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Geographical Estimation of Natural Potential of the North Caucasus for the Cultivation of Fruit Trees

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***Abstract* – The analysis of the suitability of climatic resources in the winter-spring period at the South of Russia territories for the placement of fruit trees (an apricot, a peach) the most vulnerable to the analyzed period was carried out. The correlation between the geographical coordinates of the area and regularity of fructification of fruit crops were established.**

Landscape maps of the optimum placement of an apricot and a peach under the conditions of the overwintering of their floral buds in the territory of the South of Russia are submitted.

***Keywords* – Apricot, Geographical Estimation, Landscape, Natural Resources, Peach, Placement, South of Russia.**

I. Stating of the Problem

Natural resources of the earth – the single source of life support of mankind, in particular the providing with food [1]. This source includes two groups of conditions:
1. group of a space environment (light and heat);
2. group of terrestrial conditions (water and nutrition of plants).

The first group of life conditions of plants does not fall within a sphere of human influence since it originates from interplanetary space, and we cannot change the size of inflow of light and heat to the earth. Only in restricted sizes in agriculture in some cases it is possible to regulate inflow of light and heat. Due to the features of the first group of conditions of life plant, human is forced to adapt (through selection and placement of specieses and varieties).

The second group of conditions of plants life – water and elements of mineral nutrition – terrestrial origin and therefore are susceptible to human influence. Therefore, there is the essential difference between the two mentioned groups of plants life factors. If space factors (light and heat) inflow to plants directly, then terrestrial affect on plants only through the intermediary. Such an intermediary between water and mineral nutrition and the plant itself is soil. Presence of this intermediary (soil resources) allows a human to influence the relation of a plant to water and elements of a nutrition in significant limits [2].

The development of agriculture should be considered and be forecasted through a prism of ecologic-geographic problems. This problem is especially important for perennial fruit trees grown up in the extremely various relief, climatic and soil conditions [3]. And it should be considered in the «eco-geographic conditions – a plant» system taking into account interaction of factors of agro-ecosystems [4, 5, 6, 7, 8].

Geographical approach allows to consider the features of growth of plants productivity in various soil and climatic conditions. The integral and important part of it is the determination of typicalness of soil and climatic conditions of the territory of growth for specific specieses within the specific geographical, agro-soil and agro-climatic region [9].

II. Objects and Methods

In this article the analysis of the suitability of natural climatic resources of the winter-spring period of the territory of the North Caucasus for the placement of fruit species (valuable and at the same time the most vulnerable during the analyzed period) depending on geographical coordinates of the area is offered.

Long-term data (for the last 15-30 years) about the death of floral buds during the winter-spring period in various regions of the South of Russia and the actual materials of scientific research institute of the North Caucasus and State varietal plots (on 15 geographical points, table 1) were used.

Work methods – mathematical and geo informational modeling, the eco-genetic analysis of the experimental data.

III. Results and Discussion

At first the classification of geographical regions which were divided into three groups was made.
The first group includes the points where the total loss of floral buds ranged from 0 to 10%, i.e. the coefficient reliable overwintering (CRO) – from 0.9 to 1.

The success of overwintering turned to be dependant from geographical coordinates that was established by means of the path analysis of S. Wright. The calculations showed that 77% of the complete death from the cold during the winter period is bound to height above sea level (the coefficient of determination – R^2 about 1). The higher above sea level, the lower percent level of death within studied areas (up to the height of 600 m).

The geographic latitude determines 18% of death of harvest, its direct effect: -0,35, indirect effect through the longitude is equal -0,14. The direct effect of longitude is also the negative (-0,20). It means that in the first group in order to avoid harvest losses the placement of an apricot within the North Caucasus advisable to promote to the southeast with simultaneous increase in height above sea level. With the promotion to the south it is more expedient to place an apricot on slopes of 0-200 m high. These are areas of the Republic of Dagestan (Hasavyurtsky, Kizlyar regions), Chechnya and Ingushetia (Argunsky, Naursky regions).

