

ІННОВАЦІЙНІ ЛАНДШАФТОЗНАВЧІ ДОСЛІДЖЕННЯ

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ACOUSTIC PROPERTIES OF THE MODERN LANDSCAPE: PROBLEMS OF KNOWLEDGE AND PROSPECTS OF RESEARCH

Annotation. The problem of research of acoustic properties of a modern landscape is considered; the analysis of foreign and domestic experience of knowledge of these properties, and also understanding of concept «sound landscape» is carried out; It is noted that natural geographers pay more attention to the study of acoustic properties of residential, mostly urban, as well as road and recreational landscapes. In Ukraine, knowledge of the acoustic properties of the modern landscape needs to be intensified. In particular, this applies to studies of the sound landscape of individual cities, industrial regions, road landscape engineering systems, recreational areas, and so on. The study of the sound landscape of Vinnytsia was conducted using the methods of classical and anthropogenic landscape science and specific approaches, which made it possible to develop the basis of the future map of the sound landscape of Vinnytsia – a map of the sound relief of the city. Phytocomponent of the modern landscape of Vinnytsia and, in part, road landscapes of Podillia. In the future, more attention should be paid to comprehensive research of sound landscapes, their classification, the importance of sounds in the formation of the landscape itself and human life and health.

Keywords: anthropogenic landscape, acoustic landscape, sound landscape, acoustic space, sound background, biophony, geophony, anthropophony, acoustic properties, sound relief, rational use.

Денисюк Г. І., Канський В. С., Канська В. В. АКУСТИЧНІ ВЛАСТИВОСТІ СУЧАСНОГО ЛАНДШАФТУ: ПРОБЛЕМИ ПІЗНАННЯ Й ПЕРСПЕКТИВИ ДОСЛІДЖЕНЬ

Анотація. Серед цих нових, унікальних і перспективних напрямків сучасного ландшафтознавства особливо актуальним є вивчення його акустичних властивостей, зокрема, дослідження різноманітності та глибини звуків, певні якості яких проявляються в ландшафті. Ландшафтні звуки – це елементи геоінформаційної системи середовища, які відображають певні природні, соціально-економічні та культурні явища. Вони є специфічними для кожного регіону і є частиною «духу місця». Звучання ландшафту є важливим елементом природної та культурної спадщини і звуки особливо «чутливими» до змін ландшафту, викликаних розвитком цивілізації. Акустичні властивості ландшафтів необхідно охороняти як складову нематеріальної культурної спадщини. Звуки, які з певних причин є унікальними або мають особливу цінність для місцевої спільноти, можна знайти майже в кожному середовищі. Між людиною та місцем, яке визначається звуковим фоном ландшафту, можуть виникати сильні зв'язки.

У статті розглянуто проблему дослідження акустичних властивостей сучасного ландшафту; здійснено аналіз зарубіжного і вітчизняного досвіду пізнання цих властивостей, а також розуміння поняття «звуковий ландшафт»; зазначено, що географи-природники більше уваги приділяють дослідженням акустичних властивостей селитебних, переважно міських, а також дорожніх і рекреаційних ландшафтів. В Україні пізнання акустичних властивостей сучасного ландшафту необхідно активізувати. Зокрема це стосується досліджень звукового ландшафту окремих міст, промислових регіонів, дорожніх ландшафтно-інженерних систем, районів рекреації тощо.

Дослідження звукового ландшафту м. Вінниці проведено з використанням методів класичного й антропогенного ландшафтознавства та специфічних підходів, що дало можливість розробити основу майбутньої карти звукового ландшафту Вінниці – карту звукового рельєфу міста, здійснити «звукове» профілювання, а також показати можливості використання наявних матеріалів у процесі формування фітокомпоненту сучасного ландшафту м. Вінниці та, частково, дорожніх ландшафтів Поділля. У майбутньому необхідно більше уваги приділити комплексним дослідженням звукових ландшафтів, їх класифікації, значимості звуків у формуванні самого ландшафту та життєдіяльності й здоров'ї людей.

Ключові слова: антропогенний ландшафт, акустичний ландшафт, звуковий ландшафт, акустичний простір, звуковий фон, біофонія, геофонія, антропофонія, акустичні властивості, звуковий рельєф, раціональне використання.

