ISSN 2079-9705, Regional Research of Russia, 2017, Vol. 7, No. 4, pp. 395–401. © Pleiades Publishing, Ltd., 2017.
Original Russian Text © N.N. Klyuev, 2017, published in Izvestiya Russkogo Geograficheskogo Obshchestva, 2017, Vol. 149, No. 3, pp. 4–15.

GEOGRAPHY OF RESOURCE USE MANAGEMENT

Agrarian Nature Management in Russian Regions: Ecological and Resource Dissonance

N. N. Klyuev

Institute of Geography, Russian Academy of Sciences, Moscow, Russia

e-mail: klyuev@igras.ru

Received December 16, 2016

Abstract—This article considers the ecological consequences of the transformation of agricultural nature management in post-Soviet Russia in a regional context. It has been revealed that approximately half the regions have changed their specialization from livestock farming to crop growing. The regional indices (1990–2014) of agricultural production and indices of resources being utilized (cultivated areas, livestock population, and fertilizer utilization) have been compared. The phenomenon of ecological and resource dissonance in agriculture, which leads to degradation of agrolandscapes, has been revealed. It has been established that the more successful the development of regional agriculture is, the higher the resource and ecological dissonance. Two groups of regions that differ by diametrically opposite ecological trajectories have been distinguished: (1) regions with accelerated agricultural simplification, where changes in regional climatic characteristics can be expected; (2) Central Chernozem regions, in which excessive utilization of agrolandscapes threatens their accelerated ecological degradation.

Keywords: agriculture, nature management, ecological consequences, regions, postreform Russia

DOI: 10.1134/S2079970517040049

Since 1991, Russian agriculture has undergone significant transformations: private land ownership has been introduced, the collective and state farm system has been liquidated, farm enterprises have been formed, and large agricultural holdings have been created. This article discusses some real and potential ecological consequences of post-Soviet changes in the agrarian sphere in Russia and its regions.

By 2015, the agricultural output of 21 Russian regions significantly exceeded the level recorded in 1990 and 16 regions reached this level or were close to it: the agricultural production index (naturally, in comparable prices) varies from 95 to 105%, while in the other regions, the index varies from 7 to 94%[1]. The leading position is occupied by Central Chernozem Economic Area oblasts and North Caucasian republics (Dagestan and Kabardino-Balkaria), while the Far Eastern and northern regions are outsiders. However, Russian regions are very inequivalent with respect to agrarian output. The highest absolute losses of production, i.e., losses on a national scale, are observed in Moscow, Tver, Nizhny Novgorod, and Kurgan oblasts rather than in the north and east of Russia (where the relative losses are maximal).

[1] Here and elsewhere, the calculations are based on official data unless otherwise indicated [9–11, 13, 14].

The new agrogeographical reality is a change in agricultural specialization. In 1990, 65.5% of agrarian products were yielded by livestock, while in 2015, it was only 47.7%. This led to a change in the agrarian profile of Russian regions. In the late 1980s, crop production prevailed only in several southwestern areas; today, it is dominant almost in a half of Russian regions [5]. Accordingly, the size of natural forage lands, i.e., haylands and pastures, significantly decreased (by 15 mln ha).

Over the period from 1990 to 2015, cultivated areas for agricultural crops decreased by one-third the total cultivated areas in 1990. This resulted in a change in the pattern and degree of agrarian effects on natural components and complexes, as well as the whole image of contemporary rural landscapes.

For instance, forest–meadow–field landscapes, which were traditional for the Non-Chernozem Zone, were transformed into meadow–forest landscapes in some areas. A peculiar landscape rotation is clearly observed here. It is appropriate to recall that Yu.G. Saushkin advanced the idea of territorial nature rotation [12, p. 346] by analogy with crop rotation in agriculture, i.e., the idea of targeted change in the functions of territorial units, as well as their periodic inclusion and exclusion from economic turnover and changes in the intensity of their use, e.g., giving "rest" to lands that are "exhausted" from being exploited.

