COMPARISON OF SUBJECTS OF THE URAL FEDERAL DISTRICT BY THE SHARE OF VEGETABLE COVER

Dr. Sc., Prof. Peter Mazurkin
Volga State University of Technology, Yoshkar-Ola, Russia

ABSTRACT

The ecological consolidation of vegetation according to three classes of the UN soil cover (grass + shrub + trees) is considered. The ecological coefficient is calculated by dividing the share of vegetation by the share of changed land. For the rating, the forest-agricultural coefficient is convenient as the ratio of forest area to arable land. The ecological principle of the consolidation of 13 types of land is proposed, which makes it possible to carry out the ecological consolidation of the vegetation cover and altered human land. According to these proposed criteria, the ranking of the subjects of the Ural Federal District was carried out.

Keywords: *categories, lands, vegetation, ecological factors*

INTRODUCTION

According to N.F. Reimers [1], [2], the ecological balance is a continuously changing ratio. In terms of value, this dynamic ratio must be brought closer by scientific and technical measures to the golden ratio of 0.618 between the vegetation cover and the entire land area.

Ecological consolidation implies the consolidation of land belonging to the vegetation cover. Then it is necessary to identify a rational ratio of 61.8% between the vegetation cover and anthropogenic lands, that is, territories changed by man. These ratios become environmental factors. They will characterize the achieved level of ecological balance.

Land consolidation has a long history, the first work was carried out in Denmark in the middle of the 13th century; in Sweden in 1757, a land consolidation law was passed. In Russia, the process of unification of lands was carried out during the implementation of the Stolypin reform of 1906. One of the measures was the elimination of the communal form of land use, the formation of farms and cuts in order to allocate land in one place instead of numerous inter-striped areas scattered at a considerable distance from each other [3]. As a result, land plots are consolidated on a territorial basis.

Data for ecological consolidation of land are given in [4].

The purpose of the study is to distribute the shares of land from the land area [5] in the subjects of the Ural Federal District (UFO), and then to consolidate them according to the first three classes of the UN soil cover [6] and by identification method [7] to identify patterns.

According to the Land Code of the Russian Federation (No. 136-ФЗ dated 25.10.2001; 2019), agricultural land includes: 01. Arable land; 02. Deposit; 03.

Perennial plantings; 04. Hayfields; 05. Pastures. Non-agricultural lands are subdivided into types: 06. Forestlands; 07. Forest plantations not included in the forest fund; 08. Land underwater; 09. Building land; 10. Lands under the roads; 11. Swamps; 12. Disturbed lands; 13. Other lands.

MATERIALS AND METHODS

For the ecological consolidation of land, a matrix is needed, in which 13 types of land are located in columns and seven categories of the cadastre in rows. Rosstat [7] has such a matrix only as of 01.01.2013. Then the area of land underwater was subtracted from the area by categories and the land area was obtained $S_c = S - S_{08}$ (Table 1). After dividing the area of 12 land by land area (100), the proportion of land (%) was calculated. The shares of land (Table 2) are calculated as follows: $\alpha_{jk} = 100 S_{jk} / (S - S_{08})$, where j — is the number of the UFO subject, k — is the number of the type of land; S — the total area [7] of the Urals Federal District.

Table 1. *Fragment of data on UFO lands by land area [7], thousand hectares*

Cate-gory	Total area	Underwater	Land area	Land area by type					
				01	02	03	…	12	13
1	49505.1	3352.7	46152.4	7866.1	877.7	53.1	⋯	76.8	22192.2
2	2630.3	160	2470.3	308	8.9	51.3	⋯	31.5	178
3	1127.2	92.8	1034.4	15.4	0	0	⋯	67.9	97.9
4	2576.6	175.3	2401.3	0.5	0.7	0	⋯	0	619.6
5	108665.2	4847.7	103817.5	37	1.9	0.2	⋯	97.1	1082.5
6	8951.1	8681.2	269.9	0	0	0	⋯	0.1	13.4
7	8394.2	725.8	By land	103.5	73.2	0.1	⋯	9.1	2219.1
Total	181849.7	18035.5	163814.2	8370.5	962.4	104.7	⋯	282.5	26402.7

Table 2. *Shares of land species from the land area of the Ural Federal District*