Table 1: The interrelation of regularity of fructification of an apricot and peach in the North Caucasus with geographical coordinates depending on overwintering conditions

Region	Geographic coordinates			Percentage of years with the total loss of the crop from freezing temperatures and frost	
	Latitude	Longitude	Altitude (height above sea level)	apricot	peach
Krasnodar region					
Krasnodar	45,1	39,0	33	60	50
Belaya Glina	46,1	40,9	69	70	70
Kanevskaya	46,1	38,9	17	60	60
Ust-Labinsk	45,2	39,7	92	60	50
Labinsk	44,6	40,7	264	40	30
Stavropol region					
Georgiyevsk	44,2	43,5	302	45	35
Kabarda and Balkaria					
Nalchik	43,5	43,6	441	40	30
Prohladnoye	43,8	44,1	200	40	40
Dagestan					
Hasavyurt	43,3	46,6	146	40	35
Kizlyar	43,9	46,7	5	40	40
Kasumkent	41,7	48,2	477	20	10
Buynaksk	12,8	47,1	472	30	20
Ichkeria and Ingushetia					
Grozny	43,4	45,7	124	20	20
Naurskaya	43,7	45,3	80	30	30
North Ossetia					
Vladikavkaz	43,0	44,6	670	40	30

Geographic locations of an apricot are carried to the second group with coefficient of reliable overwintering 0,7-0,9 (height above sea level 400-600 m). Within its limits causes of death in overwintering are caused by a geographical position only on one-third (30%), and most of all – the height above sea level. Most of death (70%) is bound to other factors: micro-relief conditions, air inversion, proximity of large water reservoirs, etc. In this belt winter temperatures are steadier, thaw is rare, therefore floral buds in the period of the forced rest can safely withstand even -25°C, and the total loss of them during the winter period in this belt does not exceed 30% of cases. To reduce losses from freezing in this group need to find out exactly unrecorded reasons and, if possible, eliminate them by technological and breeding techniques. Apricot loss can be reduced through the promotion of geographical coordinates in the south-east and to the sublime (from 400 to 600 m) relief elements. For example, this group should include the following state varietal plots: in the Republic of Dagestan – Buynaksk, in Stavropol Territory – Essentuki, in Kabardino-Balkaria – Primalkinsky, in the Krasnodar region – microzones Labinsky district, in North Ossetia – Suburban CSO.

In the third group (from 30 and above percent of total death of the harvest) extent of overwintering is caused by a geographical position (within height above sea level from 200 to 400 m) and makes 50% of years with safe overwintering. As in the previous group, it is necessary to find out unaccounted part of causes of death from a frost here. In this group it is possible to reduce losses of a crop of an apricot from freezing by promotion of landings to the east since the larger proportion of the impact falls on the geographical longitude (a share of influence of width and height above sea level is less considerable). The following areas can be included to this group: in Dagestan – Kasumkentsky, in Krasnodar region – Chelbassky, Krasnodar, etc.

The presence of varietal differences when placing culture was established. For example, in the Ust-Labinsk area (Krasnodar region), Novoaleksandrovsky (Stavropol region), Vladikavkaz (North Ossetia) the total death of buds of a grade Red-cheeked was observed in 50 percent of years, for grade Arzami – it is more than 60%. A similar analysis gives the opportunity to come out not only to recommendations of geographical placement of gardens, but also to a question of placement and cultivation of specific varieties. Trees without winter damage will be more resistant to lesion by fungal diseases, require less chemical treatments.

The preliminary analysis revealed the possibility of further improving of accuracy of such forecasts due to exarticulation from dispersions of estimates of the specific combinational ability (SCA) of the linear component. Quantitative characteristics of the location for groups of an apricot with various reliability of fructification were as follows.

1st group. The fructification reliability coefficient – from 0,9 to 1, limits of latitude are 43,8°±0,5°. The longitude is 46,1°±0,7°. Average height above sea level is 89 m, limits of 5-150 m.

Correlation between the fructification reliability coefficient (FRC) on the latitude and longitude of a place in this group of reliability of fructification made 0,7.

The percent of the total death of yields from frosts poorly correlates with the latitude and longitude, but significantly – with height above sea level (r = -0,66±0,20). The smaller height above sea level in these limits of geographical coordinates, the greater percent of death of floral buds.