However, the current landscape rotation is spontaneous and its ecological compatibility is extremely questionable.

A small number of farm animals disturb the harmony between livestock farming, which produces wastes, and crop farming, which utilizes them. The multiple reduction in the utilization of organic fertilizers in Russian fields is notably caused by a decrease in the livestock population: there is simply no one to produce fertilizers. Certainly, an abstract statement about the optimal ratio between livestock farming and crop production without analysis of natural and economic conditions of certain farms is devoid of any sense. However, one cannot but take into account that the agricultural sector has also incurred a deficit of organic fertilizers during the postreform period, when the livestock population was much higher. The intensive construction of large livestock breeding complexes in chernozem oblasts over the past decade aggravates the age-old problem of utilization of bulk wastes that are concentrated near them. Due to the high cost of transportation, as well as to lack of equipment and organizational factors, a much higher share of manure and dung wastes is discharged into manure storages, sewage ponds, treatment facilities, adjacent lands, and water bodies rather than being utilized as fertilizers. This naturally affects the quality of the water in the water bodies and water courses.

By the early 1990s, the stock of nutrients was created in Russian arable soils; however, at the present time, the balance is hopelessly negative. In total, nutrients that were removed from soil together with crops were compensated by fertilization in the following quantities throughout Russia: 15% nitrogen, 15% phosphorus, and 5% potassium [3]. The deterioration of agrochemical soil properties and their progressing degradation are also due to a sharp decrease in liming of acid soil (by 16 times over 1990–2014), as well as to a reduction in gypsuming of solonetz soil (by 106 times).

Farm enterprises are distinguished by progressing unbalance. The share of livestock farming in the structure of their production was 32.3% in 1995 and 21.4% in 2015. In some regions, this share is much lower, e.g., in Kursk oblast, where it is only 7.5%.

Modern crop farming is based on controlled two-way (drainage combined with irrigation) regulation of the hydrological, thermal, and other soil regimes. In post-Soviet Russia, the size of reclaimed areas is decreasing and hydrotechnical systems are being destroyed. Degradation phenomena (fires on drained peat soils, secondary bogging, and salinization) occur in previously reclaimed areas. As a result, productive lands lose their economic value, while the lands that remain in circulation are used under conditions of a spontaneous, unregulated soil regime. This is one of the features of simplification of domestic agriculture.

As of January 1, 2015, only 27% of reclaimed lands was in a good state in Russia, while Bryansk, Ryazan, Sverdlovsk, and Chelyabinsk oblasts, the Jewish Autonomous Oblast, Adygea, and North Ossetia had no such lands at all and a half of the other Russian regions had less than 10% of total reclaimed lands [1]. At the same time, only these lands are improved and are ecologically valuable, while the opposite is more likely for the rest. It is no accident that the catastrophic wildfires in summer 2010 covered regions with large fallow lands and where the state of previously reclaimed lands is poor.

There appears to be a paradoxical effect of the difference between the agricultural production indices and the resource utilization indices (cultivated areas, livestock population, the use of organic and mineral fertilizers, equipment, electric power, etc.) in postreform agriculture (Fig. 1). Increasingly fewer resources are utilized per unit of production. At first glance, this is the intensification of production, and it is actually observed on some farms that use new equipment, technologies, productive plant varieties and cattle strains, and institutional and organizational factors that have observed over recent decades. For instance, milk yield per cow in agricultural enterprises increased from 2731 to 5699 kg over the period from 1990 to 2015; however, the cow population decreased almost two times on these farms over this period. Wool yield decreased from 3.9 to 2.5 kg per sheep. A significant share of agricultural products (38.4% in 2015) is still produced on households largely by physical labor with a low level of agrotechnology. Field studies [4] showed that peasant land use is not as ecologically friendly on household plots as may seem at first. The structure of their cultivated areas is dominated by potato crops, which hinders the use of ecologically rational crop rotation. The technologies for using fertilizers and pesticides are violated, which deteriorates the phytosanitary state of agroecosystems.

