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*Original Research*

# Assessment of Strength of Interaction between Nature-Resource Potentials in Provincial Ecosystems of Ukraine

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**Abstract**

The strength of the interaction is quantitatively established between nature-resource potentials in 14 provincial ecosystems of Ukraine, the latter being the equivalents of physic-geographical provinces (krais) of Ukraine. Nature-resource potential that covers mineral, water, land, forest, fauna, and natural recreation resources is regarded as one of the most essential characteristics of the field of ecosystems' influence (effect). It is asserted that the strength of the effect of nature-resource potential of the ecosystem, or the bio-center, or the eco-region is the result of interaction between its central place and the surrounding area (periphery). The bigger the core (central place) and the less the distance to the neighboring core (other place of the ecosystem) with its own mass, the stronger it will affect the surround. The above strength is calculated according to the developed gravity methods. The value of the potential of nature resources in ecosystems in 2015-2021 prices represents the "body mass", and the distances between the provinces are established to be those between their geometrical centers. The closest interaction is found to exist between nature-resource potentials of the Dniester-Dnieper and the Prychornomorskyy, as well as between the Donetsk and the Zadonetsko-Donskyy, the Left-Bank-Dnieper-Pryazovskyy and the Donetsk, the Left-Bank-Dnieper and the East-Ukrainian, and the Podilsko-Prydniprovskyy and the Dniester-Dnieper provincial ecosystems. The least strength of interaction between nature-resource potentials is observed between the Ukrainian Carpathians and the Crimean Mountains, the West-Ukrainian and the Crimean Mountains, the Polissia and the Crimean Mountains, the Zadonetsko-Donskyy and the Crimean Mountains, the Ukrainian Carpathians and the Prychornomorsko-Pryazovskyy provincial ecosystems.

**Keywords:** nature-resource potential, strength of interaction, provincial ecosystems of Ukraine

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## Introduction

We consider the nature-resource potential (NRP) of the territory (water area) to be the aggregative productivity of its nature-resource means of production and the items of consumption expressed in their social use value. Monetary indicators represent a single measure of comparability of naturally different nature resources, should we speak of administrative rayons or ecosystems of different hierarchical levels. Undoubtedly, the study of ecosystems' NRP is an important trend in scientific research, since we have in mind the integrity and stability of these natural and natural-anthropogenic complexes, the specificities of their interaction, and material-energetic metabolism. It is no coincidence that proceeding from the integrity of different-level ecosystems, S.M. Kravchenko and M.V. Kostytskyy regard the "reduction of nature-resource potential" and the "resource constraints" to be among the most important ecological laws [1].

The realization of the ecosystems approach at the macro-level (the highest hierarchy) presupposes the material-energetic exchange and interaction of provincial ecosystems and biomes. For example, V.P. Kucheriavyy considers the biome to be the totality of biogeocenoses, species of plants, and animals of a single natural zone characterized by a specific type of structure of grouping that represents the complex species' adaptation to the environment [2]. M.A Holubets, in his turn, identifies "provincial ecosystems" with "physic-geographical provinces" [3]. According to P.G. Shyshchenko, the same are "part of a physic-geographical zone or physic-geographical subzone of the plain country or directly the part of a mountainous physic-geographical country outlined when the zone's or subzone's geological-geo-morphological framework within their borders is not homogeneous, possessing lowlands and uplands, mountain ranges, and intermontane hollows, and when the territory is distant from oceans with respect to a specific level of continentality and different patterns of transformation of air masses over lowlands and uplands" [4, P.340]. And, as we know, provinces represent non-zonal units of physic-geographical demarcation.

