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Agrosteppe Method

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Abstract

Steppes, pusztas, prairies, savannas, the Pampas and other natural ecosystems function on one biological principle: they are multicomponent, self sustaining within a certain flora (and fauna) biodiversity, vertical structure, zone associations, dominants, bioproductivity (yield) and erosion resistance. Fully degraded steppes and the analogues slowly reestablish over succession stages- within 80-100 and more years.

Keywords: agrosteppe, competition for light, wild plants

1. Introduction

Man's active intervention in natural ecosystems started since the Paleolithic-about 10(12)000 years ago. Anthropogenic stress increased 6(7)000 years later with the introduction of animals herding and farming. Only 32% of the world's land area is undisturbed wild lands (Grigoryev & Kondratyev, 1994). The rest area is subjected to digressive processes such as desertification and weakening of zonal dominant flora, vegetation types, and animal life against the background of climate warming (Mabbut, 1981; Lavrov, 1989; Lazukov, 1989; Koronovsky, Khain, & Yasamanov, 2008; Rooth, 1992; Salem, 1993). Science suggests various protection measures as an alternative: reservations and national parks establishment, anthropogenic stress reduction by 30-60% (Schmid & Thomet, 1986; Odum, 1986). These measures are of great value and are used by countries where primary vegetation is preserved. But they do not solve the problem of eroded and desertified land rehabilitation on wide areas. The remaining soil and vegetation continue to degrade. This is a burning issue in the regions with mean annual rainfall of 200-500 mm; these are steppes, prairies, savannas, the Pampas, etc.

The first prairie restoration experiment was held by Curtis in Wisconsin University (USA) in 1935. He transplanted small blocks of initial prairie sod (Green & Curtis, 1953; Cottam Grant, & Wilson, 1966). The other methods included harvesting seeds of certain plants (Stipa spartia and other) further introduced at plain segments, transplantation of mature plants, and hay application. Curtis stated that sod method gave good results but it was expensive and labour-consuming. Sodding was used in Russia for meadow steppe restoration in the North Caucasus at Stavropol Botanical Garden. Restoration process took 8-17 years (Skripchinsky, 1973 and other). Wisconsin and Stavropol studies were of great importance, but they stayed within the limits of science experiment and failed to lay the foundation for a large-scale application. The author of this article has also conducted experiments with sod at Stavropol Botanical Garden and stated that spaced sod planting initiated a competition between sod blocks' mature plants and seedlings of the next generation. This was the reason for delayed steppe restoration by the abovementioned method, besides it turned out to be anti-ecological as sod-making areas became weeded for a long time and there were very few natural steppes left (Dzybov, 1980, 2008 and other).

2. Methods

The author of the project used another method. A plough land was sown with complex steppe seeds mix. The major difficulty of this method-different ripening time of rich steppe flora-was overcome by combine harvesting of equal adjacent areas of seed donor in two or three stages at 25-30 days intervals. Seed mixes of different harvest time were then combined into one mix representing a "portrait" model of initial steppe. The final mix was not cleared of impurities and weeds to preserve in the future steppe relative abundance of steppe plants species: dominants, assectators and other accompanying species. Some plants give few seeds (Carex humilis, Cleistogenes bulgarica), others have week germination capacity or spring up very slowly (Adonis vernalis, Paeonia tenuifolia). These species were scarcely represented in the agrosteppe. In some cases we transplanted some mature plants (Adonis vernalis, Paeonia tenuifolia) manually. Such species account for about 3% of the agrosteppe flora.

The first natural seed mix sowing experiment was conducted at Stavropol Botanical Garden in 1975 (Dzybov, 1979). Soil-chernozem, humus-3%, annual rainfall-623 mm, seed bearing plot (donor)-meadow steppe. Steppe seed mix was harvested at two stages – on July 17, and on August 21, 1975. Seed bearing plot (donor) comprised 59 plant species per 100 m^2. Association: Brachypodium rupestre, Carex humilis, Galium ruthenicum, Phleum phleoides. Sowing was carried out with surface applicator on September 10, 1975, seed rate-4 g of mix per 1 m^2 (40 kg/ha). The seeds were twice rolled over. The project's name is "Agrosteppe method"; agricultural practices applied were as follows: plowing, combine harvesting, etc.; reconstructed phytocenoses were similar to original steppes in all basic characteristics (Dzybov, 2001 and other).