Importance and relevance of the researched topic. The rapid development of landscape science in the second half of the XX century has led to the advancement of the research into new areas, which gradually formed corresponding science fields. Among these are geochemistry and geophysics of landscapes, reclamation landscape science, landscape ecology, historical and anthropogenic landscape science, and others. These areas of research have developed unevenly. At the end of the XX century, for various reasons, only landscape ecology (2000-2010) (Hrodzynskyi, 2014) and anthropogenic landscape science (2005-2020) were studied. These areas continue to develop more intensively in Ukraine at the beginning of the XXI century (Mikheli, 2008). In the second decade of the XXI century, natural geographers and landscape scientists of Ukraine began to explore and partially develop new promising areas of landscape research, due to the needs of aesthetic design of modern landscape (landscape design), the importance of its functioning and prospects for the development of anthropogenic micro-, meso- and macro-focal processes (Denysyk, Shmahelska & Stefankov, 2010), understanding of the historic perspective and possibilities for modern use of geoglyphs in the landscape (Kanskyi & Kanska 2016). The research shift has resulted in the development of the areas that were previously out of consideration by many Ukrainian landscape researchers, such as the landscape in people's everyday lives (Denysyk et al., 2020), acoustic processes and phenomena of the modern landscape, the landscapes of the solar system's planets (Kyryliuk S. & Kyryliuk O., 2019), etc.

Among these new, unique and promising areas of the modern landscape research, the study of the acoustic properties is especially relevant, in particular the exploration of the variety and depth of sounds, certain qualities of which are manifested in the landscape. Landscape sounds are elements of the geographical environmental information system that

reflect certain natural, socio-economic and cultural phenomena. They are specific to each region, and they are part of the «spirit of the place». The sound of the landscape is an important element of natural and cultural heritage; it is particularly sensitive to changes in the landscape, which are caused by the development of the civilization. It must be protected as a component of intangible cultural heritage (Bernat, 2011).

Sounds that for some reason are unique or of particular value to the local community are found in almost every environment. Strong connections, called topophonophilia, can occur between a person and a place defined by the sound background of the landscape (Drever, 2005). Changes in the sound background of the landscape are an important indicator of changes in the landscape (Bernat, 2004).

Since the foundation of landscape science, most scientists have not studied all the physical and dynamic characteristics of landscapes. Generally, the main preference was given to the study of hydro-climatic conditions, vegetation, soil cover, relief configuration, landscape structure and its development, anthropogenization, etc. Few scholars paid attention to such characteristics of landscapes as tone, pattern, smell, energy and sound. Usually, these properties of the landscape are explored by artists, musicians, sculptors and others. However, these properties are no less important in the formation of natural (natural, natural-anthropogenic and anthropogenic) landscapes. The sound is one of the important physical characteristics (Hrodzynskyi, 2005a, p. 226).

The study of the «sound landscape» as a research field began in the middle of the XX century abroad. In Ukraine, it is just beginning. It is not surprising that at the beginning of the 21st century, there is no sound methodology for studying the «sound landscape» in Ukraine. There are still many controversial issues regarding the term «sound landscape».

Current state of the researched issue. Specialists in various fields of science and culture were first

engaged in the description, then the study of sound, sound background and, finally, the study of the sound landscape. Each of them considered sounds in the landscape and explored the sound landscape noting some aspects relevant to their creative activity. However, most scientific papers are devoted to the sound landscapes of cities or certain settlements and localities (the term «sound space» is also used). There are many foreign publications, so we note only those that relate to certain aspects of the perception of sounds in the landscape and the definition of «sound landscape».

In Humboldt's artistic descriptions of travels, the characteristics of individual sound phenomena in the atmosphere, on the surface and underground are often found, as well as attempts to give them a scientific explanation (*Humboldt, 2000*). Much attention was paid to sounds in landscapes by V. P. Semenov-Tian-Shanskyi. In the work «Geography of landscape tones, smells and sounds» (chapter XX) he notes: «... the tundra is characterized by the sound of a white owl, ... granite massif in Finland with its pine forests is characterized by a special resinous odor, with weak development of bird sounds, represented by weak, monotonous squeak of the tit throughout the summer and excessive cuckoo cuckoo in the spring» (*Semenov-Tian-Shanskyi, 1926*).

At the beginning of the 20th century, the Finnish geographer Johannes Gabriel Grand noted that the landscape is perceived on the basis of the sensory properties of the environment as a real object of interest for the geographer. Auditory phenomena, according to Grand, are an essential factor that creates a context for landscape perception in the area of close contact. These phenomena consist of tones, sounds, noises and harmonies / disharmonies. Grand created links between science and art. He pointed out that it is necessary to take into account the factor of sound perception in environmental planning and spatial management (*Grano, 1997*).