Problems of evaluation of nature-resource potential of the ecosystems were given closer attention in a great many scientific studies. Among all others, O. Marynych was undoubtedly a pioneer of thorough scrutiny of nature-resource complexes of ecological systems of Ukraine and cognition of their interaction and diversity [5]. Questions of methodology and practice to be applied to help assess the territory in Ukraine as an integral resource with the purpose of its (resource) preservation, rational use, and reproduction were systemically addressed by the authors guided by L.G. Rudenko [6]. The same scientists were analyzing the dynamics of the development of the land resource potential of the Ukrainian Forest Steppe in the course of 1991-2018, as well as methodical approaches to and major trends in its development [7]. Once suggested, their approaches are still used in the cognition of present-day landscapes of the Ukrainian steppe zone to soon become conservation areas [8]. I.V. Myron and T.M. Shovkun focus on the assessment of the landscapes' ecological balance as the proportion of the potential of plow lands and the total area of eco-stabilizing agricultural lands [9]. Recognizing and monitoring the biodiversity of eco-regions, L. Bilous and the collective of authors suggest conducting territorial identification of biotopes and establishing types, quality, and amounts of ecological resources [10]. The same explorers apply geo-information models to assess the anthropogenic impact on the landscapes of the Podilsko-Prydniprovskky Region of Ukraine [11]. No less important is the cognition of the diversity and fragmentation (division) of landscapes of the Forest Steppe Zone of Ukraine carried out on the basis of geospatial GIS-analysis and geo-informational mapping [12]. This allows for the assessment of the ecological state of geo-systems and the establishment of the integral value of the potential of nature resource self-cleaning within the landscapes [13]. The estimative trends in the study of nature-resource potential of ecosystems and landscapes can, to our opinion, be traced in the works by M. Malska, N. Pankiv [14], C.E. Chasovschi [15], G.-L. Cioban [16], S. Yaromenko [17], etc.

Nature-resource potential of provincial ecosystems is among the most essential characteristics of the field of their interactions with the difference of potentials, strength, and diffusion being its derivatives. Besides the integral (total) NRP, the same (though with less effect) fields are formed by NRP components, that is, by mineral, water, land, forest, fauna, and natural recreation potentials. At the same time, it should be noted that the field of such "single" potential possesses different directions and different intensities of nature-resource flows; the interaction between the points of such fields is often multidirectional, as well as their gravity or repulsion.

The authors of the present study aimed to achieve a quantitative assessment of the strength of interaction of nature-resource potential in the provincial ecosystems of Ukraine.

## Methods and Materials

Intrinsically methodical questions to help assess the strength of interaction between single bio-centers, landscapes, and eco-regions were addressed by a good few of the scientists. In particular, C. Ranires-Marquez et al. consider "Society 5.0" as the integral model for the solution of modern global challenges in the sphere of management and preservation of nature-resource potential and design the future where technologies would fit with sustainable, fair, and human-oriented development [18]. In their quantitative evaluation of the impact of inhomogeneity of the potential

of agricultural lands upon landscape biodiversity, A. Martina et al. come to the conclusion that said impact is equal to or even stronger than the performance of the technologies applied in the agrarian nature use [19]. In his reliance on an aggregate econometric model on the basis of time-varying data, T.C. Kinnaman emphasizes the determinative role of nature-resource potential on the growth of economic efficiency of production [20]. Substantiating the necessity of substitution of the potential of land, water, and biotic and abiotic resources for ecologically pure and steady alternatives, the authors [21] assert that efficient ecological intensification requires an understanding of ecological services, ecosystems' components, and resource flows in agro-systems. Speaking of the same estimative direction, we cannot help but make a reference to interesting and methodically important works by L. Krtička, I. Tomčikova, and I. Rakutova, where they study alternative approaches to the development and preservation of landscape structures in the Demänovská Dolina [22]. Specifically, methodical and applied instrumentation of spatial analysis as the GIS-based description-study-explanation is exhaustively presented by G. Grekousis [23]. With respect to quantitative evaluation of the strength of interaction between eco-systems, eco-regions, and landscapes on the whole, we cannot but mention the studies by W. Isard [24], P. Haggett [25], V.M. Petlin [26, 27], and M.D. Grodzinski [28].

Their initial position was that the strength of the place's effect is the result of the influence of the central place upon its periphery (surround). The bigger the mass of the core (central place, e.g., bio-center), and the shorter the distance to the neighboring core (bio-system's other place) with its own mass, the strongest will be the effect of this central place on the surround. Vice versa, the less the core's mass and the longer the distance between the studied cores (places), so much the less will be the effect (interaction) between them. Thus, the mass as the quantity of matter in ecosystems and the distance between their centers will be determinative for the assessment of the strength of interaction between them.