2nd group. The FRC is 0,7-0,9. The latitude borders are 43,7°±0,5°, the longitude is 43,6°±4,0°. Height above sea level – from 400 to 600 m.

FRC negatively correlates with the latitude and longitude. This communication is statistically significant (r = -0,96±0,15). Communication with height above sea level is the weak negative (-0,32).

3d group. The FRC is 0,5-0,7. The latitude borders are 45,02°±0,9°, the longitude is 40,3°±8°. Height above sea level is from 17 to 200 m.

FRC negatively correlates with the latitude and longitude (r = -0,8±0,24).

Thus, in the studied region with promotion to the south the apricot can fructify regularly within analyzed geographical coordinates at low height above sea level (r=-0.95±0.13). In moving to the east an apricot should be placed higher above sea level (r=0,77±0,26).

In moving on the southeast within given geographical coordinates it is possible to achieve 9-10 steady yields of an apricot (R^2 about 1) in 10 years term.

In the northeast direction the regularity of fructification will not raise above FRC of the 3rd group (R^2=0,77).

Analysis of variance showed that division into three groups based on the percentage of death is significant – value of criterion of Fischer (F) the estimated equal to 59,4; F table – 3,74. The share of influence of group affiliation on death of yield makes 91,4%. It means that distinctions in death percentage in these groups are significant and between the 1st and 2nd groups. F est.=3 (F table=2,23). Between the 2nd and the 3rd – F est.=7,05 (F table=2,20). Within the studied geographic latitude the last one influences to a death percent (32%) – F est.=3,59; F table=3,24.

Distinction in death of harvests between the above groups makes 34% (F est.=3,90; F table=3,74). Which means, that the longitude significantly affects on an accessory area to one group or another. The analysis of different groups at change of longitude showed that FRC significantly differs only in the first and third groups (F factorial = 2,41; F table = 2,23).

By dependence consideration in analyzed groups of a regularity of fructification from height above sea level, it appeared that the last one influences authentically 77% (F est. = 20,0; F table = 3,74).

Significant differences of the FCR due the height above sea level between the 1st and 2nd groups (F factorial = 9,02; F table = 2,36); between the 2nd and 3rd groups (F factorial = 5,24; F table = 2,20). This results from the fact that the 2nd group is located at height, and the 1st and 3rd are in one altitudinal belt, but at different latitudes.

Let's emphasize that the calculations were carried out up to the height of 600 m, because placed the main areas occupied with an apricot are placed within this height in the North Caucasus. Similar work was carried out and for culture of a peach [10].

The correlation between the regularity of its fruiting in southern Russia with the geographic coordinates and altitude. During the mathematical analysis geographic points were divided into two groups:

1st: percent of years with the total death of yields from frosts makes from 33 to 60%;

2nd: percent of years with the total death of yields from frosts – less than 30%.

It is established (by method of the ecological and genetic analysis) that in the 1st group the geographic latitude of the area has the main impact on a regularity of fructification of a peach. Equation of the connection of the percent of harvest's death from frosts with geographic coordinates for the 1st group is as follows:

$$y = -599,8 + \frac{0,70}{12,1x_1} + \frac{0,16}{2,5x_2} - \frac{0,14}{0,03x_3}$$

where x_1 – latitude, x_2 – longitude, x_3 – height above sea level.

In this equation the shares of influence of each of these factors with a coefficient of determination equal to 1 are specified above the line. These shares of influence can be considered on direct and indirect ways by means of Wright's coefficients (table 2).

Table 2: The coefficients of paths of direct and indirect influence of geographical coordinates and altitude above sea level for percent of death of crops of a peach from frosts

Numbers of Factors	Path coefficients		
	1	2	3
1	0,94*	-0,29	0,24
2	-0,60	0,46	-0,28
3	-0,77	0,44	-0,30

* the direct paths of influence are located on a diagonal (emphasized)

From the Table 2 follows that the latitude has the greatest direct influence (0,94) on the death of harvests of a peach. Indirect effect through the longitude makes -0,29. Then, the death of harvests of a peach from frosts increases with the advancement to the West on one latitude. Direct influence longitude less (0,46) compared with the latitude. Besides, influence of longitude is reduced by an indirect way through latitude (-0,60) and height above sea level (-0,28).

