земель на консервацію та під заліснення – це найбільш екологічно обґрунтований та економічно доцільний спосіб їх використання. Загалом по всіх ґрунтово-кліматичних зонах області з інтенсивного обробітку слід вивести близько 37,3 тис. га ріллі, з яких 23,0 тис. га слід залужити і перевести в сіножаті та пасовища, а 14,3 тис. га потрібно було би залісити.

Висновки. Щоб подолати негативний антропогенний вплив, який призвів до екологічного дисбалансу, який подекуди перетворюється на екологічний бумеранг особливо небезпечних руйнацій – змиву ґрунту, розвитку струмкової та яружної ерозії, збіднення видового складу лучних трав, деградації агроландшафтів слід впровадити комплекс екологічних та організаційно-економічних інновацій. В рекреаційному Закарпатті доцільно створити фермерські екогосподарства, агропромислові екофірми, біопідприємства, які здатні забезпечити раціональне використання гірських територій; провести агроекологічний моніторинг с.-г. угідь, екологічну паспортизацію підприємства та формування ринку екологічно безпечної продукції.

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METHODOLOGY FOR DETERMINING POLLUTION CONTROL POINTS IN HIGH DANGER AREAS

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Environmental security is an integral part of national security. Therefore, the existing or predicted environmental situation in the state should ensure the preservation of the health of the population, and the solution of social and economic issues without degradation of environmental components, especially soils, the pollution of which directly determines the quality of water, air, and human health. This is especially important now, when as a result of the war of the russian federation against Ukraine, the biota, water, air, and soil have experienced several unprecedented destructive effects and, in particular, such negative consequences for the soil as: relocation of subdivisions; military engineering works; temporary and long-term deployment of armed forces; destruction of military equipment, defense structures, warehouses, etc.; partial or complete destruction of business facilities the; the fire of different intensity; creation of minefields and detonation of ammunition; ingress of chemical substances of different components to the soil (fig. 1); mass burials of people. In addition to pollution directly from military intervention, huge volumes of household waste and mutilated ecosystems are observed in places where troops are temporarily or permanently stationed.

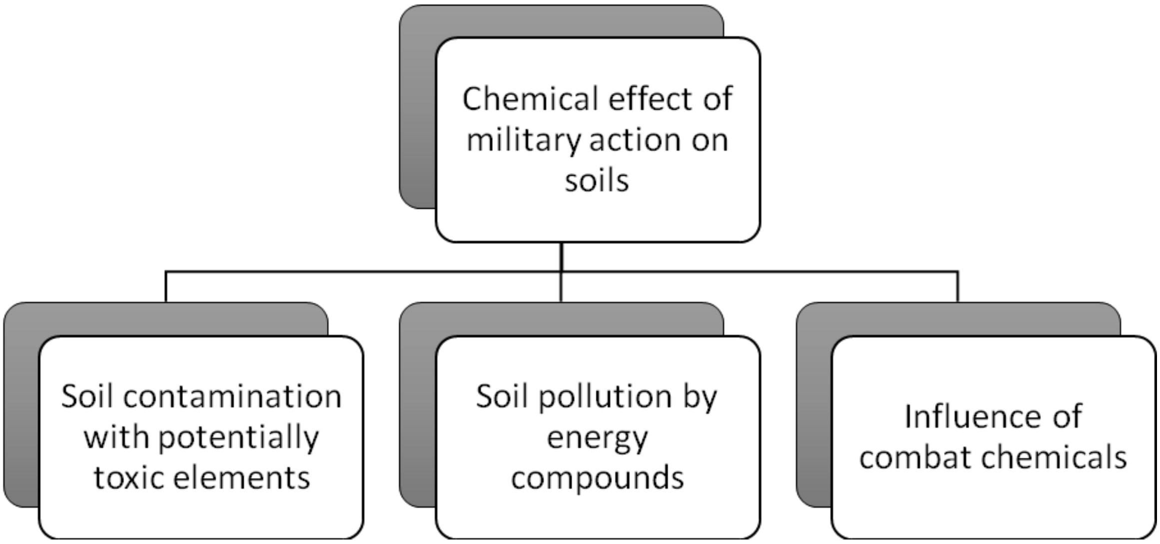

Fig. 1. Main chemical effect of military action on Ukrainian soils

We identified such areas, in particular determined the qualitative and quantitative characteristics of the soil cover, which has undergone or will undergo the described impacts. For this assessment, we used the previously constructed predictive map of agro-production groups of soils of Ukraine, which characterizes the entire area of Ukraine on a scale of 1:10,000. This map allows you to conduct a study of the qualitative composition of soils. At a certain level of reliability, the problem of the quantitative composition is also solved, because the modeling carried out on such a detailed scale for the entire territory of the state allows estimating of the distribution areas of various soil taxa for the entire territory that is or was occupied as accurately as possible. The total area of such soils is 146,315 square km [1].

A huge number of pollutants of various kinds have high mobility due to migration in dissolved form or adsorbed on the surface of soil particles during their movement due to erosion processes. Modern monitoring, especially soil monitoring, is based on several models of the movement of water flows and sediments or on the use of the concept of curvature of the topographic surface. The use of GIS for its calculation and use for monitoring purposes significantly increases its effectiveness [2].