With respect to the "economic landscape", W. Isard [24] found the dependence of gravity between two bodies upon their mass and distance. The scientist described the interaction between the two settlements as follows:

$$I_{ij} = k\frac{P_i P_j}{D\frac{b}{ij}}$$

where $I_{ij}$ – the strength of interaction between cities *"i"* and *"j"*;
$k$ – coefficient of the environment "conductivity";
$P_i$, $P_j$ – population in the cities *"i"* and *"j"*;
$Dij$ – the distance between the cities;
$b$ – parameter.

According to M.D. Grodzinski [28], *"k"* in this relation is more often taken to be 1, and *"b"* to be 2. *"P"* as the number of populations is taken as the analog of their "mass".

Further, to establish the borderline of the fields of interaction between two places-spots (in particular, bio-centers), the following relation is suggested [28]:

$$l_{jx} = \frac{D_{ij}}{1 + \sqrt{\frac{P_i}{P_j}}}$$

where $l_{jx}$ – distance of the point of equal effect on places *"i"* and *"j"* calculated from the disposition of *"j"*;
$D_{ij}$ – the distance between places *"i"* and *"j"*;
$P$ – variable describing places *"i"* and *"j"* (e.g., stock of biomass, bio-centers' species diversity, number of single populations in bio-centers *"i"* and *"j"*, etc.).

Suggestions and conclusions of the aforementioned scientists were taken as the basis to help realize the aim of this study, which was the assessment of the strength of interaction (mutual influence) between the NRPs of the provincial ecosystems of Ukraine. The "body mass" was represented by the value of nature-resource potential of each of the provincial ecosystems of Ukraine calculated in the present-day dimension in 2015-2021 prices [29] (see Table 1). The method to adjust the inflation rate while evaluating the NRP of Ukraine is in thorough detail described in [29]. Said re-evaluation proceeds from the UAH/USD balance formed within 2015-2021. Further calculations of the strength of interaction between nature-resource potentials of provincial ecosystems of Ukraine are based on national (Ukrainian hryvnias) rating scales.

On the second stage of our research, we have established the geometric centers (core centers) of provincial ecosystems and the distances between said centers with respect to all 14 provincial ecosystems of Ukraine. The results of the measurements are presented in Table 2.

Finally, we had all the needful materials available to help assess the strength of interaction between the NRPs of provincial ecosystems of Ukraine as suggested by the equation W. Isard, [24].

## Results and Discussion

Tables 3 and 4 represent the matrix of the interaction of the total NRP and the land resources potential in 14 provincial ecosystems of Ukraine correspondingly.

Table 1. Nature-resource potential of the biomes and provincial ecosystems (according to M. Holubets [3]) of Ukraine in present-day dimension (in 2015-2021 prices).