The total gain in production throughout the country is largely achieved by intensification of land resource exploitation, which is fraught with the consumption of soil fertility and degradation. As positive results of agrarian reforms, some researchers [8] note an increase in crop productivity. However, the growth in crop yields[2] is notably achieved via concentration of crop farming in lands with the highest quality, while less productive lands are withdrawn from agriculture. Under conditions of uncompensated (by fertilizer application) crop farming, this may lead to quick transformation of some of the best lands into wastelands, followed by the inevitable transfer of agriculture to less fertile lands, as well as their further degradation,

[2] A certain improvement in hydrothermal conditions in agricultural areas over recent decades is also an important factor of growth in crop yields; i.e., this is a kind of climatic humanitarian aid for Russia being constantly reformed.

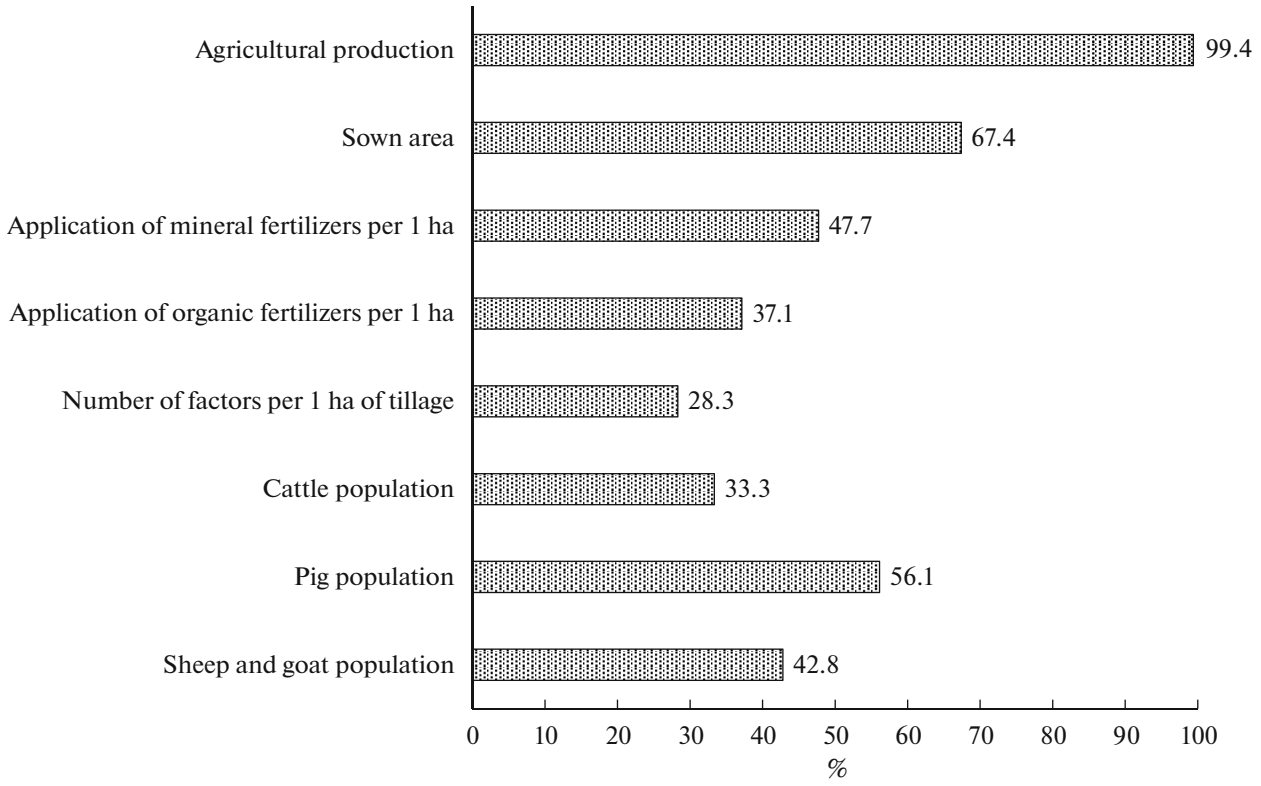

Fig. 1. Russian agricultural indices from 1990 to 2015, % (1990 level is assumed to be 100%).

etc. In turn, the repeated rehabilitation of abandoned lands will require costs comparable with those required for their primary development, since not only agro-sod-podzolic but also more fertile agro-gray soils degrade according to the humid type after their abandonment. In forest zones, soils intensively lose their fertility in wilding landscapes due to podsolization and solodization, as well as eluvial-gleying and other processes.

