Development of Methodic Approach to Formation and Selection of the «Green Belt» while Ensuring Environmental Safety of Steppe Zone Cities

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Abstract. The article is devoted to solving the urgent problem - increase of ecological safety of cities due to the use of specific functions of green spaces in the formation of the «green belts». The aim of the work was to develop a technique of forming and selecting the «green belt» zones of steppe zone cities through the example of Rostov region, based on a deep situation analysis of cities’ ecological situation, selection of regional range of perennial vegetation with subsequent selection of plants with tolerance to technological area load and providing performance of certain functions (micro- and mesoclimatic, sanitary and hygiene, safety, etc.). During the studies, we were solving the issue of studying the basic principles of green belts and cores formation of the cities on the basis of analysis of known methodological approaches with further systematization of the most important criteria and development of methods applied to steppe zone cities (through the example of Rostov region). Analysis of existing methodological approaches to the formation of «green belts» of large cities allowed to reveal their advantages and disadvantages, to systematize the most important of the criteria and develop the method of forming of «green belts» of major cities of the steppe zone for Rostov region. Developed methodical approach can be adapted and refined for other physical and geographical zones of the territory of the Russian Federation.

1. Introduction
Vegetation is the basic element of city’s ecological belt necessary to create a comfortable and healthy living environment in major cities [1, 2]. Strengthening of urbanization processes, especially in the steppe zone, brings the formation of «green belts» of cities to the first place for the purpose of ensuring environmental safety of the population. It is known that besides traditional environmental functions, vegetation fulfills a number of specific, but no less important to human features (figure 1) [3-5].

The authors suggest that the green plantings of cities and suburban areas depending on destination, size and location in the plan it is advisable to divide into two areas – the core of the city and outer belt (figure 2.). Updating and creating new elements of «green belt» of the core, the so-called «green islands» – parks, squares, boulevards, recreation areas, pedestrian streets, sports areas is done, but slowly. Forests located on the lands of settlements (urban forests) are often in critical state.
Rehabilitation of urban forests should be well organized and therefore requires development of methodical approach to formation and choice of «green belts» of cities.

| 1. Traditional | 2. Specific |
|----------------|-------------|
| - primary production as a result of photosynthesis; | 2.1. Micro and mesoclimatic: |
| - release of oxygen (as a by-product of photosynthesis) into the atmosphere; | - cooling of the urban “heat island” by increasing the surface albedo and transpiration; |
| - formation of a living space for the consumers and decomposers (environment-forming). | - stabilization of the wind regime, "unloading" of the air masses; |

2.2. Sanitary and hygiene:  
- an increase in the concentration of negatively charged ions (having a positive effect on human health) in the atmosphere over tree-shrub plantings;  
- allocation of biologically active substances that inhibit the development of pathogenic agents in the atmosphere;  
- absorption of air and air polluting solid and gaseous pollutants;  
- reduction of noise due to absorption of energy of the mechanical vibrations that cause it;  
- improving the structure, increasing permeability and, in some cases, soil fertility;  

2.3. Protective:  
- retention of part of precipitation and reduction of surface runoff;  
- retention of snow cover and melt water;  
- consolidation of loose soil;  
- reduction of erosion;  

2.4. Aesthetic:  
- improving the visual properties of urbanized landscapes;  
- improving the appearance of the city and suburban area;  
- creating an interesting design;  

2.5. Recreational:  
- creating good conditions for walks and outdoor recreation;  
- beneficial effect on the human psyche, relief in stressful situations, relaxation.

Figure 1. Functions of green space in cities and suburban areas.

«Green belts» of a city and suburban area

- General use vegetation (urban parks, botanical, zoological parks and gardens, mini-parks, boulevards, etc.)
- Limited use vegetation (vegetation at the kindergartens, schools, colleges, universities, in the residential microdistricts, etc.)
- Dedicated use vegetation (vegetation of sanitary protective zones, water protection zones, along motor roads and railways, forest nurseries, etc.)

«Green belt» core of the city (inside the city)

«Green framework» of the city (city's external boundary)

Urban forests

Forest belts

Figure 2. Green framework of the city and suburban area.

Examination of international (Paris, New York, Pittsburgh, and others) and local (Sochi, Krasnodar, Volgograd, Perm, Voronezh, and others) experience in the creation of «green belts» of large cities [6-22] revealed many problems:
tendency of forming «green belts» without use of specific functions of the vegetation such as participation in the formation of micro- and mesoclimate of the territory, absorption of solid and gaseous air pollutants, noise reduction, etc.;

– absence of accounting data of botanic inventory and study of sanitary and ecological state of existing vegetation of the core and framework of «green belt»;

– absence of accounting of local technogenic loading on components of the environment, and landscaping features of the territory, etc.

All of the above entails the use by different authors of unrelated and uncoordinated principles and criteria of creation of «green belt» of cities, requires systematization and optimization and, consequently, the development of evidence-based methodological approach to formation and choice of «green belts». At that maximum use of specific functions of vegetation (micro- and mesoclimatic, sanitary and hygiene, safety) will facilitate increase of environmental safety of cities.

2. Materials and methods

On the first stage of the research we were solving the issue of identifying the main principles and criteria of «green belt» creation of cities based on the analysis of the known methodological approaches [6-16], their ranging with subsequent development of science-based methodological approach to development and choice of «green belt» frames of cities. At the same time, creation of continuous belts of «green framework» of cities should, in the opinion of the authors, be based on landscape and territorial specifics. Principle of continuity in the formation of the zone of «green belt» should be used in the analysis of the existing landscaping areas, the principle of continuity – when designing new zones to ensure the normal functioning of «green belt», etc.

The principle of relative optimality – with the best combination of the species composition of tree and shrubbery vegetation, necessary for implementation of specific functions of vegetation.

