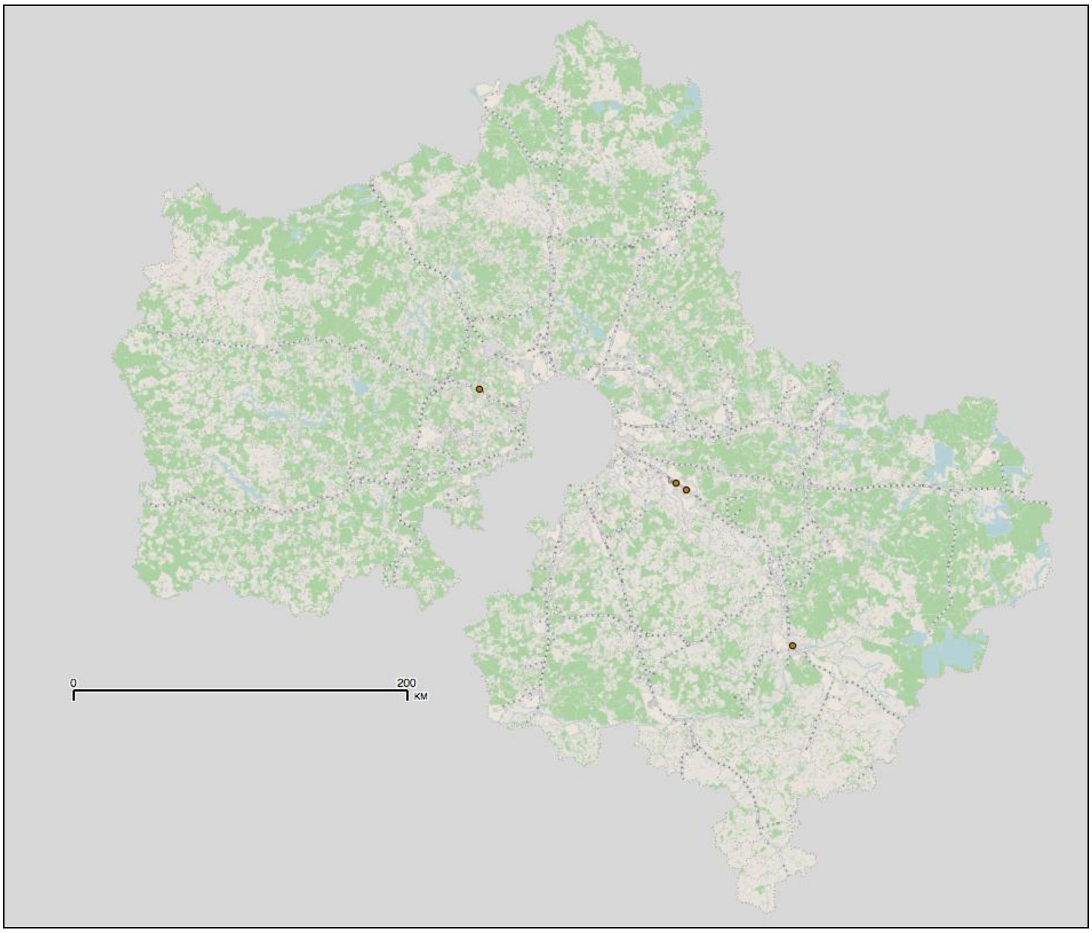

Fig. 11. Findings of *Ambrosia artemisiifolia* on the territory of Moscow region (station Golutvin, Kolomna and Ramenskiy Regions; station Dedovsk, 1 plant; station Kratovo, found by V.N. Tikhomirov).

The species composition of parks and boulevards of Astana and Almaty has many various species, so we decided to divide them into groups: coniferous, small-leaved and broad-leaved trees, and to attach the radius of possible distribution to each group (table 5).

The applying of the remote sensing methodology was the next stage of our work. We used the high resolution space images from SAS.Planet (Web-Cartography ..., 2015) for Astana and Almaty, and GoogleEarth, Yandex Maps, 2Gis to visualize the objects under consideration (parks and boulevards). Besides, we used the reporting materials on urban planning and landscaping. We found out that Astana has 9 parks and 13 boulevards to date, and Almaty has 20 parks. All parks and boulevards have footpaths, benches and various sports and entertainment facilities that stimulate the citizens to spend a lot of time during vacations in these parks.