Cate-gory	The share of land according to the numbers of their types of land area,%											
	01	02	03	04	05	06	07	09	10	11	12	13
1	4.802	0.536	0.032	1.354	1.750	2.172	2.252	0.028	0.084	1.567	0.047	13.547
2	0.188	0.005	0.031	0.072	0.275	0.322	0.046	0.228	0.098	0.113	0.019	0.109
3	0.009	0.000	0.000	0.018	0.006	0.211	0.008	0.113	0.136	0.030	0.041	0.060
4	0.000	0.000	0.000	0.002	0.002	0.794	0.061	0.002	0.001	0.225	0.000	0.378
5	0.023	0.001	0.000	0.219	0.130	41.276	0.001	0.016	0.166	20.823	0.059	0.661
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.156	0.000	0.008
7	0.063	0.045	0.000	0.279	0.150	0.442	0.701	0.001	0.007	1.632	0.006	1.355
Total	5.110	0.587	0.064	1.943	2.314	45.217	3.069	0.389	0.492	24.546	0.172	16.117

According to the UN classification [6] (soil cover classes KPP), in the first place is grass I (04 Hayfields, 05 Pastures and 11 Swamps), in the second place - bush (03 Perennial plantations and 02 Fallow, which in 4-7 years overgrown with

bushes) and on the third III - trees (06 Forest lands and 07 Forest plantations not included in the forest fund).

The vegetation cover is equal to the sum of I + II + III. Then the activity of the vegetation cover on land will be equal $\alpha_{I+II+III} = \alpha_I + \alpha_{II} + \alpha_{III}$. Negatively modified land $\alpha_N = \alpha_{01} + \alpha_{09} + \alpha_{10} + \alpha_{12}$. Then the ecological coefficient will be defined as $K_E = (\alpha_I + \alpha_{II} + \alpha_{III}) / \alpha_N$. In a simplified version, the ratio of the share of forests to the share of arable land gives the forest agricultural coefficient $K_0 = \alpha_{06} / \alpha_{01}$.

Table 3 shows that the forest agricultural coefficient K_0 is sensitive in comparison with the coefficient K_E. The share of the vegetation cover of the Ural Federal District is 75.90% and this is more than 60% according to N.F. Rey-mersu. The main share of 56.04% belongs to the forest fund of the Ural Federal District.

Table 3. *Shares (%) of soil cover classes and ecological factors*

Cate-gory	Proportion of UN soil cover classes and their sum				α_N	K_0	K_E
	α_I	α_{II}	α_{III}	$\alpha_{I+II+III}$			
1	4.672	0.568	4.423	9.664	4.960	0.45	1.9482
2	0.460	0.037	0.368	0.865	0.534	1.71	1.6213
3	0.054	0.000	0.219	0.272	0.299	22.44	0.9101
4	0.228	0.000	0.855	1.084	0.004	2602.20	295.9500
5	21.172	0.001	41.277	62.450	0.264	1827.44	236.2085
6	0.156	0.000	0.000	0.156	0.000	∞	426.5000
7	2.061	0.045	1.144	3.249	0.077	7.00	42.2429
Total	28.803	0.651	48.286	**77.740**	6.163	8.85	12.6144

The total activity of the vegetation cover of the Ural Federal District is 77.74%, which is much higher than the rational ecological balance of 61.8%.

RESULTS AND DISCUSSION

The ecological principle in land use. The main habitat is vegetation. As you know, forests with trees are the core of the planet's biosphere and thus become the main part of the vegetation cover on land [2]. The greatest anthropogenic changes in the soil cover occur in arable land. Therefore, the forest/arable land ratio becomes the first and main environmental factor.

Each person strives for the best, therefore, two vector orientations in behavior are possible [2], [5]: a) less is better (so it will be better) for anthropogenic objects; b) more is better (and this is a blessing) for natural objects.

Table 4 shows vector ecological landmarks for 12 types of land (without underwater) in relation to any territorial unit.

Table 4. *Direction of the vector is better worse by types of land*

Types of land	Less is better	Bigger is better	Types of land	Less is better	Bigger is better
1. Arable land	+	-	7. Plantations outside forests	-	+
2. Deposit	+	-	9. Building land	+	-
3. Perennial plantings	-	+	10. Land under the roads	+	-
4. Hayfields	-	+	11. Swamps	-	+
5. Pastures	-	+	12. Disturbed lands	+	-
6. Forest lands	-	+	13. Other lands	+	-

Land types 1, 9, 10 and 12 clearly belong to natural objects modified by anthropogenic interference. Many people, especially non-specialists, want the quality characteristics of the territory. This is more familiar and more convenient.

