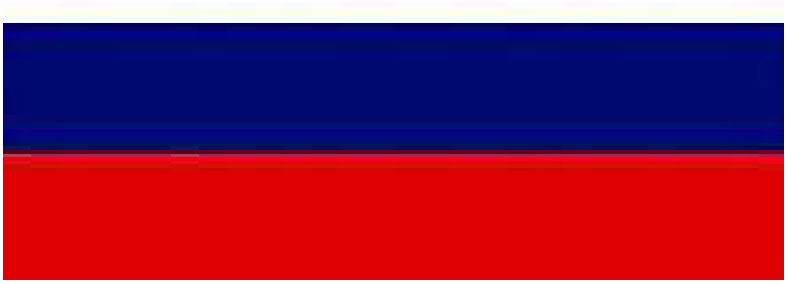
Country Pasture/Forage Resource Profiles

RUSSIAN FEDERATION



by

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1. INTRODUCTION

The Russian Federation (Russia) is the north-eastern part of Eurasia (see Figure 1). Its territory is more than 17 000 000 km^2 (the largest country in the world), which is 12.6% of the globe; it spans 11 time zones and spreads for more than 9 000 km from east to west and more than 4 000 km from north to south. Due to its size Russia has many landscapes, climatic and soil zones and rich flora and fauna. Forests occupy almost half of its territory - 45%, water - 4%, agricultural land - 13%, deer pastures - 19%, the rest - 19%. About 70% of its territory is occupied by vast plains. There are about 120 000 rivers with lengths over 10 km, their total length is 23 000 000 km. The longest rivers are: Lena, Enisei, Ob', Amur and Volga. There are about 2 000 000 fresh and salt lakes in the Federation. The biggest are: Baikal, Ladozhskoe, Onezhskoe fresh lakes, and the Kaspiyskoe sea - a salt lake.

All kinds of mineral fuel are mined in Russia, the bulk being oil (including gas condensate) and natural gas. The Russian land border is about 20 000 km and Russia borders on fourteen countries: Kazakhstan (6 846 km), China (3 645 km), Mongolia (3 441 km), Ukraine (1 576 km), Finland (1 313 km), Byelorussia (9,59 km), Georgia (723 km), Estonia (294 km), Azerbaijan (248 km), Lithuania (227 km), Latvia (217 km), Poland (206 km), Norway (167 km) and North Korea (19 km). The coast along two oceans and twelve seas is more than 37 000 km.

Russia has seven federal okrugs (regions – see Figure 2), which consist of 89 administrative bodies: 49 oblasts, one autonomous oblast, 21 republics, 6 krais (territories), 10 okrugs (divisions) and two large metropolitan centres - Moscow and St. Petersburg.

Russia's population is the sixth largest in the world; on 1 January 2001 it was 145 600 000 people (According to the World Factbook the July 2006 population was estimated at 142 893 540 with a growth rate of -0.37% – see Table 1; population density is 8.6 per km^2 Russia is a multinational state and has more than 100 nationalities, with Russians making up more than four fifths of the population.

Recently there has been a redistribution of the work force which resulted in a decrease in the number of agro-industrial complex employees. This trend correlates with the general tendency in the country – workers are transferring to private business.

The decrease in the number of people directly employed in agriculture is a result of such factors as the collapse of collective system of management, decrease in living standards of sovkhozes (state farm) employees, lack of funds in territorial and local budgets, lack of state support, dramatic

Table 1. Population in millions

	1997	1998	1999	2000
Total population	147.1	146.7	146.3	145.6
Working population	84.3	84.8	85.6	86.1
Rural population	39.8	39.6	39.5	39.4
Working rural population	20.6	20.7	21	21.2
Population employed in agriculture	9.3	8.6	8.2	7.8

** Source: Goscomstat*

Figure 1. Location of Russia

Figure 2. Regions of Russia

decrease of agricultural construction, and low salary. Recently, some improvements of the agro-industrial complexes (AIC) of Russia have been seen, but the general social-economic situation in AIC is difficult. Despite the absolute increase of the gross value added the AIC quota in the country's gross domestic product is only 7%.

Russia is in a risky zone for farming, because the average soil fertility level is low; moreover, great damage is caused by anthropic factors. Russia's agricultural land is about 200 000 000 ha, including over 120 000 000 ha arable, about 2 000 000 ha of fallow, 2 000 000 ha of perennial crops, and over 87 000 000 ha of permanent meadows and pastures. On average there is about 1.5 ha for each resident of the country.

In 1992, after the collapse of the USSR the so-called campaign on kolkhoz (collective farm) and sovkhozes (state farm) reorganization started which intended:

- Transfer of land and non-land means of production into the ownership of work collectives of agricultural enterprises,
- Division of these funds into individual shares and
- Re-registration of farms into one of the permitted legally-organized forms according to the current legislation of that date.

During recent years all kolkhozes and sovkhozes of the country have been re-organized. The majority, regardless of name, transformed into production co-operatives, where capital assets belong to a collective as share property and management is based on electoral co-operative principles. As a result of all reforms in the agrarian sphere a contradictory, rather sophisticated transitional structure of land ownership was formed: land owners are members of former kolkhozes and sovkhozes, land users are agricultural enterprises. Recently a small market in land shares has emerged (Table 2). Partly land belongs to individual farmers and families running domestic units.

Table 2 Agricultural enterprises split on form of ownership, year 2000 *

	Unit	%
TOTAL	23 536	100
Joint stock company of open type	851	3.6
Joint stock company of closed type	3 071	13.0
Limited liability partnership	2 387	10.1
Partnership on trust	191	0.8
Association of individual farms	381	1.6
Agricultural co-operatives	10 194	43.3
Kolkhoz	2 545	10.8
Collective enterprises	518	2.3
Sovhhoz	611	2.6
State enterprises	1 548	6.6
Other (crop testing and seed station, bee yards,)	1 239	5.3
Branch unions of agricultural producers	182	

** Source: Goscomstat*

Federal land legislation is quite liberal: it admits the right of private land ownership, and does not prohibit land transactions and foreign citizen ownership. But according to the Constitution land relations in Russian Federation are regulated by

federal and regional legislation. Today 13 units of the Federation have their own land laws, where private ownership of land is very restricted or does not exist at all. Moreover, the Federal Law is not well enough developed; it does not guarantee enough property rights, and does not establish mechanisms for land transitions. The legislation is not observed properly, the modern system of real estate is at the stage of formation. That is why there is no reason to speak about a developed system of land private ownership in agriculture so far. At the moment the Russian Federation State Duma has adopted a Land Law, which may solve problems of land private ownership. So at present a new structure of agricultural enterprises has been established.. With market development in agriculture, big farms slowly evolve towards commercial corporate type enterprises.

Farmers received the right to leave a collective farm with land and some property and to organize their own farm. This accelerated formation of individual farms. Nevertheless, most farmers stayed on large farms. Because of insufficiently considered policy the authorities' expectations of quick formation of efficient farming did not come true. Today not more than 40 000 individual farmers out of 270 000 practice commercial production. Despite the fact that huge accumulated debts keep large agricultural production from collapse, the leading role in agriculture belongs to smallholdings (Table 3).

Table 3. Number of individual farms *

		1997	1998	1999	2000
Total number of farms	Thousand units	274.3	270.2	261.1	261.7
Total land	Thousand ha	13.1	13.9	14.4	15.3
including:					
Agricultural land **	Thousand ha	12.1	12.9	13.5	14.3
	%	5.8	6.6	6.9	7.3
Arable land	Thousand ha	9.1	9.8	10.3	11.1
	%	6.6	8.0	8.5	9.2
Average per farm:					
Total land	ha	48	51	55	58
Agricultural land	ha	44	48	52	55
Arable land	ha	33	36	39	43

** Source: Goscomstat*

*** Agricultural land includes native and improved grassland and arable land*

Table 4. Indices of physical volume of agricultural production split by farm categories (in comparable prices; in% to the previous year)

	1997	1998	1999	2000
Farms of all categories				
Agricultural production	101.5	86.8	104.1	105.0
Crop husbandry	107.3	77.7	109.1	108.9
Animal husbandry	95	98.2	99.2	100.6
Agricultural enterprises*				
Agricultural production	102.4	78.5	105.4	105.1
Crop husbandry	113	64.9	115.5	110.8
Animal husbandry	92.7	96	96.5	99.4
Domestic holdings**				
Agricultural production	99.4	94.6	102.8	104.4
including:				
Crop husbandry	100.5	90.2	104.4	106.6
Animal husbandry	98	99.8	101.2	101.7
Individual farms***				
Agricultural production	126.3	80.2	116.6	116.8
Crop husbandry	143.8	69.5	131.1	123.8
Animal husbandry	94.7	104.1	98	100.1

** Former states and collective farms*

*** Agriculture production of small farms mainly for family consumption*

**** Agriculture production of small farms for trade*

Though the significance of individual farms is increasing quite quickly, their share in agricultural production is small (Table 4). Correspondingly, their share of agricultural markets is not significant, and most likely this will not increase appreciably, but individual farms show alternative ways of production, create competition with traditional producers on some food markets and form new production chains.

The main change in the last few years is modification of the state's function in agricultural and food markets (Table 5). The state changed quite quickly from market monopolist into an ordinary market agent, dealing with produce purchasing for regional and federal funds within the framework of its market quote. The unit weight of these purchases tends to decrease, though in animal husbandry the unit weight of state purchase is still high.

Lack of normal market infrastructure, or stable links with agents, sometimes leads to the other extreme: producers keep their old customers as best as they can, willingly taking risks of sale losses due to low prices or extremely protracted terms of payment for produce. This is especially typical of meat and dairy produce. Producers are "chained" to local processors; they agree to any terms, not knowing and not risking to look for alternative customers.

Many agricultural producers make contracts with the state on produce supply in exchange for fuel and lubricating materials or fertilizers. This credit enable them to get inputs necessary for planting or harvesting, but, on the other hand, ties producers with obligations to sell to state bodies on much worse

terms than exist on the free market at the moment of payment for credit. Private goods credit occurs when there is lack of state means. Often it means terms more profitable in comparison with state credit, but not all producers agree to make contracts with private companies being afraid of non payment for the credit taken with new counteragents (the state may write off debt, but not private bodies).

As a result, today, subjects of agricultural activity, which are legal bodies, can be split into two groups that have managed to become established in these market conditions. The first one is about 40 000 individual, commercial farms, which is 15% of the number registered. The second is 3 000–4 000 (10–12%) of collective enterprises – joint stock companies, partnerships on trust, limited liability partnerships, reorganized kolkhozes and sovkhozes out of 27 000 rural enterprises.

At the same time there is another category of farms whose role increased dramatically in the nineties - the private domestic holdings of the rural people (Table 6). Today they produce half of all agricultural produce. And though their market share is not very high so far, their specific features are production efficiency, because nobody can run a private farm at a loss.

Table 5. Individual farm activities

		1997	1998	1999	2000
Crop husbandry					
Cereal and pulses					
Planted area	Thousand ha	4 099	4 329	4 058	4 623
Gross harvest	Thousand tonnes	5 493	3 238	3 874	5 507
Yield	Quintal/ha	13.4	7.5	9.6	11.9
Unit weight of planted areas on all categories of farms	%	7.6	8.6	8.7	10.1
Unit weight of gross harvest on all categories of farms	%	6.2	6.8	7.1	8.4
Sunflower for grain					
Planted area	Thousand ha	510	655	993	864
Gross harvest	Thousand tonnes	307	327	524	556
Yield	Quintal/ha	6	5	5.3	6.4
Unit weight of planted areas on all categories of farms	%	14.2	15.7	17.8	18.7
Unit weight of gross harvest on all categories of farms	%	10.8	10.9	12.6	14.2
Sugar beet					
Planted area	Thousand ha	28	32	54	40
Gross harvest	Thousand tonnes	484	433	830	687
Yield	Quintal/ha	175.8	134.4	153.1	171.4
Unit weight of planted areas on all categories of farms	%	2.9	4	6	5
Unit weight of gross harvest on all categories of farms	%	3.5	4	5.4	4.9
Potato					
Planted area	Thousand ha	40	37	36	41
Gross harvest	Thousand tonnes	353	304	316	365
Yield	Quintal/ha	89.4	81.6	88.7	89.8
Unit weight of planted areas on all categories of farms	%	1.2	1.1	1.1	1.3
Unit weight of gross harvest on all Categories of farms	%	0.9	1	1	1.1
Vegetables					
Planted area	Thousand ha	21	26	32	35
Gross harvest	Thousand tonnes	164	188	256	273
Yield	Quintal/ha	74.9	71	78.5	77.2
Unit weight of planted areas on all categories of farms	%	2.8	3.5	3.9	4.2
Unit weight of gross harvest on all categories of farms	%	1.5	1.8	2.1	2.2
Livestock produce					
Cattle and poultry sold for slaughter:					
Live weight	Thousand tonnes	128.5	126.8	121.7	136.2
Dressed weight	Thousand tonnes	77.6	75.9	74.4	85.5
Milk	Thousand tonnes	526.7	546.8	558.3	555.0
Egg	Million	118.8	120.3	124.7	133.8
Wool	Tonnes	2 660	2 416	2 110	-

Animal husbandry was the most sensitive branch in restructuring of agriculture, and the least profitable. In the USSR the herds of all livestock were kept at a stable level by state subsidies. Recent processes led individuals and weak farms to get rid of livestock due to the impossibility of obtaining enough fodder, high energy prices and non-profitability of production. Due to the imbalance of exchange between agriculture and other branches of the economy, prices of industrial production and services used in agriculture increased 9 000 times from 1991, at the same time prices of agricultural products only increased 200 times. As a whole, herd decrease in the public sector is faster than on private individual holdings. Now the pace of herd reduction is slowing down (Table 7). It is linked to organizational

measures taken recently, as a result of which slowing of herd reproduction and animal preservation improves and mortality falls.

There is a decrease in meat and meat foods production. The same applies to milk production and its resources for industrial processing (Tables 8, 9).

Apart from the decrease in consumption of animal products there is concern about inequality of consumption level in regions caused by lack of efficient organizational and material infrastructure connecting producing and consuming regions. Very often redistribution is blocked by local authorities, prohibiting food exports, which causes high differentiation of prices between regions.

International trade

Up to 2000 the decrease in export-import operation of the agro-industrial complex was at a stable rate (Table 9).

At the same time, after three years of decrease, export of main goods of agroindustrial complex tends to increase (Table 10).

As far as fodder is concerned the tendency is the same (Table 11).

Table 6. Private domestic holdings of rural population activity

		1997	1998	1999	2000
Crop husbandry					
Potatoes					
Planted area	Thousand ha	3 000	2 975	2 988	2 980
Gross harvest	Thousand tonnes	33 821	28 659	28 849	31 393
Yield	Quintal/ha	112.7	96.4	96.5	105.4
Unit weight of planted areas on all categories of farms	%	90	91	92	92
Unit weight of gross harvest on all categories of farms	%	91	91	92	92
Vegetables					
Planted area	Thousand ha	555	564	606	631
Gross harvest	Thousand tonnes	8 493	8 393	9 466	9 708
Yield	Quintal/ha	150.9	146.6	153.7	151.6
Unit weight of planted areas on all categories of farms	%	74	76	74	76
Unit weight of gross harvest on all categories of farms	%	76	80	77	78
Livestock produce					
Cattle and poultry sold for slaughter:		4 340	4 266	4 052	4 017
live weight	Thousand t	2 712	2 674	2 563	2 544
dressed weight	Thousand t	16 113	16 046	16 039	16 114
Milk	Thousand t	9 787	9 852	9 763	9 757
Egg	Million pieces	31 163	26 347	22 020	-
Wool	T	-	-	-	-
Unit weight of animal husbandry production on all category of farms					
Beef and poultry (dressed weight)	%	55	57	59	57
Milk	%	47	48	50	51
Egg	%	30	30	29	29
Wool	%	51	55	56	-

Table 7. Animal husbandry development

		1997	1998	1999	2000	2002*	2004*	2005*
Number of cattle and poultry on all categories of farm at the end of the year								
Cattle	Thousand head	31 520	28 481	28 032	27 294	27 107	24 935	22 988
including cows	Thousand head	14 536	13 473	13 144	12 660	11 873	10 425	9 792
Pigs	Thousand head	17 348	17 248	18 271	15 708	16 048	15 980	13 413
Sheep and goats	Thousand head	18 774	15 556	14 751	14 772	15 327	17 030	17 771
Poultry	Thousand head	359 717	355 512	345 568	343 300	343 000	334 188	334 708
Cattle and poultry productivity in agricultural enterprises								
Milk yield per cow	Kg	2 066	2 250	2 283	2 341			
Average egg production per hen	Pieces	234	240	248	264			
Average annual wool yield per sheep	Kg	2,7	2,7	2,9	3,2			
Average live weight of one head sold for slaughter on agricultural enterprises								
Cattle	Kg	276	279	270	277			
Pigs	Kg	79	82	76	76			
Sheep and goats	Kg	32	31	31	31			
Offspring output per 100 dams in agricultural enterprises								
Calves	Head	72	74	76	77			
Piglets	Head	1 029	1 147	1 261	1 155			
Lambs and kids	Head	61	62	69	73			
Livestock deaths in agricultural enterprises in% to herd rotation								
Cattle	%	5.5	5	4.2	3.9			
Pigs	%	12.7	11.6	11.5	11.3			
Sheep and goats	%	11.6	10.2	8.6	7.5			

**FAOSTAT data for 2002, 2004 and 2005.*

Agrarian policy in external trade of agricultural production in Russia is run according to Federal laws "State regulation of external economic affairs" (1995); "Customs tariff" (1993 with additions from 1995 and 1997); "Measures on protection of economic interests of Russian Federation on realization of external merchandise trade" (1998); as well as Russian Federation Presidential Decrees; regulations and directions of the Government of the Russian Federation.

These standard documents allowed:

– protection of Russian economy and individual subjects of Russian Federation from unfavourable influence of foreign competition;
– provide conditions for Russia's efficient integration into the world economy;
– upport the country's purchasing balance by goods import regulation;
– promote Russian goods on the world market.

Regulation of agricultural production external trade is done by tariff, non-tariff and combined measures. Tariff measures imply stated level of customs duty for imported and exported goods, which defends the country's economic interests. Non-tariff measures (mainly different restrictions and inhibitory actions on import and export) are implemented by means of Russian Federation Presidential Decrees or federal laws. Combined measures - quotes on import and export.

Production of food (oat) units was over 79 000 000 tonnes per year in 1986–1990.

Table 8. Production and consumption of the main foodstuff per capita

		1997	1998	1999	2000
Production					
Meat dressed weight	Kg	33	32	29	30
Milk	Kg	232	226	221	220
Eggs	Pieces	219	223	226	234
Consumption					
Meat dressed weight	Kg	50	48	45	43
Milk	Kg	229	221	215	216
Eggs	Pieces	210	218	222	228

Table 9. Import of main goods by agro-industrial complex of Russia

		1997	1998	1999	2000
Agricultural production - total	Million dollars	12 714.6	10 265.6	7 660.8	6 909.7
Meat	Thousand tonnes	1 166.4	946.4	979.7	593.5
Poultry meat	Thousand tonnes	1 146.6	814.5	236	686.9
Fresh fish. frozen	Thousand tonnes	496.5	348.3	298.2	319.8
Milk	Thousand tonnes	126.9	223.9	243	111.7
Butter	Thousand tonnes	169.7	83	38	53.7

Table 10. Export of main goods of agro-industrial complex of Russia

		1997	1998	1999	2000
Agricultural production - total	Million dollars	1 407.1	1 186.9	761.9	1 292.7
Meat	Thousand tonnes	13.9	6.4	0.2	0.3
Poultry meat	Thousand tonnes	4.6	2.2	1.2	2.4
Fresh fish. frozen	Thousand tonnes	209.2	326	249.3	304.4
Milk	Thousand tonnes	27.6	31	18.5	78.9
Butter	Thousand tonnes	6.3	3	2.1	4.9
Oil	Thousand tonnes	25.8	34.5	30.8	185.7
Grain	Thousand tonnes	1 857.4	1 890.3	801.3	988.7
Flour and groats	Thousand tonnes	81.2	110.5	146.3	191.5
Oil-producing crops	Thousand tonnes	1 208.6	1 241.3	365.1	1 244.9
Sugar	Thousand tonnes	47.7	44.4	135.8	155.2
Spirit	Million dollars	59.2	7	0.3	0.2
Vodka	Million dollars	68	23.7	23.2	32.7
Cigarettes	Million dollars	5.2	2.1	1.2	1.9
Tobacco	Million dollars	1.8	0.5	0.4	0.04
Chemical fertilizers	Thousand tonnes	15 167.9	16 119.4	19 076.2	20 120.1
Herbicides	Thousand tonnes	4	3.6	3.6	4.6
Skin	Million dollars	335.5	287.1	125.6	117.9
Fur/fluff raw materials	Million dollars	38.4	24	17.4	23.1
Wool	Thousand tonnes	23.7	6.97	0.97	0.7
Cotton fibre	Thousand tonnes	1.2	5.7	0.3	0.2

Table 11. Fodder import - export

Code IEA*	Name	Unit	1997		1998		1999		2000	
			Export	Import	Export	Import	Export	Import	Export	Import
1201	Soybean crushed and non-crushed									
	Total	Tonnes	84 908	22 712.6	65 156	13 255	16 631	205 972	45 813	40 927
Incl. CIS countries		Tonnes	118	84.3	109	4	0	185	185	187
1208	Flour and cake from seeds or oil-producing crops (apart from mustard)									
	Total	Tonnes	10 208	60 150	7 310	49 024	-	-	-	-
Incl. CIS countries		tonnes	591	26 380	8	4 480	-	-	-	-

** internal economic affair*

2. SOILS AND TOPOGRAPHY

The most important landforms in Russia are plains, which occupy more than 1 180 million ha (70.4% of the country). The relief of the plains is complicated depending on composition of rock deposits as well as denudation and accumulation processes. Most of the plains are at an altitude of less than 300 m. In East Siberia and in the Far East the altitude of plain territories is between 300–600 m. About half of the East European plain, the biggest part of the West Siberia plain and the northern part of the Far East are flat. Undulating slopes represent most of the East Siberia plain.