The data on green spaces was used for the maps of pollen distribution objects.

It is worth noting that the methodology of areal simulation OND1-84 was developed for stationary point-sources only, so, for our areal objects we made additional calculations in ArcGIS and created a buffer, which allowed us to simulate the radius of distribution from the areal objects.

Table 4. Repeatability of various wind directions expressed as a percentage.

Astana													
Direction	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Year**
N	2	3	4	7	9	12	15	13	8	4	4	2	7
NE	9	14	14	13	12	16	19	17	12	8	9	6	12
E	7	7	11	13	11	15	12	12	10	8	8	5	10
SE	13	13	12	12	11	9	9	11	12	12	12	13	12
S	29	25	20	14	15	11	9	11	13	20	22	29	18
SW	29	26	21	17	17	12	9	11	18	24	26	30	20
W	9	10	14	17	16	15	15	15	18	18	15	12	15
NW	2	2	7	7	9	10	12	10	9	6	4	3	6
Calm weather	7	6	4	6	5	6	7	8	8	6	4	5	6
Almaty													
Direction	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Year**
N	26	28	25	20	17	15	15	17	17	19	22	25	20
NE	9	10	10	9	8	9	8	9	10	9	9	9	9
E	6	7	8	10	11	10	10	9	10	9	9	9	9
SE	13	10	13	15	19	21	22	21	22	21	15	12	17
S	18	16	15	19	20	23	23	23	22	20	20	16	20
SW	11	10	11	10	10	9	10	8	7	8	10	12	9
W	10	10	10	10	9	8	7	8	6	8	9	9	9
NW	7	9	8	7	6	5	5	5	6	6	6	8	7
Calm weather	35	32	26	20	18	20	17	18	22	30	34	39	26

This methodology takes into consideration the features of pollen grains of allergenic species (their dimensions and distribution range) and meteorological indices (wind repetition).

As the result we produced maps of allergenic pollen distribution in Astana and Almaty cities (fig. 12, 13).

Parks of Astana are concentrated in the central part of the city. As we can see in the figure 1, the distribution of the pollen complexes during the period of trees flowering covers almost the whole territory of the city, with southern and south-western directions prevailing. Maximal concentration is in the central parts of the city, where the main zones of recreation are situated (parks and boulevards). Allergenic pollen of coniferous trees can be distributed to the range of 800 m and occupy comparatively small areas, while the pollen of small-leaved trees is distributed for 2500 m, thus making the contact with them outside the park zones possible.

Parks in Almaty are evenly distributed in the city, but the majority of them is situated in the south-eastern part. This phenomenon can be explained by piedmont belt in the Medeo and Bostandyk Districts of the city.

Table 5. Pollen size and radius of allergenic plants distribution (Golovko, 2004).

Genus	Pollen size, µm	Radius, m
Group of broadleaf trees		
Acer (maples)	>35	2500
Tilia (lindens)	30-40	2500
Ulmus (elms)	35-40	2500
Group of small-leaved trees		
Betula (birch trees)	20-30	1500
Populus (poplars)	25-34	1500
Salix (willows)	25-34	1500
Group of coniferous trees		
Pinus (pine trees)	45-65	800
Picea (fir trees)	70-90	800