| Biomes, Provincial Ecosystems | Value of the potential ($\frac{\text{UAH milliard}}{\text{USD billion}}$) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Mineral | Water | Land | Forest | Fauna | Natural recreation | Integral |
| East European Plain | 383,613 / 14,800 | 153,152 / 5,900 | 591,308 / 23,000 | 40,506 / 1,600 | 6,487 / 0,251 | 104,679 / 4,000 | 1279,745 / 49,551 |
| Mixed Forests Zone | 6,042 / 0,234 | 26,119 / 1,010 | 64,537 / 2,495 | 17,796 / 0.688 | 0,807 / 0,031 | 14,045 / 0,543 | 129,346 / 5,001 |
| Polissia | 6,042 / 0,234 | 26,119 / 1,010 | 64,537 / 2,495 | 17,796 / 0.688 | 0,807 / 0,031 | 14,045 / 0,543 | 129,346 / 5,001 |
| Deciduous Forests Zone | 8,272 / 0,320 | 16,911 / 0,654 | 72,927 / 2,819 | 5,877 / 0,227 | 0,414 / 0,016 | 10,460 / 0,400 | 114,861 / 4,436 |
| West-Ukrainian | 8,272 / 0,320 | 16,911 / 0,654 | 72,927 / 2,819 | 5,877 / 0,227 | 0,414 / 0,016 | 10,460 / 0,400 | 114,861 / 4,436 |
| Forest-Steppe Zone | 21,790 / 0,842 | 36,906 / 1,427 | 214,935 / 8,300 | 12,023 / 0,465 | 2,411 / 0,093 | 26,947 / 1,042 | 315,012 / 12,169 |
| Podilsko-Prydniprovskyy | 7,754 / 0,300 | 17,169 / 0,664 | 117,908 / 4,548 | 6,363 / 0,246 | 1,086 / 0,042 | 11,837 / 0,458 | 162,117 / 6,258 |
| Left-Bank-Dnieper | 10,409 / 0,400 | 13,962 / 0,540 | 72,756 / 2,815 | 3,346 / 0,130 | 1,051 / 0,040 | 7,387 / 0,286 | 108,911 / 4,211 |
| East-Ukrainian | 3,627 / 0,142 | 5,774 / 0,937 | 24,272 / 0,937 | 2,313 / 0,089 | 0,274 / 0,011 | 7,724 / 0,298 | 43,984 / 2,414 |
| Steppe Zone | 347,509 / 13,400 | 73,216 / 2,800 | 238,909 / 9,400 | 4,810 / 0,200 | 2,855 / 0,100 | 53,227 / 2,000 | 720,526 / 27,900 |
| North-Steppe Sub-Zone | 333,716 / 12,867 | 37,045 / 1,402 | 148,374 / 5,900 | 3,839 / 0,162 | 1,970 / 0,076 | 31,805 / 1,162 | 556,749 / 21,569 |
| Dniester-Dnieper | 54,681 / 2,113 | 10,807 / 0,418 | 55,607 / 2,150 | 0,481 / 0,019 | 0,610 / 0,024 | 9,254 / 0,358 | 131,440 / 5,082 |
| Left-Bank-Dnieper-Pryazovskyy | 70,594 / 2,729 | 12,990 / 0,502 | 50,869 / 1,967 | 1,205 / 0,047 | 0,677 / 0,026 | 9,964 / 0,385 | 146,299 / 5,656 |
| Donetsk | 157,399 / 6,051 | 7,935 / 0,277 | 25,722 / 1,152 | 0,998 / 0,051 | 0,238 / 0,009 | 7,481 / 0,222 | 199,773 / 7,762 |
| Zadonetsko-Donskyy | 51,044 / 1,974 | 5,313 / 0,205 | 16,332 / 0,631 | 1,154 / 0,045 | 0,445 / 0,017 | 5,106 / 0,197 | 79,394 / 3,069 |
| Mid-Steppe Sub-Zone | 6,513 / 0,252 | 12,136 / 0,469 | 43,454 / 1,680 | 0,300 / 0,012 | 0,346 / 0,013 | 7,305 / 0,282 | 70,054 / 2,708 |
| Prychornomorskyy | 6,513 / 0,252 | 12,136 / 0,469 | 43,454 / 1,680 | 0,300 / 0,012 | 0,346 / 0,013 | 7,305 / 0,282 | 70,054 / 2,708 |
| South Steppe (Dry Steppe) Sub-Zone | 7,280 / 0,281 | 24,035 / 0,929 | 47,081 / 1,820 | 0,671 / 0,026 | 0,539 / 0,021 | 14,117 / 0,546 | 93,723 / 3,623 |
| Prychornomorsko-Pryazovskyy | 1,144 / 0,044 | 9,782 / 0,378 | 23,310 / 0,902 | 0,418 / 0,016 | 0,285 / 0,011 | 4,149 / 0,160 | 39,088 / 1,511 |
| Crimean Steppe | 6,136 / 0,237 | 14,253 / 0,551 | 23,771 / 0,918 | 0,253 / 0,010 | 0,254 / 0,010 | 9,968 / 0,386 | 54,635 / 2,112 |
| Crimean Mountains | 2,530 / 0,098 | 2,111 / 0,082 | 8,996 / 0,300 | 1,257 / 0,049 | 0,041 / 0,002 | 11,014 / 0,426 | 25,949 / 0,957 |
| Ukrainian Carpathians | 8,179 / 0,316 | 27,216 / 1,052 | 19,095 / 0,700 | 16,430 / 0,635 | 0.083 / 0,003 | 18,846 / 0,729 | 89,849 / 3,435 |
| Ukraine | 394,322 / 15,245 | 182,479 / 7,055 | 619,399 / 24,000 | 58,193 / 2,250 | 6,611 / 0,256 | 134,539 / 5,201 | 1395,543 / 54,007 |

