Ecological and economic interpretation of the soil map constructed by the method of plastic of relief

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Abstract. The paper deals with the possibilities of soil maps, constructed by the method of plastic of relief, to distinguish soil differences based on their association with specific relief forms. It gives examples of the ecological and economic assessment of lands in the Kashirsky district (Moscow region), which were carried out with the help of a map of plastic of relief. The method of plastic of relief was developed by Professor I.N. Stepanov in the eighties of the last century. The authors give a comparative analysis of the results of soil mapping by the traditional method and the method of plastic of relief. Using the example of soil maps of the Ozherelyevsky state farm, they discuss the advantages of the method of plastic of relief for representing soil differences on different relief elements. The soils of the Ozherelyevsky state farm are shown on the map as flows. The hierarchy of height levels of flows is shown. These levels correspond to specific soils according to V.V. Dokuchaev (normal, transitional, soils of depressions). The flows revealed by the method of plastic of relief have a specific direction in space. Due to this quality, it’s concluded that it’s possible to determine the ways of transport of geochemical substances and contaminants in space. This is important to take into account when carrying out reclamation work. The map at the design stage allows structuring land use in the most optimal way and taking a differentiated approach to the economic assessment of lands involved in production.

1. Introduction
Under current economic conditions the world’s population is growing so intensively that according to UN forecasts, by 2050 there will be a need to increase food production by 70%. The requirements for an accurate assessment of soil fertility are increasing, which, in turn, depends on a correct assessment of the structure of the soil cover. According to V.M. Friedland, the structure of the soil cover “has the unity of the history of the development of the processes that created it”. Within any geomorphological system, the heterogeneity of the soil cover is determined by the change in parent rock materials, meso- and micro-relief, erosion processes, and human economic activity.

Based on research, which was carried out by R.S. Ilyin, V.R. Volobuev and V.A. Kovdoyin the 70s of the last century, I.N. Stepanov and his followers [1, 2, 4 - 6] developed the method of plastic of
relief, which allows understanding the processes that to a certain extent determine the spatial structure of the soil cover. The method is based on the representation of the soil as a developing natural body in constant motion. The essence of the method is to represent the structural elements of the earth surface in the form of flows of soil-geological substance. Application of the method in soil mapping allows increasing the degree of its detailing. Studies by A.S. Strelkov, carried out for the Leningrad region [4], showed that 51 soil contours were identified when mapping at a scale of 1:10000 on a soil map compiled on a morphoisographic basis (by the method of plastic of relief). While on the soil map, compiled by the traditional method, 21 contours were revealed. It is obvious that the detailed soil map created on the morphoisographic basis is 2.4 times higher.

The purpose of this paper is to show that the use of the method of plastic of relief to construct soil maps of the Kashirsky district of the Moscow region can significantly increase the detailing and objectivity of soil maps in comparison with soil maps, which were constructed by the traditional method. The subject of research is the method of morphoisographic soil mapping. The object is the soil and relief of the Kashirsky district of the Moscow region.

The application of the method of plastic of relief to mapping the soils of the Kashirsky district and, in particular, the soils of the state farm “Ozherelyevsky”, made it possible to significantly detail the existing soil maps. It is especially important to note that these maps “tied” soils to relief elements. The ecological and economic assessment of the region’s soils using a morphoisographic soil allowed clarifying their information component, which is important for the development of schemes for the territorial organization of production.

2. Materials and methods

Figure 1 shows flow systems and their elements – separate flows. Each flow has a starting point (the highest in the system) – a repeller (R). Soil material is displaced from the repeller to the attractor (A). The bifurcation point (b) is the point from which the bifurcation of the flow of soil substance begins. The boundaries of the flow are determined by the morphoisograph – the line connecting the points of zero curvature (point punches in fragment 3 of Figure 1 D). The line of maximum positive curvature shows the position of the dividing line. The convex surface of the flow (shown in brown) rises above the concave surface (shown in green). Each flow has a common slope from its repeller starting point (R) to the attractor (A). The convex surface of the flow (depicted in brown and number 1 in fragment B of Figure 1) rises above the concave surface or substrate (depicted in green and number 4 in fragment B of Figure 1). Number 3 in fragment B marks the day surface of the flow. This part of the flow is usually depicted on the flat surface of a paper map. Its configuration, general slope, degree and nature of branching are determined by modern soil-forming processes. Number 2 in Figure 1 (fragment B) shows the bifurcation point (b). Here, the flow, developing in a straight line from point R to b (fragment A), suddenly under the influence of fluctuations begins to branch, divide itself into parts, creating a tree-like system. The flow (brown) reflects the past and present movement of soil masses in the gravitational field relative to the green background (substrate). Fragment C shows the hierarchy of height levels of the flow (they are marked with the letters H, P, A). According to V.V. Dokuchaev, these levels correspond to specific soils (normal, transitional and soils of depressions). The highest position on the relief elements is occupied by normal soils (marked with the letter H). Transitional soils of slopes are shown by the letter P. Soils of the lower parts of slopes and depressions are shown by the letter A. Soils, marked with the letter A, occupy concave areas (depressions). Similar forms were identified by the Romanian soil scientist V. Floria (1994), who called the flows peditors, and the structural parts of the flows – pediomas.

