The current natural-anthropogenic threats to the steppe landscape stability

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Abstract. The article is devoted to estimating the current ecological-geographical situation in Russia and North Eurasia's steppe zone connected with global natural-anthropogenic changes. Results of several scientific branches, first of all, domestic steppe sciences, were generalized. Historical, agroecological, and climatic factors that could be identified as challenges to stable steppe nature management are considered. Interpretation of the new epoch in the steppe history called "agrocen" was paid considerable attention. Novel management scenarios for the society's feedback on the challenge were offered.

1. Introduction

Humanity inevitably meets with challenges of various characters: resource, ecological, macroeconomic, and pandemic at different historical stages. Suppose one crisis and challenge is a consequence of the long accumulation of negative results caused by the entire system of various environmental and anthropogenic factors and phenomena scientifically proven and theoretically grounded. In that case, the others are consequences of brief but powerful and unpredictable impacts with catastrophic aftermaths. The singularity of the steppe zone's current situation consists in the fact that the long destructive result of the economic activity has been accumulated within the steppe zone. The unpredictable climatic changes lay upon it. The most evident examples of catastrophic phenomena in the Northern Hemisphere's steppe zone have already happened in the period of so-called dust storms in the 1930s and the 1960s of the past century in North America and the USSR, respectively [1].

The transforming impact of the rural sector, first of all, agriculture, is comparable with the global geological power. It promoted a crisis of title biological steppe species, soil degradation, and a lack of considerable resources of loess lithogenic basis of zonal steppe landscapes. It forms the foundation to consider the modern period of the Earth's natural development as the Anthropocene [2]. Regarding the steppes, a new period of their development was accompanied by the replacement of "grasslands" with title steppe species of the biota by dominating agrocenoses, anthropogenically transformed pastures with a loss of fine-grained sediments and organics, attended by the intensity of greenhouse gas emission. In the Pleistocene and the Holocene, loess accumulation happened. Profiles of chernozem type soils were developed on the loess structure due to specific climatic factors and vital functions of cryoarid and semiarid grasslands changing each other. In the Anthropocene, the accumulation of these sediments was sharply changed by transient, comparing to the previous period, reducing the area and power of loess and loessial deposits. We consider these deposits' resources as a basis for the zonal steppe ecosystem and steppe soil – the principal condition for the highly productive agricultural
industry. Our target is to highlight the irretrievable loss of resources of loess-like sediments and design a scenario of feedback on this challenge.

2. Target setting

Each geographical zone of North Eurasia is characterized by its history of settlement, the intensity of development, typical ecological challenges, and nature conservation specifics. On this background, the steppe zone is primarily distinguished by natural resources, the history of evolution by nomadic and agricultural tribes, and the consequences of virgin land management [3, 4]. The Eurasian steppe is a specific space. Being in the pure state and occupied by nomadic cultures, it was a source of increased danger for agricultural neighbors (from south to north). In Ancient Rus, the steppe was considered as a source of constant threat from the steppe nomads' side, and struggle with them became the heaviest recollection of the Russian people [5, 6].

When, at the degree of change of correlation of forces between nomadic and agricultural cultures and an opposite expansion of agricultural tribes to the steppe territory in the south of European Russia, the steppe challenge acquired dual nature traits. On the one hand, the zonal steppe's mass plowing, especially in "wheat fever" of the XIX century, was the challenge for the natural systems of the European steppe. On the other hand, droughts and dust storms became a challenge for the country and the Russian Empire's social network. The cultural and scientific community compared droughts and hot, dry winds with nomads' invasion [7].

In the XX century, when engineering facilities, compared with times of "wheat fever," increased many times and Soviet transformism reached prosperity, zonal steppe vegetation was practically destroyed due to agrarian-social megaprojects. The steppe zone faced a scale agroecological crisis, i.e., the steppe itself received the anthropogenic challenge. This challenge was typical for the steppes of Eurasia and all grasslands of the Holarctic [8]. Even the steppes of Mongolia, where nomadic traditions have still developed, are degraded by overgrazing [9]. Development of organic farming in Russia, including by secondary introduction of fallow lands that partly recovered its lost fertility, is soil-exhausting and directs to mobilize and expend soil fertility. The equivalent of products grown without chemicalization is humus of steppe soils and fine steppe earth of which they were formed.

3. Material and Methods

Materials of own field landscape studies, answering data, expert assessment methods, cartographic process, results of former historical, geographical, agricultural research, and logical approach were used in the study.