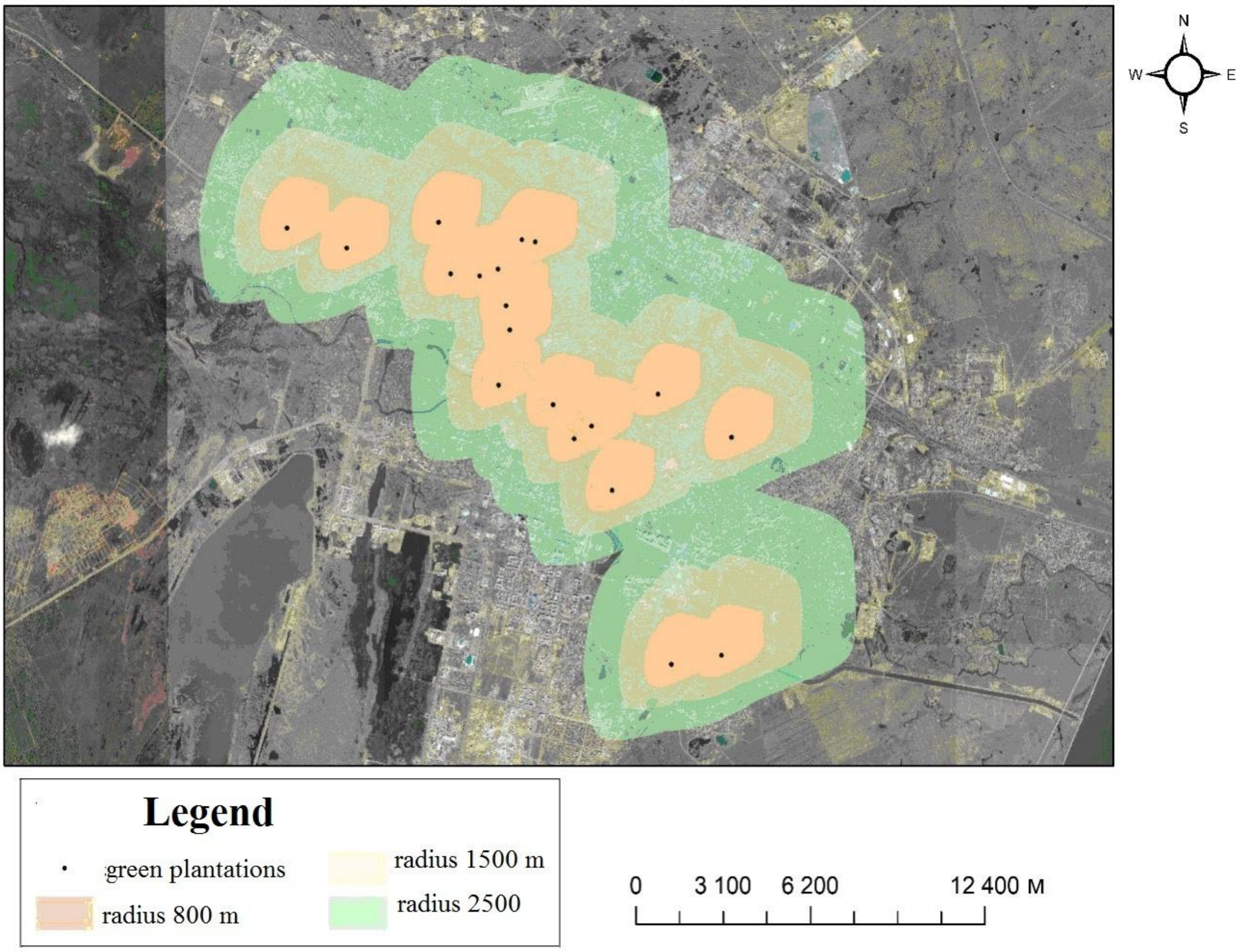

Fig. 12. Map of allergenic species pollen complexes distribution in Astana.

While studying the maps of allergenic pollen of coniferous trees distribution in Almaty, we found out that its maximal concentration is in the southern and south-eastern parts of the city. Those areas are situated at different distances from each other and thus form an area, closed for the allergenic pollen. On the contrary, the pollen complexes of small-leaved and broad-leaved trees form a homogeneous habitat structure. It is especially typical for the small-leaved trees, which are widespread in the city during their flowering period.