Mountains are the landform ranking second in Russia, most of them are below 1 000 m. Mountain areas comprise the Alpine-Gimalay belt, Tian-Shan up-lifting belt, the Middle and East Siberian Mountain highlands and the Pacific Ocean mountain belt. Plateau landforms are widely developed in Eastern Siberia and the Far East. They were formed as a result of relief levelling (denudation) during long-term periods. Undulating (5–8%) and slightly undulating (2–5%) relief is widespread on plateau landforms.

Soil information is based on a simplified version of the "Soil Map of Russian Federation" at scale 1:2 500 000 with classification according to national "Classification and diagnostics of the soils of the U.S.S.R." (1977) and the revised legend of the Soil Map of the World (1988). Figure 3 illustrates the Digital Soil Database for Russia at scale 1:500 000 (FAO, 1999).

Two main soil types of the territory are Podzols and Gleysols, which occupy 22 and 16% of the total land area, respectively. Practically 80% of the country is under the dominant influence of cold and humid soil forming environments. 44% of the country is in continuous permafrost regions. Wetlands (221 000 000 ha), wet tundra (253 000 000 ha) and boreal coniferous forest are formed under conditions of excessive moisture.

The most agriculturally valuable major soil grouping - Chernozems - occupies about 94 000 000 ha, or less than 6% of the land area. Four major soil groupings also favourable for agriculture are Fluvisols, Greezems, Phaeozems and Kastanozems. Together they occupy about 160 000 000 ha, or approximately 10% of the land.

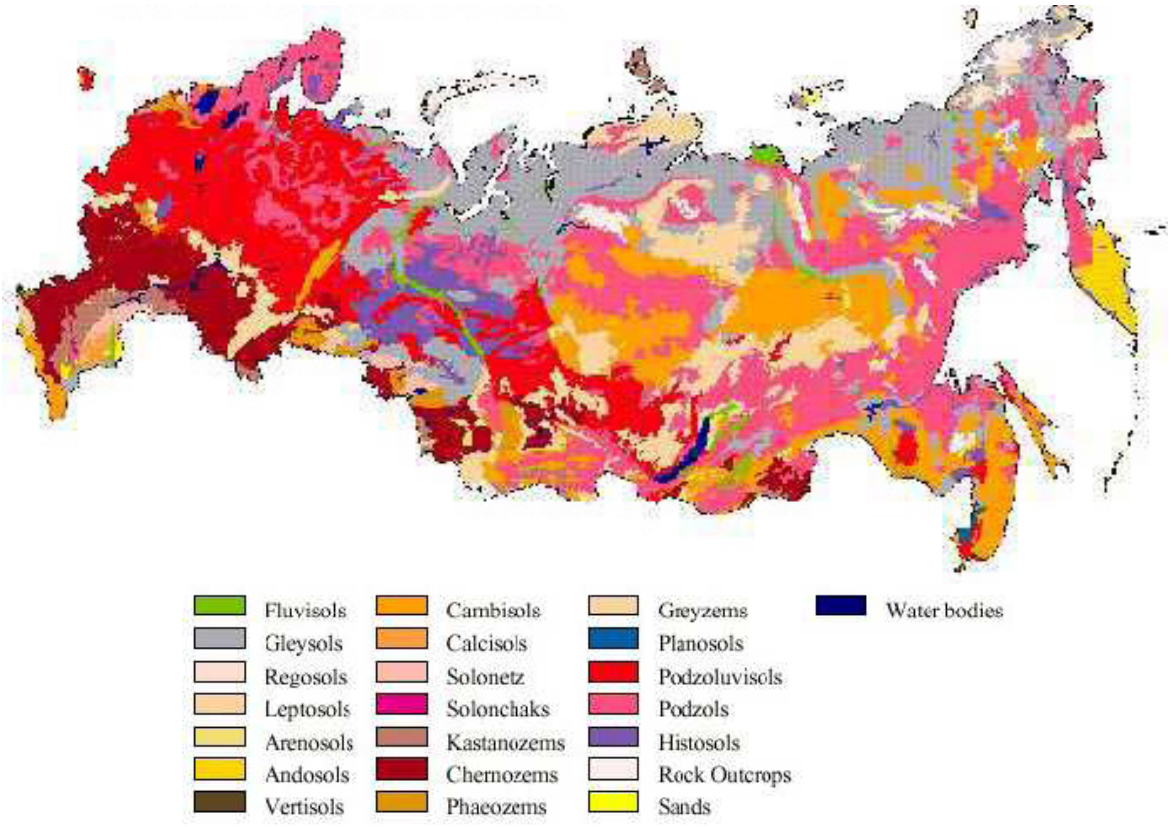

Figure 3. Soil map

The main soil order associated with the taiga is soddy-podzolic soil (Podzoluvisols). Acid brownzems and sod-brownzems (Dystric and Gelic Cambisoils) are found in the Siberian part of the region. Flat interfluves are usually waterlogged, with predomination of podzolic peaty and peat boggy soils (Gleyic Podzoluvisols and Histosols, respectively).

Podzoluvisols occupy 207 400 000 ha, which corresponds to 12.4% of the soil cover in Russia. Podzoluvisols show some features of Podzols (a strongly bleached horizon) and of Luvisols (clay accumulation). These soils are well differentiated by texture and total composition, the general pattern of sesquioxides and clay fraction distribution is eluvio-illuvial. Podzoluvisols have an argic B horizon with an irregular or broken upper boundary resulting from deep tonguing of the E into the B horizon. The reaction is acid, with the pH increasing downward. The humus content is 3–7% in the humus horizon (5–12 cm), with noticeable decreasing downwards (0.2–0.5% in the E horizon). The typical properties are as follows: CEC changes in the profile depend on humus and clay fraction distribution; the soils are base-unsaturated, aluminium and hydrogen are common in the exchangeable complex. Mineralogical, granulometric and chemical composition are inherited or strongly connected with parent material properties. For example, residually calcareous sod-podzolic soils, which are formed from carbonate rocks, have a neutral or even slightly alkaline reaction in Bt/BtC horizons.

Gleyic Podzoluvisols and Histosols are formed on slow-drained terrain, characterized by seasonal surface waterlogging, or in relief depressions with relatively high ground water levels (flat plains, shallow depressions, river valleys and terraces, correlate to high and low moors). Flat and weakly dissected vast territory of the West Siberia lowland is a swampy plain, with waterlogging predomination within the south taiga zone. Gleyic Podzols are formed from sand and loamy sand parent material under excessive ground moistening on large alluvial and fluvio-glacial plains (polesye) in the taiga-forest zone.

Grey forest soils are formed as a result of specific soil processes under forest steppe vegetation. Based on difference in darkness and thickness of the humus horizon and expression of podzolized AhE or EB horizons, this soil group was subdivided on three sub-units: dark-grey (Haplic Greezems), grey (Haplic Greezems) and light-grey (Eutric Podzoluvisols). The grey forest soil group has the following profile:

O - forest litter horizon;

Ah - grey horizon of humus accumulation;

AhE (EB) - eluvial horizon with humus accumulation;

B - illuvial horizon.

The AhE (EB) horizon has a fine sub-angular structure with bleached fine material and humic bright cutans on ped faces (the last feature is usually absent in the forest-steppe of Central Siberia). Carbonates appear usually deeper than 1.5–2 m in various forms of accumulation. The humus content is the biggest in dark grey soils (5–12% in the Ah, with calcium-humate composition). Soil organic matter (SOM) stock in these soils ranges from 100–150 in light-grey soils up to 300 tonnes/ha in dark-grey soils. Humus content decrease drastically after clear-cutting and during the subsequent cultivation. The reaction is acid to slightly acid in the topsoil of light grey and grey soils and close to neutral in the topsoil of dark grey soils. pH values become mostly acid in the lower part of the Ah or in AhE horizons, change to slightly alkaline downwards for soils with carbonates or neutral. The sum of exchangeable bases is 10–15 cmol(+)kg^{-1} for light grey soils and 25–45 cmol(+)kg^{-1} for dark grey soils. Base saturation is 70–95%, some exchangeable H or Al may be present in the upper horizon.

The distinctive features of grey forest soils are the accumulation of calcium, potassium and phosphorus in the topsoil as a result of biological accumulation processes. Properties of light grey soils closely correlate with those of Eutric Podzoluvisols and of dark grey forest soils - to chernozems. Soil cover exists as soil sequences - regular alternations, mostly due to meso-relief. The typical feature of the northern forest steppe is more intensive manifestation of the podzolic process in the upper slope positions. Interfluves are considered as the area of light grey forest soils predomination. Grey forest soils are common on the mid-slopes and dark grey soils - at the foot slopes with participation of groundwaters in their genesis. Sod-gleys (Umbric Gleysols) and meadow-boggy soils (Mollic Gleysols) are formed in depressions with seasonal surface waterlogging, under meadow and meadow-shrub vegetation. Within the southern part of region dark grey forest soils are situated in watersheds or on slopes alternating with Luvic Chernozems. Semi-hydromorphic soils are represented by meadow-chernozemic (Haplic Phaeozems) and meadow soils (Umbric Gleysols). The influence of more continental climate features

is related with decreasing the thickness of Ah horizon and additional SOM and exchangeable base accumulation in the profile of grey forest soils.

Leached and typical chernozems (Luvic and Haplic Chernozems) are formed under grass steppes and meadows, which have net primary production (NPP) in the range 20–30 tonnes/ha, with root biomass predomination (65–75%). The annual detrital losses amount to 50–55% of NPP, or twice more than litter fall of deciduous forests. Forest steppe chernozems have periodically percolated water regime, when leaching usually occurs once in ten years. Abundance of plant debris, enriched with nutrients (Ca, K, N) and absence of regular leaching during the time when decomposition processes are the most active favours nutrient accumulation in the upper horizons.

Periodical alternation of the wet and dry periods serves as a natural regulator of meso- and macro organisms activity and promotes formation of different end products of humification, including recalcitrant organic-mineral complexes. Humus accumulation is the leading soil forming process (mostly as a calcium-humate complex) and the characteristic feature of chernozems is a mollic A horizon with a moist chroma of 2 or less, which have a granular or subangular-granular structure. The reaction is neutral. The soils have high cation exchange capacity, base saturated (with the exchangeable Ca predomination). The distribution in the profile of clay and sesquoxides is undifferentiated. The lower parts of the Ah or AhB horizons are effervescent. General soil profile perturbation by burrowing fauna is a common feature. Typical chernozems can be considered as a central subtype of chernozem, with the most characteristic features of these soils.

Typical chernozems have the following profile: Ah-AhBk-BCk-Ck.

The humus horizons are subdivided into 2 parts: the Ah (45–50 cm) is dark grey or black. They have a granular or subangular-granular structure. The AhBk has a browner colour with larger peds. The Ah+AhBk thickness is in the range of 70–130 cm. Native soils have O upper layer of plant detritus. The Bk horizon has a maximum of secondary carbonates. Humus content is 5–12% in the Ah with gradual decreasing downwards, SOM stock varies from 600 to 700 tonnes/ha. Calcareous neoformations appear in the form of meld, mycelia, and veins, and below 2 m depth, as loess dolls.

Leached chernozems (Luvic Chernozems) are formed in colder climate compared with Haplic Chernozems. They are distinguished from typic chernozems by more pronounced differentiation of the humus fractional composition and deeper effervescence. It usually starts 30–40 cm deeper the lower boundary of the Ah horizon, resulting in formation of the carbonate-free Bt horizon. These soils do not have a carbonate horizon if formed on non-calcareous parent rocks. The Bt horizon has features of clay and sesquioxides illuviation, a dark brown colour, a dark cutans on the ped faces. The soil reaction in the Bt horizon is neutral or slightly acid.

Podzolized chernozems (Luvic Phaeozems) can be identified as an intergrade between chernozems and grey forest soil types. They have more pronounced eluvio-illuvial differentiation of the soil profile comparing with leached chernozems. The humus horizon is subdivided into 2 sub-horizons based on colour and structure, the lower part of it (the AhB horizon) has abundant bleached mineral particles cover the ped faces. The Bt horizon has weak but consistent features of clay illuviation. The thickness of the non-calcareous and humus-free layer is not less than 40–50 cm. The calcareous Bca horizon has carbonate accumulations in the form of veins, often segregated as white patches.

The morphological features of chernozems are subject to strong fluctuations in accordance with climatic regimes.

Mild climatic conditions of *East Europe* with a long warm periods accompanied by frequent precipitation in summer and also winter periods (snow, wet snow and snow with rain) favour high quantity of the biomass returned by plants to the soil and the intensive decomposition processes. The soils usually freeze up to 40 cm during one-two months. The soil formation is associated with the preferential upward water movement as well as high amplitudes of the soil solutions translocation. The thick mollic horizon (up to 1 m) is formed with moderate SOM accumulation (the humus content is 3–6%). SOM stock in these soils ranges from 300 to 600 tonnes/ha.

In more cold and dry climate conditions of *East Siberia* the soils of the forest steppe region are distinguished from the East European chernozems by thicker mollic horizon with the humus content 6–12% and tongued lower boundary. SOM stock ranges from 300 to 700 tonnes/ha (the highest values of soil organic C accumulation in the world). The soils are characterized by deep freezing (up to 1 m) during winter. Leaching takes place only in wet summers.

Low temperatures of *West and Middle Siberia* lead to more rapid and deep soil freezing (up to 2 m) and slow spring thawing. These soils have a shallow humus horizon (25–45 cm) with a well-expressed tongued or pocket-like lower boundary as a result of formation of frost wedges, which have been filled subsequently by the mollic horizon material. Low winter temperatures favour humus accumulation in the Ah horizon, with noticeable decreasing downward. As a result, SOM stock rarely exceeds 500 tonnes/ha the calcic horizon is a common feature, but it lies deeper compared with East Europe chernozems. The severe continental climate of *West Siberia* with negative mean annual temperatures, harsh winters with little snow, low annual precipitation and late summer temperature maximum gives rise to a specific soil moisture regime: dry spring and early summer and wet late summer. The latter period is characterized by a periodical leaching. The West Siberian chernozems (Glossic Chernozems) have a thinner humus horizon (45–55 cm) as compared to the other chernozems. The humus content (in the Ah) is 4–6%, with noticeable decreasing downward. The effervescence boundary is distinct. Calcareous accumulations are in the form of patches, veins and white soft carbonate spots. Soluble salts are not present in the profile as a result of periodical leaching and late summer precipitation maximum.

The main features of soil formation in the steppe region are nonpercolative water regime with leaching processes only in the upper horizons, carbonate accumulation at some depth (excluding chernozems which was formed in monsoon climate), less humus accumulation compared with the forest steppe soils, a weak solonetzic features in automorphic soils inherited from solonetzic parent material. In the northern part of the steppe zone ordinary chernozems (Haplic Chernozems) predominate, more southern analogues are southern chernozems (Calcic Chernozems).

Ordinary chernozems (Haplic Chernozems) of the European part of the steppe region have a distinct upper humus layer with a well-defined granular structure of several orders. The humus content in the upper Ah horizon is 5–8%, the reaction is neutral. The cation exchange capacity is about 40–55 cmol(+) $kg^{-1,}$ the soils are base saturated. Effervescence appears in the humus horizon (the Ah or AhB), white soft carbonate spots in the B horizon and soluble salts and gypsum at a depth 300 cm. The distribution of either the clay fraction or the sesquioxides in the soil profile is undifferentiated.

Southern chernozems (Calcic Chernozems), which occupy 26 500 ha, or 1.6% of the land area of the country, are situated in the south of the steppe region, in dry grass steppes. The humus content (in the Ah) is 3–6%, that is lower compared with ordinary chernozems. They have a thinner humus horizon and the cation exchange capacity is 35–40 cmol (+)/kg. The reaction is neutral or slightly alkaline. Some features of solonetz processes, such as a prismatic block angular structure, are present as a result of the increased mineralization of the soil solution. Effervescence begins in the Ah horizon or on the soil surface. Carbonate concretions are in the form of white soft spots. Gypsum and soluble salts appear at a depth of 150–300 cm. In the dry steppe dark-chestnut and chestnut soils (Haplic Kastanozems) are zonal automorphic soils. This soil unit occupies 17 300 000 ha, which corresponds to 1.0% of the area of the country.

Chestnut soils have the following profile: Ah-AhB-Bkc-BCkc,y-Cy. The Ah horizon has a light-brown colour, crumbly structure. In virgin and fallow soils, weak fine platy structure is common on the surface. The transitional layer is subdivided into two parts: the AhB is brownish and unevenly collared by humus, compact. It is underlain by the Bkc horizon, which has more compact consistency, prismatic-crumbly structure and mottled colour. The Bk horizon has humus spots or local humus cutans on ped faces, as well as white soft calcium carbonate spots. The thickness of Ah+AhB+Bkc horizons decreases from 45 cm in the European part of the region to 25 cm in East Siberia. The BCkc,y is an illuvial carbonate horizon with abundant carbonate spots and some gypsum. The lower boundary of humus cutans reaches this horizon. In some profiles it is possible to subdivide the BCkc,y into two horizons. The lower part of the BCkc,y have a lack of humus illuvation features, has yellowish-brown colour and abundant $CaCO_3$ patches and spots. The Cy horizon lies at a depth of 150–200 cm. It contains considerable quantities of gypsum and, usually, soluble salts. This horizon is less compact and has more moisture as compared with the upper horizon. The humus content is usually in the range from 2.2–3.2% (arable soils) to 4% (virgin soils) in the Ah of clay and clay loam Kastanozems and 1.5–3% in more sandy soils. The CEC is 20–30 cmol (+) kg^{-1} and exchangeable sodium forms 1.5–5% of CEC. The soil reaction changes from slightly alkaline or neutral (pH 7.2–7.4) in the upper horizons to alkaline (pH 8.2–8.5) in the lower ones.

In the north of the dry steppe region, where precipitation amount is higher, *dark chestnut soils* (Haplic Kastanozems) are formed under dry steppe vegetation. They differ from the chestnut soils in a more

pronounced Ah horizon (Ah+AhB+Bkc horizons are 35–50 cm thick) and in increased humus content. The humus content of the Ah horizon varies within the limits of 3.2 (arable soils)- 5% (virgin soils) in clay and clay loams and 2.5–4% in sandy loams and loamy sands. Effervescence usually appears from 45–50 cm. Gypsum and soluble salt start from a depth of 2 m. The soil reaction changes from neutral in the upper horizons to slightly alkaline and alkaline in the lower ones. The CEC is 30–35 cmol (+)/kg. The exchangeable cations are mainly represented by Ca^{2+} or Mg^{2+}.

Meadow chestnut soils (Haplic Phaeozems) are dispersed among chestnut and light chestnut soils. They are formed in relief depressions (flat ditches, gullies, micro-depressions) on slow-draining terrain (flat plains, river terraces, pre-mountain deluvial areas). They are formed under influence of excessive surface wetting, sometimes connected with high ground water table (2.5–5(7) m). Extra-water permits plant community of the herb species-grass-small bushes to exist as a continuous cover. The morphological properties correlate with those of the meadow chernozem soils. They differ from Kastanozems in more favourable water regime, in a more thick the Ah horizon, in a high humus content (4-6%, sometimes more than 8% in the Ah that gradually decreases with depth). The Ah horizon has sod in the upper layer and a dark-grey colour. Exchangeable sodium occupies not more than 2% of the CEC.

The characteristic feature of the dry steppe is high soil heterogeneity (soil complexes). Soil complexes represent alteration of small (5–30 m^2) spots of different interdependent soil types or subtypes, linked to the micro relief elements. The latter is connected with redistribution of scarce water reserves between the different parts of micro-catenas. Soil heterogeneity has a tendency to increase southward. The most complex soil cover in the region is in lowlands (Caspian and West Siberia lowlands) or depressions (Manych and Tourgay depressions). The agricultural value of soil complex components may differ, but the potential land utilization determined by the properties of the soil complex as a whole.

3. CLIMATE AND AGRO-ECOLOGICAL ZONES

Russia's far northern location and harsh climate causes most of the area to be unsuitable for crop production. Most rainfed agricultural activities are located between 40 degrees N and 60 degrees N latitude. The transitional seasons of autumn and spring here are short, creating a brief window of opportunity for crop seeding and harvest. Higher latitudes are associated with long, cold winters, and short, hot summers that limit the growing season. The distribution of cultivated land, perennial crops, cultivated forage/grazing as well as forest and natural vegetation is shown on Figure 4. This figure reproduces a generalized version of the map "Land categories of the USSR" at a scale 1:4 000 000 with division of land use into 6 top level classes. This map complements the map "Agricultural regionalization of the USSR" at a scale 1:4 000 000 (Figure 5), which depicts regions with the different agricultural intensity as well as farming specialization.

In this brief review the representation of the agricultural regions relies on the map *"Soil-geographical regionalization of the USSR"*, considering agricultural use within natural agricultural regions. A considerable spatial variability of climatic conditions in Russia such as large annual, daily, and day-to-day ranges in temperature, relative humidity, and rainfall are accounted for identification the main natural agricultural zones based on temperature and precipitation ranking. Mean January and July air temperatures for the territory of Russia are shown in Figures 6 and 7. The amount of precipitation, growing season and land resources are connected with the type and intensity of agriculture in a particular region.