Then, the probability of death of floral buds of a peach from the frost increases when promoting the culture of a peach in the North-East with a simultaneous decrease in height above sea level.

The deviation to the east on the same latitude conducts to mitigation of influence of low temperatures on floral buds of a peach, as well as advance to the North on the same longitude.

Height above sea level has the negative correlation with degree of kidneys' freeze (-0,30), i.e. with its increase the

probability of peach freeze decreases. Thus, the indirect influence of latitude (-0,77) with the advancement to the North, this effect weakens, and with advance to the East (0,44) strengthens. Therefore, for successful cultivation of a peach it should be promoted to the East with simultaneous increase in height above sea level.

It is established that on longitude 43,5°, latitude 44,2° with a height above sea level to 300 m the percent of years with death of harvests from a frost will not exceed 30%. The high percent of death of harvests from low temperatures during the winter and spring period (60% of years and above) takes place on longitude 46°, latitude 40,9° and height above sea level is lower than 170 m. Here should not be placed industrial planting of peach.

The regularity of influence of geographical coordinates on a peach freezing for the second geographical group (the percent of years with the total death of harvests from frosts less than 30%) is different. Height above sea level comes out on top on significance (26%). The larger it is, the less freezing of peach. The longitude in this group does not play a role, influence of the latitude makes 4%.

Equation of the connection of the percent of harvest's death from frosts with geographic coordinates of the area is as follows (for the 2nd group):

$$y = 84{,}3\text{-}1{,}13x_1 - 0{,}34x_2 - 0{,}01x_3$$

The death of harvests from frosts will be less with the advance of a peach on the South-West with simultaneous increase of height above sea level.

The received results of a geographical assessment of natural resources are used for development of ecological maps of optimal placement of cultures of an apricot and a peach on climatic features of the territory of the North Caucasus in a landscape (fig. 1, fig. 2) on the basis of geoinformational technologies [12, 13, 14].

The areas of different degrees of usefulness for the cultivation of apricot and peach in terms of their over-wintering floral buds indicates on the maps by a different colors.

Appendix 1 provides a list of administrative regions of analyzed territory.

IV. Conclusion

The geographical estimation of natural resources of the North Caucasus for optimal placement of fruit trees has been carried out.

The dependence of a regularity of their fructification with geographical coordinates of the area has been established.

Ecological maps of optimal placement of an apricot and peach under the conditions of over-wintering of their floral buds in the south of Russia has been developed (in a landscape).

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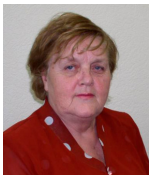

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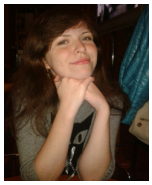