3. Results and Discussion

After wintering on May 6, 1976 there were recorded the following steppe plants seedlings: Anthyllis macrocephala, Betonica officinalis, Brachypodium rupestre, Bromopsis riparia, Echium maculatum, Festuca rupicola, Filipendula vulgaris, Medicago romanica, Phleum phleoides, Galium ruthenicum, Poterium polygamum and other. Weeds grew quicker than steppe plants and germinated mainly from soil seed reserve, among them were the following: Amaranthus blitoides, Amaranthus retroflexus, Ambrosia artemisiifolia, Bromus japonicas, Capsella bursa-pastoris, Lactuca serriola and some other. During its first summer the test plot resembled one of the primary stages of layland demutation. In order to reduce weeds competition for water, nutrients and light young phytocenosis was twice cut on May 6, and on June 28, 1976. Cutting did not damage steppe plants due to their short height. Before the next winter 1976-1977 grasses finished tillering, the other groups of plants had good vitality.

The second summer (1977) agrosteppe was very bright (Figure 1) and looked like initial steppe: lots of virgin land plants were blossoming against the background of green vegetative organs and had high occurrence (%):

Brachypodium rupestre	80	Medicago romanica	100
Echium maculatum	100	Phleum phleoides	100
Festuca pratensis	80	Silene densiflora	80
Festuca rupicola	80	Stachys atherocalyx	70
Galium ruthenicum	100	Stipa pulcherrima	80
Linum nervosum	100	Thymus marschallianus	80

Occurrence of the rest species in the agrosteppe varied from 20 to 60%.

Figure 1. The first agrosteppe method science experiment. Professors V. V. Skripchinsky and V. G. Tanfilyev (1975)

Experimental plot comprised 42 species, including 8 weeds from soil seed reserve: Ambrosia artemisiifolia, Lamium amplexicaule, Setaria pumila, Sinapis arvensis and some other annuals. Over 82% of agrosteppe flora was in generative phase and gave seeds. Ground vegetation was dense, degree of soil coverage reached 70%. Hay yield equaled 468 g/m^2 exceeding the yield of reference standard by 35.6 gram. The reason for this was low competition of roots in sod horizon of the young agrosteppe. Specific features of experimental agrosteppe development in different years are shown in Table 1.

Table 1. Agrosteppe development dynamics within 10 years

Phytocenosis, years	Quantity of species per 100 m²	Weeds		Botanical groups					
				Grasses		Legumes		Mixed herbs	
		QTY	%	QTY	%	QTY	%	QTY	%
Reference standard (1975)	83	13	16	16	19	9	11	58	70
Agrosteppe, 1977	60	19	31	12	20	6	10	42	70
1978	86	15	17	13	15	12	14	61	71
1979	74	10	14	16	22	13	18	45	60
1980	65	6	9	17	26	13	20	35	54
1981	65	6	9	16	25	12	18	35	57
1982	81	10	12	14	18	11	13	46	57
1983	83	13	16	13	16	14	17	43	51
1984	94	18	19	17	18	18	19	41	44
1985	83	11	13	15	18	14	17	43	52
1986	84	13	15	18	21	14	17	39	47
Agrosteppe average (1977-1986)	78	12,1	15,5	15,1	19,9	13,6	16,3	43,0	56,3

Table 1 data shows the following: 1) species composition per 100 m^2 increased in 10 years time from 42 to 78; 2) high index of diversity preserved; 3) flora groups ratio (grasses, legumes, and mixed herbs) stabilized and equaled approximately 1:1:4 as in reference standard; 4) biological hay yield varied from 224 to 511 g/m^2 within 10 years.

The second agrosteppe was started in 1980 on 10 ha of sandy soil (humus-0.9-1.0 %, annual rainfall-450 mm). Association: Festuca valesiaca+Koeleria cristata+mixed herbs, flora diversity of seed bearing plot (donor) comprised 62 species per 100 m^2: grasses and sedges-21.0%, legumes-11.3%, mixed herbs-67.0%, annuals-1.6%, perennials-98.4% (Table 2).

Table 2. Agrosteppe dynamics over the period from 1981 to 1991 compared to data registered at 17 and 32 years

Agrosteppe age, years	Species per 100 m^2	Floral groups, %			Life cycles, %		
		Grasses+sedges	Legumes	Mixed herbs	Annuals	Biennials	Perennials
2	47	17.0	2.1	80.9	30.0	4.3	65.7
3	55	22.0	3.5	74.5	9.1	16.4	74.5
4	30	26.7	3.3	70.0	16.6	6.7	76.7
5	58	15.5	3.4	81.0	10.3	10.3	79.4
6	61	18.0	18.0	64.0	0.0	9.8	90.2
7	60	11.7	11.7	76.6	3.3	5.0	91.7
8	65	10.8	17.0	72.2	1.5	10.8	87.7
9	54	13.0	11.1	75.9	0.0	11.1	88.9
10	62	16.0	13.0	71.0	1.7	8.1	90.3
11	68	13.2	16.2	70.6	4.4	10.3	83.3
Agrosteppe average over 10 years	56	16.4	9.9	73.7	7.7	9.3	82.8
17 years	56	14.3	19.6	66.1	7.1	5.4	87.5
32 years	66	21.0	14.0	65.0	0.0	3.0	97.0

Fluctuation of agrosteppe basic characteristics within 32 years was insignificant and approached 10 and 17 years' average. By 2012 legumes and mixed herbs ratio slightly decreased. A natural result of reestablished steppe ageing was the sharp fall of therophytes. The number of perennials reached its maximum-97% of the flora on the experimental plot of 100 m^2. There was recorded stabilization of agrosteppe composition and vertical structure whereas weeds invasion resistance increased.