4. Results and Discussion

The Institute of Steppe establishment in Orenburg and regular discussion of ecological problems of Steppe Eurasia on the international forums "Steppe of Northern Eurasia" by the scientific community was the current search of replays on the steppe challenge [10]. Since the foundation of the Institute of Conservation and Rational Use of Natural Resources in 1975 and the Orenburg branch of steppe nature management (1990), a range of problem concerning threats to steppe has been studied, and specifics of complex challenge within the post-virgin land space of the Trans-Volga-Urals region has been discussed, first of all on the example of model Orenburgskaya oblast (located in the center of the steppe zone), where almost all types of soils and ecosystems peculiar to the steppe zone are represented, and all principal kinds of industry and agriculture are developed [11]. Conducted complex convergent studies, taking into account climatic changes, promoted to set multi-vectorial peculiarities, so-called, current "steppe problems":

- discrepancy of steppe perception in the modern society;
- socio-economic problems of the steppe regions expressed in "space compression" for the last years;
- formation of the unclaimed land fund;
- a crisis state of landscape-biological diversity of steppes, a loss of resources of dominant and title natural and agrarian bioreresources of steppes;
• reduction of the steppe agricultural lands’ productivity, inferior to bioclimatic potential by many times, etc.

Contradictoriness of steppe perception consists in a fact that, on the one hand, cult, romanticism, and esthetic perception of the steppes exist between servants of art and nature conservation science. On the other hand, citizens’ main body is either indifferent to the steppe or influenced by prejudices and biases formed due to historical circumstances discussed above. It complicates the steppe conservation and arrangement of its management. According to the answering data, most of the population treats kindly such biological steppe species as tulips, irises, marmots. Still, one dominant kind – feather grass is only a sign of arability of agricultural lands. Fixed consumer’s relations to an open feather-grass space served a peculiar reason for agricultural expansion and realization of agrarian-social and meso- and megaprojects concerning steppe transformation similar to the German sheep colonization and "wheat fever" in the Black Sea region in the XIX century, the Stolypin's Tselina (Virgin land) (1905-1914), the Stalin's Plan of Nature Transformation (1948-1953) and the Khrushchev's Tselina (the Virgin land Campaign) in 1954-1963. Despite the evident success and achievements of the post-Soviet states to conserve steppe ecosystems, the agrarian megaprojects’ tendency has still saved that confirmed by a line of neo-virgin land campaigns within Russia and Kazakhstan of the XXI century.

On the example of the model region - Orenburgskaya oblast, we can observe that agricultural transformation of the steppe was worsened by the influence of other power anthropogenic factors: metallurgy development (since the 1930s), oil extraction (since the 1930s), gas extraction (since the 1960s), radical reforms, first of all agricultural (since the 1990s), a critical increase of hunting load on bioresources (since the 1990s), the crisis and reforms in the forestry sector (since the 1990s), an explosive growth of household rubbish (since the 2000s), a transition of agriculture to the uninhibited priority of commercial monocultures, especially sunflower, and cucurbits crops (since the 2010s). Approximately since the 2000s, the climate change and steppe fires increase has started to lay upon these economic initiatives.

Problems and expenses of steppe land use accumulated for the preceded historical periods have not been overcome yet in Russia by the present time. These problems can be listed as preconditions of threats to steppe landscapes and inexhaustible steppe management:
1. Prejudice and narrow-mindedness concerning the virgin steppe and its title biological objects as useless landscape elements have remained.
2. Problems and issues of steppe land use are considered irrationally without an understanding of ecological and social consequences.
3. The trend of nature conservation politics, unstable for the last 100 years, with typical "peaks" of increased attention to nature conservation with the subsequent collapse already created territorial nature conservation [12].
4. Limitation to a degree of steppe transformation has not been developed yet; a line of agricultural expansions to unclaimed land resources has been initiated.
5. Virgin zonal steppe was practically wholly lost on the full-profile loamy soils. First of all, the steppe tragedy is a loss of upland (plakore) steppe landscapes.
6. Title biological species of the steppe, the majority of which is rare and endangered species, have suffered to the most degree.
7. The problem of conservation of natural steppe forests, including the age-specific woods, resources of which rapidly decrease and are replaced by aggressive introduced species, has remained.
8. Since the 1960s, resources of the most popular hunting types of game, including waterfowl, have reduced. Also, fish resources considerably decrease.
9. In the Russian Empire, the USSR, and in post-Soviet Russia, the productivity of the principal crops, to a considerable degree, gives place to values of their bioclimatic potential.
10. On the whole, in the steppe zone, soil cost-based way of agriculture has remained; mass degradation of steppe soil and destruction of pedogenic fine material in the course of the systematic erosion has continued; the total bulk of anthropogenic (arable) greenhouse gas emission has increased in the steppe zone.
The remaining inertia of the former steppe management exacerbated by unpredictable climatic changes has continued to form new threats to steppe landscapes. We attempted to systematize diversity as the most significant threat, making difficult or impossible ecological optimization of landscapes. The scheme of our systematization is generalized in the monograph of the author [4].