Different understanding of sound phenomena in the landscape and the corresponding terms are used by Polish scientists: audiosphere, phonosphere, melosphere, sonosphere, auditory horizon, sound sphere, acoustic landscape, sound landscape, acoustic space, background space, landscape sound layer, acoustic climate (*Bernat, 2008*).

The concept of «sound landscape» is also understood differently. Below are some examples. Raymond Murray Schafer (1994): «Sound landscape»

is any acoustic field of study ... We can single out the acoustic environment as a field of study just as we can study the characteristics of that landscape. However, it is not so easy to formulate an accurate impression of the sound landscape as of the landscape»; B. Krause (1987, 2002): all sounds (biophony, geophony and anthropophony) that are present in the environment at the moment, the sound landscape as a finite resource competing for spectral space (niche hypothesis) (*Bryan C. Pijanowski et al., 2011a*); A. Farina (2006): a set of sounds that are related to a certain landscape in the perception of the organism (hypothesis about the ecological field) (*Bryan C. Pijanowski et al., 2011a*); B. Pijanowski (2011): it is a complex composition of sounds from various sources, including biophony, geophony and anthropophony, which creates acoustic patterns in space and time (*Bryan C. Pijanowski et al., 2011c*).

In Ukraine, there are no fundamental scientific principles of acoustic characteristics of the landscape. Some scientists draw attention to the importance of studying sounds in the landscape (*Hrodzynskyi, 2005a, p. 242*). M. D. Hrodzynskiy notes, that «The perception of sounds in the landscape has been studied much worse than the peculiarities of its visual perception. Of course, in its importance, the perception of the landscape hearing is inferior to sight. However, for some cultures (such as the Eskimos, who live much of the year in the darkness and the polar night), the sound perception of the landscape has the same meaning as the visual. Even a man of modern metropolises, who is guided by the rule «it is better to see once than to hear a hundred times», without any sounds and noise in the landscape feels discomfort» (*Hrodzynskyi, 2005b, p. 169*). This scientist also considers the concept of «audio landscape» – a landscape full of sounds (*Hrodzynskyi, 2005b, p. 226*). In this case, M. D. Hrodzynski notes that «not only does a place need sounds, but sound also needs a clearly defined place (meaning geographical sounds)» (*Hrodzynskyi, 2005b, p. 242*). The influence of the sound background of road landscapes on human health was partially studied by Hr. I. Denysyk and O. M. Valchuk-Orkusha (*Denysyk & Valchuk, 2005*). V. S. Kanskyi and V. V. Kanska began to study some properties of the sound landscape of Vinnytsia buildings.

Research methods. The issue of developing methods and techniques for the study of sounds in the landscape and, in general, the sound landscape

remains difficult in the scientific research of foreign and Ukrainian geographers and landscape scientists. However, at the beginning of the XX century (1928) V.P. Semenov-Tian-Shanskyi noted: «... the natural bright tones of the landscape, smells and sounds geography is quite amenable to scientific research» (*Semenov-Tian-Shanskyi, 1926, p. 233*).

Various scholars and people devoted to creative activities are engaged in research of sound propagation in the natural environment, and everyone perceives the ways to addressing the issues differently. For individual sounds, this is acceptable and necessary. However, as our field research shows, if the research examines the sound landscape, where the basic object of research is the landscape, then in the process of learning its sound features it is essential and important to use appropriate methods of modern classical and anthropogenic landscape research (*Denyshyk, 2012*).

The acoustic background of the landscape and, therefore, the sound landscape are so complex and multidimensional that it is impossible to understand and characterize them during a single research. Features of the design of the acoustic background of the landscape and its understanding is that the background must be adapted to the needs arising from the correlation between the current state of the sound background of a particular landscape and the activities carried out by those who use this landscape. Constant, especially stationary sound landscape studies are possible only with the use of various scientific methods, including physics (especially its section of acoustics), mathematics, some technical sciences, as well as biology, ecology, geology and others.

The technique of mapping the acoustic landscape background, fixing its individual sound landscape complexes is an important and complex issue. In particular, the map of the sound landscape makes it possible to understand how the corresponding landscape is structured acoustically, what sounds overlap it completely, where more active sound forms are distinguished, which areas serve as a certain sound background, and which create relative silence. In the process of mapping the sound background, the landscape of Vinnytsia is taken as a model.