In table 5, the scales of forest cover (06 + 07) and plowing (01) are suggested. These two scales were compiled on the basis of the principle of ecological balance of the territory according to N.F. Reimers [2].

Table 5. *Scale classification of the territory of the constituent entities of Russia*

Intervals of values of the coefficient of forest agrarianity, %	Qualitative characteristics of intervals values of the ecological state of the territory	
	forest cover	plowing
More 85	Solid forest	Extremely agrarian
65 - 85	Multi-forest	Ultra-high plowing
45 - 65	Moderate forest	High plowing
25 – 45	Partial forest	Medium agricultural
10 - 25	Low-forest	Moderately agricultural
1 – 10	Non-woody	Low plowing
0 – 1	Treeless	Non-agricultural

Maintaining the ecological balance in a given territory can be carried out by specially allocated plots of land for new forests. The Ural Federal District has a share of the area under trees 48.29% (Table 3) and a share of arable land 5.11% (Table 2). According to table 5, the UFO territory is characterized as moderate forest and low agricultural.

The activity of the vegetation cover by the subjects of the Ural Federal District. Territorial units have a wide range of values in terms of area (Table 6 [4]). To be able to compare the subjects of the federation, it is necessary to switch to the relative shares of the area of categories and lands, divided by the total land area of a group of subjects (federal districts).

Table 6. *Fragment of data on the subjects of the Ural Federal District by land area, thousand hectares*

Code	Subject of the federation	General area	Under water	Square under land	Types of land		
					01	…	13
	Ural federal district	181849.7	18035.5	**163814.2**	8330.5	⋯	26402.7
45	Kurgan region	7148.8	318.6	6830.2	2402.6	⋯	54.7
66	Sverdlovsk region	19430.7	264.5	19166.2	1453.4	⋯	229.6
72	Tyumen region	16012.2	508.5	15503.7	1397.3	⋯	69.5
74	Chelyabinsk region	8852.9	275.9	8577.0	3063.4	⋯	189.4
86	Khanty-Mansiysk jsc	53480.1	3185.6	50294.5	12.9	⋯	520.5
89	Yamalo-Nenets JSC	76925.0	13482.4	63442.6	0.9	⋯	25339.0

For the subjects, the relative shares of land were calculated by dividing the area from Table 6 by the total land area of the Ural Federal District 163814.2 thousand hectares (Table 7).

Table 7. *Shares of land types of subjects of the land area of the Ural Federal District*

Code	The share of land according to the numbers of their types of land area, %											
	01	02	03	04	05	06	07	09	10	11	12	13
45	1.47	0.28	0.01	0.34	0.63	1.07	0.02	0.03	0.05	0.23	0.00	0.03
66	0.89	0.07	0.02	0.38	0.22	8.32	0.14	0.09	0.14	1.25	0.04	0.14
72	0.85	0.20	0.01	0.55	0.46	4.34	0.09	0.05	0.06	2.81	0.00	0.04
74	1.87	0.03	0.02	0.36	0.83	1.65	0.05	0.08	0.09	0.12	0.02	0.12
86	0.01	0.00	0.01	0.21	0.16	17.52	0.10	0.08	0.10	12.17	0.03	0.32
89	0.00	0.00	0.00	0.10	0.02	12.31	2.67	0.06	0.05	7.96	0.08	15.47

Table 8 shows the shares of the first three classes of soil cover according to the UN classification, the sum of the three classes as the share of vegetation cover by regions in relation to the land area of the Ural Federal District, as well as the share of human-changed lands, forest agricultural and ecological coefficients.