Based on the sum of active annual temperatures two main agricultural *climatic zones* are identified. They include all diversity of the main *natural agricultural regions* to characterize regularities and distribution of the natural vegetation as well as Precipitation/Evaporation ratio over the country. The territory of the each region was characterized based on *lowland soil provinces* division, and on climate regimes, the soils cover zonal features, the percentages of land use, types of predominant agricultural crops and husbandry as well as cropland improvement and reclamation.

Cold tundra - north taiga (boreal forest) zone exists as a continuous belt across the high latitudes of Eurasia. The south boundary coincides with the annual sum of average daily temperatures 400–600 °C for the period with T>10 °C (the sum of active temperatures). Winters are harsh, arctic air masses

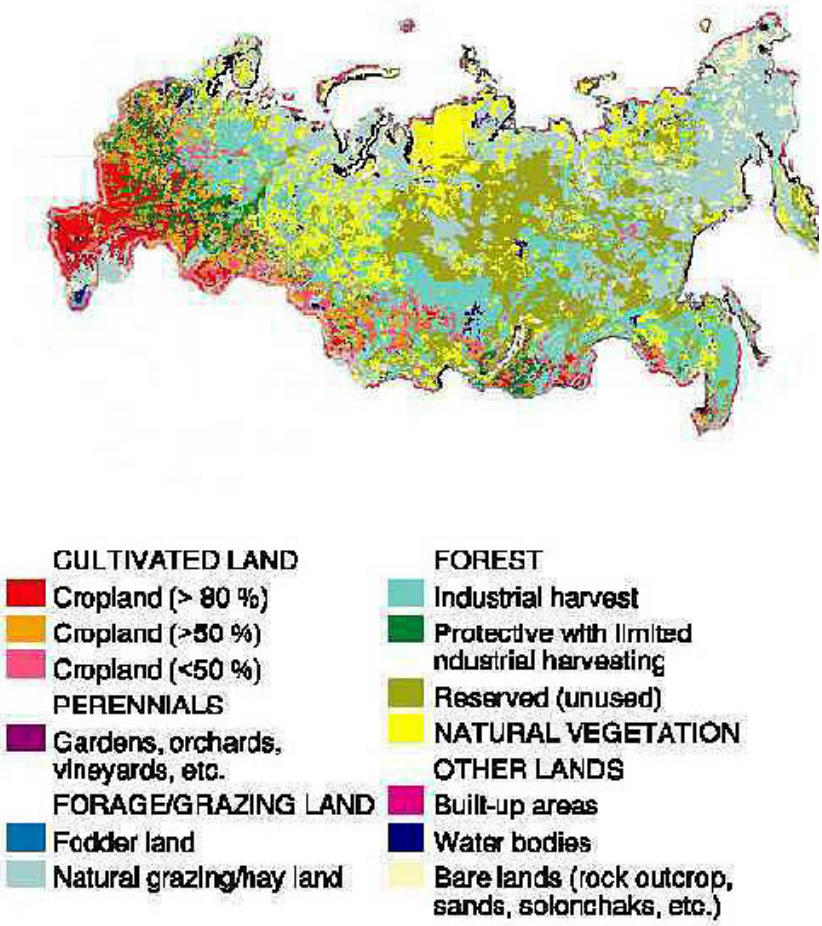

Figure 4. Land categories of Russia

predominate during the whole year. Permafrost, cryogenic soil features are spread throughout the entire territory. Mean annual temperature ranges are –10 to –14 °C, with mean temperatures –25 to –30 °C in winter and less than –5 °C in summer. The frost-free period is 12–14 days in a year, annual precipitation is about 150 mm, mainly as snow, including the summer period. Harsh climatic conditions restrict agriculture to the sub-arctic zone of the agroregion, where reindeer breeding remains the most important activity on vast tundra territories. Lichen tundra in winter and tundra with predominating mosses, sedge-mosses and dwarf birch thicket in summer are the main types of pastures suitable for reindeer. Common adverse soil phenomena are low intensity of biochemical processes, lack of nutrients, acidity, unfavourable air and heat regime.

Due to climatic conditions, the development of farming, dairy cattle

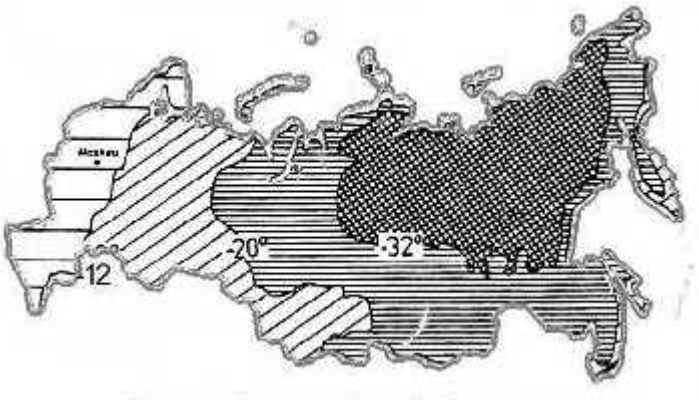

Figure 6. Average temperature in January
Source: Lydolph 1990

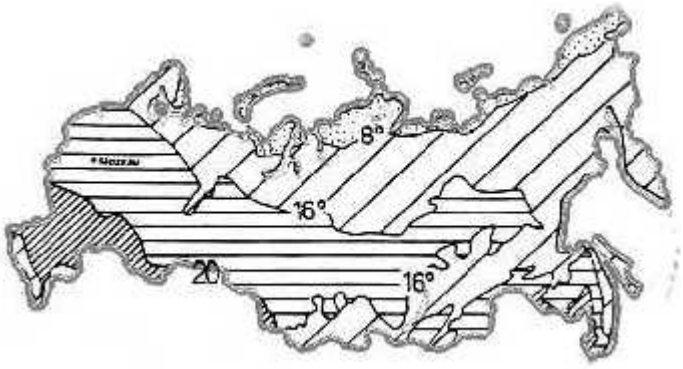

Figure 7. Average temperature in July
Source: Lydolph 1990

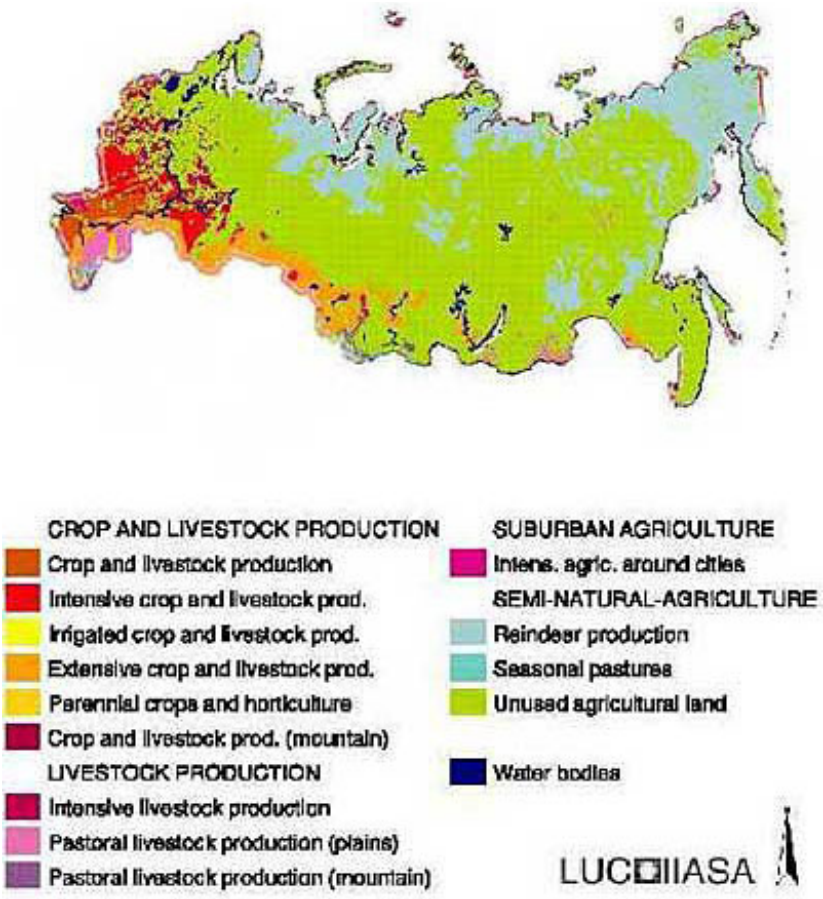

Figure 5. Agroregions of Russia

husbandry and poultry would require large capital investments. Sparse agricultural farms, represented mainly by glasshouse enterprises with vegetable production are situated around big cities-industrial centres. Perennial grazing of tundra soils is an effective practice, as it is less time-consuming and a more successful technology compared to fodder crop growing.

In the north taiga farming is also constrained by climate. Agriculture is mainly restricted to individual farms of industrial enterprises or to private vegetable gardens and subsistence farming. Commercial forestry is the main activity in the economy of this region. Crop and cattle husbandry is mainly practiced to meet the local needs of the sparsely populated territory. Highly developed agriculture is only around big cities.

Moderate climate zone is characterized by a wide range of environmental conditions varying from the middle taiga (boreal forest) in the north to the desert in the south of this belt, as a result of combined influence of maritime air masses and the vast territory with climate continental in natural.

Climate aridity increases gradually southward. Continental climate features are present to a very small extent in the western part of Russia and quite pronounced in Trans-Baikal and Pre-Amur, with changing winters from no-snow mild to harsh with thick snow cover. The sum of active (>10 °C) annual temperatures range from 1 600 to 4 000 °C. The belt represents intensive crop and cattle rearing zone, with predomination of pastoral cattle rearing and restricted crop production zones southward. The zone, which encompasses the biggest part of Russia, can be subdivided into the following natural regions: taiga (middle and south), forest steppe, steppe, dry steppe, semi-desert and desert.

South taiga region is situated between 56–58 degrees (50 degrees in the west part) to 60 degrees northern latitude, with the south and north bounds coinciding with the sum of active annual temperatures 160–2 500 °C and 1 400–1 600 °C, respectively. Climate is temperate to moderate continental in the west, severe continental to very severe continental in Siberia and monsoon in Far East. Mean temperature range is –2 to –32 °C in January and 16 to –2 °C in June (the coldest and the warmest month, cons.) Annual precipitation ranges are 500–700 and 350–500 mm in the European and Asian parts of the region, which according to the ratio of precipitation/evaporation can be classified as excessively wet or wet.

The climate favours natural coniferous (gymnosperm) tree domination with deciduous species or mixed forest (coniferous and deciduous species) with a diversified herb layer. In European Russia fir (*Picea abies*) and oak (*Quercus*) are dominant with hazelnut (*Corylus avellana*) in under storey. Pine woods or mixture of oak and pine species are typical for light soils. In Ural and across West Siberia birch (*Betula*) and aspen (*Populus tremula*) are common components of deciduous or mixed (larch and cedar species) forestSufficient precipitation and satisfactory temperature regimes cause this area to be more suitable for crop production. Common crops in the European part of this region are vegetables and potatoes, cereals, sugar beet, hops, tobacco, fruit crops. The Asian part of the agroregion has a comparatively shorter growing period and a less favourable temperature regime as a result of a more continental climate. West and East Siberia are regions of highly developed meat-dairy husbandry and crop farming. Grain (mainly spring wheat) -fallow rotations are common. Fodder crops, natural grasslands and hay lands are of great importance. In the surroundings of the urban centres there is very intensive agricultural production of vegetables and potatoes as well as fruit crops and berry shrubs. The agricultural sector of the Far East has been mainly developed around Khanka lake, in the vicinity of large cities, and along the Trans-Siberian railway line. Agriculture has specialized in fisheries, hunting locally reindeer herding, dairy cattle husbandry. The main crops are cereals (wheat, rice (5.2% of cultivated land), soybean (15%), buckwheat) and potatoes.

South taiga agroregion is an intensive crop and cattle rearing zone, arable lands occupy 17% of the total area. The agroregion has a diversified agricultural land use: dairy and meat husbandry, potato cultivation, intensive cultivation of wheat, barley and other grain crops, intensive vegetable cultivation (for example, near the Oka river), flax and hemp (*Cannabis sativa*) cultivation. Potato cultivation for commercial and non-commercial use is typical for this region. This agroregion have the biggest area available for expansion of agricultural lands, including those for intensive haymaking and livestock grazing, comparing with the other natural zones, but high expenditures to improve soil through reclamation are necessary. Periodical liming and high rates of mineral and organic fertilizers are necessary for intensive crop growing.

Forest steppe region is situated in the centre of Eurasia, southward of the taiga zone. The area is situated between 43–45° (a south boundary in the Pre-Caucasian steppes) to 50–51° north, with 45° east as a west boundary. Climate is moderately continental to severely continental, with increasing aridity southward and eastward and continental climate features in the east direction. Precipitation deficit is a common feature of the territory (the range of precipitation/evaporation ratio is 0.7–1 and 0.5–0.66 in the northern and the southern part of the region). The range of active annual temperatures sum is a characteristic of great variability: from 2 400–3 200 to 400-1 800 °C. Mean temperature range in January is –4 to –25 °C and the growing season is 188 to 93 days, diminishing from the west to the east. Mean summer temperature are quite close within the zone: 18 to 20 °C. Geographical features of the West Siberian part of the region are severe winters, lower precipitation and more continental climate comparing with the European part. There is periodical precipitation deficit connected with the transitional position of the region between the wet and dry districts. Deep gullies and valleys are common, especially in the European part of the region. These strongly affect soil erosion processes and there is substantial surface water re-distribution between the different parts of mezo- and micro-catenas. In Asia the main terrain components are the West Siberian lowland (the southern part) and undulating sloping territories of Altai and Sayany mountains.

Agricultural activities are well developed, mainly based on intensive crop growing (cropland accounts for 71% of the area used as arable in Russia), meat-dairy cattle breeding, pig and sheep breeding, poultry. The region produces cereals (winter and spring wheat, rye, and corn), grain legumes, industrial crops (flax, *Cannabis sativa,* sugar beet, tobacco), vegetables, and fodder crops, fruits and berries. The natural vegetation before the intensive cultivation period is supposed to have been diverse: grass steppe was alternating with meadows composed of numerous steppe herb species, groves of deciduous species (broad-leaved in the European part of the region with predomination of *Quercus* and accompanying lime (*Tilia), Fraxinus, Ulmus, Acer platanoides*). In the Ural zone, birch (*Betula*) and larch-broadleaved species were predominate. Birch and aspen (*Populus*) were a common component of deciduous forests with tall herb layer across the West Siberian lowland. Soil cover is represented by grey forest soils (Haplic Greezems), chernozems podzolized (Luvic Chernozems), chernozems leached

(Luvic Chernozems), chernozems typical (Haplic Chernozems) and meadow chernozem soils (Gleyic Chernozems). These soils extend as a continuous belt from Carpathian mountains to the Yenisey river, more to the east they exist as patches ("islands") allocated to slopes of the Middle Siberian highland landforms or intermountain depressions of East Siberia. Main parent materials are loess, loess-like loams and heavy loams. Clay fraction content in the parent material of the European part of the region has a tendency to increase eastward; the west slopes of the Pre-Volga upland represent a boundary of loams and fine loams.

The *type of agriculture development* as well as differentiation in intensity within the region is mainly connected with diversified climate and soil conditions. Agricultural lands in the *western European part* of the agroregion account for 20–80%, the fractions of hay land and pastures are in the range 4–12% and 3–7%, respectively. The cultivation of sugar beets and grain crops have a main importance, with highly intensive production of such crops as winter wheat, corn, sunflower, hoop, potatoes, cucurbitaceous crops and fruits concentrated in collective farms. In the southern-west areas of European Russia cultivation of seed fruits, grapes, vegetables and locally tobacco is well developed. Sometimes catch crops are grown in crop rotations. Among soil degradation processes soil erosion is common. Local farming systems include measures aimed at protecting soil from erosion: cross-slope tillage, decreasing runoff, snow storage.

Agricultural lands in the *central European part* of the northern and southern forest steppe account for 47 and 72%, respectively. The fractions of hay land and pastures are in the range 3–6%. Grain crops are mostly cultivated. Local climatic conditions are favourable for growing spring and winter cereals, industrial crops (sunflower, sugar beet), fodder crops, fruits and berries. Soil protection from erosion, soil moisture protection measures and artificial afforestation has a primary importance, especially for highland plain territories. Reclamation of meadow chernozemic solonetzic soils (Phaeosems Luvic) and solods (Planosols Eutric) and prevention of secondary sodic salinisation in irrigation agriculture is important for the Oka-Don lowland.

Agricultural lands in the forest steppe zone of the *Volga-Ural* interfluvial account for 46-58%. The hay land and pastures are in the range 5–6 and 5–11%, respectively. Grain crops cultivation has the main importance, with limited possibility of winter cereals growing due to severe winter conditions. Natural conditions are favourable for grain legumes, potatoes, vegetables, sugar beet cultivation. Soil protection from water erosion and soil moisture protection measures, seeding of perennial grasses and cross-slope tillage have a primary importance, as well as local wind erosion protection (e.g. in Bashkiria).

Cropland accounts for 15 and up to 36% of the northern and southern forest steppe, situated *between Ural Mountains and the Ob River*. Hay lands account for 10–12% and pastures - for 7–15% of the total area. Dairy-meat husbandry and grain corn (mainly spring wheat) growing are practiced. Flax cultivation is of great importance. Local farming practices include measures for water accumulation in soil, such as conservation tillage; protection from deep freezing based on snow storage, chemical reclamation of solonetzic soils, artificial drainage of boggy soils. Seeding of perennial grasses in crop rotations is of great importance.

Cropland, hay land and pastures account for 41, 10 and 10% of the agroregion, situated *between the Ob and the Yenisey rivers*, mainly concentrated in the southern part of the forest steppe. Grain growing is common. Meat -dairy husbandry is practiced. Spring wheat, sugar beet, sunflower, flax, potatoes and vegetables are of great importance. Soil-protective measures include soil water accumulation, protecting soil from erosion, local reclamation in the mining areas (e.g. Kuzbass).

The forest steppe *east of the Yenisey River* (including the Far East steppe area) is in patches ("islands") allocated to the southern part of the Krasnoyarsk Krai and Irkutsk Region. It is the province of the very intensive production of grain as well as intensive livestock dairy and wool specialization. Soil water and heat protection measures are of great importance. Winter erosion is a common feature in the pre-mountains areas. The region is suited to the early maturing cultivars.

Steppe region is situated to the south of the forest steppe zone and exists as a continuous belt from the west Russian border to Altai Mountains. More to the east it have a patchy occurrence on the slopes of inter-mountain depressions reaching the west slopes of Big Khainag ridge. Climate is warm and dry, P/E coefficient is 0.44–0.47. Typical climate features are a regular moisture deficit of vegetation periods, quite close mean summer temperatures (20–24 °C in the western part and 17–21 °C in the

eastern part of the region), distinct difference of mean winter temperatures (–2 to –10 °C in the western part and up to –24–27 °C in the eastern part of the region). Range of active annual temperatures sum is a characteristic of great variability: from 2 300–3 500 to 1 500–2 300 °C. The growing season is 180 to 97 days, diminishing eastwards.

The natural vegetation is subdivided into 2 subzones: herbaceous-sod-forming grass and sod-forming grass steppe communities. In the former subzone xerophytic species are quite common growth forms. Bunch grasses, such as *Stipa* species and sod grasses, commonly *Festuca* are dominant. Associated species are herbs, *Carex*, rhizomatous grasses. Blue-green alga and lichens are common in the ground layer. A quasi-dormant period is typical for many species and their narrow upright stem reduces heat-gain in the hot summers. The southern sod-forming grass communities are even more xerophytic, with the increasing role of low-growing shrubs and spring ephemers. Blue-green alga and lichens are quite common in the ground layer. Bunch grasses can form an open canopy. Perennial grasses can remain dormant in the hot summer period. The differentiation of dominant natural steppe species have a distinct eastwards trend. Net primary production (NPP) of steppe natural communities is in the range 20–30 tonnes/ha, with a slight shoot biomass predomination (55%). Forests are few (8.6% of the steppe area) on watersheds, mainly allocated to valleys and flat bottom valley (balka) slopes.

At present approximately 80% of the steppe is cropland.

The southern area of the European Russia steppe zone includes the western and the central parts of Pre-Caucasian steppes with fertile soils and favourable climatic conditions. The cropland is up to 90% of that area. This territory has a very intensive agriculture. Hay lands account for only 3% and pastures - for about 11% of the area. A highly developed agricultural sector includes production of grain crops, sugar beet, sunflower, tobacco, rice, grape and fruits. Animal husbandry specializes in dairy, beef and pigs Irrigated farming is important for intensive cropping. Application of high fertilizer rates provides a considerable crop return. Water accumulated in the soil is of primary importance in the northern part of this zone. Wind erosion is common.

The north of the agroregion (the south part of Middle Russian Upland*)* has a colder and more continental climate with lower winter mean temperatures comparing with the southern part. The cropland is 60–70% of the area. Hay lands account for only 2% and pastures - for 18% of the area. A highly developed agricultural sector has specialization in cultivation of winter wheat, corn, sunflower, legumes, industrial crops (sugar beet, tobacco), vegetables and cucurbitaceous crops. Animal husbandry specializes in dairy and beef, pigs and fine fleeced pedigree sheep. Farm practices are oriented towards water conservation, water and wind erosion protection measures.

In the *left bank of the Volga River and the pre-Ural* area the climate becomes more severe, characterized by large temperature variations and irregular rainfall. Soil freezing may reach a metre deep. Cropland is about 50% of the area. Natural hay lands occupy less than 5% and pastures - about 25% of the area. Spring wheat and oil crops are the main crops. In animal husbandry dairy and beef breeding are well developed. Complex measures to protect soil from erosion and prevent moisture deficit are important in farm practice, such as forest belts, snow storage, conservation tillage, cropped and bare fallow.