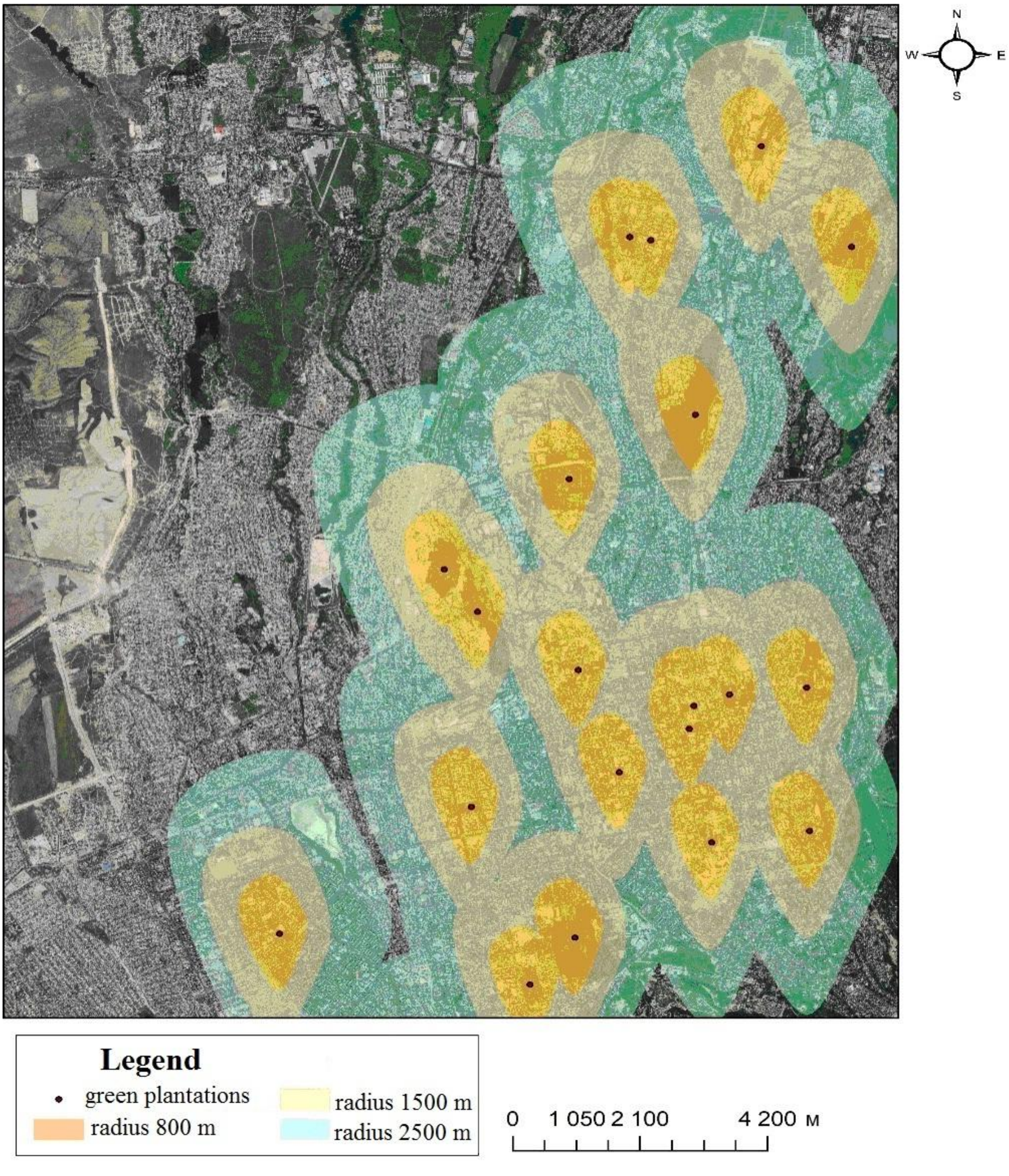

Fig. 13. Map of allergenic species pollen complexes distribution in Almaty.

Results to the Chapter 5

Analysis of the main directions of pollen distribution in Astana and Almaty cities showed that parks and boulevard zones are unfavorable and dangerous for the population that suffers from allergy symptoms.

This problem should be solved at the stage of recreation areas design, namely – the smaller amounts of allergenic species with short pollination period should be used for parks and boulevards.

Coniferous trees can also be an alternative option, become which pollen grains are not distributed to the long distances because of their dimensions and can cause allergy only in individual cases.

Small-leaved trees are of high danger for patients with hay fever and should not be planted in the central parts of the city. They may be planted in the periphery of the city in the well-ventilated areas for pollen to distribute outside the city.

6. Description of Morphological Composition of Pollen Grains and their Role in Allergenic Reactions

Getting into human body, pollen grains may cause pathologic process such as allergenic inflammation. The term "allergy" means an exaggerated body response to various substances (allergens) that normally don't cause any reactions. Usually the protein substances act as allergens, because they bring in heterogeneous genetic information and can cause immune response (sensitization) with formation of immunoglobulins of E class. The repeating contacts between sensitized individuals and allergens will result in allergenic reactions.

Results and Discussion. The pollen grain has from 3 to 17 various water soluble proteins or glycoproteins (antigens) with molecular mass from 10 to 70 kDa. They are mostly concentrated in sporoderm, in electronically dense parts of cytoplasm (mitochondria and ribosomes) and close to the starch granules. Pollen antigens have fermentative activity which influences the transformation of allergen inside the organism and increases its allergenic potential. Thus, the allergenic molecules have additional physiological and biochemical activity which may lead to formation of specific antibodies.