Table 2. Distances (in km) between the cores of provincial ecosystems (natural krais) of Ukraine.

| Polissia | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 245 | West-Ukrainian | | | | | | | | | | | |
| 266 | 350 | Podilsko-Prydniprovskyy | | | | | | | | | | |
| 343 | 546 | 263 | Left-Bank-Dnieper | | | | | | | | | |
| 483 | 693 | 406 | 151 | East-Ukrainian | | | | | | | | |
| 420 | 508 | 168 | 294 | 385 | Dniester-Dnieper | | | | | | | |
| 616 | 770 | 427 | 308 | 263 | 312 | Left-Bank-Dnieper-Pryazovskyy | | | | | | |
| 728 | 910 | 571 | 396 | 291 | 466 | 161 | Donetsk | | | | | |
| 725 | 924 | 602 | 385 | 249 | 525 | 242 | 116 | Zadonetsko-Donskyy | | | | |
| 490 | 571 | 245 | 350 | 420 | 77 | 298 | 452 | 525 | Prychornomorskyy | | | |
| 602 | 676 | 343 | 413 | 462 | 175 | 273 | 420 | 511 | 105 | Prychornomorsko-Pryazovskyy | | |
| 725 | 798 | 473 | 518 | 543 | 305 | 301 | 427 | 536 | 235 | 130 | Crimean Steppe | |
| 784 | 851 | 536 | 592 | 613 | 371 | 371 | 480 | 592 | 294 | 193 | 70 | Crimean Mountainous |
| 399 | 165 | 455 | 683 | 826 | 616 | 879 | 1019 | 1050 | 637 | 728 | 847 | 886 | Ukrainian Carpathians |

With respect to total NRP, the strength of interaction in provincial ecosystems manifests its highest values between the Dniester-Dnieper and the Prychornomorskyy (1,553), Donetsk and the Zadonetsko-Donskyy (1,179), the Left-Bank-Dnieper-Pryazovskyy and the Donetsk (1,128), the Left-Bank-Dnieper and the East-Ukrainian (0,210), and the Podilsko-Prydniprovskyy and the Dniester-Dnieper provincial ecosystems. The least strength of NRP interaction was observed between the Ukrainian Carpathians and the Crimean Mountains (0,003), the West-Ukrainian and the Crimean Mountains (0,004), the Polissia and the Crimean Mountains (0,005), Zadonetsk-Donskyy and the Crimean Mountainous (0,006), and the Ukrainian Carpathians and the Prychornomorsko-Pryazovskyy (0,007) provincial ecosystems.

To be comparable with the total NRP, the strength of interaction between provincial ecosystems was also assessed with respect to their land potential, the dominant resource in practically every region. The results were as follows: the highest interaction of land potential was observed between the Dniester-Dnieper and the Prychornomorskyy (0,408), the Left-Bank-Dnieper and the East-Ukrainian (0,077), the Podilsko-Prydniprovskyy and the Dniester-Dnieper (2,232), the Polissia and the Podilsko-Prychornomorskyy (0,108), and the Prychornomorskyy and the Prychornomorskyy-Pryazovskyy (0,092) provincial ecosystems. The least close interaction was seen between the land potentials of the Ukrainian Carpathians and the Crimean Mountainous, the Ukrainian Carpathians and the Zadonetsk-Donskyy, the Crimean Mountainous and the Zadonetsk-Donskyy provincial ecosystems (0,0002-0,0004).