In *Trans-Ural (*east of Ural to Altai mountains) with a severe continent climate, the depth of soil freezing reaches 200 cm, with a freezing period of about 5 months. The cropland is 55% of the area. Natural hay lands occupy less than 4% with the increased role of pastures – 30% of the area. The agriculture has specialized in grain crops (spring wheat, barley), oil crops, silage maize and fodder crops. Animal husbandry includes meat and dairy cattle and fine fleeced pedigree sheep rearing. Local soil-protection measures include water accumulation in soil, prevention of wind erosion, snow storage, introduction of bare and cropped fallow in crop rotations, chemical reclamation of solonetzic soils.

Dry steppe region is as a continuous wide belt from the West Pre-Caucasus to the Altai Mountains. Besides, it includes “islands” of chestnut soils within intermountain depressions of East Siberia. The main climatic feature of the region is decreasing precipitation and increasing evapotranspiration, as compared with the steppe region. Annual precipitation decreases from 350–400 in the west of the area to 200–300 mm in the east, P/E ratio ranging within 0.3–0.5. Changes of climatic conditions within the agroregion are the same as in the steppe zone. Average summer temperatures are quite close within the region: 20…24 °C. Amplitudes of mean average temperature in January increase eastward: –3…3 °C in Pre-Caucasus and –24…-27 °C in Trans-Baikal, with the respective decrease of the growing

season from 180…190 to 110…129 days and the mean active temperature sum from 3 000–3 500 to 1 600–2 000 °C eastward. The next important feature of Trans-Baikal region is its monsoon type of precipitation distribution. Snow cover depth is small and because of strong winds in the eastern part of the region easily removed from the soil surface. Vegetation difference is determined by local changes of the climatic conditions and is closely connected with the soil heterogeneity in different provinces of the region.

A continuous cover of perennial grasses in the western part of the region, where *Stipa* and *Festuca* are predominant in the dry steppe communities is marked by the replacement of the dominant plants due to the climatic regimes altering along the eastward axis dry steppe communities in the eastern part of the region are composed typically of *Stipa-Festuca-Artemisia*.*Artemisia* is also not infrequent on the solonetz-like spots in the European part of the region. *Artemisia* -small-bunch grass dry steppe is typical in Tuva area, an open *Caragana* layer is also common in dry steppe communities. Trans-Baikal province has grass-*Artemisia* dry steppe communities with a *Caragana* bush layer; they form an open canopy and have poor species composition. Net primary production (NPP) is lower, than the steppe region, as a result of climate aridity, usually not more than 100 kg/ha, with rather distinct predomination of root biomass (85%). Annual input of nitrogen and plant ash elements with detrital and root losses amounts to 160 kg/ha.

The dry steppe region territory can be subdivided into three areas, based on the continental climatic features, the soil cover and the land use systems predominating.

The East-Pre-Caucasus province allocates to east slopes of the Stavropol plateau (Stavropol Krai, Kalmykia, Ingushetia, and Chechnya). Predominant landforms are defined as weakly undulating plain with shallow balkas (flat-bottom valleys). Absolute altitude range within 100–300 m. Parent materials are clay loam deluvial sediments of hard rocks. Moderate continental climate of the area has the following specific features: short and mild winter, almost snowless and a hot long summer. It is hard to find plots of unchanged natural vegetation which is supposed to have been represented by a continuous cover of perennial grasses and forbs, predominantly *Festuca* and *Stipa.* The soil cover is rather homogeneous and represented by dark chestnut and chestnut (Haplic Kastanozems) soils, excluding the south-eastern part of the province with the soil complex of solonetz (Haplic Solonetz), chestnut (Haplic Kastanozems) and solonetzic dark chestnut soils (Luvic Kastanozems). Soil freezing has been registered in the upper layer. Agricultural lands account for 49%. The fractions of hay land and pastures are about 10 and 35%. The crop sector specializes in wheat, oilseed and stone fruits, grapes. Agricultural practices are connected with water accumulation in soil, increased fertilizer rates, forest belts construction.

The Don province, between the Manych depression and the Volga River, includes Volgograd and Rostov Regions, and Kalmykia. The province has a moderate continental climate, drier and colder (the lower winter temperatures) compared with the previous province. Natural vegetation is dry steppe, composed typically by *Festuca* and *Artemisia.* The soil cover is represented by sequences of dark chestnut and chestnut (Haplic Kastanozems) soils of the interstream areas and solonetzic chestnut soils (Luvic Kastanozems) on the slopes. The participation of the solonetz (Haplic solonetz) soils in the complexes and manifestation of the solonetzic morphological features in the profiles of Kastanozems (compaction, prismatic structure) within the province is common at the foot slopes and in the valleys. The north of the province is intensively dissected, so soil erosion is widespread. Agricultural lands account for 52% - the highest fraction for the steppe region. Hay land and pastures are about 7 and 29%. Crops are mainly cereals. The necessary agricultural practices include water accumulation in soil, reclamation of solonetzic soils and soil-protective measures from erosion on elevated plains, highly dissected by a system of balkas and gullies. Irrigated agriculture has been developed, with rice, vegetables and cucurbitaceous crops.

In the *Volga-Ural River interstream* province (Saratov, Orenburg, Volgograd, Ural regions) the continentality of climate increases. Snow cover depth is small and as a result of strong winter winds is removed from the soil surface, limiting potential moisture recharge. Dry periods in June and July are accompanied by influxes of hot, dry air (air moisture below 15%) commonly known as sukhoveis. Adverse weather such as droughts, water deficit, hot, dry winds (sukhoveis), and winter freezes are common phenomena, making rainfed grain more marginal. Agricultural lands account for 41% of the province. The fractions of hay land and pastures are about 6 and 44%. The main crop is spring wheat.

Animal husbandry includes meat and dairy cattle. Agricultural practices are connected with water accumulation in soil, chemical reclamation of the solonetz and solonetz-like soils, irrigation, and soil-protective measures from water and wind erosion.

In the *Tuva and Trans-Baikal* intermountain depressions the dry steppes zone has an absolute altitude range within 500…700-800…1 200 m. Typical parent rocks are sandy loams, sandy gravel loams, sands and gravel sediments. The province has severe continental climate, with long winters, almost snowless. The mean winter temperatures are –18…–20 °C in Tuva and –24…–27 °C in the Trans-Baikal area. The soils usually freeze to 2–3 m for 5–8 months. The mean summer temperature is 17–20 °C. Mean active temperature sum ranges within 1 400–1 900 in Tuva and 1 600–2 100 °C in the Trans-Baikal area. Annual precipitation is 180–300 mm. Agriculture is mainly stock-raising: sheep and beef cattle, rearing of horses and camels. The agricultural productivity of these soils is limited mainly by adverse weather, water deficit for irrigation, stoniness and very broken terrain.

Semi desert and desert regions in East Europe as a belt within the north coastline of the Caspian Sea, bordering on Pre-Caucasus in the west. The region includes parts of Daghestan, Kalmykia, Ingushetia, Chechnya, Stavropol Krai, Volgograd and Astrakhan Regions. The Caspian lowland is a young accumulative plain, infilled with marine and continental late Quaternary sediments of alluvial or lacustrine origin. The monotonous topography was produced by the levelling accumulative effect of the sea transgressions, sometimes it is broken by shallow depressions and the "limans" - shallow elongated 1–12 km^2 depressions 2–7 m deep, whose provenance is related to the coastline. Elevations range within 48–50 m (the Yergeni foothills) and –26 to –28 m below sea level. Saline platy chocolate clays or sandy-loam sediments are the main parent materials. The province has a severe continental climate, with moderate cold winter, usually snowless or with small depth of the snow and a dry moderately hot summer, accompanied by sukhoveis and mist.

The soil and plant cover is highly heterogeneous. Development of different soil types is connected with plant communities. Light chestnut solonetzic soils (Luvic Kastanozems) on fine textured substrates under *Artemisia* and *Festuca* vegetation usually form soil complex with meadow chestnut soils (Haplic Phaeozems) under grass vegetation. Brown semi-desert (Haplic Calcisols) soils are widespread in the southern and south-east parts of the region. They are formed from coarse-textured parent material under *Artemisia* and *Artemisia-Festuca* vegetation. The latter soil unit occupies 1 700 000 ha, which corresponds to 0.105% of the land area of the country. The morphology of light chestnut soils and brown semi desert soils is almost the same so it is very hard to distinguish between them. Common quantitative criteria are low humus content (less than 1.5%), a shallower Ah horizon, higher position of the calcic and gypsic horizons. These soils usually form soil complexes with solonetz soils (Haplic Solonetz).

In the *Volga-Ural River interstream* province sandy sediments occupy large areas of the Caspian lowland. Solonchaks soils (Haplic and Gleyic Solonchaks) which are quite common, are formed around brackish lagoons, on un-flooded parts of salt lakes and low river terraces. This soil type occupies 980 000 ha, or 0.059% of the land of Russia.

Meadow soils (Eutric Fluvisols, Calcaric Fluvisols, and Mollic Gleysols), formed from alluvial deposits in the Volga, Terek, and Ural floodplains and in the Volga-Achtuba delta, have high fertility. Their distinct features among the semi-desert zonal soils favours intensive irrigated vegetable and cucurbitaceous crops cultivation, as well as rice and wheat. Gleyic features in the lower part of the profile are common. These soils are periodically flooded. Salinization of the middle and lower parts of the soil profile sometimes accompanies meadow features. These saline soils correlate with Salic Fluvisols or Mollic Gleysols. Agriculture has livestock based and includes meat and dairy cattle, fine fleeced pedigree sheep breeding. Arable land account only for 5% of the province. The fractions of hay land and pastures are 7 and 70%. Agricultural is limited to small areas of irrigated fields or depressions in mesorelief, including shallow limans, with extra-water accumulation during snow melting. Irrigated agriculture has been developed mainly in the western part of the region. Canal systems bring water from the Volga River. Mountain crop and cattle husbandry includes cattle rearing on the basis of natural grazing at different altitudes. Combination of different forms of agriculture, such as fruit growing, viticulture, vegetable growing, beef cattle rearing and sheep rearing is typical for one farm.

4. RUMINANT LIVESTOCK PRODUCTION SYSTEMS

Specialized enterprises in animal husbandry production

In the pre-reform period (1970–1991) a great job was done to intensify animal husbandry. It was based on large specialized farms (complexes), constructed in different regions of the country, which had high technological level of production. Experience in implementation of modern technologies, accumulated there by other farms, influenced production development a lot, quality improvement and increase of economic efficiency.

Activity analysis of different sizes of animal husbandry complexes proves the high efficiency of large specialized enterprises. The biggest unit weight (75%) among dairy production complexes belonged to those for 800–1 600 cows; they were characterized by high efficiency. Beef production was most efficient on large complexes with 10 000 young stock herds for rearing and fattening. Here fodder and labour consumption per unit of production were lower and production profitability were higher. Complexes with the full cycle of cattle rearing and fattening were the most efficient.

Among pig breeding complexes about half of weight gain was produced on large complexes with 108 000 head for fattening. They had high efficiency, less feed and labour consumption per quintal of weight gain. Many of such enterprises did not yield to foreign enterprises. Investments for construction were recovered more than once during the period of their functioning.

At the same time management analysis of specialized enterprises showed that many of them did not have enough agricultural land and it was used inefficiently. There were omissions during their design and construction. They have extreme herd concentration without consideration of fodder base, depended on purchased concentrates (from state reserve) manure removal was not thoroughly worked out and led to environment pollution. These shortcomings are taken into consideration in the development of new cattle fattening units. It is feasible to update and reconstruct existing large enterprises in order to keep and use them efficiently for high quality production.

Hasty and poorly thought-out market reforms in the national economy and its agrarian sector led to loss of potential achieved earlier. As a result of the transmission to “free” market relationships the possibilities of state regulation of agricultural enterprise economical development were eliminated, production-economical links established earlier were broken, monopoly of enterprises, processing raw materials and supplying means of production, were strengthened wrongfully, price imbalance on agricultural production and resources necessary for its production increased dramatically. In these conditions the majority of agricultural enterprises found themselves unprofitable. This especially influenced big specialized enterprises, and many of them collapsed, having great difficulty with supply of concentrates and whole milk substitutes, with herd gathering (due to reduction of dam herd by farm-suppliers), and with sale of their products at low prices dictated by monopoly processors.

It is necessary to stimulate the development of animal husbandry branches on all types of farms: agricultural enterprises, peasant households (farmsteads) and individual subsidiary farms. It will be based on a rational combination of large, medium and small-scale commodity production. At the same time animal concentration should be limited by ecological and economic criteria.

Integration of livestock into forage systems

In northern and north-western regions of the forest zone forage crops occupy 60–65% of sown area, including more than 50% of legumes. The main crop rotation is grass-cereal with a high content of perennial grasses and legumes. In central and eastern regions of the zone forage crops occupy 35–40% of sown land, including perennial swards – 25–30%.

The important agricultural regions of black soil lands are forest-steppe and steppe zones of European Russia. Farms mainly produce grain, *Beta vulgaris* var. *altissima*, *Helianthus* here. The attendant branches are sheep and beef cattle raising; 60–80% of land is arable. The proportion of row crops and fallow, which causes a negative humus balance and soil erosion, is more than 30%. There are only 0.16 ha of native forage land left per hectare of arable land.

Forage crops cover 25% of sown land, including not more than 10% of perennial swards with an environment-regenerative ability, which is extremely low. Organization of soil protection and erosion control means reduction of bare fallow and row crops and more perennial grassland. Perennial pasture

is 50% of slopes in soil protection crop rotation in strips. If the arable land is cut with gullies, part of it should be transferred to grassland. Increase of perennial sward proportion in combination with forage land makes it possible to increase animal husbandry production in this region.

In Western and Eastern Siberia the zonal character of agricultural production systems, together with moisture and heat provision, is determined by such features as short growing period, extremely unequal precipitation distribution and severe winters. Spring crops are the basis of grain sowing; only in the semi-taiga zone, where the snow cover is thick enough, is winter rye included in rotations.

In the semi-taiga zone and northern forest-steppe, with enough precipitation, crop rotations consist of winter rye, annual and perennial grasses, forage grain, some row crops. These regions could increase planting of barley*, Brassicaceae* forage-legumes, and perennial grasses.

In southern forest-steppe and steppe, field forage production is based on diversified species, enabling maximum forage harvesting in difficult weather conditions. In crop structure there are crops providing the maximum harvest accumulation due to autumn-winter precipitation (winter rye, winter *Brassica napus,* perennial grasses); with early spring and summer moisture (annual grasses of different time of planting, grains) and precipitation in the second growing season (millet-like cereals, maize, legume-grass mixtures, cabbage family). The advantage of brassicas is their ability to continue growth after the first autumn frosts.

The main means of soil fertility maintenance in field crop rotations dominated by cereal-fallow and cereal-sown crop is sown and bare fallow. In contrast to European Russia there are spring *Triticum, Hordeum*, *Avena, Pisum, Helianthus*, forage *Panicum* in such rotations. Bare fallow should be changed to sweet clover fallow in the steppe of Western Siberia, especially on light soils. Grain specialization in the Siberian steppe, requiring a much arable land kept as bare fallow, leads to erosion, deflation and destruction of soil organic matter. It is necessary to re-orient farming of drought-affected regions to expand field forage production and development of pastures.

In sub-montane regions of Asian Russia with sufficient moisture and increased erosion risk, grain-fallow-grass crop rotations are the most feasible, where perennial pastures occupy 25–33% and in soil protection crop rotations up to 70–80% of arable land.

Farming of the Far East with monsoon climate and dramatically expressed continentality is characterised by relatively optimal arable land structure, where 34% is occupied by forage crops, including 21% of perennial pastures. The unit weight of bare fallow and row crops does not exceed 15%. Only here soya, perennial and annual grasses occupy 30%. In Primorie region perennial pasture in crop rotations occupies from 20% in the forest-steppe to 40% in taiga. On farms of the steppe zone crop rotations or soya is up to 30%, perennial pastures - 20%.

Vegetables and forage crop rotations prevail in Sakhalin island. Annual and perennial grasses are the main forage crops.

Feeding systems. Dairy cattle raising is mainly concentrated in the forest zone of European Russia and to a lesser extent in Asian Russia. Most farms have feeding systems based on native and sown pastures. In spring, before the pastureis ready for grazing, cattle are given green chop from winter crops. In autumn cattle graze on the aftermath of perennial grasses on arable land, or eat green chop transported and distributed to troughs. Some farms prefer stall summer maintenance of dairy herds with walking pens, feeding green chop on a “cut-and-carry” system with different forage crops, including forage from grassland. Such a system is used on farms with high cattle concentrations. Farms with native pastures far from cowsheds set up summer camps with milking equipment, electricity supply and sheds. Pasture establishment close to cowsheds have big advantages in comparison with summer camps. It is economically feasible to use remote pastures for replacement young stock.

Beef cattle are kept mainly in the forest-steppe and steppe zones of European and Asian Russia. System of maintenance includes combination of grazing native pastures, mainly on slopes, and additional feeding with green chop. The proportion of pasture forage in beef cattle feeding in Asian Russia is higher than in European Russia due to the different amount of ploughed land. High efficiency is achieved with intensive fattening at the final stage of rearing for slaughter. The suckling cow-calf system proved itself.

Grazing is the main method of sheep rearing. On the steppe sheep graze on steep gully slopes with fine grasses. Sown pastures are established mainly for pure bred herds of goats and sheep. Arid pastures

are used mainly for sheep grazing. Pastures are the main source of forage for herbivores in summer. Steep slopes and mountain tops are used for sheep and goats. Gentle slopes and low- and middle mountains are suitable for cattle.

Horses are most efficiently reared on native pastures. In forest-steppe and steppe *Festuca*, *Agropyron*, and *Stipa* pastures are most suitable for horses. The urgent need is for more full pasture forage provision for animals.

Location of animal husbandry branches in the country regions

Development of animal husbandry branches occurs according to the native and economic features of regions. Dairying is developed in north-western and central parts of the forest zone of European Russia, close to industrial centres, where it is combined with poultry farming, due to high population density and impossibility of transporting such products.

Dairy-beef husbandry prevails in the south-west of the forest zone of European Russia which supplies the federal fund with butter, cheese and beef. The northern forest-steppe zone of European Russia has developed cattle husbandry, pork and poultry. Here there is the highest level of pork production per capita.

The southern forest-steppe, steppe and semi-desert zones are a key area of meat and fine wool production with more than 20% of Russia's sheep. Dairy - beef and beef cattle husbandry is developed here as well. Dry steppe and foothills of European Russia favour different branches of animal husbandry: dairy-beef and beef cattle, sheep, pig and poultry rearing. A third of Russia's sheep herd is here and more than 40% of all wool is produced here.

Forest and forest-steppe zones along the Ural mountains are characterized by development of dairy-beef husbandry; pig and poultry rearing is developed close to urban areas. In the south of the region, in the steppe, semi-fine wool and fine wool sheep and specialized beef husbandry are developed.

Branches of animal husbandry in Western Siberia, include dairy-beef husbandry and fine-wool sheep. This region supplies the federal fund with dairy products. Eastern Siberia has less intensive development of animal husbandry. Significant quantities are imported. In the Far East dairy husbandry and poultry breeding are developed to meet local demand since it is impossible to transport these products.

Animal breeds

There are 48–50% of Black and White, 20% of Red and White (including Simmentals and Sychev), 8% of Red (including Red Steppe – 93%), 4% of Brown (including Brown Swiss – 78%, Kostromskaya – 19%, Caucasus Brown – 3%) breeds. Furthermore 7 breeds are used mainly for pure-bred rearing. Their proportion in total herd are: 8,4% of Holmogorskaya, 3,8% of Bestuzhevskaya, 2,7% of Ayshire, 2% of Yaroslavskaya breed. In the future it is planned to increase the proportion of Black and White breed up to 55%, and in some regions up to 60–70% in dairy cattle husbandry. The unit weight of Red breeds will be 15%, Brown – 5%. In suburban areas with dairy (whole milk) cattle breeding the main breeds will be Black and White, Holmogorskaya, Kostromskaya, Ayrshire, and in the South – Red Steppe breed.

In dairy-beef cattle husbandry the main breeds are dual-purpose ones: Simmental and Brown Swiss, and some dairy breeds (Black and White, Holmogorskaya, Yaroslavskaya). Beef cattle are represented by Beef Simmentals, Kalmyk, Kazakh Whitehead, Hereford, Aberdeen Angus, Limousin and Charolais. The structure of beef breeds is as follows: Kalmyk – 42%, Hereford – 27%, Kazah Whitehead – 20%, Aberdeen Angus – 7%, Limousin – 3%, Charolais – about 1%. Specialized beef cattle husbandry will mainly be developed due to receiving and rearing of hybrid young stock from crossing of dairy-beef cows with sires of beef breeds.

Breed structure for sheep is determined by zones of their location. In the main sheep zones the principal breeds are fine-wool and semi-fine wool (in mountains – wool-meat focus), in central regions of forest zone – semi-fine wool breeds with meat-wool focus of productivity, in some regions of forest zone – Romanoff. In 2000 sheep and goats numbered about 14 800 000 heads and according to FAOSTAT 2006 the number had reached 17 771 000 by 2005. Goat percentage is 5%. The increase of this livestock capita is envisaged up to 30 000 000 million including 3 000 000 goats. Most of this livestock is actually on individual farms.

Mainly local crossbreds are used in poultry, created on the basis of genetic fund of egg and meat production.