Knowing the location of the points of concentrated accumulation, it is possible to establish approximate schemes for the distribution of the flow of solid particles and dissolved substances in order to predict the trajectories of the movement of all types of pollutants. The use of such an approach is especially relevant in the case of weak relief, where it is impossible to visually determine the location of pollutants.

Still, a common problem of thorough monitoring, regardless of its type, is the selection of the minimum necessary number of control points at which samples will be taken for analytical procedures. In connection with the uneven distribution of environmental pollution, the creation of a network of sampling points based on innovative methods (in contrast to the classic ones based on wind roses, intersections of kilometer grid lines, and sector-segment sampling schemes) is of great importance. Therefore, the development and testing of the method of specific detection of places of possible concentrations of pollutants based on the analysis of the terrain model is an important and urgent task.

Modern geomorphology studies the field-specific forms of the Earth's relief from the point of view of the features of the "Earth's surface - gravitational field" system [3, 4]. Of the four classes of morphometric variables and concepts, the ones that determine the two main mechanisms of accumulation: plan and profile curvature are of greatest interest. The first mechanism of accumulation (fig. 2) reflects the convergence of surface flows [5]. It was shown that the divergence of the flow lines is equal to the plan curvature of the surface (kp). This is the basis for the quantitative description of the first mechanism of accumulation.

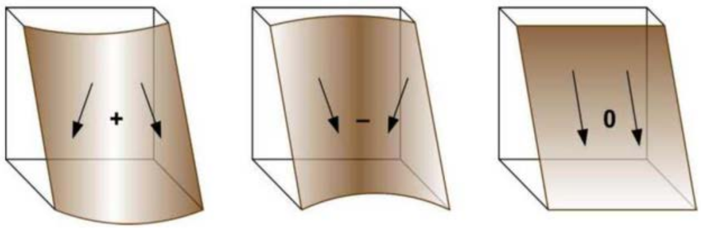

Fig. 2. Influence of plan curvature on convergence/divergence surface runoff [6]

The second mechanism of accumulation(fig. 3), as was proved [5], is the derivative of the gradient factor along the flow line and represents the vertical (or profile) curvature kv. Thus, the second accumulation mechanism acts on profile-concave slopes, where $kv < 0$, and can be described using kv maps (similarly to kp). Therefore, the flow lines converge where $kp < 0$ (convergence zones) and diverge where $kh > 0$ (divergence zones). In contrast to the first type of accumulation, the second type shows that flows slow down where $kv < 0$ (areas of relative deceleration) and accelerate where $kv > 0$ (areas of relative acceleration).

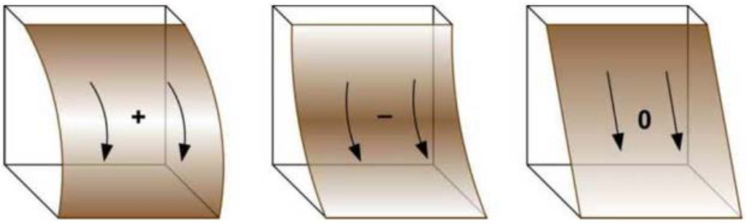

Fig. 3. The profile curvature is parallel to the direction of the maximum slope and characterizes the curvature of the streamline in the vertical plane[6]

To generalize these two main types of accumulation, it is proposed to use accumulative curvature (Ka) [5]. Ka is the product of vertical and horizontal curvature and is equal to Ka = kp* kv/ The classical theory states that the accumulative curvature is an integral variable and the unit of Ka is m^{-2}. However, when setting the monitoring points, this calculation algorithm was slightly modified by us, as was shown in the source [2].

The essence of the technique is that based on the analysis of the digital terrain model in GRASS GIS, several local morphometric variables such as plan (or horizontal) and vertical (or profile) curvatures are identified. Calculation according to the modified formula gives results that allow you to separate the total accumulation zones from the divergence zones, that is, to choose the most characteristic places of spatial localization of pollutants.

The main result of the proposed method is a cartographic model that indicates the places of concentration (localization) of pollution. Local accumulative zones, where it is advisable to take samples for research, are clearly visible in areas with a relatively weak relief.

Such a solution scales well and can be used for any areas. A positive effect of the conducted modeling is the possibility of establishing monitoring points based on the analysis of the digital terrain model. The proposed method allows to adapt it for any applied monitoring tasks in ecology, soil science, agronomy and land management etc.

Soil contamination can be investigated by separately analyzing and then modelling the content of each of the investigated chemical elements. For instance, a number of heavy metals enter the soil as a result of hostilities and can be accumulate in agro-ecosystems, so modelling of heavy metals is necessary. But there is often a need to assess the status of soils according to the content of various chemical elements at the same time, in which case an integral indicator is called for, such as the heavy metals saturation index (SI) [2] which allows us to differentiate areas of the background content of heavy metals from their anomalous content.

Therefore, the cartographic models obtained by such methods with the locations of potentially maximum concentrations of pollutants, expand the possibilities of monitoring the environment, help in determining the speed of spread of pollutants and to identify natural barriers where the accumulation of toxicants is possible. The models offered by us contribute to the correct determination of control points when developing appropriate monitoring programs.

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