3. Results of the study

Methodological approach developed by the authors to the formation and choice of the «green belt» of cities was tested on lands of Salskoye urban settlement (area of the steppes of the European part of Russia, the steppe zone). The object of the study was the urban forests of the region located in the steppe zone (climax ecosystem). To assess the state of urban forests conventional techniques of botanical studies and forest quarters inventory based on terrain walks in 2018and visual assessment of the ecological state of perennial vegetation by types within the boundaries of test sites (sites 30x30 m, 22x50 m), forest taxation techniques were used. Analysis of natural reforestation was held on test areas of 10x10 m diagonally within test plots boundaries [18-20]. Assessing the environmental status of the stand of urban forests was conducted by the method of V.A. Alekseev [21]. Analysis of assessment data of natural renewability of steppe zone forests reflected adverse, often critical situation in most urban forests of the cities of Rostov region.

Proposed methodic approach allows to form for a certain territory landscaping block of source data comprising information on sanitary and environmental state of perennial vegetation, technogenic load on environment components, choose options of combinations of regional range of plants with ecological plasticity to existing technological load of the area and providing performance of predetermined functions to reduce dust load, noise level and adjusting microclimate parameters. Subsequently it enables to choose the best option for forming «green belt» frames through the use of three groups of criteria and design urban forests planting, providing performance of the required functions.

The proposed methodic approach (figure 3) includes the following basic stages:

1. Preliminary stage – situational analysis of specific city ecological situation, including:

1.1. botanical inventory (determination of species composition of perennial vegetation; main (dominant) forest-forming species; perennial vegetation age; layer age, planting configuration, crowns closure; mean distance between perennial vegetation);
1.2. monitoring of the state of existing perennial plants (determination of the degree of long-term damage to vegetation (climate, pests); projected lifetime of perennial vegetation by habit; values of forest stand state coefficient);  
1.3. evaluation of anthropogenic impact on the components of the environment (landscape characteristic of the territory (area exhaustion); assessment of the chemical, physical and biological contamination of environmental components).  

2. The main stage – formation of the belt of the «green frame», consisting of:

![Diagram](image.png)

**Figure 3.** Sequence of methodical approach realization to formation and choice of a «green framework» belt of the cities.

2.1. selection of regional range of perennial vegetation (plant life form; basic habitual and morphometric characteristics, ecological and biological properties (winter hardiness, drought-resistant, disease and pest resistance), growth rate and vegetative mobility; decorative durability);  
2.2. selection of plants with ecological plasticity to anthropogenic load of the area (gas resistance of woody plants (anatomical and morphological, biological, physiological); smoke resistance of wood species; wind resistance of trees and shrubs (crown shape); photosynthesizing activity);  
2.3. selection of plants, ensuring the execution of predefined functions (by performance of the function (based on preliminary monitoring of plants observation); duration of function performance
(taking into consideration reduction of plant life under anthropogenic loads on the territory); economic expenses for planting and landscaping care).

3. Final stage – designing of «green belt» frame planting by three criteria of selection:

1) environmental safety criteria (to create comfortable conditions for the urban environment):
   - noise reduction efficiency (required $E_{\text{noise}}^{\text{req}}$, required efficiency, dBA (%) and actual $E_{\text{noise}}^{\text{act}}$, dBA (decibels by A scale) (%));
   - dust load reduction efficiency (required $E_{\text{dust}}^{\text{req}}$, mg/km² per day (%) and actual $E_{\text{dust}}^{\text{act}}$, mg/km² per day (%));

2) criteria reflecting parameters of the micro- and mesoclimate of the territory:
   - temperature reduction efficiency (required $E_{\text{temp}}^{\text{req}}$, C (%) and actual $E_{\text{temp}}^{\text{act}}$, C (%));
   - air relative humidity increase efficiency (required $E_{\text{rh}}^{\text{req}}$, % and actual $E_{\text{rh}}^{\text{act}}$, %);
   - wind velocity reduction efficiency (required $E_{\text{w}}^{\text{req}}$, m/s (%) and actual $E_{\text{w}}^{\text{act}}$, m/s (%));
   - change in the aeration of the territory (required $E_{\text{aer}}^{\text{req}}$, % and actual $E_{\text{aer}}^{\text{act}}$, %);
   - solar radiation transmittance coefficient (required $E_{\text{sol}}^{\text{req}}$, % and actual $E_{\text{sol}}^{\text{act}}$, %);

3) the criteria for the designed «green belt» frame:
   - share of green space area in the area of the city ($\eta_{\text{gs}}$, km²/km²);
   - compositional structure (perimeter, shape, configuration);
   - planting densities (G, units/km²);
   - species composition of vegetation, i.e. combination of coniferous and floriferous species (number of coniferous bands $N_{c}$, pcs/km²; number of floriferous bands $N_{f}$, pcs/km²);
   - layerage (number of layers $N_{l}$, pcs.).

At all stages of the implementation of the methodology, regular botanical monitoring of perennial plantings is carried out.

4. Discussion and conclusions

Thus, the analysis of foreign and domestic experience did not reveal a unified approach to a systematic solution to the problem of creation of a «green belt» framework of cities. The study of the advantages and disadvantages of existing methodological approaches to the formation of «green belt» frameworks of cities helped to organize, select and scientifically substantiate the evaluation criteria taking into account climatic conditions, landscape, the impact of anthropogenic factors, the effectiveness of creating comfortable environment, etc. and apply to the cities of the steppe zone.

The developed methodological approach allows to maximally take into account the existing ecological and climatic situation of the territory under consideration and optimize the choice of plants for the formation of the city’s «green belt» framework. It can be adapted and refined for other physical and geographical zones of the territory of the Russian Federation.

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