Let us term the noted difference between the production indices and resource indices and the paradoxical inconsistency between the decreasing flow of material resources and the increase in agricultural production output (the input—output paradox) as ecological and resource dissonance, in order to focus on the main factor of this inconsistency, namely, the restriction of land resource use.

Let us consider the ecological and resource dissonance in a regional context (Fig. 2). The integral indices of resources being utilized over the period from 1990 to 2014 (I_i) were preliminarily calculated by the following formula:

$$I_i = \frac{I_c + I_f + I_l}{3},$$

where I_c is the index of cultivated areas, I_f is the mineral fertilizer index, and I_l is the livestock population index[3]. In other words, the integral index was determined as the arithmetic average of the three special indices of resources being utilized, which, in our view, crucially determine the agricultural production output (it is unlikely that other summation methods would trigger fewer questions).

The three indices are clearly insufficient for more local studies; however, this approach is acceptable for the first experience of interregional analysis. During calculations, it would be also useful to isolate the gain in production induced by its intensification; however, this is possible only in the case of field studies by individual farms. During interregional comparisons, the contribution of individual advanced high-technology farms is generally smoothed, although detailed field studies may reveal regions with a high share of environmentally oriented farms; however, so far, this is no more than a hypothesis.

The minimum values of the integral index are characteristic of Kostroma, Smolensk, Ivanovo, Tver, and Kaluga oblasts. Specifically, in Kostroma oblast, cul-

[3] We used rounded coefficients of the conversion of livestock population into arbitrary units according to [15] to reduce the livestock of different species to a common denominator.