Since the beginning of the 21st century, scientists have been developing online projects that help expand the understanding of the sound places and show the connection of sound scenes with places. Some of the projects are international in nature, for

example: Sound cities (*Soundcities*), Sonic Postcards (*Sonic Postcards*), Save Your Sounds (*Save our Sounds*), Sounds of Europe (*Europeana Sounds project*), Sound Tourism (*Sound Tourism*), Sounds of New York (*SONYC. Sounds of New York City*), London Sound Survey (*London Sound Survey*), 100 Finnish Soundscapes (*100 Finnish Soundscapes*). Canadian composer, writer and environmentalist R. M. Schaefer introduced the term «soundscape» into scientific usage. His project «World Soundscape», implemented with the support of UNESCO in the second half of the XX century, deals with acoustic ecology – the impact of anthropogenic noise on the environment and human interaction with the world of sounds.

The purpose of the research is to consider the challenges of understanding the acoustic properties of the modern landscape, the isolation of the sound landscape, its importance in human life, including the impact on health, as well as the need to preserve as an intangible cultural heritage.

Main material. Understanding of the landscape's sound background is similar to the studies of foreign scientists in the acoustic space. According to Marshall McLuhan (*McLuhan, 2001*) acoustic space is a space in which there is no center and no boundaries, in contrast to the strictly visual space. The acoustic space of the city is a place of everyday and functional experience. The sound enhances the feeling of space, expanding it with what we cannot see. The space allows sound to manifest; it emphasizes certain qualities (for example, tone and dynamics) and gives sounds depth and richness (*McLuhan, 2001*). The sounds are characterized by dimensions related to space, namely height, depth, length, volume. The space reveals the tone of sound and acoustic potential manifested in reverberation. The propagation of sound depends on the terrain, the underlying surface and meteorological conditions.

The perception of the sounds quality that accompany various phenomena (pitch, tone, intensity, mood), and perception of the quality of movement phenomena (speed, rhythm, dynamics, tempo) lead to a clearer perception of the outside world. A fuller understanding of the «image of the world» is impossible without the acoustic factor (*Bernat, 2014*). These and other properties of acoustic space are inherent in the sound landscape, in addition to the fact that the latter – the boundaries, perhaps sometimes conditional, but there are. The «landscape» of

sounds is also manifested in the fact that they play the role of boundaries in the landscape (Hrodzyskiy, 2005a, p. 226).

The general perception of the landscape background sound, only as an acoustic space, leads some scientists to believe that sound can be only one of the landscape components, namely a certain derivative that is formed chaotically. It does not. The landscape is multicomponent, and each of them creates its own unique sound. «The peculiarity of the sounds perception in the landscape is that most of them are not simple sounds with their amplitude and frequency, but are the result of mutual overlap of different sound waves. However, we do not hear the cacophony of sounds, but are able to identify them as individual events («sound elements of the landscape»), determine to which places the landscape and its components, these sounds and noises belong» (Hrodzyskiy, 2005b, p. 170). The variety of landscape components sounds, interacting with each other, forms a unique sound background for each

landscape complex. Sound backgrounds are divided into three groups: biophony, geophony, anthropophony. Biophony is the sounds of living organisms used by animals to communicate. These include the sounds of birds, amphibians, insects, mammals, fish, amphibians and crustaceans in both terrestrial and aquatic systems. Geophony is understood as a set of sounds caused by physical processes, such as wind, water flow, thunder and the earth movement. Anthropophony is formed by sounds that occur in the process of human use of mechanical devices (technophony): stationary machines such as fans and air conditioners, mobile machines, in particular, aircraft, cars, boats, construction cranes, bulldozers, etc. (Bryan C. Pijanowski et al., 2011c).

Together they form a certain «sound ensemble» peculiar only to this landscape complex. The basis of any sound landscape is its sound relief. Consider in more detail the sound relief on the example of Vinnytsia (fig. 1).