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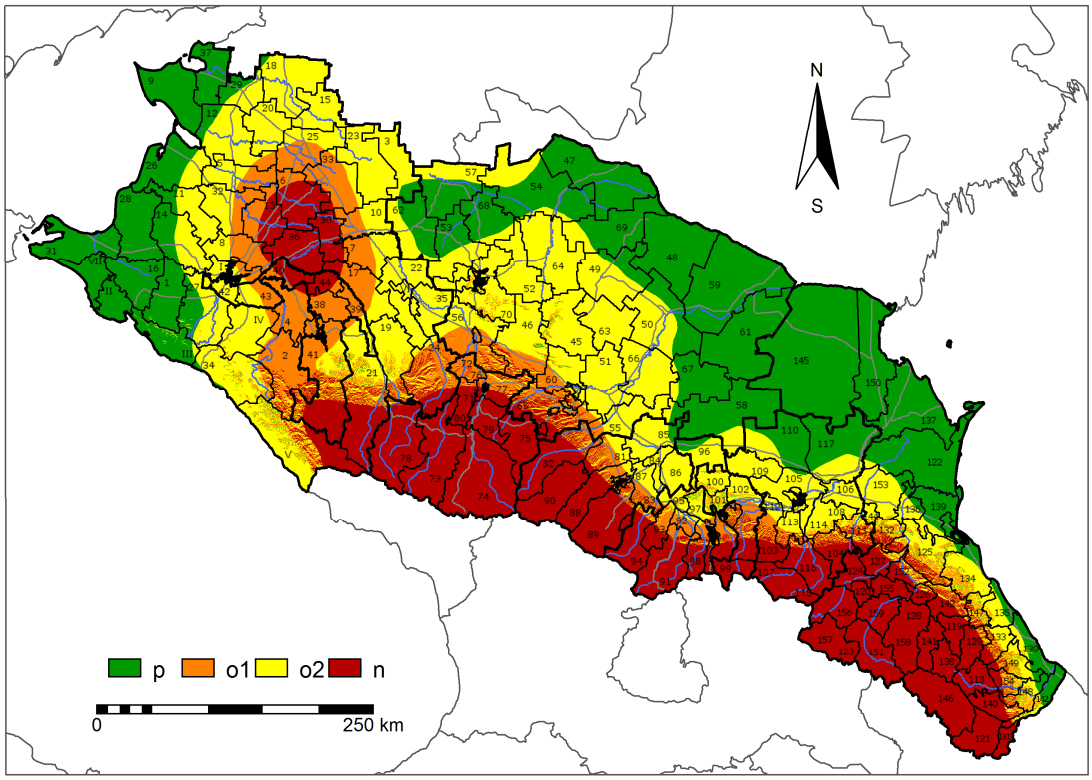
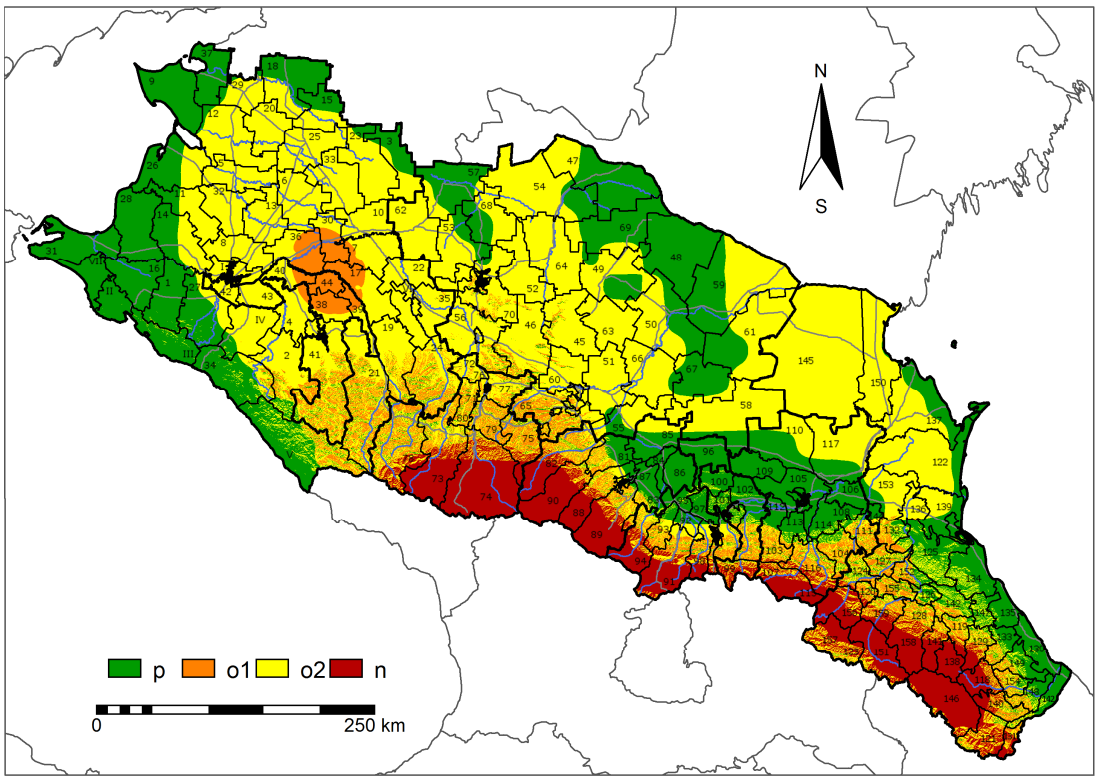