Table 5 is our attempt at the systemic generalization of the strength of the effect of total nature-resources and land potentials in the provincial ecosystems of Ukraine. Said ecosystems are compared with respect to their maximal and second-big value of the strength of interaction between their NRPs. As follows from the table, the strength of interaction of total NRP and land potential coincides in 7 of 14 provincial ecosystems of Ukraine. However, the rest manifests that the mutual effect of their total NRPs differs from those of their land potentials. Here we mean the West-Ukrainian, Podilsko-Prydniprovskyy, Left-Bank-Dnieper, East-Ukrainian, Left-Bank-Dnieper-Pryazovskyy, Donetsk, and Crimean Mountainous provincial ecosystems.

## Conclusions

According to M.A. Holubets [3], provincial ecosystems are the analogue of physic-geographical provinces (krais) of Ukraine. Their nature-resource potentials are regarded as one of the most essential characteristics of the field of ecosystems' mutual influence (effect), with the difference of potentials, strength, and diffusion being their derivatives.

The strength of NRP's ecosystem of bio-center mutual influence is the result of the effect of the central place upon its periphery (surround). The bigger the

Table 3. Strength of interaction between total nature-recourse potentials in provincial ecosystems of Ukraine.

| | Polissia | West-Ukrainian | Podilsko-Prydniprovskyy | Left-Bank-Dnieper | East-Ukrainian | Dniester-Dnieper | Left-Bank-Dnieper-Pryazovskyy | Donetsk | Zadonetsko-Donskyy | Prychornomorskyy | Prychornomorsko-Pryazovskyy | Crimean Steppe | Crimean Mountainous | Ukrainian Carpathians |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Polissia | | 0,248 | 0,296 | 0,120 | 0,024 | 0,096 | 0,050 | 0,049 | 0,020 | 0,038 | 0,014 | 0,013 | 0,005 | 0,073 |
| West-Ukrainian | 0,248 | | 0,152 | 0,042 | 0,011 | 0,059 | 0,028 | 0,028 | 0,011 | 0,025 | 0,010 | 0,010 | 0,004 | 0,379 |
| Podilsko-Prydniprovskyy | 0,296 | 0,152 | | 0,255 | 0,043 | 0,755 | 0,130 | 0,099 | 0,036 | 0,189 | 0,054 | 0,040 | 0,015 | 0,070 |
| Left-Bank-Dnieper | 0,120 | 0,042 | 0,255 | | 0,210 | 0,166 | 0,168 | 0,139 | 0,058 | 0,062 | 0,025 | 0,022 | 0,008 | 0,021 |
| East-Ukrainian | 0,024 | 0,011 | 0,043 | 0,210 | | 0,039 | 0,093 | 0,104 | 0,056 | 0,017 | 0,008 | 0,009 | 0,003 | 0,006 |
| Dniester-Dnieper | 0,096 | 0,059 | 0,755 | 0,166 | 0,039 | | 0,198 | 0,121 | 0,038 | 1,553 | 0,168 | 0,077 | 0,025 | 0,031 |
| Left-Bank-Dnieper-Pryazovskyy | 0,050 | 0,028 | 0,130 | 0,168 | 0,093 | 0,198 | | 1,128 | 0,198 | 0,115 | 0,077 | 0,088 | 0,028 | 0,017 |
| Donetsk | 0,049 | 0,028 | 0,099 | 0,139 | 0,104 | 0,121 | 1,128 | | 1,179 | 0,069 | 0,044 | 0,060 | 0,022 | 0,017 |
| Zadonetsko-Donskyy | 0,020 | 0,011 | 0,036 | 0,058 | 0,056 | 0,038 | 0,198 | 1,179 | | 0,020 | 0,012 | 0,015 | 0,006 | 0,006 |
| Prychornomorskyy | 0,038 | 0,025 | 0,189 | 0,062 | 0,017 | 1,553 | 0,115 | 0,069 | 0,020 | | 0,248 | 0,069 | 0,021 | 0,016 |
| Prychornomorsko-Pryazovskyy | 0,014 | 0,010 | 0,054 | 0,025 | 0,008 | 0,168 | 0,077 | 0,044 | 0,012 | 0,248 | | 0,126 | 0,027 | 0,007 |
| Crimean Steppe | 0,013 | 0,010 | 0,040 | 0,022 | 0,009 | 0,077 | 0,088 | 0,060 | 0,015 | 0,069 | 0,126 | | 0,289 | 0,007 |
| Crimean Mountainous | 0,005 | 0,004 | 0,015 | 0,008 | 0,003 | 0,025 | 0,028 | 0,022 | 0,006 | 0,021 | 0,027 | 0,289 | | 0,003 |
| Ukrainian Carpathians | 0,073 | 0,379 | 0,070 | 0,021 | 0,006 | 0,031 | 0,017 | 0,017 | 0,006 | 0,016 | 0,007 | 0,007 | 0,003 | |