Table 8. *Shares (%) of soil cover classes and ecological factors*

Code	Proportion of UN soil cover classes and their sum				α_N	K_0	K_E
	α_I	α_{II}	α_{III}	$\alpha_{I+II+III}$			
45	1.20	0.29	1.10	2.59	1.55	0.732	1.669
66	1.85	0.09	8.46	10.40	1.16	9.376	8.978
72	3.82	0.21	4.43	8.46	0.96	5.090	8.784
74	1.31	0.06	1.70	3.06	2.06	0.884	1.491
86	12.54	0.01	17.61	30.16	0.22	2224.5	134.14
89	8.09	0.00	14.99	23.07	0.19	22411.1	123.48

Due to the relatively low forest cover (1.10% at the border of the treeless area according to Table 5), the Kurgan region received a forest agricultural coefficient of 0.731. However, the lowest value of 1.491 ecological coefficient is observed in

the Chelyabinsk region. The best environmental conditions are observed in the Khanty-Mansiysk Autonomous Okrug.

Rank distribution and rating of the subjects of the federation. The rank ($R = 0,1,2,3,...$) differs from the place in the rating ($I = 1,2,3,...$) by the addition of the digit 0. This allows the use of the positive semi-axis of the abscissas in modelling by the identification method [6], [7].

Table 9 shows the rating of the constituent entities of the Ural Federal District, taking into account the vectors of semantic orientation according to Table 4.

Table 9. *Ranks of lands and rating of subjects by land area of the Siberian Federal District*

Code	Ranks of lands by codes of their types from land area, %												ΣR	I
	01	02	03	04	05	06	07	09	10	11	12	13		
45	6	6	0	0	0	1	0	4	3	2	5	6	33	4
66	5	4	1	3	1	4	3	6	4	5	3	2	41	6
72	2	0	2	4	4	5	4	5	5	6	4	1	42	7
74	0	0	2	5	5	2	2	2	1	3	0	3	25	1
86	3	3	2	2	3	0	5	3	6	0	6	4	37	5
89	0	0	2	6	6	6	6	0	0	4	0	0	30	3

When ranking = RANK (T5; T$5: T$11; 1), the following designations are adopted for the Excel environment: T – is the identifier of the ranked column S01; T5, T$5 - first line; T$10 - last line; $0 \vee 1$ - ranking in descending (0) or ascending (1). The program gives places $I = 1,2,3,.....$. For ranks (more convenient for modelling), the expression is used $R = I - 1$.

According to the environmental conditions from Table 4, the first place among the subjects of the Ural Federal District in 2012 was taken by the subject of the federation 74 - the Chelyabinsk region.

The ratings separately for the share of vegetation cover and separately for the ecological factors are shown in Table 10.

Table 10. *Proportion of vegetation and ecological coefficients from the influence of ranks*

Code	Vegetation		Modified land types		Forestry and agricultural coefficient		Total environmental factor	
	R_{PII}	$\alpha_{I+II+III}$	R_N	α_N	R_0	K_0	R_E	K_E
45	5	2.59	4	1.55	5	0.732	4	1.669
66	2	10.40	3	1.16	2	9.376	2	8.978
72	3	8.46	2	0.96	3	5.090	3	8.784
74	4	3.06	5	2.06	4	0.884	5	1.491
86	0	30.16	1	0.22	1	2224.5	0	134.14
89	1	23.07	0	0.19	0	22411.1	1	123.48

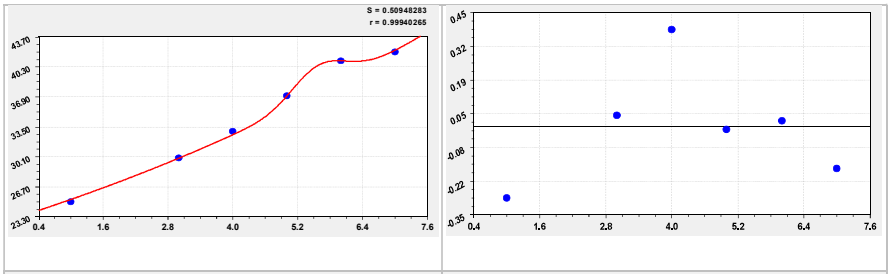
In terms of the share of vegetation cover, the zero rank (first place) and the general ecological coefficient is occupied by 86 - Khanty-Mansi Autonomous Okrug, and according to the least changed lands and the highest forest agricultural coefficient - 89 - Yamalo-Nenets Autonomous Okrug.

Regularities of rank distributions. By rating (Table 9), as well as by the share of vegetation cover and separately by ecological coefficients (Table 10), the models in the form of trends (due to the small number of subjects, only six) are given in Table 11.