According to the ability of causing an immune response, the allergens are classified as main (major), small (minor) and intermediate.

Major allergens are dominant antigenic determinants that are big, numerous and more immunogenic.

Minor allergens are smaller in dimensions and quantity and less immunogenic. Due to the high homology of protein structures, the immunogenic similarities may occur, that can serve as trigger for immunological cross-reactivity. For example, the main major allergen of birch pollen, which has the greatest input into allergenic reaction, is glycoprotein Bet v1 with molecular mass of 17 kDa, it is included onto the PR-10 Superfamily of pathogenesis-related proteins.

Proteins PR-10 can be found in the trees pollen (birch, hazel, alder, oak) and some products of plant origin (carrot, apple, peach, peanut, kiwi fruit, soya, celery). Consummation of any of those products may result into an oral allergenic syndrome. Meanwhile, PR-10 proteins rarely cause the severe reactions, because they are thermolabile and can be easily destructed under the heat influence and hydrochloric acid.

It is considered that content of PR proteins is higher in plants under stress conditions (for example, high humidity and ecological disadvantage). Therefore, we can assume that residents of environmentally disadvantaged areas are vulnerable for sensibility progression. It is prooved by some epidemiological studies (Pollen Club, 2015; Peredkova, 2012; Shiryaeva et al., 2016).

The hay fever is more widespread among urbanites than rural people due to several factors of urban life, causing allergens to spread. One of those factors is air pollution, such as smog. The mixture of gases, mist and solid particles forms in the atmosphere of megalopolis and may worsen the symptoms of asthma or allergenic rhinitis or cause breathing problems.

Smog is a type of air pollutants, the consequence of reaction between gases, solid particles and sunlight. It is composed of carbon monoxide (CO), carbon dioxide (CO_2), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), and some volatile organic matter and solid particles, such as dust, sand and pollen.

Usually the cars are considered to be the main source of pollution, however trains, buses and trucks also decrease the air quality. Pollution is also partially caused by mechanical (construction, raw materials production) and chemical (coal, oil and gas burning) processes. Smog with high ozone concentrations is very dangerous for people with respiratory tract allergies (Kulusheva, Malosieva, 2016; Pollen Calendar, 2015).

Another birch allergen, named Bet v2 (profilin), may cause the cross-reaction among unrelated plants, such as alder, birch, poplar, olive, elm, sycamore, oak, horse chestnut and maple. However its specific activity is never higher than 5% and does not affect the structure of hay fever morbidity.

Clinical and immunological relevance of minor allergens of birch (Bet v4, Bet v5 and Bet v6) is still actively studied nowadays.

Despite the fact that allergen Bet v1 is the cause of 90% of allergenic reactions, some patients are more vulnerable to the minor allergens than to major ones.

The recent studies showed that not only the pollen allergens can cause sensitization among the people vulnerable to allergies, but other non-protein substances, with pollen origin, for example, “pollen-associated lipid mediators” (PALMS) and adenosine may cause rearrangement of the allergic immune response (Pollen Club, 2015).

Results to the Chapter 6

Thus, some protein and non-protein substances of pollen have different impact on sensitization and clinical manifestation of the disease. People, who are not prone to allergic reactions, will not become hypersensitive to pollen even after a long contact with the large amounts of it. Patients with atopic constitution, worsened by heredity, may become quickly sensitized even to the small amount of pollen and after a short period of contact with it. Contact with allergenic pollen during 2 seasons causes hay fever for the genetically predisposed people.

In some cases the hay fever may affect those people who were previously insensitive to the pollen under the impact of additional provocative factors such as stress, malnutrition, smoking, unfavorable ecology, etc.

Recommendations for Reducing of Hay Fever Risk

As the researches of the allergologists show, the hay fever is more widespread among city people rather than country folk. From the very birth the urbanites are exposed to the impact of exhaust gases and pollutants from industrial enterprises. The mucous membranes of urbanites are always is in the state of dystrophic process or chronic inflammation. On the other hand, the city people have fewer contacts with weeds pollen than the country folks. All this show us that we must analyze the environment in detail and understand its natural-climatic conditions to make further recommendations.