Table 4. Strength of interaction between land potentials in provincial ecosystems of Ukraine.

| | Polissia | West-Ukrainian | Podilsko-Prydniprovskyy | Left-Bank-Dnieper | East-Ukrainian | Dniester-Dnieper | Left-Bank-Dnieper-Pryazovskyy | Donetsk | Zadonetsko-Donskyy | Prychornomorskyy | Prychornomorsko-Pryazovskyy | Crimean Steppe | Crimean Mountainous | Ukrainian Carpathians |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Polissia | | 0,078 | 0,108 | 0,040 | 0,026 | 0,020 | 0,009 | 0,003 | 0,002 | 0,012 | 0,004 | 0,003 | 0,001 | 0,008 |
| West-Ukrainian | 0,078 | | 0,070 | 0,018 | 0,004 | 0,016 | 0,006 | 0,002 | 0,001 | 0,010 | 0,004 | 0,003 | 0,012 | 0,051 |
| Podilsko-Prydniprovskyy | 0,108 | 0,070 | | 0,124 | 0,017 | 0,232 | 0,033 | 0,009 | 0,005 | 0,085 | 0,023 | 0,012 | 0,004 | 0,011 |
| Left-Bank-Dnieper | 0,040 | 0,018 | 0,124 | | 0,077 | 0,047 | 0,039 | 0,012 | 0,008 | 0,026 | 0,010 | 0,006 | 0,002 | 0,003 |
| East-Ukrainian | 0,026 | 0,004 | 0,017 | 0,077 | | 0,009 | 0,018 | 0,007 | 0,006 | 0,006 | 0,003 | 0,002 | 0,001 | 0,001 |
| Dniester-Dnieper | 0,020 | 0,016 | 0,232 | 0,047 | 0,009 | | 0,029 | 0,007 | 0,003 | 0,408 | 0,042 | 0,014 | 0,004 | 0,003 |
| Left-Bank-Dnieper-Pryazovskyy | 0,009 | 0,006 | 0,033 | 0,039 | 0,018 | 0,029 | | 0,050 | 0,014 | 0,025 | 0,016 | 0,013 | 0,003 | 0,001 |
| Donetsk | 0,003 | 0,002 | 0,009 | 0,012 | 0,007 | 0,007 | 0,050 | | 0,031 | 0,005 | 0,003 | 0,003 | 0,001 | 0,001 |
| Zadonetsko-Donskyy | 0,002 | 0,001 | 0,005 | 0,008 | 0,006 | 0,003 | 0,014 | 0,031 | | 0,003 | 0,001 | 0,001 | 0,0004 | 0,0003 |
| Prychornomorskyy | 0,012 | 0,010 | 0,085 | 0,026 | 0,006 | 0,408 | 0,025 | 0,005 | 0,003 | | 0,092 | 0,019 | 0,005 | 0,002 |
| Prychornomorsko-Pryazovskyy | 0,004 | 0,004 | 0,023 | 0,010 | 0,003 | 0,042 | 0,016 | 0,003 | 0,001 | 0,092 | | 0,033 | 0,006 | 0,001 |
| Crimean Steppe | 0,003 | 0,003 | 0,012 | 0,006 | 0,002 | 0,014 | 0,013 | 0,003 | 0,001 | 0,019 | 0,033 | | 0,043 | 0,001 |
| Crimean Mountainous | 0,001 | 0,001 | 0,004 | 0,002 | 0,001 | 0,004 | 0,003 | 0,001 | 0,0004 | 0,005 | 0,006 | 0,043 | | 0,0002 |
| Ukrainian Carpathians | 0,008 | 0,051 | 0,011 | 0,003 | 0,001 | 0,003 | 0,001 | 0,001 | 0,0003 | 0,002 | 0,001 | 0,001 | 0,0002 | |