Table 11. *Parameters of the model of rank distribution of subjects*

Indicator y	Trend equation $y = aexp(-bx^c) + dx^e\exp(-fx^g)$							Coef. correl.
	Exponential law			Biotechnical law				
	a	b	c	d	e	f	g	r
$\sum R$	23.22671	-0.084800	1	9.20654e-39	122.99813	21.99186	1	0.9994
$\alpha_{I+II+III}$	30.39541	0.094098	1	-1.36563e8	5.75246	17.02885	0.24352	1.0000
α_N	0.13270	0	0	0.27947	1.19626	0	0	0.9856
K_0	22413.7	2.52831	1	0	0	0	0	0.9999
K_E	142.77683	0.13563	1	-1.09525e9	9.11700	17.82529	0.35127	1.0000

The greatest adequacy in terms of the correlation coefficient is 1.0000 (due to the equality of the number of model parameters to the number of subjects) for the share of vegetation cover on the land of the Ural Federal District and the ecological coefficient (Fig. 1).



Two-term trend | Remains from the trend

Fig. 1. *Rating graphs (Table 9) the sum of ranks from place*

(S - standard deviation; r - correlation coefficient)

The first term of the trend is Laplace's law (in mathematics), Mandelbrot (in physics), Perl-Zipf (in biology) and Pareto (in econometrics).

The rest of the graphs by ranks are given in Figure 2. The share of vegetation changes according to the Mandelbrot law of exponential decline, and the biotechnical law is subtracted from it (therefore, it is a crisis law). The proportion of altered lands increases according to a power-law function.

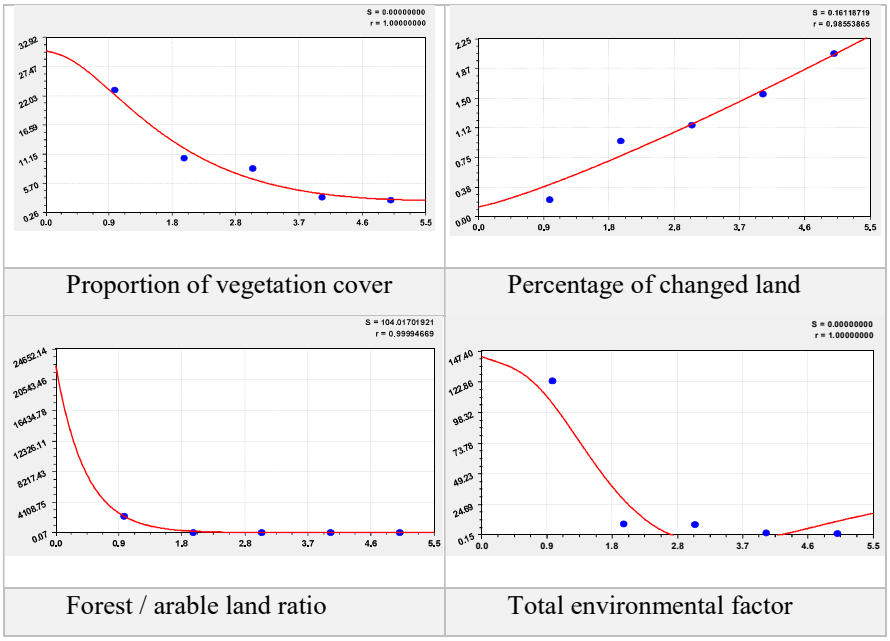


Fig. 2. *Rank distributions of subjects by vegetation parameters*

The greatest simplicity (only one component in the model) has the forest-agrarian coefficient, which decreases according to the Mandelbrot law, and the general ecological coefficient decreases with the crisis according to the biotechnical law.

CONCLUSION

The hierarchy of the constituent entities of the Ural Federal District according to the ecological possibilities of consolidation of vegetation cover according to three classes of soil cover according to the UN classification (grass + shrub + trees) is considered. On land, it is proposed to rank the shares of vegetation cover and human-modified land, as well as ecological coefficients. The total ecological coefficient is calculated by dividing the share of vegetation as a whole and by soil cover classes, the total share of anthropogenic (human-modified) lands. Particularly considered is a very accurate forest agricultural coefficient, as the ratio of forest area to arable land area.

In the future, it becomes possible, in addition to vegetation, to take into account geomorphological, climatic, socio-economic, migration and other subgroups of factors.

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