Deer herding. Russia has about 60% of all reindeer. It is a principal agricultural business for northern populations. Essential reindeer breeds are: Nenets, Avenk, Evenk and Chukotka; the fifth one – Tofalar has almost disappeared. Reindeer stocks amount to almost 1 200 000 million head. In small hill submontane and mountain regions of Altai and taiga regions of the Far East the breeding of Siberian stag is in progress. The principal product of this agricultural branch is velvet antlers. Up to 40 tonnes of preserved velvet antlers are produced annually and 70% of this is from Altai where there are about 36 thousand head of Siberian stag and East deer.

Horse breeding. The horse herd in 1999 was about 1 800 000 but is expected to increase to 2 600 000 in the near future (However, according to FAOSTAT data (2006) the horse herd numbered 1 801 000 in 1999 but had declined to 1 505 000 in 2005). The production of horse meat is anticipated to achieve 110 000 tonnes, that of kumis 3 300 000 tonnes. The main horse use is: work, production, breeding and sport. The most wide-spread are Orlov, Russian trotter, Don and cart-horse breeds.

Veterinary and sanitary condition

Veterinary hygiene and animal husbandry condition is satisfactory. Veterinary services periodically carry out prophylactic control of infection diseases. In addition, activities on invasive and parasitic diseases are carried out. The main causes of morbidity and mortality of agricultural animals are non-contagious diseases. Among infectious diseases tuberculosis and brucellosis, as well as leucosis, are commoner than others.

Increased volumes of import of agricultural production create a danger of other cattle disease movement, including exotic ones. In this connection necessary measures for strengthening of veterinarian and sanitary control and prevention (prophylactic) of possible infection diseases, which have recently occurred abroad (BSE, foot and mouth disease,) are accepted on Russian territory and in some regions of Russia.

Imports and exports

Russia continues to import large quantities of meat (eg. in 2004: 510 949 M tonnes of beef and veal, 1 116 838 M tonnes of poultry meat and 395 208 M tonnes of pig meat) and also dairy products (between 2000 and 2004 milk equivalent imports ranged from 1 007 010 to 2 156 294 M tonnes while exports were lower ranging from 248 000 M tonnes to 686 000 M tonnes per year).

5. THE PASTURE RESOURCE

Description of fodder resources

The role of fodder production is increasing in importance in modern Russian agriculture, providing the base for animal husbandry as well as for maintaining soil fertility on arable land, preserving landscapes and biodiversity. Forage is now the main source of livestock feed, accounting for over two thirds of the total. Dynamic growth of forage crops productivity before 1990 was followed by lower harvests and reduction of forage production, especially during the first years of the Perestroika period, and some unsteady stabilisation during the last 3–4 years. (Table 12 percentage of previous year).

The main reasons for forage production decrease on arable land are:

- Decrease of material-technical input level;
- Slowly transformed species composition of forage crops and of plants on arable land structure, typical of rather intensive systems of agricultural production at a rapidly changing level of resources provision.

In the past a significant sown area was occupied by grasses and other forage crops, where productivity was provided by mineral, mainly nitrogen, fertilization. Row crops also occupied large areas. During these years significant reduction of irrigated and improved land occurred, a large part of which had been used for forage production. Reduction of productive agricultural land, including that previously occupied by fodder crops, is also caused by construction of dwellings and social objects, roads and other engineering

Table 12. Fodder making, availability and consumption on agricultural enterprises

Name	Unit	1997		1998		1999		2000	
			%		%		%		%
Dry fodder	Thousand tonnes	192.2	95.2	197.6	102.8	174.4	88.3	168.2	96.5
Hay	Thousand tonnes	21 626	102	14,813	68	16 002	108	17 700	111
Silage	Thousand tonnes	63 349	97	44 803	71	41 995	94	49 899	119
Feed root	Thousand tonnes	2 578	98	1 505	58	1 998	133	2,149	108
Total roughage feed units	Thousand tonnes	34 953	96	2 3061	66	23 897	104	2 7358	114
Per cattle units	Quintals of feed units	19.3	111	15	78	16.4	109	19.8	121
Availability of all fodder in feed units									
TOTAL:		33 125	103	22 045	67	20 496	93		
Per cattle units	Quintals of feed units	14	115	10.1	72	9.6	95		
Availability of all concentrates in feed units									
TOTAL:		10 273	117	6 140	60	5 048	82		
Per cattle units	Quintals of feed units	4.3	130	2.8	65	2.4	86		
Fodder consumption per 1 Quintal of production									
Milk									
Total feed units	Quintal	1.7	100	1.6	94	1.5	94		
incl. Concentrates	Kg	40		40	100	35	88		
Unit weight of concentrates	%	23		23.4		23.3			
Cattle weight gain									
Total feed units	Quintal	17.7	94	16.6	94	14.8	89		
incl. Concentrates	Kg	4	98	4	100	3.3	83		
Unit weight of concentrates	%	22.7		24.1		22.3			
Pig weight gain									
Total feed units	Quintal	11.7	91	10.8	92	10.9	101		
incl. Concentrates	Kg	10.1	92	9.4	93	9.5	101		
Unit weight of concentrates	%	86		87		87			

communications and structures. The main directions to raise and stabilize the increase of forage production on arable land, and improve its quality include: expansion of the area under forage crops in combination with improvement of crop structure with an increase of perennial legume-grass swards in all regions, especially in southern ones, as well as using resource saving technologies.

Table 13. Arable land for foddercrops

Name	Million ha	% of total area	% of fodder crops
Total area for fodder crops	45.9	100	
Incl. Forage grain	17.7	38.5	
Fodder	28.2	61.5	100
Of which perennial sward	16.0		56.7
Annual sward	6.9		24.5
Maize for silage	4.1		14.5
Other silage	1.0		3.5
Fodder roots	0.2		0.8

Fodder production is very important and covers three quarters of all agricultural land. Natural grassland (NG) occupies huge territory – 87 600 000 ha, besides 328 100 000 ha is used for deer grazing. Natural meadows and pastures make up 39.6% of agricultural land. Significant areas of arable land (Table 13) are also allocated for fodder production. Now fodder crops occupy 45 900 000 ha.

Natural grassland and perennial swards on arable land provide the cheapest forage for herbivores, containing all complexes of nutritious substances. The cost of perennial forage swards in Russia is 1.5 times less than grain forage and 2–2.5 times less than other tilled fodder crops.

Animal maintenance on pasture is the cheapest system. Fuel and lubricating material expenses are 3 times less, labour – 2.5 times less on pastures in comparison with green chop feeding in stables. Natural grassland is a major source of fodder, medicinal, feed, technical, decorative and other plants. It is a biodiversity bank of most valuable vegetative resources inhabited by relic plants and animals. Grassland vegetation is very important in natural protection. Natural grassland is part of landscape-geochemical barriers in river valleys, lowlands, ravines and other relief depressions. These barriers' role in environmental protection is increasing. Vegetation of pastures and meadows plays a large anti-erosive role, protecting flood plains and slopes from water and wind erosion in steppe and arid zones. These features are especially important for Russia, where erosion-liable agricultural land makes up about 12 000 000 ha. The direct influence of grassy vegetation on soil fertility is caused by the sod-forming process of meadows and pastures, promoting accumulation of organic matter and fixing of basic nutritious substances in it.

A special advantage of natural grassland and perennial grass on arable land is yield stability over time. So, productivity comparison over 25 years (from 1970 to 1995) shows that the coefficient of variation of such fodder crops as feed roots, corn, barley and oat usually makes up more than 20%, which is significant, whereas natural grassland and perennial grass coefficient is less than 20%. Natural grassland is an important component in substance circulation and energy flows in agro-zoo-eco-systems. Overall natural grassland efficiency of photosynthetic active radiation in vegetative cover of Russia is about 0.7% (according to Chernikov, 2000).

Preservation and study of spontaneous course of natural processes and phenomena, genetic fund of flora and fauna, certain plants and animals and communities, typical and unique ecological systems is carried out in 183 reserve and national parks of Russia on an area of 28 400 000 ha.

Natural grassland

Natural pastures occupy 64 200 000 ha, meadows – 23 400 000 ha. Natural grasslands vary in structure of plants, soil, relief and humidity. This variety is caused by the vastness of the territory and the extensive range from north to south and from east to west.

There are six soil-climatic zones in Russia: tundra, forest, forest-steppe and steppe, semi-desert, desert and subtropics (Table 14). Subtropics on the Black Sea coast occupy a very limited territory in relation to other zones and have no essential importance in animal husbandry.

The grazing period is 120–150 days in forest zone, about 180 days - in steppe, more than 220 days in semi desert, almost the year round in desert and tundra. Each natural zone has a large variety of vegetative associations according to relief features, soil type, degree of drainage and salinisation. Prof. Ramensky developed the most comprehensive phyto-type classification of grasslands (1938), which is still used. According to this classification of grasslands and pastures in the country zones all fodder land is divided into 25 classes, with 1 500 taxonomic units. Flood plains and mountain areas are found in all zones.

Tundra and forest-tundra

Tundra and forest-tundra occupy the Far North. The southern border is at 65° in the European part, 72° in Taimyr, 60° in the Far East. Deer pastures occupy 290 200 000 ha. A specific feature of tundra is the absence of forest, which only occurs close to the southern borders of the zone. The warm current of the Gulf stream influences natural conditions a lot - vegetation, climate, soil of Western part of tundra (Kola Peninsula). Central and eastern parts of the tundra differ a lot from western part. The continental climate of Northern Asia and cold sea climate of Barentsevo Sea influence them. The growing period is 2-4 months.

Total amount of light in tundra is one third less than in middle latitudes, and the effect on active photosynthetic radiation is even bigger. Strong winds cause active moisture evaporation, and plants suffer from lack of moisture at low temperatures of soil and water. Snow cover on plains is only 20–30 cm. Wind moves snow crystals and this damages plant shoots above snow surface.

These climatic features interfere with forest formation. Short bushes, herbaceous plants with leaves growing close to the surface, Lichens, Musci are typical of the tundra. Sedges (Cyperaceae), grass and some kind of mixed herbs prevail among herbaceous plants. Deer eat plants of these groups and separate kinds of plants unequally. Swamp lands are very widespread.

A severe climate with a combination of poor fodder resources only allows reindeer herding. Other livestock are extremely limited and live, for example, on flood plains.

Bushes of the tundra, for example Salicaceae (*Salix glauca*, *Salix lanata, Salix myrsinites, Salix reptans)* have the greatest fodder importance; Betulaceae (*Betula nana, Betula exilis, Betula middendorfii)* also have fodder importance, but to a smaller extent. Bush

Table 14. Distribution of natural grassland in zones of Russia (million ha)

Zone	Meadows	Pastures	Total NG	% NG of agricultural land	Deer pastures
Tundra and forest-tundra		0.4	0.4	100	166.8
Forests	11.2	12.3	23.5	40.5	97.0
Forest-steppe and steppe	7.2	26.1	33.3	27.9	
Semidesert and desert	1.0	8.2	9.2	83.6	
Mountains	4.0	17.2	21.2	66.8	64.3
Total	23.4	64.2	87.6	39.8	328.1

height in the tundra does not usually exceed 50–60 cm. Deer browse bushes in summer, partially in spring and autumn.

Lichens *(Cetraria islandica, Cladonia rangiferina)* are the basic winter feed of deer. They eat *Lichens* actively, starting in the second half of September and in spring till the end of May. Bushy *Lichens* are of the greatest fodder importance – *Cladonia* (*Cl. alpestri, Cl. rangiferina, Cl. silvatica)* and *Cetraria (C. islandica C cucullata*). *Stereocaulon paschale* and *Alectoria sarmantosa* (in winter) are also significant feed for deer.

Sedges (Cyperaceae) occupy the third place. *Eriophorum*, *Baeothryon cespitosum, Carex (Carex aquatilis, Carex rariflora, Carex oncolor, Carex juncella)*) represent the greatest fodder value. These plants are eaten most willingly at the end of May, June, then in autumn and winter (from under snow). Grasses are eaten willingly in the second half of May, June and the first half of July. *Arctophila fulva, Deschampsia brevifolia, Festuca airoides* have the greatest importance among fodder grasses. *Equisetum arvense* and *Equisetum silvaticum, Antennaria dioica, Menyanthes trifoliata*, *Polygonum bistortum Geum nivale,* and *Pedicularis* have the greatest importance among mixed herbs. Legumes are not widespread in tundra, but particularly include *Astragalus* (*Astragalus alpinus, Astragalus umbellatus*).

Judging from rumen contents, deer diet in spring is 60–65% of green forage, 35–40% of Lichens, in summer - green forage, in autumn there is an almost equal amount of green forage and Lichens, in winter - Lichens and partially green forage from under the snow. Yield of dry matter eaten varies from 100 (sphagnum bogs) up to 400 kg/ha (osier-beds and birch pastures are the most productive).Deer graze all the year round with seasonal use of separate types of pastures. In summer deer go to the ocean coast, where there are fewer mosquitoes, in winter - to forest - tundra. Basic measures of stability are:

1. Moderate use of fodder, not more than 30% of gain.
2. Pasture rotation observance with breaks between grazing within 3 years.

Forest zone

The forest zone makes up almost half of the Russian territory. Its northern border reaches 67° North, southern border 52° North (in Siberia). The forest zone is characterized by prevalence of forests and bushes in the structure of the land - 61% of total territory: agricultural land is 9% of the area, including 3% of grasslands and pastures. Along with natural pastures, about 50 000 000 ha of forests, bushes and bogs are partially used for grazing and grasslands. The lowland plain is in the European part and Western Siberia up to the river Yenisei. Elevated-mountain part is located in the East Siberia. Due to the large extent of the zone the parameters of moderate climate have essential distinctions in extreme points. For example, precipitation is from 308 up to 620 mm (St. Petersburg – 522, Moscow – 620, Krasnoyarsk, Siberia – 306, Vladivostok – 537). Annual average temperature is from –3° up to + 4.6° (St. Petersburg +4.1°, Moscow +3.6 °C, Chita, Siberia –3 °C, Vladivostok +4.6 °C).

The period with temperature above +5° is from 146 to 194 days, i.e. close to the duration of perennial grass growth (St. Petersburg 174, Moscow 173). Two thirds of the northern territories are covered with coniferous forests (*Picea, Pinus, Larix*, *Abies*). Deciduous trees (*Betula, Populus tremula*)grow in the south. Natural pastures and meadows between rivers were formed on land previously occupied by forest. Natural grassland on watersheds is subdivided into two basic groups: grasslands of the upland and lowland grassland.

Upland grassland occupies 50% of the area, the proportion of lowland and bog types is significant, flood plain grasslands occupies up to 15% of the area. Uplands are on elevated elements of relief. Upland pastures are more than 30% of pasture area in the forest zone.

Absolute upland occupies the tops of elevated elements of relief, the top third of slopes. The underground water is far from the surface and grass roots cannot reach it. Soil is poor sod-podzol, sometimes - shallow sod-calcareous, deeply drained. Vegetation - thin short small grass. In summer it dries up quickly and regrows badly after grazing. *Festuca ovina* and *Nardus stricta* grasslands prevail on strongly podzolic soil, with rather poor organic matter and strongly acid.

Agrostis tenuis and *Anthoxanthum odoratum* grasslands are found on sod medium- and strongly-podzolic loamy soil. *Festuca rubra* and *Poa* grasslands occupy richer sod loamy calcareous soil. Mixed herbs, such as *Antennaria, Hieracium* prevail on poor soil. *Centaurea jacea, Leucanthemum vulgare, Potentilla argentea* are on richer soil. Pasture productivity is 0.3–0.7 tonnes/ha DM.

Absolute upland with acid soil is more suited to afforestation. Grasslands on calcareous soil can be made more productive by seeding with legumes and top dressing of mineral fertilizers.

Upland grassland of normal moisture status

These upland grasslands occupy plains, medium parts of slopes, dry river valleys. Soil is humidified enough due to good absorption of atmospheric precipitation. *Nardus stricta* - mixed herb grasslands prevail on sod medium- and strongly-podzolic sandy and sandy-loam soil. *Agrostis* mixed herbs and *Anthoxanthum odoratum* mixed herbs grasslands occupy sod loamy medium- and weakly-podzolic soil. Such grass stands are used for grazing. Productivity is 0.6–1.0 tonnes/ha DM. *Festuca pratensis, Dactylis glomerata* grasslands prevail on sod loam calcareous soil. Grass-stand consists of *Festuca pratensis, Dactylis glomerata*, *Elytrigia repens, Poa pratensis* Prevailing legumes are *Trifolium pratense* and *Trifolium repens*, *Lathyrus pratensis, Vicia cracca*, sometimes - *Lotus corniculatus*. Legumes on dry valley grasslands are sometimes background plants and make up 10–20% of the total mass. Mixed herbs consist of *Leucanthemum vulgare, Alchemilla, Ranunculus*, *Centaurea jacea*, *Poterium*. They are used mainly for grasslands. Productivity is 1.2–1.5 tonnes/ha DM of quite good quality hay or haylage. Productivity and quality can be improved by fertilizer application.

Grassland-steppe plants, such as *Phleum phleoides, Bromopsis inermis*, *Poa angustifolia, Medicago falcata* emerge along with the above-mentioned in the southern part of the forest zone on shallow grey forested and sod calcareous soil. They are used as grasslands and pastures. Productivity is 0.8–1.0 tonnes/ha DM.

Uplands with temporary waterlogging prevail on plains without rain water drainage, and superficial depressions where waters collect. These grasslands have superfluous humidity in spring and autumn. Sod strongly and medium-podzol soils prevail. Soil acidity is, as a rule, rather high. The structure of prevailing vegetation is as follows: *Deschampsia caespitosa, Agrostis canina*, *Nardus,* fine *Carex* (*Carex nigra, Carex cineria, Carex panicea*), hygrophilous mixed herbs (*Filipendula ulmaria, Ranunculus)*; legumes are *Lathyrus pratensis, Trifolium hybridum*). They are used mainly as grasslands. The productivity of rather poor quality hay is 1–1.5 tonnes/ha DM. The priority improvement measure is drainage of surface water.

Lowland grassland

These occupy about 5 000 000 ha in the forest zone on low plains, in hollows, and lowland between elevated relief elements. In spring thaw snow water flows down here. Gley soils have more humus than dry valley ones, often they are rich in calcium, pH is 6–8. Depth of ground water is 1–1.5 m.

Moist - mixed grass and Cyperaceae grasslands prevail most of all. Along with *Deschampsia caespitosa* grass stands consist of *Agrostis gigantea* and *Agrostis canina, Anthoxanthum odoratum, Festuca rubra, Ranunculus*, *Trifolium hybridum, Trifolium repens*. Cyperaceae grasslands with abundance of grasses : *Phleum pratense, Alopecurus pratensis, Festuca pratensis* or with significant amounts of mixed forbs: *Trollius*, *Polygonum bistorta, Polygonum*, *Geum rivale* often prevail. They are used as meadows and as pastures to a smaller extent. Hay or haylage productivity is 1.2–2.5 tonnes/ha DM.

Bogs occupy a significant part of the zone – 86 200 000 ha.

Forest-steppe zone

In Russia arable land prevails in the forest-steppe zone land structure (48% of total area); natural grassland makes up about 30%. It is flat and sloping steppe and dry-steppe pasture. In European forest-steppe all land between rivers with black soil and grey forest-steppe soil is ploughed. Forests occupy a limited area and consist of birch, aspen and oak. Natural grassland remains only on gully slopes and bottoms and in river valleys. Northern and western gully slopes are flat and covered with thick leached black soil.

Bromopsis inermis, *Bromopsis riparia*, *Festuca pratensis*, *Poa pratensis*, *Elytrigia repens*, *Trifolium pratense*, *Vicia cracca*, *Salvia pratensis*, *Leucanthemum vulgare* prevail if used as meadow. There are not many legumes in natural grassland, but such legumes as *Vicia*, *Lathyrus*, *Trifolium* sometimes prevail on flood plain grasslands, forest glades and fallow. Productivity of rather high quality hay or haylage is 1–1.5 tonnes/ha DM. Southern and eastern slopes are usually more abrupt, dry, with shallow washed off

black soil. Xerophilous grass, such as *Festuca rupicola*, *Poa angustifolia*, *Agropyron repens*, *Bromopsis inermis*, *Phleum phleoides* prevail in grass stands. There are far fewer legumes than on northern and western slopes. Legumes are *Medicago falcata*, *Onobrychis*, *Astragalus* and *Melilotus*. Mixed forbs are mostly *Achillea millefolium* and *Artemisia austriaca*. Slopes of this aspect are used as pastures. Productivity of grazed grass is 1.2–1.5 tonnes/ha DM. Gully bottoms are covered with vegetation, similar to that of northern slopes.

Short forb vegetation with domination of *Poa angustifolia, Poa bulbosa, Festuca rupicola, Achillea millefolium, Anisantha tectorum , Plantago media, Potentilla argentea* prevails on slope soils with excessive grazing, *Trifolium repens* can be seen as well. Sometimes ravine slopes are transformed into association of plants unpalatable for cattle, for example *Salvia nutans, Circium, Euphorbia* and *Achillea millefolium.* Productivity of fine grass associations does not exceed 0.9–1.2 tonnes/ha DM of grazed mass. It is expedient to expand the areas with perennial grass on slope soils; unpalatable grasses are destroyed with herbicides, then subsequently undersown to grass without mechanical treatment of the sod.

Meadows and pastures of Asian forest-steppe

15% of Asian forest-steppe is covered with forests. *Betula, Populus tremula* with an admixture of *Salix* L., are present in the forests.

Basic types of pastures are located on solonetz with small patches of alkaline black soil. Typical vegetation is mixed grass with a prevalence of *Calamagrostis epigeia, Poa pratensis* and *Poa angustifolia*, *Phleum phleoides* are also present, *Galatella* or *Artemisia* grow on solonetz. Productivity is 0.6–0.8 tonnes/ha DM. Mixed grass with *Melilotus*, *Elymus trachycalus*, *Bromopsis inermis*, *Medicago falcata* can be sown for improvement. Productivity of sown grass mixture is 1.5–2.0 tonnes/ha DM and more.