The Vinnytsia sound relief schematic map is

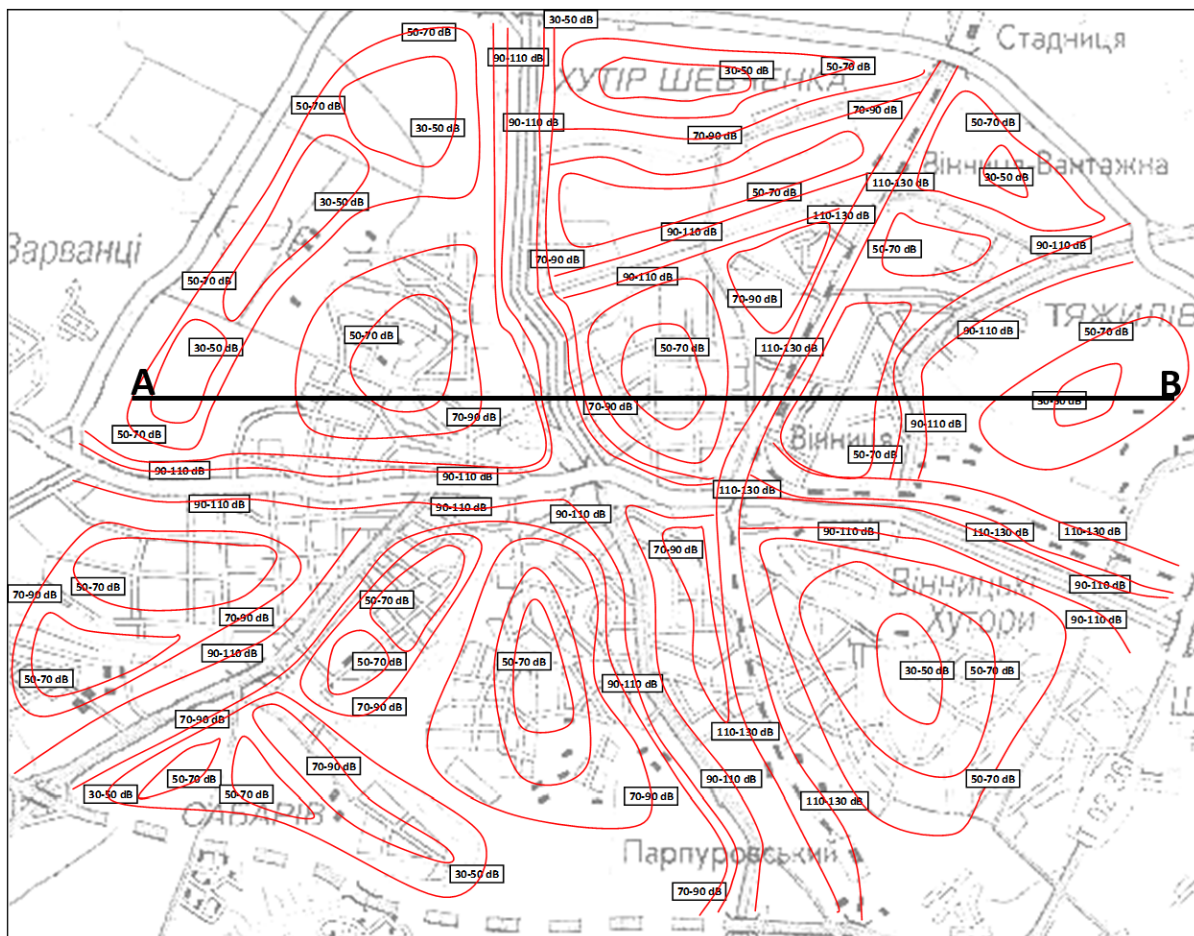


Fig. 1. The Vinnytsia sound relief schematic map

on the Vinnytsia bypass road, the noise increases by 3-4 dB, Kyiv highway (Stryzhavka) – by 3-4 dB, Khmelnytskyi highway (Yakushyntsi) – by 4-5 dB, and if the speed doubles, then – by 10-14 dB. For humans, the objective indicators of noise exposure are not its intensity (threshold 70-80 dB), but the pitch (2-2000 Hz) and exposure time. In the residential and road landscapes of Vinnytsia and Podillia, these indicators and their adverse effects on people, best optimize greenery, including roadside forest belts.

Properly designed and created roadside forest belts have a complex nature of protective measures. To some extent, they not only optimize unwanted geochemical processes, absorb dust and other harmful substances that pollute the air, but also neutralize noise pollution. However, the analysis of existing roadside forest projects, designed with landscape requirements in mind, shows that the «interests» of optimizing unwanted chemical and noise pollution may not coincide. The decrease in the noise level of the environment pollution because of green spaces is due to such phenomena as scattering, absorption and

diffraction of sound waves.