Table 5. Relatedness of provincial ecosystems of Ukraine according to effect of their NRPs*

| | Total NRP | Land potential |
|---|---|---|
| Polissia | 1. Podilsko-Prydniprovskyy<br>2. West-Ukrainian | 1. Podilsko-Prydniprovskyy<br>2. West-Ukrainian |
| West-Ukrainian | 1. Ukrainian Carpathians<br>2. Polissia | 1. Polissia<br>2. Podilsko-Prydniprovskyy |
| Podilsko-Prydniprovskyy | 1. Dniester-Dnieper<br>2. Polissia | 1. Dniester-Dnieper<br>2. Left-Bank-Dnieper |
| Left-Bank-Dnieper | 1. East-Ukrainian<br>2. Dniester-Dnieper | 1. East-Ukrainian<br>2. Podilsko-Prydniprovskyy |
| East-Ukrainian | 1. Left-Bank-Dnieper<br>2. Donetsk | 1. Left-Bank-Dnieper<br>2. Left-Bank-Dnieper-Pryazovskyy |
| Dniester-Dnieper | 1. Prychornomorskyy<br>2. Podilsko-Prydniprovskyy | 1. Prychornomorskyy<br>2. Podilsko-Prydniprovskyy |
| Left-Bank-Dnieper-Pryazovskyy | 1. Donetsk<br>2. East-Ukrainian | 1. East-Ukrainian<br>2. Donetsk |
| Donetsk | 1. West-Donetsk<br>2. East-Ukrainian | 1. Left-Bank-Dnieper-Pryazovskyy<br>2. Zadonetsko-Donskyy |
| Zadonetsko-Donskyy | 1. Donetsk<br>2. East-Ukrainian | 1. Donetsk<br>2. East-Ukrainian |
| Prychornomorskyy | 1. Dniester-Dnieper<br>2. Prychornomorsko-Pryazovskyy | 1. Dniester-Dnieper<br>2. Prychornomorsko-Pryazovskyy |
| Prychornomorsko-Pryazovskyy | 1. Prychornomorskyy<br>2. Dniester-Dnieper | 1. Prychornomorskyy<br>2. Dniester-Dnieper |
| Crimean Steppe | 1. Crimean Mountainous<br>2. Prychornomosrko-Pryazovskyy | 1. Crimean Mountainous<br>2. Prychornomorskyy- Pryazovskyy |
| Crimean Mountainous | 1. Crimean Steppe<br>2. Left-Bank-Dnieper- Pryazovskyy | 1. Crimean Steppe<br>2. Prychornomosrko – Pryazovskyy |
| Ukrainian Carpathians | 1. West-Ukrainian<br>2. Polissia | 1. West-Ukrainian<br>2. Polissia |

*Provincial ecosystems are compared with respect to the maximal and second-biggest value of the strength of interaction between their NRPs.

core's (central place's) mass and the shorter the distance to the neighboring core's (ecosystem's other place) with its own mass, the stronger the effect of said central place upon the surround. Assessment of strength of NRPs' interaction in provincial ecosystems of Ukraine based on the methodical approach W. Isard [24], where the value of the ecosystem's potential in 2015-2021 prices represents the "body mass", and distances between the provinces are those that lie between their geometrical centers.

With respect to total NRP, the value of the strength of interaction is found to be the highest between the Dniester-Dnieper and the Prychornomorskyy, the Donetsk and the Zadonetsko-Donskyy, the Left-Bank-Dnieper-Pryazovskyy and the Donetsk, provincial ecosystems. The least strength of interaction is observed between the Ukrainian Carpathians and the Crimean Mountainous, West-Ukraine, and the Crimean Mountainous provincial ecosystems. Assessment of the strength of interaction between nature-resource potentials at the level of the oblasts' natural ecosystems (57 such oblasts in Ukraine) is the next important stage of our research.

## Conflict of Interest

The authors declare no conflict of interest.

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