Alopecurus and *Elytrigia repens* prevail on grassland-solonetz soil. This grass stand is used for hay or haylage. Productivity is 1.2–3 tonnes/ha DM. *Puccinellia* grasslands are formed on solonetz. *Festuca rupicola*, *Festuca ovina*, *Galatella* and *Calamagrostis epigeios* dominates. *Artemisia pontica*, *Carex praecox*, *Achillea*, *Inula salicina* are most typical. They are used for grazing. Productivity is 1–1.5 tonnes/ha DM.

Steppe zone

The climate of steppe is continental, more humid at the foothills of the Caucasus, Ural and Altai Mountains. Average annual precipitation is from 277 (Semipalatinsk) up to 649 mm (Krasnodar), average annual temperature is from 2.8 (Semipalatinsk) up to 11.1^0 (Krasnodar), frost-free period (with temperature higher than +5° ?) is from 174 days (Semipalatinsk) to 245 days (Krasnodar).

Natural steppe grassland in Western Russia remains as separate small patches. Unploughed steppe is covered with grassy vegetation. There is no forest. *Stipa lessingiana*, *Festuca rupicola* are the most typical. Bushes such as *Spiraea*, *Laburnum* Medic, *Cytisus* are in depressions. Forests are only on flooded plains and in gullies. During summer drought, significant amounts of perennial xerophilous grasses are dormant. In this season they already start to turn yellow at the end of flowering. The whole steppe turns yellow and looks burnt out. At the end of August - beginning of September rain occurs, temperature lowers, and the vital ability of these plants reactivates. New sprouts appear and some spring sprouts turn green. Ephemeron emerge in the steppe, which grow only in spring (*Ceratocephala testiculata*, *Alyssum desertorum*, *Lepidium perfoliatum*, *Anisantha tectorum*, *Bromopsis squarrosus*, *Eremopyrum orientale*, *Ranunculus bulbosus*, *Euclidium syriacum*, and also ephemeridae (*Poa bulbosa*, *Carex uralensis*).

Large and sloping areas are usually used as pastures. Vegetative cover is very thin here. *Artemisia*, *Achillea*, *Matricaria*, *Euphorbia seguierana* dominate on slopes. *Kochia prostrata* sometimes dominates. There is not much legume and grass on slopes. Legumes include *Medicago falcata*, *Melilotus alba*, *Melilotus officinalis*, and *Vicia tenuifolia*. Grassses are *Festuca*, *Bromopsis riparia*, *Bromopsis inermis*, *Poa angustifolia*, *Poa bulbosa*, and *Andropogon*. *Stipa* prevails on less intensively used soils. Pasture productivity on slopes is 0.8–1.5 tonnes/ha DM.

Small areas of unploughed natural steppe are found on combinations and complexes of black soil and dark-chestnut soil with solonetz. Prevailing vegetation of solonetz is *Artemisia lerchiana*, *Artemisia*

pauciflora, *Kochia prostrata*, *Festuca sulcata*, *Pyrethrum* and *Galatella tatarica*. Such spotty steppes are used mainly for grazing. Productivity varies from 0.8 up to 1.8 tonnes/ha DM depending on soil and vegetation. Sown grass can be established on these soils after appropriate treatment. Adapted cultivars of grass, such as *Agropyron cristatum*, *Agropyron desertorum*, *Medicago falcata*, *Melilotus alba* are used for sowing.

Lowland, flood plain, liman grasslands and even bogs occur in forest-steppe and steppe zones. They alternate with steppe and grassland-steppe pastures on sandy and sandy loam soil. They occupy river flood-plain terraces or watersheds, where bumpy, ridging sand is generated. Lowland areas called liman occur in the steppe, as well as in semi desert. They look like dishes. Lowland edges are 1–1.5 m higher than the level floor. They are flooded by snow melt. Liman soil is of grassland type with a different degree of salinity and solonetzicity. Sward structure consists of grass - forbs; *Elytrigia pseudocaesia*, *Alopecurus arundinaceus* as grass, mixed forbs are *Artemisia absinthium* and *Artemisia maritima.* Limans are flooded very unequally: from several days to about one month. Grass stand productivity changes from 0.3 up to 4 tonnes/ha DM because of uneven moisture provision. A liman occupies tens and even hundreds of hectares.

Semi-desert zone

Semi-desert and desert zones are characterized by domination of natural grassland, pastures occupy 70% of total area. Semi-desert and desert pastures prevail (66%). The semi desert zone is to the south of the steppe and occupies a significant part of areas to the north of the Caspian Sea. In Siberia typical semi desert does not exist. In areas behind the Volga River, where the peculiar characteristics inherent to semi-desert are most obviously shown, the temperature sometimes falls to –40 °C in winter. In summer (July) temperatures reach +42 °C; precipitation is 206 up to 268 mm. About a quarter of the precipitation is in June - July. At this season the soil surface temperature is often more than 50°, and relative humidity of the air less than 40%, therefore rain evaporates very quickly. Duration of the warm period (above zero) is 211–240 days.

On the watershed between the Volga and Ural rivers semi-desert has well expressed spottiness. Soil is loam and clay. Its background is presented by even microelevations. Small and superficial (15–30 cm) depressions occur every 5–50 m. Semi-bush associations of a desert type with domination of the following plants - *Artemisia pauciflora*, *Artemisia lercheana*, *Kochia prostrata*, *Camphorosma monspeliacum* and less often *Halimione verrucifera*, *Anabasis salsa* and *Limonium suffruticosum* prevail in flat sites. Proportion of legumes is less than 2% in the semidesert zone. Ephemeroids play an important role in structure of grass stand - *Poa bulbosa*, *Tulipa gesheriana*, *Tulipa biflora* and less often *Tulipa biebersteiniana*, *Allium lineare*, *Allium paniculatum*. Among ephemeron *Alyssum turkestanicum*, *Lepidium perfoliatum*, *Chorispora tenella*, *Eremopyrum orientale*, *Eremopyrum triticeum*, *Euclidium syriacum* and some others prevail.

Depressions are round or oblong. Their size varies within 2–100 m^2. *Kochia prostrata*, *Crinitaria villossa*, *Tanacetum achilleifolium* grow on the slopes of depressions. Below associations with prevalence of *Festuca valesiaca*, *Agropyron pectiniforme*, *Stipa lessingiana*, *Stipa capillata* occur, legume - *Medicago romano.* Low land occupies less than 20% of the total. Transitions between lowland and level areas are found on light-chestnut alkaline soil or even deep solonetz. Vegetation of these transitions is represented by *Tanacetum achilleifolium*, *Agropyron desertorum*, and *Kochia prostrata*. Lowlands make up about 8% of the area. Lowland productivity is 1–1.2 tonnes/ha DM.

Light-chestnut soil with domination of *Stipa lessingiana* and *S. capillata*, *Festuca rupicola*, *Pyrethrum*, *Agropyron desertorum*, *Artemisia austriaca* prevail in semi desert located on the right bank of the Volga river (Volgograd and Astrakhan oblasts) on levelled sites. Solonetz with *Artemisia lerchiana* and *Artemisia pauciflora*, *Camphorosma monspeliacum* prevail on slight depressions; *Stipa capillata*, *Festuca rupicola*, *Euphorbia seguierana* grow in depressions on black-soil-like patches.

East of the Urals (Siberia) *Artemisia* communities, characteristic of solonetz and rock debris soil often occur. Here *Artemisia austriaca* and *Artemisia pauciflora* communities with prevalence of *Anabasis salsa*, integrating or combining with *Artemisia*-grass and grass communities frequently dominate.

Watershed spotty semi desert is used as a pasture for sheep, goats, camels and sometimes cattle and horses. A little snow allows grazing not only in warm seasons, but also quite often in winter. In years

with plentiful precipitation it is possible to cut such complex for hay. The productivity of hay changes from 0.3 up to 0.8 tonnes/ha DM.

Sand and sandy massifs of the semi desert

They occupy not less than 15–20% of semi desert territory. Steppe grasses - *Stipa, Festuca, Leymus* occur in significant amounts on sandy soil, not only in semi desert, but even in the northern part of deserts. In low places ground water is usually at a depth of 1–2 m; mesophyll grass (*Elytrigia repens*), bushes and trees develop on them. In such cases, grain and melons are grown successfully, even on desert sand. Scattered clumps or small patches of *Leymus racemosus* and *Agriophyllum asauarosum* occur on barchan slopes, sometimes on barchans themselves and in basins of aeolian erosion. *Carex colchica* (sometimes a lot of it), *Carex vesicaria* (in the southwest), *Gypsophila paniculata*, *Stipa pennata*, *Artemisia arenaria*, *Chondrilla*, *Salix*, *Salsola* and some other are mixed with them. On barchans and their slopes often only one large plant grows every ten square metres.

Bumpy sand is almost stationary so it often has richer vegetative cover. The same plants grow as on barchan slopes, but others always occur, namely: *Artemisia arenaria*, *Kochia* Roth, bushy *Astragalus*, *Alhagi* and some others. Ground water in depressions is often close to the surface, especially in sandy massifs formed on river drifts. There is a lot of *Artemisia arenaria*, *Alhagi* and in the east - *Ceratoides* and *Carex vesicaria* on bumpy, usually stiff sand.

Wavy-hilly and ridge sands are sands with low hills and ridges, and also with well expressed alternating depressions or elevations. Hills and ridges seldom rise above 2–3 m. *Agropyron cristatum* is the basic plant (70–80% of mass). *Kochia*, *Chondrilla*, *Euphorbia seguieriana* and less often *Stipa capillata* mix with it. Sandy plains encircle sands. Well expressed light-chestnut or brown soil are developed here. *Artemisia* dominates here and is mixed with *Agropyron cristatum* and other plants peculiar to the previous type of sand.

Wavy, wavy-hilly sand with *Agropyron cristatum* is most valuable for fodder. Productivity is up to 0.6–1 tonnes/ha DM; they can be used for autumn and winter grazing. Sandy plains with prevalence of *Artemisia* are mainly used as early-spring, autumn and winter pastures with productivity 0.5–0.6 tonnes/ha. Barchan and bumpy sand, especially the first, should be closed to grazing and oversown with *Elymus* and other plants, then grazed, but moderately, after grass stand improvement.

Limans

Now natural liman pastures occupy 3 500 000 ha. Slope steepness influences their vegetation and soil. Limans are extremely varied as to vegetation and soil. The main soils are variants of solonchak(saline) and grassland-alkaline soil; halophytes of the Chenopodiaceae and plants resistant to soil salinization (*Artemisia*, *Leymus ramosus*, *Elytrigia repens*, *Alopecurus*) prevail here.

Different soil types and liman vegetation are located as strips. The peripheral strip is rarely flooded with spring water and only for some days. *Artemisia*, *Halimione verrucifera*, *Limonium suffruticosum* prevail on solonetz. Patches of *Agropyron pectinatum*, *Crinitaria villosa*, *Festuca valesiaca*, *Koeleria* occur less often. Productivity is 0.2–0.4 tonnes/ha DM. It is used as early-spring and autumn-winter pastures.

The strip which is not flooded annually with spring water occupies sometimes more than half of the liman area. Depth of water is about 20 cm, at the end of April - beginning of May water evaporates or goes to the lower places. Soil is shallow solonetz. *Artemisia* dominates, *Agropyron pectinatum* occurs less often with some mixture or in strips, with patches of *Limonium suffruticosum*, *Aeluropus*, *Crinitaria villosa* and *Chenopodiaceae*. Sometimes there is a lot of *Medicago falcata* in *Elytrigia* associations. Productivity is 0.6–1 tonnes/ha DM. It is used as spring and autumn-winter pasture or as grassland.

In the strip which is flooded by spring waters most years, water depth is not more than 30–40 cm for 20 30 days. Soil is grassland dark solonchak. *Puccinellia* dominates, but *Artemisia* patches and strips occur quite often in the grass stand. *Puccinellia* grasslands occupy small areas, and *Puccinellia* – solonchak – *Artemisia* often make up 20–30% of liman area. *Puccinellia* grasslands produce 1–1.2 tonnes/ha DM high quality hay.

In the strip which is flooded by spring waters almost every year, water depth is 40–60 cm (rarely more) and it stays till the beginning of June–middle of July. Soil is grassland dark solonchak or grassland solod

(degraded solonetz). *Elytrigia* prevails and *Bromopsis*, *Calamagrostis*, *Galatella*, *Eleocharis* replaces it. Very often *Elytrigia* is 1.5 m high in almost pure stand with hay productivity up to 6–7 tonnes/ha DM. *Elytrigia* grasslands occupies no more than 15% of all liman areas. Very often limans on hundreds of hectares are almost totally covered with *Elytrigia*. Average productivity is 2–2.5 tonnes/ha DM.

The lowest liman strip is covered with patches of *Carex melanostachya*, *Phragmites* or *Scirpus maritimus* (if the soil is very salty) with mixture of *Scirpus lacustris, Typha*, *Eleocharis.* The middle is occupied by open water without vegetation (if it is deep) or with *Potamogeton* and other water plants. It occupies not more than 5% of liman area. Reeds are used for fuel and construction. Elevated streaks with *Halocnemum*, *Salsola* and others succulent Chenopodiaceae and depressions with *Juncus gerardii* often occur on strips. Limans in semideserts have great economic importance. Almost all hay in semidesert is harvested limans, which enables the use of neighbouring pastures to the full. Liman productivity can be increased considerably by constructing low banks which guide spring waters to areas occupied with the most valuable fodder plants - *Elytrigia*, *Beckmannia*, *Alopecurus*, *Bromopsis* and *Medicago*.

Desert zone

In Russia deserts occupy limited areas compared to the former USSR. Dominant plants are *Artemisia*, *Poa bulbosa*, *Salsola*, *Eremopyrum*; annual grass on loam and clay soil Productivity is 0.1–0.3 tonnes/ha DM. *Aristida*, *Artemisia*, *Salsola*, *Agriophyllum*, *Haloxylon* prevail on sandy and loam soil. Productivity is 0.2–0.4 tonnes/ha DM. Flatland desert pastures dominate the topographical structure. Pastures are used mainly for sheep and goats.

Meadows and mountain pastures

Mountains occupy a huge area: they include Southern-European mountain, Eastern-Siberian taiga mountain and Southern -Siberian mountain zones. Forests and bush make up more than 40% of the territory in mountain zones. Natural grassland occupies about 13%. Mountain grasslands and pastures are: small hill submountain (36–51%), mountain and high-mountain (16–61%) types. In the forest zone mountain grasslands and pastures (Ural, East Siberia) differ from those of flatland plains only in their higher zones - subalpine and alpine grasslands. In forest-tundra and tundra mountain vegetation is similar to flatland vegetation.

Bush semi desert, found in the European part of Northern Caucasus at a height of 1 100–1 500 m above sea level, is characterised by thin vegetative cover with a lot of xerophilous grassy plants (*Andropogon*) and thorny subshrubs and bushes (*Paliurus spin-christi*). It is low-quality pasture. *Stipa*, *Festuca*, *Andropogon* and *Elytrigia repens* dominate in steppe zone. They have a lot of ephemeron and *Poa bulbosa*, mezophyll plants: *Dactylis glomerata*, *Bromopsis inermis*, *Bromopsis riparia, Elytrigia repens*, *Vicia tenuifolia* and *Medicago falcata* often occur. This mountain zone is used for crops and less often for grazing (steeper slopes) and hay. Productivity is 0.6–0.8 tonnes/ha DM.

In the grassland-steppe zone the prevalent groupings are: xerophytic grasses (*Festuca ovina*, *Festuca rupicola*, *Koeleria cristata*, *Phleum phleoides*, *Poa pratensis*, *Stipa pennata*); mesophytic grasses (*Bromopsis riparia*, *Poa pratensis*, *Dactylis glomerata*, *Festuca pratensis* and *Carex supina*) and forbs. The Caucasus grassland-steppe zone is used for crops and only partially for grazing and hay cutting. Grasslands here produce 1.2–1.4 tonnes/ha DM of high quality hay.

In the forest zone in places which used to be forest, grasslands are in patches with a domination of *Calamagrostis arundinacea*, *Dactylis glomerata*, *Agrostis*, *Veratrum lobelianum*, *Vicia tenuifolia*, *Onobrychis* and *Trifolium* They are used for hay cutting and grazing. Productivity is 1–2.5 tonnes/ha DM.

High grass lands are developed in the top of the forest zone where forest has been felled, characterised by strong growth of plants reaching often two metres and more. *Heracleum*, *Lilium*, *Campanula*, *Centaurea*, *Dactylis glomerata*, *Calamagrostis arundinacea* and *Arrhenatherum elatium* often occur here. Some years the green mass yield is 40–50 tonnes/ha, but due to low palatability as pasture or hay it is expedient to use this vegetation for silage.

Sub alpine grasslands are distinguished by many vegetative groupings. Here grasslands occur with prevalence of one of the following plants: *Bromopsis inermis*, *Festuca valesiaca*, *Nardus*, forbs (*Anemone*, *Polygonum bistorta*, *Scabiosa*, *Pimpinella* and *Veratrum lobelianum*), and forbs-grass

grasslands with prevalence of mesophyll grass; legumes are represented by *Trifolium* and *Anthyllis lachnophora.* Forbs of sub alpine grasslands are rich and tall (70–100 cm high). The grasslands on Caucasus are used for hay, less often for grazing. Hay productivity is 1.5–2.5 tonnes/ha DM. Hay and pasture quality varies.

Alpine grasslands are specific in grass stand density and low height (10–30 cm). Typical grasslands have one or several cultivars of the following plants: *Nardus*, *Festuca valesiaca*, *Bromopsis variegata*, *Alchemilla*, *Campanula.* Mixed grasslands often occur: the first storey consist of grass, *Carex*, *Viola* and others, the second - forbs of bright colour (*Gentiana*, *Campanula*, *Carum*, *Anemone*, *Alchemilla*). Caucasus Alpine grasslands are perfect summer pastures grazed by vast herds of sheep and horses in summer. Productivity is 0.2–0.7 tonnes/ha DM.

Mountain pastures are used seasonally. In spring animals graze on semi desert and partially steppe pastures. At the end of May - beginning of June herds move to grassland-steppe and forest zone, in mid June - to sub alpine zone and stay there till mid (seldom the end) of September. In some areas animals go immediately to alpine grasslands, not staying on sub-alpine grasslands, and then in late autumn or winter return to villages. Animals make good weight gain on mountain pastures, but fat is quickly spent during winter underfeeding. That is why after grazing in mountains animals always stay for a long time on *Artemisia-Salsola* pastures. Their fat becomes dense, and they survive the winters perfectly.

Flood plain grassland

There are 15 000 000 ha of flood plain grasslands according to the Land Register.

Flood plain grasslands produce higher and more stable yields compared to other fodder lands. Flood plain grasslands are found all over Russia, their vegetation differs. Annual or periodic flooding with high water changes their soil and vegetation very much, that is why a flooded plain is allocated a special class. Rivers mostly flood in early spring due to snow melt (in the European part and Western Siberia). Some rivers of the Far East flood late summer, when there are intensive rains. Perennial plants on flood plains get more water than plants on watersheds and do not lack moisture. Mesophytes and hygrophytes grow here.

Flood plain grasslands of tundra and forest-tundra. Spring floods of tundra rivers are taxing, but low and short (this does not refer to such large rivers as Ob', Yenisei, Lena). Sandy and sandy loam soil prevail on flood plains. Low bushes, Lichens, Musci dominate on high patches of flood plains. Middle and low levels are covered with osier-beds, and in the north - even with moss-low bush associations. Grassland vegetation occupies small areas, mainly on most long flood plain patches. Mixed grass - tall grasslands with *Bromopsis inermis*, *Alopecurus pratensis*, *Calamagrostis langsdorffi* and *Seseli libanotis* developed here. *Carex aquatilis* dominates on swampy grasslands. Flood plain grasslands of tundra are almost unused.

Flood plain grassland of the forest zone. The best Russian grasslands are on flood plains of the forest zone and the north of forest steppe zone. Soil is richer than on watersheds, and plants suffer from lack of moisture less often. There are many forests (mostly coniferous) in under-populated regions on the central flood plain and there are many Cyperaceae and *Alnus* bogs on sub-continental flood plains. The following succession may be observed on flood plains: associations of *Nardus*, *Festuca ovina* and even *Antennaria dioica* prevail on high crests, not flooded or flooded for a short time; creeping fescue fine grass with prevalence *Festuca rubra* and significant mixture of *Leucanthemum vulgare*, *Rhinanthus*, *Anthoxanthum odoratum*, *Agrostis tenuis*, *Deschampsia caespitosa*, *Poa pratensis* and *Medicago falcata* (south) are typical on slightly lower crests.

Forbs with *Agrostis gigantea* are widespread on annually flooded plains (middle level), close to riverbeds and often on central flood plains: *Agrostis albus*, *Trifolium pratense*, *Lathyrus pratensis*, *Vicia cracca*, *Festuca pratensis*, *Phleum pratense*, *Equisetum arvense*, *Geranium pratense*, *Ranunculus acris* and *Heracleum sibiricum* are the most constant in this type. Tall grass land with prevalence of *Alopecurus*, *Agropyron*, *Bromopsis* and grass stand mixed from them are located lower than bentgrass. Associations with prevalence of *Phleum*, *Alopecurus*, *Festuca pratensis*, *Trifolium pratense*, *Geranium pratense* and *Rumex confertus* are typical of grasslands in the central zone. Grassy and alder bogs, damp swamp Cyperaceae and deschampsia grassland with *Filipendula ulmaria* Maxim, *Geum*, *Trollius* prevail on sub-continental flood plains.