Sound energy, getting from the air into the space filled with tree canopies, passes into another environment – air + leaves, which has the ability to scatter and absorb it. These properties are more noticeable with increasing density of roadside plantings and its maximum approach to the road. However, this is what contributes to the greatest accumulation of carbon monoxide on the road. If we take into account that the acoustic effect of noise reduction is determined by such factors as bandwidth, dendrological composition and planting design, the solution to the problem is more attention to the dendrological composition of green spaces. Analysis of different types of green spaces, their properties and opportunities to reduce noise levels makes it possible to compile appropriate dendrological structures of roadside forest belts for road landscapes of Podillia (table 1).

Construction and the dendrological composition of the strip

Three rows of deciduous trees: sharp-leaved maple, common elm, small-leaved linden, balsam pop-

Table 1. Noise reduction by various types of greenery

Road lane width	Construction and dendrological composition of the road	Level reduction noise, dB
10	Three rows of deciduous trees: a sharp-leaved maple, an ordinary elm, a small-leaved linden, a balsamic poplar (in a row structure of plantings) with a shrub in a hedge or an undergrowth of Tatar maple, spirea kaline-leaved, Tatar honeysuckle.	4-5
15	Four rows of deciduous trees – small-leaved linden, sharp-leaved maple, balsamic poplar (in a row structure of plantings) with a shrub in a two-tiered hedge and an understory of yellow acacia, spirea kaline-leaved, gorse, Tatar honeysuckle.	5-6
20	Five rows of deciduous trees – small-leaved linden, balsamic poplar, common elm, sharp-leaved maple (in a row structure of plantings) with a shrub in a two-tiered hedge and an understory of spirea, Tatar honeysuckle, and hawthorn.	6-7
25	Six rows of deciduous trees – a sharp-leaved maple, an ordinary elm, a small-leaved linden, a balsamic poplar (in a checkerboard structure of plantings) with a shrub in a two-tiered hedge and an undergrowth of white sod, hawthorn, Tatar maple.	7-8

lar (in the ordinary design of plantings) with a bush in the hedge or undergrowth of Tatar maple, spirea viburnum, honeysuckle.

Four rows of deciduous trees – small-leaved linden, maple, balsam poplar (in the ordinary design of plantings) with a shrub in a two-story hedge and undergrowth of yellow acacia, spirea, viburnum, and Tatar honeysuckle.

Five rows of deciduous trees – small-leaved linden, balsam poplar, common elm, maple (in the ordinary design of plantings) with a shrub in a two-story hedge and undergrowth of spirea kalinolisty, honeysuckle, and hawthorn.

Six rows of deciduous trees – sharp-leaved maple, common elm, small-leaved linden, balsam poplar (in the checkerboard pattern of plantings) with a shrub in a two-story hedge and undergrowth of white turf, hawthorn, and Tatar maple.

In cities, there are mostly no opportunities and it is impractical to create such roadside forest belts. There are other patterns and a variety of measures that can be used (fig. 3).

The interdisciplinary project «Sounds of European Cities and Landscapes» (*About Soundscape of Eu-*

ropean Cities, 2009), that was implemented in 2009-2013, covered 23 countries. The main goal of the project was to develop an interdisciplinary research approach to sound landscapes, aimed at improving the quality and protection of the acoustic environment through legal instruments. In the framework of field seminars, laboratory research and conferences, research methods, general indicators of sound landscape assessment, etc. were partially developed. The project focused on the connection between the sound landscape and human health, quality of life, cultural heritage and economy. In particular, in US national parks, sound landscapes are protected as a valuable natural and cultural resource. The Careggi Landscape Declaration on Soundscapes (*Careggi, 2012*) confirms the value of sound landscapes as an element of cultural heritage. In Catalonia, sounds are recorded that are typical of 135 Catalan sound landscapes. This is done to emphasize the connection between sound landscapes and intangible cultural heritage. Even wider practical significance of knowledge of the sound background of the landscape was determined by Semenov-Tian-Shanskyi «Different human races and individual tribes in different climates