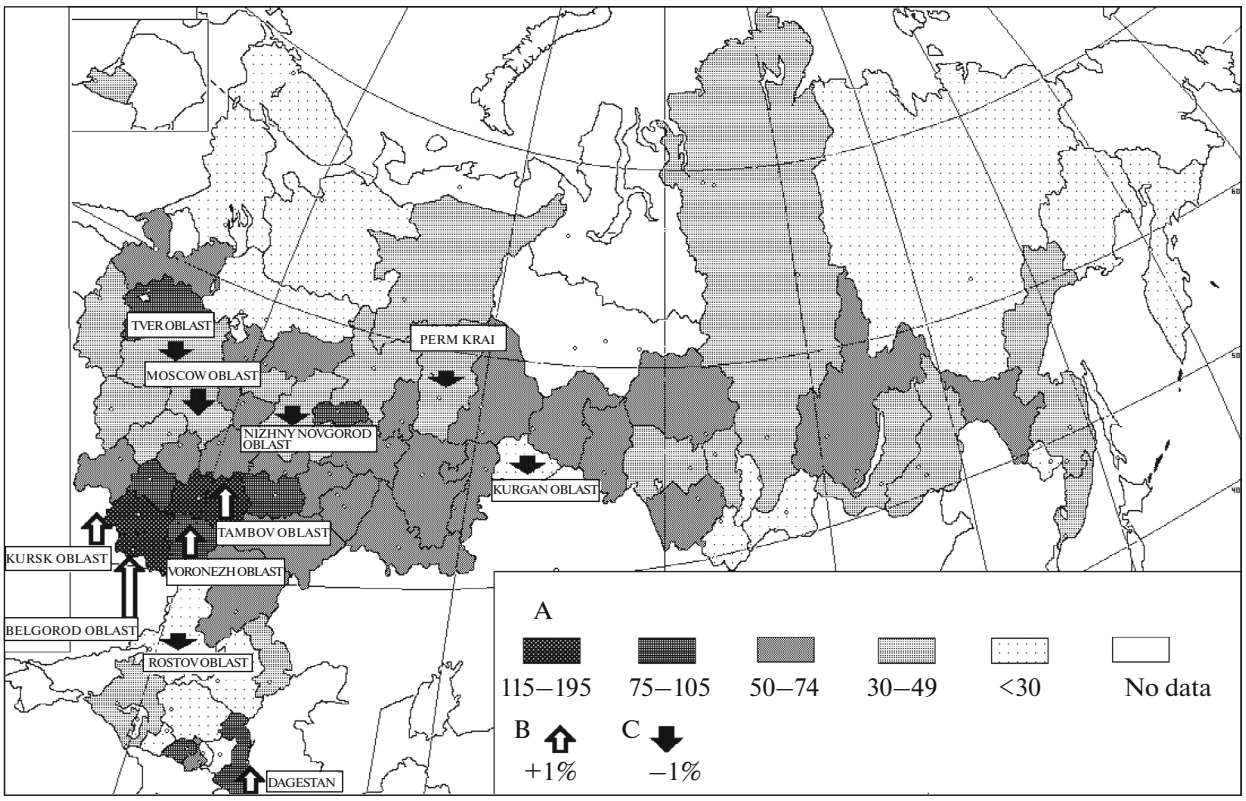

Fig. 2. Changes in load on agricultural landscapes from 1990 to 2014 in Russian regions. Notation: (A) Difference between indices of agricultural production and indices of resources being utilized (%); maximum growth (B) and reduction (C) in agricultural production 1990 to 2014 (% of agricultural production in oblasts of Russian Soviet Federative Socialist Republic in 1990).

tivated areas decreased by 3.4 times, the use of mineral fertilizers (per 1 ha) decreased by 12.5 times, and the cattle population decreased by 6 times. At the other pole, i.e., in Karachay-Cherkessia and Dagestan, this index exceeds 100% (indicating an increase in production factors involved in rotation). For instance, the sheep population increased by 1.5 times in Dagestan and by 1.7 times in Karachay-Cherkessia. In the Central Chernozem Economic Area oblasts, previously abandoned tillage was rehabilitated since the mid-2000s: thus, in Kursk oblast, the area of cultivated lands exceeded this value of the Soviet period in 2015.

A well-defined pattern was revealed: the higher the index of production is, the higher the difference between the indices (Table 1). The more successful (purely in terms of production) the development of regional agriculture is, the higher the resource and ecological dissonance.

Two groups of regions differing by diametrically opposite ecological trajectories are distinguished (Fig. 3).

(1) Federal subjects with a high difference between the indices and a significant decline in production (Tver and Nizhny Novgorod oblasts, Perm krai, etc.) are regions with accelerated simplification of agriculture. The dependence of the agrarian sphere on natural regimes and trends, especially on climate, is increasing in these regions. In addition, changes in the regional climatic characteristics can be expected in these regions. A.N. Krenke [7] showed that the formation of natural–economic zones significantly disturbed the natural–climatic zonation. Renaturalization of landscapes (due to the reduction in agricultural activity and its simplification) leads to renaturalization of regional (or even zonal) climatic characteristics. At the present time, certain changes in regional climate can be anticipated in areas with a significant reduction in agricultural activity.

(2) An increase in the effect on landscapes is observed in regions where a high difference between indices is accompanied by growth in production (Belgorod, Tambov, Lipetsk, Kursk, and other oblasts). Excessive use of agrolandscapes in the Central Chernozem and adjacent oblasts threatens their accelerated environmental degradation. Meanwhile, it is the forest–steppe zones in Russia that are most severely disturbed by economic activity.