Flood plain grassland of the steppe zone. Lack of moisture and alterations of humidity quite often create vegetative groupings from sharply opposite groups of plants, for example xerophytes and mezophytes and even hygrophytes. Grass stands are thinner and produce smaller crops in comparison with grass stands on flood plains of a forest zone. The highest patches with light alluvium and immature soil on flood plains close to river beds are covered with *Calamagrostis epigeios* with forbs - tall group (*Artemisia*, *Glycyrrhiza*, *Calamagrostis epigeios* , *Bromopsis inermis*, *Stipa capillata*), sometimes with steppe bushes (*Rosa*, *Spiraea*, *Acacia*, *Lonicera*). *Agropyron* and *Festuca* steppe-like grasslands with mixture of *Artemisia*, *Galium*, *Bromopsis inermis*, *Alopecurus* and *Medicago falcata* plants occur less often on more undulating relief. *Bromopsis inermis* often dominates lower down on this topography. Grass-forbs association with prevalence of *Festuca valesiaca*, *Agropyron sibiricum*. or their combination dominate on elevated patches of central flood plain with insufficient moisture. Mixture of *Poa pratensis*, *Alopecurus pratensis*, *Bromopsis inermis*, steppe bushes, *Artemisia* and *Medicago falcata* is significant.

On more undulating relief and flood plains with average soil moisture, *Elytrigia* grasslands dominate, on more dense (alkaline) soil - *Alopecurus* and less often on lighter soils - *Bromopsis*. These grasslands are characterised by almost constant presence of *Eleocharis palustris* and *Carex praecox*, *Vicia cracca*, *Rumex confertus*, *Sanguisorba officinalis* and *Phlomis tuberosa.* Appreciable amounts of mesophyll representatives from the forest zone flood plains: *Trifolium pratense* and *Trifolium repens*, *Festuca pratensis*, *Phleum pratense* occur here rarely. There is a lot of *Glycyrrhiza* on Ural River flood plains on solonetz soil.

Sedges *(Carex vulpina*, *Carex acuta*), less often *Elytrigia repens* and *Sonchus arvensis* prevail in depressions between crests with close underground waters. The most elevated and non saline parts of sub-continental flood plains are occupied by *Festuca valesiaca*, *Stipa capillata* with mixture of forbs and steppe bushes. *Agropyron pectinatum* or *Glycyrrhiza* with mixture *Elytrigia repens*, *Alopecurus* dominates a little lower on alkaline soil; *Puccinellia*, *Morus*, *Artemisia*- on grassland saline soils. Reed bogs often occur in this zone and Cyperaceae and shrubs (Salicaceae) much less than on flood plains of the forest zone. Deciduous forests (*Populus tremula*, *Ulmus*, *Quercus*) often grow on flood plains of steppe rivers (mainly close to the watercourse).

6. OPPORTUNITIES FOR IMPROVEMENT OF FODDER RESOURCES

Expansion of the use of forage legumes and mixtures with grasses is the strategic direction for improving sown grassland. Legumes are the basic source of natural nitrogen - the most important nutrient limiting grassland and other agricultural crops' efficiency. The renewed attention to legumes has come about because they:

- enable increased efficiency of natural grassland, perennial grass on arable land and subsequent crops in the rotation;
- reduce expenditure on nitrogenous fertilizers;
- increase nutritional value and palatability of forage ensuring less expensive and more effective systems of ruminant production;
- produce high-quality, ecologically safe fodder and livestock products to protect the environment from pollution.

Successful use of legumes depends on their adaptation to climatic and soil conditions, and also ways (grazing, cutting) and intensity of use and symbiosis with soil micro-organisms. More than 1,800 species of legume are described in the flora of Russia. Legumes make up 7-8% of the vegetative cover of fodder land in Russia.

Now *Trifolium pratense*, *Trifolium repens*, *Medicago sativa* are the most widespread legumes both in natural grassland improvement and in perennial grass establishment on pastures. *Lotus corniculatus, Onobrychis, Melilotus alba*, *M. officinalis* and some others have less significance. According to generalised data by D. M. Priashnikov, total nitrogen fixed by *Medicago* can be 300 kg/ha (up to

500–600), and *Trifolium* – 150–160 kg/ha (up to 250–300). Thus average nitrogen retained in the soil after grass harvest is up to 100 and 75–100 kg/ha.

Trifolium pratense is the main perennial legume of the forest zone of European Russia, in taiga and semi-taiga zones of Siberia and the Far East. It is feasible to have larger areas of it in the forest steppe zone and foothill areas of Northern Caucasus. *Trifolium* can be grown on well watered soil in the steppe. *Trifolium pratense* occupies about half the area of sown perennial pasture on arable land. *Trifolium pratense* yield in northern and east regions is 6-8 t/ha, in central and western areas of a forest zone of European Russia 8.5–10 tonnes/ha. Clover stands producing 10 t/ha contain more than 500 kg of nitrogen, including more than 350 kg/ha of symbiotic nitrogen. In Western and East Siberia *Trifolium pratense* makes up 20–25% from the sown perennial swards area.

Medicago sativa, M. falcata are the leading fodder crops of the forest-steppe and steppe. Nevertheless it is possible to expand *Medicago* growing in the forest zone of European Russia by 2–3 times. *Medicago* yield in central, southern and east areas of the forest zone of the European part is 8–10 tonnes/ha. *Medicago* proportion in field grass planting of the European part and Western Siberia is 40–45%.

Onobrychis viciifolia, is unsuited to acid soil, so is limited to black soil forest - steppe and steppe zones. *Melilotus* is an unbeaten crop for saline soils. In European Russia in the forest - steppe and steppe zones their spread can be 10–20%, in Western Siberia - approximately 30%, in East Siberia - about 5%.

To resolve the need for soil enrichment by biological nitrogen special importance belongs to grassland establishment based on mixtures of legumes (Blagoveschensky, 2000). High efficiency was shown by mixtures of *Trifolium pratense* with *Medicago* on sub-acid and near neutral soil, *Lotus corniculatus* with *Trifolium pratense* on more acid soil. Such mixtures have steadier and level yields over years, productive longevity, increase of protein output, increase of soil organic matter and nitrogen, increase of biological activity and other important properties of soil, low consumption of labour for cultivation.

Establishment of multicomponent legume mixtures in rotation with cereals for forage is a priority in field forage production systems for cattle farms. The proportion of perennial forage legumes in grain crop rotations depends on both provision of forage produced on natural grassland and on grass participation in support of soil natural fertility. Grain-perennial pasture crop rotation with a high proportion of mixtures saturated with legumes provides balanced manufacture of high protein forage. Such systems have the conditions for better use of photosynthetic active radiation, arable land efficiency is 50–60 GDj/ha ME, that is 1.5 times more than in traditional crop rotations. The proportion of biological resources in production process is about 60%. Seed yield is 0.2–0.4 tonnes/ha. In addition, together with *Trifolium* roots and litter the soil acquires more than 150 kg/ha of biological nitrogen which enables subsequent high and steady crop yields.

Medicago cultivars with high yield (8–10 tonnes/ha) and seed production (250 kg/ha), increased frost resistance and symbiotic fixing have been created. High coenosis stability is a specific feature of the new pasture variety of this plant. Salt resistant cultivars of *Medicago* have been bred for Russian conditions.

More and more attention is paid to *Galega*, one of the new fodder legume crops. Russia has 2 out of 11 existing species of *Galega* (*Galega orientalis* and *Galega officinalis*). Specific features of *Galega orientalis* are high efficiency of fodder mass, nitrogen-fixing ability, productive longevity, eight and more years. This crop has large ecological plasticity; it grows on sod-podzolic, grey forest soil and black soil with reaction close to neutral; drained peat bogs and briefly flooded flood plain backwaters suit it. Successful cultivation is possible at precipitations of 450–500 mm; at lower precipitation if irrigated. *Galega orientalis* is disease and pest resistant. It accumulates 140 kg/ha of biological nitrogen and more than 5 tonnes/ha of dry matter with root and stubble. It is a good precursor for other crops. *Galega orientalis* is an entomophilous plant, and compared to *Trifolium pratense* is more often visited by bees and bumblebees, which promotes stable (0.4 tonnes/ha and above) seed yield. It is used for green chop, haylage and hay.

In less favourable ecological conditions for legumes, mixtures of perennial grasses are used, the efficiency of which may be essentially increased by use of new highly - productive cultivars and mineral nitrogen. Nevertheless, it is expedient to keep the pure grass proportion on arable land below 25% of areas for cutting. The highest proportion (from 40 up to 50%) of sown grass will remain in northern regions of the European part, East Siberia and the Far East. Grass such as *Phleum, Bromopsis inermis, Alopecurus, Festuca pratensis* prevail, *Arrhenatherum, Poa pratensis, Festuca rubra,* occur less often.

Recently new cultivars of *Bromopsis inermis* have been bred with yields of 10–13 tonnes/ha and 0.3–0.5 tonnes/ha seeds; also new cultivars of *Alopecurus* are being developed using methods of synthetic populations with yields of 10 tonnes/ha and 0.2 tonnes/ha seeds; new cultivars of *Lolium perenne* are adapted to harsher ecological conditions.

Using legumes is the main method of increasing productivity and improving natural pastures, meadows and arable land in most regions. In the forest zone of European Russia the productivity of improved grass-legume pastures with tetraploid cultivars and occasional irrigation is 6 000–7 000 fodder units per hectare, the accumulation of symbiotically fixed nitrogen in above-ground mass is up to 120–140 kg/ha and more (Kutuzova *et al.,* 1998). In less intensive systems, without irrigation and fertilizing, the productivity of improved grass-leguminous pastures is more than 3 000 f.u./ha, nitrogen removal with harvest is more than 80 kg/ha, accumulation of biological nitrogen is more than 30 kg/ha. Improved pasture establishment based on mixed grass without fertilizer using mineralization of natural grass stand sod organic matter and with 50 kg/ha of nitrogen in soil ensures a productivity level of more than 2 000 fodder unit/ha, which is 1 000 f. u. less compared to legume-grass mixtures.

Grass-legume pasture productivity significantly increases with organic fertilisation to more than 4 000 f. u./ha; nitrogen removal with harvest is more than 100 kg/ha, including more than 40% from soil, almost 25% from organic fertilizers and one third due to symbiotic fixation. Such a system should be used on organic grassland farms.

Grass-legume pastures treated with phosphorous-potash fertilizers ensure productivity level of 4 000–5 000 f. u./ha. At the same time the highest – almost 70 kg/ha- accumulation of symbiotically fixed nitrogen is provided. The same productivity of grass pastures can be achieved at N120 fertilization (Blagoveschensky *et al.*, 1999). Such a system of grass-legume grass stand establishment and phosphorous-potash fertilisation is more feasible for large agricultural enterprises, where manure, as a rule, is used for crop fertilisation on arable land.

Use of N100 with accompanying PK for legume-grass pastures increases productivity to 5 000 f.u./ha, but additional mineral nitrogen fertilization of legume-grass pastures decreases the accumulation of biological nitrogen by 3 times. It causes a decrease of legume yield by 2 times and available nitrogen has a negative influence on nodule bacteria activity and symbiotic nitrogen fixation intensity.

Using legumes for pasture improvement ensures both harvest and animal productivity increase. Productivity of cows grazing on natural mixed grass pastures is 9–11 kg of milk per day. Grazing improved pastures of traditional composition (*Trifolium pratensis, Trifolium repens, Phleum* and *Festuca pratensis*) ensures daily yields of 14–16 kg per cow and 4 ton annual yield. Cows with annual productivity of 5–6 tonnes are fed barley in summer.

Trifolium repens and *Lolium perenne* ensure significant advantages at pasture establishment. This technology is implemented in the forest zone of Russian Federation by the Tacis "Beef and Dairy Project" FD RUS 9603. Cows with annual productivity of 6–8 tonnes and more have average day yield of 20–25 kg grazing on such a pasture. Russian cultivars of *Trifolium repens* are more frost resistant than imported ones, and *Lolium perenne* cultivars occupy the middle position amongst 15 western European cultivars (Blagoveschensky *et al,* 2000). Pasture improvement based on new cultivars *Trifolium repens* and *Lolium perenne* have great prospects, especially with global climate warming, because 50–80% of *Lolium perenne* dies in severe winters.

For stable and efficient pasture fodder supply farmers keep the most productive natural grass stands, improved with traditional grass–legume mixtures, as well as clover–ryegrass pastures established with adapted cultivars for adequate agricultural and ecological conditions. Productivity of improved sown grass-legume meadows in the forest zone is 3 000–5 000 f.u./ha, in the forest-step zone – 3 000–4 000 f.u./ha. Bacterial preparations increase the productivity of sown legumes. Inoculation of these plants with efficient nodulating bacteria increases the nitrogen fixation from 20–30% in natural conditions up to 40–60%.

Grass mixture composition for land improvement is chosen bearing in mind agro-ecological conditions and pasture. *Dactylis glomerata* dominates on sown pastures on loamy soils of European Russia forest zone, *Bromopsis inermis* – on sandy loam soil. Pasture legumes here consist of *Trifolium repens* and *Trifolium pratensis*; on more acid soil – *Lotus corniculatus*, on drained peat bogs – *Trifolium hybridum*: in the south of the zone – *Medicago sativa*. *Lolium perenne, Festuca pratensis, Phleum*

pratensis, Poa pratensis are used in mixture with legumes, *Alopecurus pratensis* - on drained peat bogs. Sown grass meadows on flood plains consist of *Digraphis arundinacea*, on uplands with loamy soil *Dactylis glomerata,* on flooded plains – *Alopecurus pratensis*, on sandy loam soil – *Bromopsis inermis*, on drained peat bogs and flooded plain – *Agrostis alba*. Grass–legume grasslands consist of *Trifolium pratense*, on drained peat bogs – *Trifolium hybridum*, on acid soil – *Lotus corniculatus,* on soil with neutral pH – *Medicago sativa*.

In Siberian forest-tundra and northern taiga only grass is sown, in forest zone - grass-legumes. Five or six grasses dominate in forest - tundra zone*: Phleum pratensis, Festuca rubra, Beckmannia syzigachne, Agropyron sibiricum, Alopecurus pratensis* and *Alopecurus ventricosus.* This composition extends to the south, including *Agropyron tenerum*, *Festuca pratensis* on upland, *Digraphis inermis* and *Agrostis gigantea* on flood plains; in southern taiga there are also legumes: *Trifolium pratense* and *Medicago* on upland, *Trifolium hybridum* on drained peat bogs.

In forest-steppe and steppe zones preference is given to legumes in sown grassland establishment, because they bring better yields and increase soil fertility.

For a long season of green chop provision without quality decrease, pastures of different maturity are established. For early maturity in forest-steppe zone grassland with *Dactylis glomerata*, in the south, on pastures – *Elymus*; for medium term maturity – *Bromopsis inermis*, *Festuca pratensis* of forest-steppe and steppe zones *Onobrychis* and *Agropyron* prevail on meadows – *Roegneria fibrosa*, *Medicago*; for late maturity – *Medicago, Agropyron pectiniforme* v. *glaucum, Elytrigia intermedia*. *Medicago* and *Onobrychis* are the main legumes on slopes because they are drought resistant and do not require very fertile soil. *Trifolium pratense* and *Medicago* are used in mixture on northern slopes of forest-steppe.

Bromopsis inermis and *Festuca pratensis* are the main grasses in the forest-steppe, under favourable moisture conditions they are replaced by *Phleum pratensis*, and in the northern steppe *Arrhenatherum elatius*, *Agropyron pectiniforme* v. *glaucum* and *Elymus* are the main grasses. *Bromopsis inermis* replaces *Bromopsis riparia* on eroded slopes of the steppe zone. *Roegneria fibrosa* is an early maturing variety in Siberia.

Bromopsis inermis or *Bromopsis riparia* with *Medicago* are sown on deep solonetz soil with weak and medium level of salinisation. Grass mixtures of *Melilotus* in combination with *Bromopsis riparia, Agropyron pectiniforme, Agropyron sibiricum* on medium solonetz. *Melilotus* is sown on shallow solonetz. In northern forest steppe on shortly flooded plains *Medicago* could be replaced with *Trifolium pratense* or the two could be mixed; on irrigated pastures *Trifolium repens* is grown.

Poa pratensis is added to pastures of middle flooded grasslands in the northern and central forest - steppe. When grassland is flooded for more than 30 days and used for hay, *Bromopsis inermis* along with *Digraphis arundicacea* and *Beckmannia vulgare* is highly productive and long standing.

When limans are flooded for a short time, mixtures of *Medicago* and *Onobrychis* with most grasses are sown early in spring: *Medicago* – where the ground water is deep; *Melilotus* – on saline soil. *Bromopsis inermis*, *Alopecurus pratensis*, *Elytrigia repens* and *Agrostis gigantea* survive medium term flooding well when average temperature is over 10 °C. Grass-legume mixture of *Bromopsis inermis* and *Medicago*, *Elymus trachicaulus* survive long flooding well (more than 30 days).

In the forest-steppe zone when grassland is cut for hay many times (3–4 cuts per season) grass mixtures are similar to those in the steppe, but *Trifolium repens* and *Arrhenatherum* are not used. *Medicago* is replaced by *Trifolium pratense* in the northern part of Western Siberia. To provide drought-resistant mixtures when irrigation is not regular and air is dry in summer they are enriched with *Agropyron pectiniforme* in Western Siberia or *Elymus sibiricus*, *Roegneria* in Eastern Siberia. On big and medium river flood plains and drained bogs with enough nitrogen fertilizer pastures are of *Bromopsis inermis* + *Festuca pratensis* + *Phleum pratense* in all regions; *Bromopsis inermis* + *Agropyron sibiricum* in Eastern Siberia.

In the steppe zone when grassland is cut many times (5–6 cuts per season) *Medicago* with one grass, on pastures - two grasses. In European part, Western and Eastern Siberia pure stand *Medicago sativa* is productive on irrigated meadows. On flood plains of medium-size and big rivers and on low grasslands *Bromopsis inermis* in pure stand or mixed with *Elymus trachycaulus* are sown.

Legumes-grass swards are established in favourable mountain regions: low- middle- and partly high mountains of European Russia and low mountains of Asian Russia.

Pastures for sheep are sown with highly active low grasses and legumes resistant to intensive close grazing: *Poa pratensis, Festuca rubra, Festuca rupicola* and *Trifolium repens* for patches with enough moisture and *Medicago* for dry patches. In middle- and low mountains of Asian Russia sheep pastures are sown with *Elymus trachycaulon* and *Bromopsis inermis*. *Trifolium repens* is the basis for artificial pastures for cattle in European Russia; it is used on soils of adequate moisture in low-, middle- and high mountains in European Russia and in low- and middle mountains in Asian Russia.

Pastures for cattle consist of *Festuca pratensis, Phleum pratense* with addition of *Poa pratensis* on soils with sufficient moisture right up to high mountains. *Dactylis glomerata* is a part of sward in low- and middle mountains of European Russia. In high land of Asian Russia pasture swards are established from *Bromopsis inermis*. In the Asian part preference is given to *Elymus trachycaulus*, *Bromopsis inermis*. Grass-legume swards for hay, consist in European Russia of *Trifolium pratense* right up to high mountains with enough moisture, *Medicago* and *Onobrychis* in low- and middle mountains, in Asian part mainly in low mountains and in some parts of middle mountains. In European Russia *Phleum pratense*, *Festuca pratensis*, sown with *Bromopsis inermis* right up to high mountains, in Asian part - *Dactylis glomerata* in low mountains, *Bromopsis inermis*, *Elymus trachycaulus* right up to high mountains. Sown pastures are normally established in low and middle mountains on 10 degree slopes, rarely steeper. In high mountains sown swards are rarely established and only on gentle slopes.

To improve arable land in northern deserts or semi-deserts, plants with low transpiration coefficient are used. Grass-legume mixtures are suitable for depressions; *Medicago caerulea*, *Onobrychis arenaria*, *Melilotus*, *Elymus sibiricus, Agropyron pectinatum, Kochia* are used. Shallow and stony, saline soils with a dense gypsum layer closa to the surface and southern slopes are not suitable for improvement.

Natural grassland improvement based on grass mixtures is used firstly on lands with extreme ecological conditions, unsuitable for legumes: high salinity or acidity, at long-term flood of limans and flood plains Grasses at high ecologically safe levels of nitrogen fertilizer are more productive than grass-legume grassland in favourable ecological conditions. There are economically sound advantages of productive grassland establishment on big farms, on land far from cowsheds for hay. There are advantages in combination of grass-legumes and grass lands, fertilised with nitrogen fertilizers.

Enrichment of grassland flora by oversowing into existing swards is significant in the increase of improved natural meadows. Oversowing enables increasing natural grassland productivity by 1 000–2 000 f. u./ha. Cost is 3–6 times less than full change of grassland. Oversowing with legumes increases fodder quality, especially protein content. Enrichment of grassland with legumes is equal to application of 30–160 kg/ha of mineral fertilizers. Important advantage of meadow and pasture improvement is keeping agricultural land in constant use; oversowing enables restoration of degraded grasslands to maintain the environment and stop erosion of slopes and flood plains.

Grass oversowing in forest and forest-steppe zones is mainly on thin old upland natural grasslands, depressions, flood plain meadows of normal moisture, thin grass stands of pastures, patches where bushes and tussocks that occupied less than 20% of territory were removed, with *Deschampsia caespitosa* no more than 7–10%.

Oversowing is a way of periodically renewing legumes in grasslands. In forest-steppe and steppe zones of European part it is efficient on grass-mixed herbs of flood plains and limans when weeds and toxic plants have been removed. On sheep pastures oversowing is done when grass stand is thin because of too much intensive weed control. Oversowing is usually not effective on natural grassland on plains and slopes in steppe zone on the border of Europe and Asia - Ural, and in Siberia because of lack of moisture for establishment. Oversowing on more than 20 000 000 ha of natural grassland, enabled increase of fodder production by 17–20 million tonnes of f.u. and 1.7–2.0 million tonnes of digestible protein.