Legend:
p – is suitable; o1 – degree of suitability 1; o2 – degree of suitability 2; n – is unsuitable

Fig.1. Map of the optimal placement of an apricot in the North Caucasus in relation to limiting meteorological factors of the winter-spring period



Legend:
p – is suitable; o1 – degree of suitability 1; o2 – degree of suitability 2; n – is unsuitable

Fig.2. Map of the optimal placement of a peach in the North Caucasus in relation to limiting meteorological factors of the winter-spring period

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APPENDIX

KRASNODAR REGION
Urban municipalities and their centers:
I. The Krasnodar city – Krasnodar
II. The Novorossiysk city – Novorossiysk
III. The resort city Gelendzhik – Gelendzhik
IV. The Goryachy Clyuch city – Goryachy Clyuch
V. The resort city Sochi – Sochi
VI. The Armavir city – Armavir
VII. The resort city Anapa – Anapa
Districts and their administrative centers:
1. Abinsky – Abinsk
2. Apsheronsky – Apsheronsk
3. Beloglinskiy – v. Belaya Glina
4. Belorechensky – Belorechensk
5. Bryukhovetskiy – v. Bryukhovetskaya
6. Vyselkovsky – v. Vyselki
7. Gulkevichsky – Gulkevichi
8. Dinskoy – v. Dinskaya
9. Yeisky – Yeisk
10. Caucasian – Kropotkin
11. Kalininsky – v. Kalininskaya
12. Kanevskoy – v. Kanevskaya
13. Korenovskiy – Korenovsk
14. Krasnoarmeyskiy — v. Poltavskaya
15. Krylovskiy –- v. Krylovskaya
16. Krymskiy – Krymsk
17. Kurganinsky – Kurganinsk
18. Kushchyovskiy – v. Kushchyovskaya
19. Labinsky – Labinsk
20. Leningradskiy – v. Leningradskaya
21. Mostovskiy – v.. Mostovskoy
22. Novokubansky – Novokubansk
23. Novopokrovskiy – v. Novopokrovckaya
24. Otradnenskiy – v. Otradnaya
25. Pawlowskiy – v. Pavlovskaya
26. Primorsko-Ahtarskiy – Primorsko-Ahtarsk
27. Severskiy – v. Severskaya
28. Slavic – Slavyansk-on-Kuban
29. Starominskiy – v. Starominskaya
30. Tbilisskiy – v. Tbilisskaya
31. Temryukskiy – Temryuk
32. Timashoevskiy — Timashoeivsk
33. Tikhoretskiy – Tihoretsk
34. Tuapsinskiy – Tuapse
35. Uspenskiy — v. Uspenskoye
36. Ust-Labinskiy — Ust-Labinsk
37. Shcherbinovskiy – v. Staroshcherbinovskaya

REPUBLIC ADYGEA
38. Giaginskiy area – village Giaginskaya
39. Koshehablsky area – village Koshehabl
40. Krasnogvardeyskiy area – village Krasnogvardeiskoe
41. Maikopskiy area – village Tulskiy
42. Tahtamukayskiy area – village Takhtamukai
43. Teuchezhskiy area – village Ponezhukay
44. Shovgenovskiy area – village Hakurinohabl

KABARDINO-BALKAR REPUBLIC
81. Baksanskiy area
82. Zolskij area
83. Leskenskiy area
84. Mayskiy area
85. Prokhladnenskiy area
86. Terskiy area
87. Urvanskiy area
88. Chegemskiy area
89. Cherekskiy area
90. Elbrus area

REPUBLIC OF NORTH OSSETIA (ALANIA)
91. Alagirskiy – Alagir
92. Ardonskiy – Ardon
93. Digorskiy – Digora
94. Irafskij – Chikola
95. Kirovskiy – Elkhotovo
96. Mozdokskiy – Mozdok
97. Pravoberezhniy – Beslan
98. Prigorodniy – Octyabrskoye

THE REPUBLIC OF INGUSHETIA
99. Dzheyrakhskiy area – Dzheyrakh
100. Malgobekskiy area – Malgobek
101. Nazranovskiy area – Nazran
102. Sunzhenskiy area – Ordzhonikidzevskaya