The authors of the article had the opportunity to carefully study large-scale soil maps (M 1: 10,000), which were used to draw conclusions about the areas occupied by certain soils in the Kashirsky district. Today, this scale is considered the most detailed, highly accurate and reliable for drawing up agricultural projects. A soil map of the Ozherelyevsky region was constructed by the method of plastic of relief on a scale of 1:10000 (Figure 2B).
3. Research results and their discussion
Comparing the soil map of the state farm “Ozherelyevsky”, constructed by the method of plastic of relief (Figure 2 B), to the map constructed by “Tsentrgiprozem” (Figure 2 A) allowed us to make the following conclusion. It is practically impossible to “tie” soil areas to one or another relief element on the map constructed by “Tsentrgiprozem”. The boundaries of the soil areas are drawn “by eye”. The soils of elevations in the relief are combined with soils of clearly expressed depressions. Moreover, the underestimated areas of the soils of the depressions, the most fertile, are evident.

We can distinguish between “normal” soils or soils of elevations (according to V.V.Dokuchaev) on the map constructed by the method of plastic of relief. The soils of transitional slopes and soils of depressions are clearly distinguishable (according to V.R. Williams). There are significantly more depressions on map B than on map A. Moreover, it turned out that there were significantly more soils of depressions in the calculation tables of the Tsentrgiprozem Institute as well. There is a huge disagreement in calculating areas. This significantly disorients the heads of agricultural production who plan land management and agricultural work. Map A was created during the years of collective farms (state farms) in the country (USSR). Therefore, we can assume that the soil map in Figure A was constructed “for a collective”. It was constructed when in numerous state and collective farms MTS (Machine and Tractor Stations) served the agricultural machinery, which was sufficient to process vast areas of land in a short time. Maps with a detailed image of the relief and soils, as in Figure B, were not needed for such wide-coverage machinery; on the contrary, “patchwork” maps with wide uniform fields were in demand. But after 1991, in the context of the changed Russian economy, completely different soil and soil-ecological maps were required. Maps were required that would show the heterogeneity of the relief and soils, and the biological diversity that associated with them.

![Figure 1. Flow systems and their elements (see the description in the text).](image_url)

The more heterogeneous the landscape conditions are shown on the maps, the more “ecological” the map is, and the more information about biological diversity it carries. Under new economic conditions, when an individual but not a collective became the owner of the land, the state started to distribute the former vast land plots between individual economic entities in small areas (from 0.5 to 20 hectares). The former map A, intended for collective agricultural use, ceased to be relevant, and it could no longer meet the needs of the day. So, map B, intended for a separate, individual land owner, became necessary and demanded. The official land authorities needed soil maps with a more detailed...
and objective depiction of the structure of the soil cover. However, the construction of those maps shouldn’t have required high cost.

![Soil map of the state farm “Ozherelyevsky” in the Kashirsky district, constructed by the traditional method (A) and the method of plastic of relief (B). Scale 1:10000.](image)

**Figure 2.** Soil map of the state farm “Ozherelyevsky” in the Kashirsky district, constructed by the traditional method (A) and the method of plastic of relief (B). Scale 1:10000.

What do soil maps constructed by the method of plastic of relief give for the economic and environmental assessment of lands?