Fertilizing of meadows and pastures is the most effective way to increase yield, productivity and longevity, number of cuts per season and fodder quality. Efficiency of systems of mineral fertilisation depends on geographical position, floristic composition, ways of use, natural rock bed, soil and availability of mineral elements in soil. The key criteria in fertilisation systems are ecological and economical factors. The main limiting factors to fertilisation are production of ecologically safe fodder and avoidance of environmental pollution. Fertilizer application is forbidden in water protection zones. Doses of nitrogen fertilizers are limited to prevent nitrate accumulation ($N\text{-}NO_3$) more than 46 mg in

1 kg of pasture grass of natural moisture. Permissible dose of potash fertilizer on pasture should not increase potash concentration in fodder by more than 3% of dry matter.

In the north of the forest zone on grass and grass-mixed herbs grassland the ecologically safe norm is 30–45 kg/ha of nitrogen per grazing cycle, up to 60 kg/ha for cutting, and a total 90 kg per season. In central regions of forest and forest-steppe zones ecologically safe norm should not exceed 45–60 kg/ha per grazing cycle and 90 kg/ha for cutting, total 180 - 240 kg/ha at normal moisture. Cost of nitrogen fertilization in this fodder is 15–20 f.u. per 1 kg in European part and 13–15 f.u. in Asian part of the country. Main elements of the fertilizing system of grass-legumes pastures and meadows are liming of too acid soils and application of phosphorus and potash fertilizers. Increase per 1 kg of these fertilizer mixture is 8–15 f. u. and more. Nitrogen fertilizer application (50–90 kg/ha) in limans of semi-desert zone increases hay cut from 0,8–1 to 3–4 tonnes/ha per cut per year.

Fertilizing is one of the most efficient methods of superficial improvement of natural grassland in most mountain regions. The top priority objects for fertilization are adequate moisture on low- and middle-mountain fodder land with little weed, covered by meadow and meadow-steppe vegetation, on gentle (up to 10 degrees) slopes. Fertilizer efficiency on steep slopes is less than on gentle ones due to shallow humus horizon and less humidity. Yield payback on northern and western slopes is higher than on southern and eastern ones. Nitrogen and phosphatic fertilizers are the most efficient in mountains. Potash fertilizers are used in combination with phosphatic fertilizers on grasslands with a lot of legumes to support their productive longevity.

Efficiency of nitrogen and phosphatic fertilizers decreases higher in mountains with enough soil moisture due to reduction of the growing season, in regions with not inadequate soil moisture it increases up to a certain elevation (1 500 m on Caucasus) due to moisture increase and then falls due to shortening of the growth period. Organic fertilizers are widely used on mountain meadows and pastures. Sheep manure is efficiently used on seasonal pastures. Liquid manure and slurry are used near cowsheds. Fertilizer application on meadows and pastures in ecologically safe regions enable the following yields: in low mountains with enough soil moisture – 5–6, not enough soil moisture – 2.5–3: in middle mountains – 4–5 and 2–2.5 correspondingly; in high mountains – 1.5–2 tonnes/ha DM.

Appropriate micro-fertilizers are applied to pasture and meadow soil with microelement deficiencies. Molybdenum is applied on medium- and lightly-acid soils in forest zone, it increases hay yield from natural meadows and pastures by 20% and more. Boron fertilizers are efficient in most regions of forest zone, especially on light soil, including mountains. Copper fertilizers are applied to grasslands on drained bogs. Soil rich with soluble nitrogen compounds need more copper than less fertile ones. Manganese fertilizers are mainly used in southern regions and on calcareous soils of forest-steppe zone.

Fertilizer application on meadows and pastures increases the energy and protein value of fodder. Grassland fertilization enables a stable 7–8 tonnes/ha of hay in forest zone, 3–4 tonnes/ha in forest-steppe and steppe zones, 5 000–7 000 f. u./ha on pastures and several-time hay cutting meadows, 10 000–12 000 f. u./ha on irrigated pastures in southern regions of the country.

Control of weeds and poisonous plants plays an important role in fodder quality improvement, yield increase and full safe use of natural grassland. A number of measures are used in weed control, including prophylactic measures which limit unwanted vegetation expansion. They are prevention of seed-formation and weed seed drift. Weeds are cut before seed formation starts on meadows, ungrazed patches are cut, organic fertilizers which do not contain viable seeds are used. Transformation of meadows for grazing is an efficient management method. Grazing leads to reduction or disappearance of some weeds, for example, *Geranium pratense, Archangelica* and *Libanotis.* Some unwanted plants only occur in quantity on pastures: *Alchemilla vulgaris*, *Plantago media* and *Ranunculus*. Occasional pasture use for hay is an efficient measure of controlling such plants. Many plants are edible for some stock species, but not for another. Horses rather than cattle prefer *Deschampsia,* and *Nardus stricta*, pigs prefer *Rumex alpinus*, sheep and goat - most of plants from mixed forb stands. Such measures of weed combat are used on farms with many branches.

The most efficient, simple and widespread way of mechanical control is cutting weed at the sown pasture establishment with spring planting, without nurse crops. Herbicides are used less compared to 1985–90. Herbicides, insecticides and pesticides are forbidden in water protection zones. Weed elimination increase harvest of dry feed mass of natural grasslands by 15–30%.

Management of grassland for cutting and for grazing

Optimal timing of cutting annual and perennial grasses, and rational pasture use, provides 10–25% and more productivity without or with little labour input. Time of cutting during growth or in autumn are the most important factors in optimal meadow and perennial grass use.

In the forest zone natural and sown meadows of different botanical composition on most soils gives the highest yield at twice yearly cutting. Fertilizer application allows three cuttings in central and western regions of the European part, two in Siberia. The second cut is difficult on steep slopes and in gullies, especially in the southernmost parts of the zone and in the less favourable conditions of Northern and North-western Siberia. To provide timely cutting big farms plant mixtures with different maturity times which allows extending the optimal time of cutting and increases raw material quality at the first stage of harvesting. They do three cuts on meadows with domination of *Medicago*, *Lotus corniculatus* in central, western and southern regions of forest zone.

In the natural moisture conditions of forest-steppe zone natural meadows are normally cut for hay once annually and with fertilising two or three cuts for hay. They only mow once in the steppe zone as a rule. On fertile patches with favourable moisture *Medicago* stands or grass-legumes are cut 2–3 times in European Russia, twice in Western and Eastern Siberia. In Southern regions of European Russia *Medicago* is cut at least 4–5 times to produce meal. Swards with different maturity times are established to prolong optimal time of first cutting, as in the forest zone.

Significant increase of fodder production on mountain meadows and pastures can be achieved using rational, biologically and economically reasonable systems of management. Main ecological factors such as altitude, relief, soil, vegetation, remoteness of fodder land from villages and the availability of agricultural machinery influence the intensity of grassland use in mountains. The productivity of big areas of natural grassland in mountains can be increased by rational use; at present they only cut meadows for hay once, and this is the main reason for low winter fodder quality. Repeated cutting for hay for natural and sown meadows in the mountains of European Russia ensure quality and productivity increases up to 4 500–5 200 f. u./ha. Nutrient losses through erosion on mountain hay meadows is half that on grazed pastures. Replacement, alteration and use of sward from grazing to cutting on patches more liable to erosion reduces soil losses.

Seasonal vegetation development on semi-deserts and deserts makes hay meadow use difficult as grasses coarsen quickly; natural hay meadow productivity is usually low. Hay meadows are mainly in depressions, flood plains and contain mixed herbs - grass coarse-stem swards: *Agropyron* on limans, quickly coarsening *Phragmites* on very wet patches. Moreover, significant pasture areas occupied by *Artemisia*-ephemeron, *Artemisia* - fine sward - grass and *Artemisia* - *Eurotia* types of vegetation. All these fodder lands are usually mown once, after which plants do not grow because the soil is dry in the second half of summer. Harvesting is done in a short space of time - during earing and budding, because late cutting leads to protein losses, lignification and decrease of feed value. *Phragmites* on flood plains, along channels and temporary drains, is cut before piping, because later it is inedible.

Fine-sward grasses are cut for hay at 5–7 cm from ground level. Mowing *Artemisia* (and subshrubs generally) is not feasible because it leads to elimination of some lignified shoots and dramatic vegetation deterioration. Cutting subshrubs and short bushes for 2–3 years in a row kills them. Ephemeron cutting is possible only in warm springs with sufficient precipitation (normally once in 4–5 years). Ephemeron harvesting enables storage of hay for 2–3 years. Patches with enough moisture, covered with forbs or forb-grasses, are cut twice.

Mineral fertilizing with favourable humidity increases the number of cuttings. Systematic cutting before heading stops of self-seeding and sward deterioration. That is why hay rotation is practised on tall-grass, forb-grass hay meadows of limans, flood plains and depressions (on years): 1–4 - cutting at the phase of earing - budding start; 5 - rest with late grazing at the phase of seed shedding; 6–8 - cutting at normal stages (start of earing and budding); 9 - late cutting (at seed shedding) or at normal stages with overseeding in spring. Patches of well-developed sward with high feed value plants are left to shed seed. Hay from pastures is fed to cattle in the second half of summer, autumn or in winter. This prolongs the grazing period on remote pastures by up to 20–30 days.

Pasture use

The key principle of pasture use is balancing stock numbers and pasture capacity. Rational pasture use is based on limited herd attachment to specified pasture patches. This is very important for farms with

big herds. Efficient pasture use is when dairy herd is 200 head, young stock - 400, young heifers up to 250 head. Beef herds normally do not exceed 200 cows with suckling calves, fattening cattle - 200 head, sheep herds - up to 3 000 head.

Pasture use is most efficient with a pen system with cattle corridors and pastures perimetres fenced with permanent electric fences. A movable electric fence is used for one-day grazing patches. Optimal number of grazings during the season in the northern part of the forest zone is three, in other regions – four-five as a rule. In summer when cattle graze on sown pastures with legumes or with grass treated with nitrogen, it is feasible to add carbohydrate or mineral feed additives to balance animal rations, this is specially important for cows calved in spring and in the first half of their lactation.

In the steppe zone the supply of forage is ensured by a combination of natural swards and pastures sown with perennial and annual fodders. Beef cattle graze on flat and gentle slopes. Cattle have free access to water, including movable or permanent water troughs. The cheapest watering is natural springs or accumulating ponds.

The correlation of land topography and herbage type forms the basis of a rational use of mountain natural pastures. Steep slopes are used for sheep and goats and the gentler ones for young cattle. More level lands and gentle slopes with rich vegetation are used for cows. Remote mountain lands and southern slopes with short herbage are for sheep grazing. Such pastures are of little use for fine fleeced sheep in humid regions.

There are mostly two grazing systems in mountain regions: a daily return and distant pasture one. A daily return system is used with grasslands relatively close to stock buildings; animals are put to grass in the morning and return to the farm in the evening. This system is mostly used in middle and high-mountains. The distant pasture system is usual for farms in small hill sub-mountain and low-mountainous regions and seldom used in middle mountains. In mountains cattle normally start to graze the lower belt, then on middle and upper belts, and then - again on lower one. That is why the use of mountain pastures of different belts of the same mountain system is a single whole and cattle movement from one seasonal altitude belt to another is inevitable and justified in most cases. In mountains the steepest slopes and remote pastures are used for sheep and goats, less steep - for young stock and fattening cattle, the flattest and closest pastures - for dairy cattle. Foothill dry-steppe or high-mountainous pastures are grazed once or twice during a grazing season and low-mountainous mesophyte ones are grazed 4-6 times. Grazing patches on pastures with broken relief and stony soils are marked, without fences, by natural relief elements.

With use of natural grasslands at the same seasons every year there is a decrease of pasture productivity and of herbage botanical composition. Pasture rotation together with agrotechnical practices protect herbage diversity and productivity. For this purpose a rotation of grazing periods is introduced for individual plots. For example, mesophyte grass-forbs pastures are used in the first year during tillering phase, in the second year - from the beginning of booting phase.

Semi-desert and desert zone pastures are mostly used for sheep. In the north of the zone young beef stock graze, and on better watered pastures with lush herbage beef cows. Herbivores graze in a pasture rotation system, attention is paid not only to rate of grazing, but to grazing alternating years, seasons and months. *Artemisia* - ephemeron pastures with ephemeron domination on plains with lack of moisture are grazed twice per season, in spring at the phases of earing, budding of heading of ephemeron, and in autumn at the phases of heading, drying or beginning of *Artemisia* ripening, when essential oil content dramatically decreases.

Estimation of pasture capacity and planned herd movement is done annually and in due time, using geo-botanical data from many years and a weather forecast for the current year. Grazing of all above ground fodder mass negatively influences sward productivity. For 4–5 years of such grazing the herbage yield decreases by 20–40% on average, therefore natural pastures have a permissible coefficient of 60–65%. Some plants can be grazed only at certain time; *Stipa capillata* pastures are only used till heading because of sharp caryopses which injure animals. *Artemisia* pastures are no good for summer grazing because of bitter essential oils. Cattle do not eat *Haloxylon* and most *Salsola* in spring and summer because of their high salt content.

Fencing and pen system can increase pasture capacity by 15–25%, and increase animal weight gain. Rivers, temporary streams, lakes, ground water and precipitation are sources of water. Wells and boreholes are arranged to get ground water for cattle. Water lifting is as a rule mechanised.

Hay and haylage. Winter forage storage is very important for Russia where in most regions the pasture period is much shorter than the winter. Hay, haylage and silage are major ways of conserving fodder. Most natural grassland is mown for hay. Grass drying in the field is the most widespread technology. Improvement of storage and feed value of hay is ensured by baling. Hay with additional drying by active aeration is mainly stored for highly productive animals and young stock. Hay pick up increase and quality improvement could be done through new efficient technology of grass treatment at cutting, insuring decrease of field losses twice. The main point is in deep breakage of stem by crushing with partially splitting along fibres and their pounding. Total losses of nutrient at legume hay harvesting decreases to 12–15%. Hence the feed value of hay increases up to 0.80–0.83 f. u.

Haylage is becoming the prevailing technology for perennial legumes and legume-grass harvesting and ensures high protein and energy fodder.

Silage is the main succulent winter feed; its feed value proportion of total bulky fodder (without hay) in winter makes up 40–45% of cattle rations. Silage is made from wilted perennial legumes and legume-grass containing 15–23% of protein using chemical preservatives is the most efficient technology for high-protein forage at the moment. At ensilage of such mass in pits with use of 0.4–0.5% of liquid organic acids the raw protein preservation is 92–95%, and energy value of ready-to-eat forage is 0.96 f.u. in 1 kg of dry matter. The technology of wilted legume-grass mixture (as well as *Trifolium pratense*, and other legumes) ensilage with use of biological preparations based on osmo-tolerant lactic-acid bacteria has prospects. Nutrient losses at fermentation reduce to 5–10%. Preparations have high ecological purity and low cost which also is good for their efficiency.

Grass meal production is decreasing due to rising prices of fuel and energy. Introduction of new technology of grass meal preparation will lead to an increase of its production volume, its quality improvement and decrease of fuel consumption (twice, converting to protein). Its point is in plant separation for leaves and stems when cut. Leaves are used for grass flour, stems - for hay. Raw protein content in flour made from perennial legumes is 23–28%, raw cellulose - 12.5–18%.

Silage and haylage are mainly stored in pits. At present concrete pits, meant for storage of large amount of silage and haylage (1.2–1.5 thousand tonnes and more) are commonest. When livestock farms are divided up into smaller units the majority of large silage pits will be rebuilt or built. The main condition of high quality forage preserving in pits is thorough isolation of the grass by plastic films.

Pressed and loose hay is stored in sheds and barns. Additional hay drying by active aeration is done in barns corresponding to rational location of drying equipment and conditions of high quality fodder perseverance. Fodder production strategic priority for the near future is stable provision of full feed value protein produced domestically.

Seed production

Forage seed production is an attractive and profitable business for farmers. Demand, especially for perennial grass and legume seeds is higher than supply, even the latter have increased recently, and the increased demand has to be covered by imports.

Production of new cultivars of perennial grass and other fodders is most efficient in specialized agricultural enterprises, located in agri-ecological zones corresponding to plant biological peculiarities.

Trifolium seed production is mainly in the forest-steppe and south of forest zones. Here grey forest soils and black soils prevail, vegetation period is 130–150 days with the sum of efficient temperatures (more than +10 °C) equal to 1 900–2 500 °C. Precipitation is low at the period of *Trifolium* flowering and seed ripening.

Medicago and *Onobrychis* seed production is most efficient in some regions of the steppe zone of European Russia, *Pisum* - in forest-steppe zone both in European and Asian Russia, *Vicia sativa* and *Vicia faba* - in the south of forest and north of forest-steppe zone, *Lupinus angustifolia* and *Vicia faba* - in the south of forest zone, chick-pea - in steppe zone, soya - mainly in the Far East with monsoon climate. Seed production of *Kochia*, *Salsola*, *Eurotia*, *Camphorosma* and others of different ecological and phytocenosis specialisation is feasible in arid zones of European Russia.

7. RESEARCH AND DEVELOPMENT ORGANIZATIONS AND PERSONNEL

Institutional structure

The Ministry of Agriculture is the key organization, responsible for the development of agricultural production and forage production.

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The Russian Academy of Agricultural Science is the centre, responsible for development of agricultural science. It includes the Department of Forage Production, which plans and co-ordinate research done by Russian scientific institutions, including in the area of grassland and field forage production.

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Scientific support of forage production in zonal aspect is done in agricultural scientific institutions of the oblast (autonomous republic). Each has departments doing research on grassland and forage production. Agricultural scientific institutions include experimental agricultural enterprises. These farms have experimental plots to carry out agronomic research, including on grasslands and forage production from fields. Experimental farms carry out production check of results of forage production and animal husbandry elaboration. Experimental farms produce seeds of high reproductions of new cultivars of agricultural crops, including perennial grasses and other forage crops.

Unification of efforts and co-operation of scientists of different specialisation both in and outside Russia have an important meaning in acceleration and most efficient resolving of urgent problems of forage production. The examples are the effectiveness of research on symbiotic selection of *Medicago*, in solution of problem on forage preservation (Forage Institute and Agricultural Micro-biology Institute), creation of frost-resistant cultivars of winter *Brassica oleifera* and *Trifolium pratense* (Forage Institute and "Hans Lembke" Company, Germany), composition of genetic chart of *Trifolium* (Forage Institute and Hokkaido Scientific Centre, Japan) and others.

The most important factor of the successful and stable development of forage production is more active use of the results of scientific propositions and recommendations.

The main research is directed at the use of biological techniques in intensification processes, increased efficiency and stability of production, use of forage on fields and grasslands, use of the environment-formation role of perennial grasses on arable land and other measures on erosion prevention and soil fertility increase.

The selection programme is aimed at:

- Breeding cultivars of perennial legumes (*Trifolium*, *Medicago*) with prolonged productive life, high competitiveness in swards, resistance to diseases (cancer, fusariose, anthracnose, mycoplasmose);
- On perennial grasses - creation of geographical and ecological varied cultivars for cutting and grazing, differing in rhythm of development, with high seed productivity; selection for forage quality;
- On forage legumes - creation of *Pisum* cultivars which do not shed their seed, improved grain quality, increased ability of nitrogen fixation; Creation of *Vicia* cultivars with stable high yield, absence of prussic acid in seed and low content of trypsin inhibitor;
- On *Lupinus* - increase of seed productivity in combination with resistance to fusariose, anthracnose and decreased alkaloid content in grain;
- On arid zone forage plants (bushes, subshrubs and grasses) creation of system of mutually complementary, edaphic and phytocenosis specialized cultivars with stable high forage and seed

productivity in drought years, with high forage quality, resistant to systematic grazing, resistant to soil salinity, phytocenosis stability, providing good compatibility with other cultivars in multi-species pasture agri-phytocenosis.

Manpower policy and education

There are fifty eight universities within the system of high professional education. 350 000 students study in them. More than 84 000 students entered agricultural universities in 2000. In 1996 only 5 700 students paid for their education in such a system, in 2000 – about 30 000 students, which is 35% of all first year students. In 2000, 45 600 students graduated from agricultural universities. But only 50% of graduates get assigned to agricultural complexes, 23% go to rural areas and only 18% stay there.

On 1 September 2000 a new List of lines and specialities of higher education was introduced. From 1 September 2000 all Russian universities have introduced new (second generation) state education standards of higher professional education, which take into consideration recent changes in the Russian economy.

There are 285 agricultural colleges in the system of professional technical education located in 71 subject of Russian Federation. 259 400 students study in them. In 2000 94 300 students entered them, including 52 500 (83,2%) studying at state budget expense. Organizational work done for the last 2 years enabled improvement of the situation with rural young people entering educational institutions. In 2000 the proportion of rural youth entering colleges and technical schools was 74.4%, which is 4.2% more than in the previous year. A total of 137 400 applications were submitted, which is 7 000 more than in 1977. This allowed an increase in the proportion of youth accepted by competition.

There are 121 educational institutions in the system of further professional education. Every year about 120 000 managers and specialists go through training, including 15 500 who get professional retraining; 92 300 raised the level of their skill. There are courses on grassland, forage production and preservation in higher and technical educational institutions.

Recently agricultural universities expanded their programmes and list of specialities, including management, commerce and marketing. Educational programmes include practical jobs (for agronomists in summer) after each year of studying. Students - beginners get practical experience on training-experimental farms, senior students - on farm units.

Graduates of universities and technical schools work as specialists and managers of agricultural enterprises, recently - as farmers. Education of agricultural workers, doing direct work on breeding units and fields, including forage production, is done at vocational technical schools. Periodically there is training to raise their level of professional knowledge and their evaluation.

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