THE CHECHEN REPUBLIC
103. Achkhoy-Martan area – Achkhoy-Martan
104. Vedeno area-–Vedeno
105. Grozny area – Grozny
106. Gudermes area – Gudermes
107. Itum-Kalinskiy area – Itum-Kale
108. Kurchaloyevskiy area – Kurchaloy
109. Nadterechniy area – Znamenskoye
110. Naurskiy area – Naurskaya
111. Nozhay-Yurtovskiy area – Nozhay-Yurt
112. Sunzhenskiy area – Sernovodskaya
113. Urus-Martanovskiy area – Urus-Martan
114. Shalinskiy area – Shali
115. Sharoyskiy area – Himoy
116. Shatoyskiy area – Shatoy
117. Shchelkovskiy area – Shelkovskaya

THE REPUBLIC OF DAGESTAN
118. Agulskiy area – v. Tpig
119. Akushinskiy area – v. Akusha
120. Akhvakhskiy area – v. Karata
121. Akhtynskiy area – v. Akhty
122. Babayurtovskiy area – v. Babayurt
123. Bezhtinskiy area – v. Bezhta
124. Botlikhskiy area – v. Botlikh
125. Buinakskiy area – v. Buinaksk
126. Gergebilskiy area – v. Gergebil
127. Gumbetovskiy area – Mekhelta
128. Gunibskiy area – v. Gunib
129. Dakhadayevskiy area – urban village Kubachi

STAVROPOL REGION
45. Alexandrovskiy area
46. Andropovsky area
47. Apanasenkovskiy area
48. Arzgirskiy area
49. Blagodarnenskiy area
50. Budionovskiy area
51. Georgievskiy area
52. Grachevskiy area
53. Izobilnenskiy area
54. Ipatovskiy area
55. Kirovskiy area
56. Kochubeevskiy area
57. Krasnogvardiyskiy area
58. Kurskiy area
59. Levokumskiy area
60. Mineralovodskiy area
61. Neftekumskiy area
62. Novoalexandrovskiy area
63. Novoselytskiy area
64. Petrovskiy area
65. Predgorniy area
66. Sovietskiy area
67. Stepnovskiy area
68. Trunovskiy area
69. Turkmenskiy area
70. Shpakovskiy area

KARACHAY-CHERKESS REPUBLIC
71. Abazinskiy area
72. Adyghe-Hablskiy area
73. Zelenchukskiy area
74. Karachaevskiy area
75. Malokarachaevskiy area
76. Nogai area
77. Prikubanskiy area
78. Urupskiy area
79. Ust-Dzhegutinskij area
80. Habezskiy area

130. Derbentskiy area – Derbent
131. Dokuzparinskiy area – v. Usukhchay
132. Kazbekovskiy area – v. Dylym
133. Kaitagskiy area – v. Madzhalis
134. Karabudakhkentskiy area – v. Karabudakhkent
135. Kayakentskiy area – v. Novokayakent
136. Kizilyurtovskiy area – Kizilyurt
137. Kizlyarskiy area – Kizlyar
138. Kulinskiy area – v. Vachi
139. Kumtorkalinskiy area – v. Korkmaskala
140. Kurakhskiy area – v. Kurakh
141. Lakskiy area – v. Kumukh
142. Levashinskiy area – v. Levashi
143. Magaramkentskiy area – v. Magaramkent
144. Novolaksky area – v. Novolakskoye
145. Nogaiskiy area – v. Terekli-Mekteb
146. Rutulskiy area – v. Rutul
147. Sergokalinskiy area – v. Sergokala
148. Suleyman-Stalsky area – v. Kasumkent
149. Tabasaranskiy area – v. Huchni
150. Tarumovskiy area – v. Tarumovka
151. Tlyaratinsky area – v. Tlyarata
152. Untsukulskiy area – v. Untsukul
153. Khasavyurtovskiy area – Khasavyurt
154. Hivskiy area – v. Hiv
155. Hunzakhskiy area – v. Hunzakh
156. Tsumadinskiy area – v. Agvali
157. Tsuntinskiy area – v. Kidero
158. Charodinskiy area – v. Tsurib
159. Shamilskiy area – v. Hebda