That is why for working out of methodology of risk analysis for the population health we must select the following blocks of this problem and make this approach complex: first, the approach must ne scientific; second, the cooperation between city greening organizations and clinic-diagnostic organizations is needed; third, the organization of information system is needed.

As a result of such work the problem will be solved not only by allergic persons but by various departmental bodies which activities will promote to lowering of risks of the first reaction on allergenic pollen by healthy population.

Let us consider the structure of all proposed blocks.

1. Scientific work is the integral part of the study of pollen allergy problem. It must be based on revealing of the laws of spatial, temporal and seasonal distribution of the main plant allergens in the atmosphere and on the objects, on revealing of priority allergens of plant origin. The working out of algorithm of allergenic plants monitoring in the settlements is the priority task.

The working out of recommendations for aeronological risk management will be the logical result of this process. Making decisions under conditions of ecological risk includes three main stages: estimation, analysis and risk management. The proposed model of decision making model includes the estimation of pollinose risks basing on the results of ongoing monitoring and definition of the allergenic danger of main plant taxones, analysis of risks based on estimation of pollen quantity in the air and level of hay fever morbidity as well as practical measures of risks management.

The important part of the study will be maps showing the prevailing directions of pollen grains distribution.

2. Urban planning and landscaping. In this block the main task is cooperation between urban planning and landscaping organizations and allergists, who must give instructions about degree of danger of plants used for gardening in the city parks, boulevards, small streets and highways. The employees of urban planning divisions basing on the scientific works can choose less allergenic species with short flowering period for the construction of the green carcass of the city.

During the massive flowering the allergenic vegetation produces the pollen grains in large quantities thus filling the atmosphere of the city be allergenic pollen. This time interval is very unfavorable and dangerous for allergic persons, that is why the lowering of pollen quantity is still actual. For our opinion the solving of this problem is possible thanks to the measures that urban planning and landscaping organizations will organize: first, daily morning "gushing watering" in parks, squares and boulevards. It is known from the scientific literature that maximum pollen grains in the air is during morning while the proposed system of watering will help to lower significantly the concentration of pollen in the air preventing it from distributing to the long distances; second, using of "pollen traps", for example, as duct tape which could be placed in the recreation centers (parks, boulevards) and on the building facades. All those measures will lessen the concentration of pollen grains in the air of big cities.

3. Work of information system. Working out of information and communication system based on spatial, temporal and seasonal distribution of main plant allergens will promote the organization and sustaining of the system of informing about the allergenic situation with estimation of allergenic risks for the public health in the real time conditions. The preparation of handout material about the allergenic risks and recommendations for avoiding the allergy will be necessary.

These approaches will improve the state of environment, will enlighten the population of cities or settlements and promote the organization of diagnostic laboratories. But the main task is to change the self-awareness of population because the majority of people don't know how to fight the first symptoms of hay fever, do not go to the allergic centers and self-medicate. That is why we give the main rules for the persons who feel the first symptoms of allergy.

Main rules:

1. At the first signs of hay fever it is necessary to consult a doctor and not try to treat yourself. Well-timed diagnostics of the disease and adequate allergy-specific immunotherapy will enable persons to prevent the development of bronchial asthma or other diseases. The comprehensive approach will preserve the vitality and ability of the patient.

2. It is very important to avoid contacts with pollen that cause the high vulnerability. If there is no possibility to leave the city for the period of allergenic plants flowering, it is advisable to avoid the places where there is a lot of allergenic plants (in the field or country house).

3. During clear sunny weather, especially in the mornings when the pollen is in the air it is advisable to wear sunglasses and protect the nose by handkerchief. If you work in the field or

garden it is advisable to wear face mask. During the period of allergenic plants flowering it is advisable to make wet cleaning of the apartment, especially after ventilation.

4. The principal measures are all means that can lower the concentration of pollen in the air. If the meadow herbs on the lawns are timely mowed they will not produce pollen. The weed control at least in the cities will lower the pollen content in the air and hay fever morbidity.

5. The important point in pollinosis prevention is the correct physical education and hardening of the body. Thus before voyage, trip or nature excursion the responsible for the event person must explain the members the risks of allergy, find out those predisposed to allergic diseases that will lessen the risk of hay fever danger.

Conclusion

The approaches and methodologies of studying the allergenic plants distribution presented in this paper are applied for the first time. In future the authors hope to develop the named methods and prepare the series of papers considering each method separately.

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