Let us consider a fragment of the soil map of the state farm “Ozherelevsky” (Figure 3). The fragment shows a plot of approximately 20 hectares. Map A distinguishes between gray forest soils (Л₂), dark gray forest soils (Л₃), and lands of the state forest resources (SFR). In this case, one can only assume that the soils of the lands of the state forest resources (SFR) mark the soils of depressions in the relief. A completely different picture opens up if we read the information about the same plot on map B in Figure 3. On map B, the depressions are shown with a white background, and the soils of the elevations are painted over. On map A, the entire surface of the agricultural field is flat (with a flat relief), and on map B, the surface consists of convexes (elevations) and concavities (depressions). It can be seen that the flow of soil substance with gray forest soils on the plain (on the watershed surface) on map B extends mainly in the northern direction. At the same time, it can be seen that one part of the flow (I) is directed to the west, and the other to the east (II). The middle part of the flow is flat and elevated. Each separate branch of the flow has its own ecological niches within the slopes of different exposures – northern, southern, western and eastern. On the map, these “niches” are depicted in different colours: red indicates the slope facing south (S). Blue indicates a slope facing north (N). Green marks the slope facing east (E). The slopes facing west are shown in brown (W).

![Fragments of maps A and B.](image)

**Figure 3.** Fragments of maps A and B.
What does it mean for assessing the state of ecological conditions for living organisms within these “niches”? In fragment A, a house for living organisms is presented as a hostel or barracks for common (joint) living in the same conditions for all living beings, without taking into account their species diversity. This is a dwelling for all indiscriminately, which does not correspond to the definition of dwelling as a place of residence for each type of living being. Fragment of map B, constructed for the same territory and on the same scale, corresponds much more correctly to the concept “eikos” (house for various living beings). The house (eikos) on the map B is an apartment building. Its windows and doors face south, north, east and west. This creates favorable conditions for the existence and development of different types of living organisms that determine biological diversity in the area and inhabit it. What does it mean? It means that this version of the house is more consistent with the requirements of sustainable development of the entire biological system, both natural and modified by man. What is the advantage of maps constructed by the method of plastic of relief for the economic and environmental assessment of lands? Looking at map A (Figure 4), a deceptive impression is created that all squares (1-9) characterize a flat homogeneous surface with gray forest soils ($L_2$). The only exceptions are small areas of the state forest resources (SFR) in squares 1, 4, 9. However, the same territory on map B looks different. Convex (not quite even and uniform) surfaces occupy only parts of squares 2, 5, 6, 8, 9, and the rest are depressions (white background) and slopes of different exposures. Analyzing map B, a representative of the Kashirsky district administration can take a differentiated approach to the economic assessment of the lands shown on the map. He makes sure that there is ecological diversity within the traded lands. As a seller, he is clearly convinced that lands differ in quality and their true value. The map allows the seller to correctly assess the price of a piece of land; looking at the map, a buyer (the future owner of the land) also understands what land he will deal with in the production process.

The buyer, for example, will try to choose lands located on the watershed surface (as the most even) (squares 2, 5, 6, 8, 9), or lands on the slopes of the western (I) or eastern (II) exposure. It all depends on his financial capabilities or a crop he wants to grow in certain conditions. In conditions of dry soils located within a relatively flat watershed surface, these will be crops that are less demanding for moisture. Soil conditions will also differ along the slopes of the western (I) or eastern (II) exposure. The western slopes are usually more humid and receive less light than the eastern slopes.

![Figure 4. Fragments of maps A and B, divided into squares for economic assessment of soil areas.](image-url)

After reflection or consultation with specialists, the buyer can choose the lands of squares 4 and 7 only because the end parts of the flow structures here converge in one narrow place (at number I). In such a narrow place, it is easy to build a low (2-3 m) temporary dam from boards, which will double-regulate the water regime of soils throughout the entire territory of a land plot. To do this, it is necessary to remove all or part of the boards from the grooves during a wet year, and then the soil will not become waterlogged. In dry seasons, the plank dam will act as a collector of water and soil moisture. If there are swampy soils on the plot, the map of plastic of relief will show how to properly
position the drains to drain excess water. It is most advisable to lay drains along the depressions (which are clearly visible on the relief map). It is also possible to create temporary dams of light material along the depressions. Temporary dams can be built in dry years and should be removed in excessively wet years. Such regulation will allow both to maintain the necessary water-salt regime of soils, and to prevent the occurrence of forest fires, which becomes more and more urgent in conditions of climate change.

4. Conclusion
The map of plastic of relief makes it possible to distinguish soil varieties based on their association with certain relief forms, and to identify the genetic characteristics of these soils within dynamic flow systems. Being a model of a soil flow-dynamic system, it should be supplemented with dependencies. Within the flows, these dependencies express the relationship of the quantitative characteristics of the moving soil substance with the morphometric parameters of the relief [3].

The map even at the design stage allows structuring the land use within the agrolandscapes and contributes to the creation of conditions for the conservation of biological diversity within their boundaries. Ultimately, this map will undoubtedly serve for the sustainable development of the entire ecological system, which is the agroecosystem.

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