Ecologically unfavorable changes are observed in the regional structures of cultivated areas. Chernozem regions are characterized by increase in the share of tilled crops and bare fallows, which cause erosion, as well as by a decrease in the share of soil-improving

Table 1. Regions leading in the dynamics of agricultural production from 1990 to 2014

Region	Index of production, %	Region	Gain in production, %*	Region	Difference between index of production and index of resource being utilized, %
Belgorod oblast	282	Belgorod oblast	2.87	Belgorod oblast	192
Tambov oblast	208	Tambov oblast	1.45	Tambov oblast	145
Republic of Dagestan	187	Kursk oblast	1.20	Lipetsk oblast	124
Lipetsk oblast	180	Voronezh oblast	1.15	Kursk oblast	114
Kursk oblast	176	Republic of Dagestan	1.07	Mari El Republic	104
Kabardino-Balkar Republic	164	Lipetsk oblast	0.93	Voronezh oblast	98
Voronezh oblast	155	Republic of Tatarstan	0.84	Novgorod oblast	92
Oryol oblast	141	Oryol oblast	0.42	Oryol oblast	88
Mari El Republic	137	Kabardino-Balkar Republic	0.39	Kabardino-Balkar Republic	83
Republic of Tatarstan	131	Republic of Bashkortostan	0.38	Penza oblast	77

* % of agricultural products in oblasts of Russian Soviet Federative Socialist Republic in 1990; regions leading in all the three indices are shaded.

perennial grass and leguminous crops. For example, the share of tilled crops in Tambov oblast increased to 36.5% in the post-Soviet years, which is 3.5 times higher than the biological crop farming standard, while the share of perennial grass crops decreased by eight times, i.e., to 2.3% (10 to 12 times lower than the biological crop farming standard) [6, p. 121]. In Kursk oblast, the share of grain crops, which are characterized by low soil-protective (erosion-preventive) ability, increased from 52 to 66% from 1990 to 2015. At the same time, the share of perennial grass crops (with high erosion-preventive ability) decreased from 6.5 to 2.6%.

The main grain-producing areas primarily have increased wheat export. Russia has already become a worldwide leader in wheat export. However, the activation of export of crop products (the raw sector of agriculture) against the background of the collapse of livestock farming (processing sector) indicates Russia's consolidation of raw-material specialization, which outputs products with a low share of value added.

Cultivated areas of soil-destroying sunflower have increased manifold in Chernozem regions (Table 2). Its share in crops significantly exceeds the phytosanitary standards in a number of regions. A monoculture is a subtype of a "biological weapon." It leads to soil depletion and the development of specific pests and diseases in crops. Farm enterprises are particularly environmentally unfriendly in this regard. For instance, in Rostov oblast, farmers occupy almost a half the lands with sunflower, while the standard is 14 to 15%.

Therefore, an essential feature of the transformation of agricultural nature management in postreform Russia is the change in the pattern of agroecological problems. During the late Soviet period, ecological problems were due to the intensification of agriculture, i.e., the use of fertilizers and plant protection agents, as well as load of the heavy agricultural equipment and bulk wastes from livestock breeding complexes. Today, problems characteristic of agriculturally backward countries have become prominent; these problems are associated with the consumption of soil fertility, as well as the abandonment of cultivated plowlands and primitive crop and livestock farming technologies. There is almost no state policy in Russia's agricultural ecologization. The situation is aggravated by an increasingly lower flow of information on the state of agricultural landscapes: Russia's soil service has been almost completely destroyed [2] and geobotanical land studies are carried out very rarely.

Agriculture is based on renewable natural resources; its full development makes it possible to move in the ecologically right direction. However, this is true only if agrolandscapes are rationally used. The study shows that there is a clear ecological and resource dissonance in the Russian agrarian sphere: the gain in production is significantly yielded due to excessive utilization of land resources, which threatens their degradation. As well, the ecological and food safety of the country is in danger.