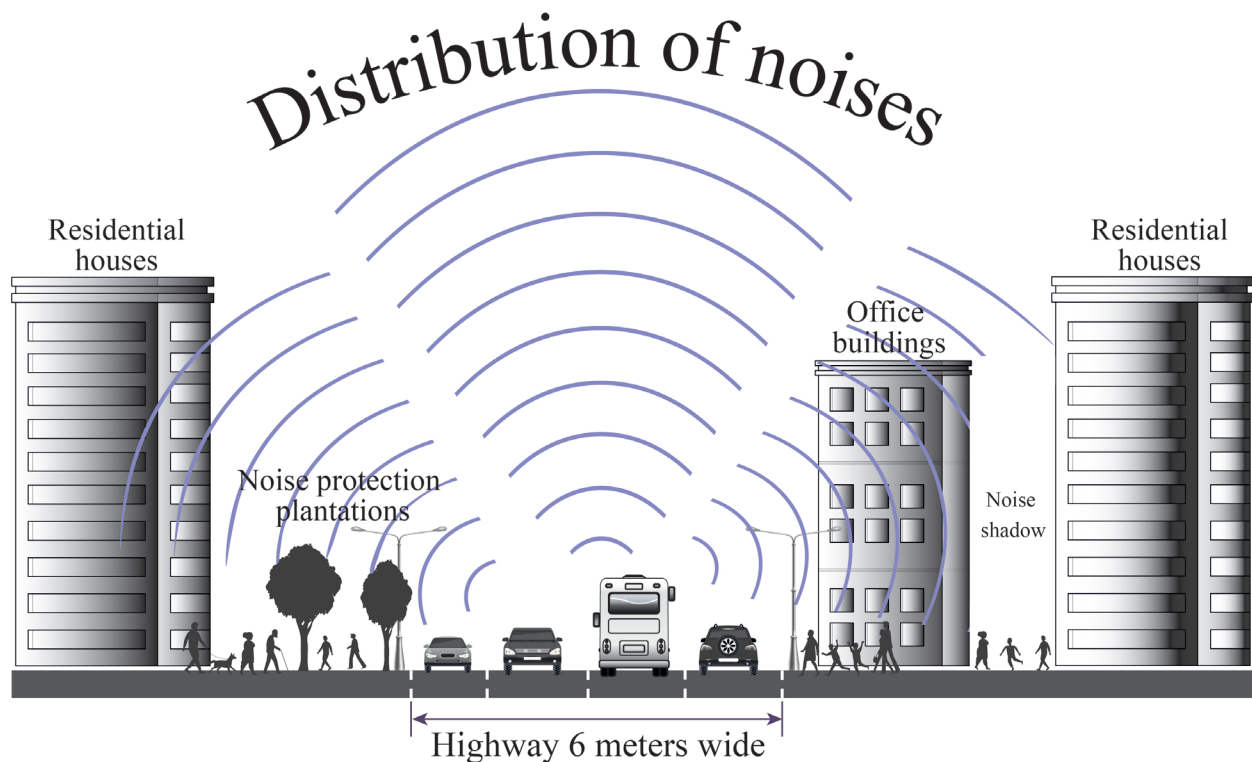


Fig. 3. Scheme of road (street) noise distribution in Vinnytsia (Kyivska Street).

undoubtedly differ in different degrees of musicality and different quantitative ratios of people with high, medium and low registers of voices, their different range, different predominant shades (timbres) of voices, different intonations of the language, then singing, then steep» (*Semenov-Tian-Shanskyi, 1926, p. 231*).

Conclusions. The further development of landscape science in Ukraine will depend not only on classical studies of the modern landscape, but also on new, perhaps at the initial stages somewhat controversial, areas in the field. Among these innovative areas are constructive and engineering landscape science, landscape design, research of acoustic (in particular «sound landscape») properties of the landscape, landscape in everyday life and tourism, etc. For the most part, this will be cross-sectorial research conducted jointly by specialists in various fields of science, or there will be a need to train specialists who will be able to cover two or three fields of science in scientific research. Detailed studies of the modern landscape sound properties require such skills.

Initiated studies of a Vinnytsia sound landscape confirm that such research requires thorough examination of its various components, in particular of its sound relief. They provide an opportunity to better understand the essence and significance of the other sound landscape components, especially phyto-, zoo-, anthropogenic components, to develop measures for their rational development and use. It should be noted that the optimization measures proposed by experts in various fields of science for the overall improvement of the ecological condition of the studied landscape may not always match.

In the course of further sound landscape studies, it is necessary to develop more detailed research methods, to carry out typology and classification, to investigate structure, and also to consider the problem of the modern landscape sound background impact on people's daily lives, their health as well as to develop recommendations on the possibilities of rational sound landscape use in people's economic activities.

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