Agrosteppes can serve as a reliable way of desertified lands ecological reestablishment (Figures 2 and 3), a source of pasture forage and hay, and a real means of saving floral biodiversity, including rare protected species (Gorbunov, Dzybov, Kuzmin, & Smirnov, 2008) (Figure 4). Table 3 shows various multiple-aged agrosteppes associations. The data suggests the following: within 1-32 years' time span agrosteppes preserved high degree of biodiversity-floral density fluctuations were within 39-93 species per 100 m^2 of test area; grasses (the Poaceae), legumes (the Fabaceae), and other families were rich in species diversity. Perennials dominated steppe flora. Jaccard similarity index of agrosteppe and its donor might vary from 42 to 80. It reached its minimum at one-time seed donor harvesting and rose to the maximum at harvesting in 3-4 stages. The hay yield of multiple-aged agrosteppes with different composition varied from 178 to 497 g/m^2 (Figure 5).

Figure 2. Ecological reestablishment of desertified stony land with agrosteppe method. Dominants: Festuca valesiaca, Bromopsis riparia, Medicago romanica. In aspect: Galium ruthenicum, Centaurea orientalis. 73 species per 100 m^2

Figure 3. Ecological reestablishment of sandy soil with agrosteppe method. 100 m^2 comprise 68 steppe plants species (Stipa pulcherrima, Dianthus ruprechtii. Festuca valesiaca, Lotus caucasicus, Onobrychis arenatia, and other)

Figure 4. Anemone sylvestris-rare protected plant in a thirty-year agrosteppe

Figure 5. Haymaking in a two-year agrosteppe

At the age of two years agrosteppe becomes a donor of new seed mixes since 87-98% of steppe plants start to blossom and give seeds. Seed mix collected from 1 ha of steppe (agrosteppe) can restore 7-10 ha of deserted area. This gives the opportunity to carry out lands reestablishment exponentially within a short period of time (Dzybov, 2010). Seed harvesting and sowing should be conducted within the limits of the same geographical area. Biological principles of multispecies natural ecosystems are valid for agrosteppes as well. This makes the agrosteppe method applicable throughout the world.

Table 3. Biodiversity and yield of agrosteppes different in composition and age

Association	Area. ha	Age (year of sowing)	Species per 100 m^2	Floral groups, %			Life cycles, %			Hay yield. g/m^2
				Grasses+sedges	Legumes	Mixed herbs	Annuals	Biennials	Perennials	
Festuca valesiaca+ Festuca pratensis+ mixed herbs	1.0	1 (2011)	59	32.0	19.0	49.0	5.0	10.0	85.0	409.1
Festuca valesiaca+ Trifolium pratense+ Festuca pratensis	1.3	1 (2011)	51	31.4	13.7	54.9	15.7	9.8	74.5	390.7
Lolium perenne+ Dactylis glomerata+ Poteriym polygamum	5.0	1 (2011)	41	27.0	22.0	51.0	27.0	7.0	66.0	225.9
Festuca valesiaca+ Bromopsis riparia+ Poteriym polygamum	50	4 (2009)	41	22.0	19.5	58.5	7.3	12.2	80.5	436.0
Festuca valesiaca+ Bromopsis inermis+ Poterium polygamum	50	4 (2009)	39	33.0	13.0	54.0	0.0	8.0	92.0	496.8
Festuca valesiaca+ Bromopsis inermis+ Poterium polygamum	2.5	16 (1995)	84	20.0	13.0	67.0	13.0	11.0	76.0	221.2
Festuca valesiaca+ Koeleria cristata+ Poterium polygamum	3.0	16 (1995)	63	20.3	11.7	68.0	11.0	11.0	78.0	178.1
Festuca valesiaca+ Bromopsis riparia+ Galium ruthenicum	4.0	26 (1986)	71	23.0	13.0	64.0	4.2	4.2	91.6	226.7
Bromopsis riparia+ Festuca valesiaca+ Bromopsis inermis	4.0	26 (1986)	93	16.0	16.0	68.0	5.4	5.4	89.2	248.4
Filipendula vulgaris+ Galium ruthenicum+ Medicago romanica	100.0	29 (1983)	88	19.0	16.0	65.0	3.0	6.0	91.0	206.9
Festuca valesiaca+ Koeleria cristata+ Filipendula vulgaris	10.0	32 (1980)	74	22.0	16.0	62.0	2.0	2.0	96.0	300.0

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