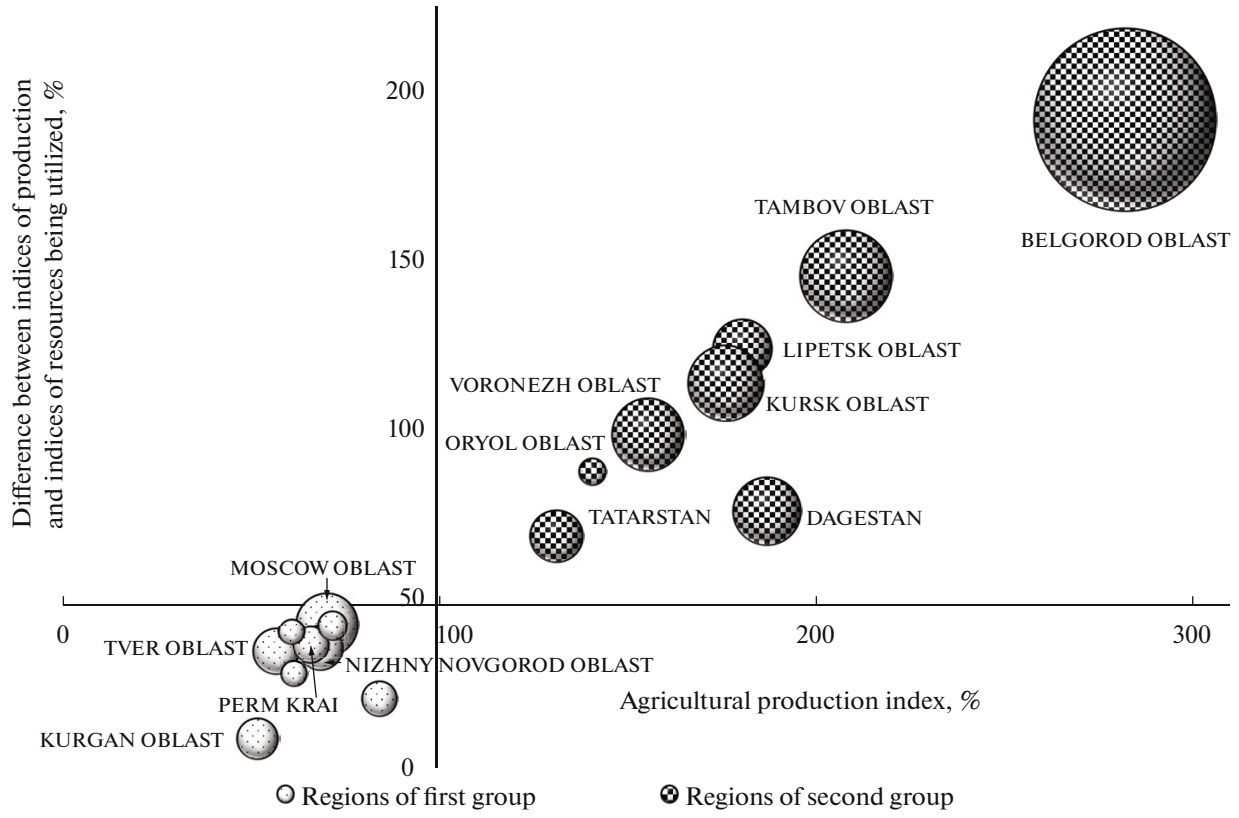

Fig. 3. Difference between agricultural production indices and indices of resources being utilized in some Russian regions from 1990 to 2014. Volume of balls is proportional to growth/reduction in agricultural output from 1990 to 2014. Axes are drawn through average Russian values of respective indices.

Table 2. Sunflower cultivated areas in some Russian regions in 1990 and 2014 (compiled according to data of [13, 14])

Region	Sunflower cultivated areas, thous. ha		Change in cultivated areas over 1990–2014, %	Share of sunflower in entire cultivated area, %		Excess of phytosanitary standard, times	
	1990	2014		1990	2014	1990	2014
Russia	2739	6907	252	2.3	8.8	–	–
Saratov oblast	355	1068	301	6.4	29.2	–	2.1
Volgograd oblast	250	601	240	5.4	20.6	–	1.5
Orenburg oblast	207	553	267	3.7	13.0	–	–
Altai krai	135	536	397	2.1	9.8	–	–
Rostov oblast	455	527	116	8.7	12.0	–	–
Samara oblast	183	518	283	6.8	25.9	–	1.8
Krasnodar krai	309	453	147	7.9	12.4	–	–
Voronezh oblast	214	450	210	7.2	17.7	–	1.3
Tambov oblast	99	386	390	4.8	23.5	–	1.7

ACKNOWLEDGMENTS

This study was performed within the State Assignment of the Institute of Geography, Russian Academy of Sciences, on the topic "Current Nature Management Trends in Russian Regions and Their Geoecological Assessment" and within Program of Basic Research no. 13 of the Presidium of the Russian Academy of Sciences.

REFERENCES

1. The governmental (national) report "On the status and use of lands in Russian Federation in 2014." https://rosreestr.ru/site/activity/sostoyanie-zemel-rossii/gosudarstvennyy-natsionalnyy-doklad-o-sostoyanii-i-ispolzovanii-zemel-v-rossiyskoy-federatsii/. Accessed December 7, 2016.
2. Dobrovol'skii, G.V. and Zaidel'man, F.R., The object of melioration: soil or land? *Ispol'z. Okhr. Prirod. Resur. Ross.*, 2004, no. 3, pp. 50–56.
3. *Izmeneniya okruzhayushchei sredy i klimata: prirodnye i svyazannye s nimi tekhnogennye katastrofy* (Change of Environment and Climate: Natural and Related Technogenic Disasters), Moscow: Inst. Geol. Rudn. Mestorozhd., Petrogr., Mineral. Geokhim., Ross. Akad. Nauk, 2007.
4. Klyuev, N.N., New trends in nature management in Russian regions and their ecological consequences, in *Prirodopol'zovanie v territorial'nom razvitii sovremennoi Rossii* (Nature Management in Territorial Development of Contemporary Russia), Volkova, I.N. and Klyuev, N.N., Eds., Moscow: Mediapress, 2014, pp. 222–239.
5. Klyuev, N.N., Russia's natural-resource sphere and trends in its development, *Herald Russ. Acad. Sci.*, 2015, vol. 85, no. 4, pp. 303–315.
6. Kosolapov, V.M., Trofimov, I.A., Trofimova, L.S., and Yakovleva, E.P., *Agrolandshafty Tsentral'nogo Chernozem'ya* (Agrolandscapes of Central Chernozem Zone), Moscow: Nauka, 2015.
7. Krenke, A.N., Anthropogenic changes in geographical zonality and their influence on the ratio of heat and moisture in the climate system, *Izv. Ross. Akad. Nauk, Ser. Geogr.*, 1989, no. 3, pp. 43–50.
8. Nefedova, T.G., *Sel'skaya Rossiya na pereput'e* (Rural Russia on a Crossroad), Moscow: Novoe Izd., 2003.
9. *Regiony Rossii: statisticheskii sbornik* (Russian Regions: Statistical Handbook), Moscow: Goskomstat, 1998, vol. 2.
10. Russian regions: socioeconomic indicators, 2015. http://www.gks.ru/bgd/regl/b15_14p/Main.htm. Accessed December 7, 2016.
11. Russia in digits, 2016. http://www.gks.ru/bgd/regl/b16_11/Main.htm. Accessed December 7, 2016.
12. Saushkin, Yu.G., *Ekonomicheskaya geografiya: istoriya, teoriya, metody, praktika* (Economic Geography: History, Theory, Methods, and Practice), Moscow: Mysl', 1973.
13. *Sel'skoe khozyaistvo Rossii: statisticheskii sbornik* (Agriculture in Russia: Statistical Handbook), Moscow: Goskomstat Rossii, 1995.
14. Agriculture, hunting and hunting economics, and forestry in Russia, 2015. http://www.gks.ru/bgd/regl/b15_38/ Main.htm. Accessed December 7, 2016.
15. Aggregative conversion factors of physical livestock of animal and poultry in the conditional heads of cattle. http://www.buildeconomic.ru/hankips-724-3.html. Accessed February 24, 2017.

Translated by D. Zabolotny