In Orenburgskaya oblast, this process has its spatial specifics: in the center and the north-west of the region, there are principal agro landscapes characterized by high plowing, a considerable bulk of low productive arable lands, and maximally developed oil production infrastructure. The central part of the oblast, along with the capital of the region, is characterized by similar agro landscapes with the enormous amount of thermal points of gas and oil burning and the complex of ecological problems, the topicality of which is exacerbated by the closeness of the regional center [13]. The extreme south-west and the east of the oblast completely coincide with a definition of a post-virgin land space developed by us. A particular risk of non-irrigated agriculture characterizes these areas. The danger is increased due to climate change, agro landscape development, and a strong influence on the territory by the mining and processing industry.

The principal threats of the natural character are joined with the climate change and differentiated according to sectors of the steppe zone:

- in the European part of Russia, a rhythm of changes and the intensity of humid and arid years with the impoundment of agricultural lands in some regions are broken [14];
- in the Trans-Volga-Urals steppe region, a trend to climate aridization with an increase of droughts' frequency, especially in late spring, is formed;
- in the steppe and forest-steppe zones of West Siberia, there is a trend in climate humidification; the growth of the surface water rate is noticed up to impoundment of agricultural lands and birch outliers.

Economic activity in all sectors of Russia's agricultural zone does not adapt to climate change, leading to catastrophic agrarian-ecological crises. The current steppe zone must be ready for the possibility of dust storms, the scale of which can exceed all storms that had been registered before, including those that led to catastrophic consequences.

On the example of Orenburgskaya oblast, we can separate the following reasons for anthropogenic threats to steppe nature management:

1. Imperfection of land regulation and lack of adequate state institutes supporting optimal agricultural use of lands:
   1.1. Institutional consolidation of the late-Soviet structure of agricultural lands in the course of the land reform. The consequences:
   - in steppe agro landscapes, a part of lands officially recognized as arable is inflated;
   - legislation regulating structural transformations in steppe agro landscapes is absent due to that a rezoning of agricultural lands from arable areas to pastures or mowing is complicated;
   - in the rural areas, territorial planning of the Soviet period, which was subordinated by plans of agricultural production but not objective natural properties of lands and opportunities of their change, has not been revised yet, due to that there is no balance of agriculture and livestock sector as a source of organic fertilizer;
   - a cadastre assessment of arable lands understates its potential productivity in the use of high intensive technologies of agriculture;
   - account of criteria of economic arability is absent in a cadastre assessment.
   1.2. The market situation subordinates the functioning of the institute of spatial land-use planning.
   1.3. The state does not motivate agricultural commodity producers to conserve steppe biodiversity and bioresources, including hunting fauna.
   1.4. Agricultural holding companies are registered out the land use region due to which tax revenue goes to the other areas.
   1.5. Agricultural lands turn into unproductive "pseudo-savanoidea" due to overgrowing of unused lands by single or group forest stand of Chinese elm, sugar maple, silverberry, suppressed kinds of common pine, and others.
   1.6. Tighten regulations to the intended use of agricultural lands promote conserve extensity and soil investment and prevent increasing agrarian culture.
2. Threats conjugated directly with the practice of agricultural production:

2.1. The existing orientation of agriculture has an extensive and soil cost-exhausting character with low actual productivity of crops and maintenance of high gross yield at the expense of large (including low productive) areas under crops. Due to it and the mentioned above (p. 1.6 of the paper):

- soil degradation and a loss of loess-like parent rocks happen;
- the total amount of anthropogenic (arable) greenhouse gas emission increases;
- plowing of new fallow lands, low productive areas become more active;
- sunflowers crops exhausting soil spreads including in soils unsuitable for this culture;
- melon cultivation developed; it always demands to involve new sandy-loam virgin and fallow lands, mainly along river terraces. Melon growing is accompanied by water consumption growth exhausting little and medium rivers in the summer drought season. Accumulation nitrate in soil and littering of lands by polyethylene film or daily waste is also connected with melon cultivation development;
- a spontaneous road network forms.

2.2. Appointed watering places are absent on small rivers and temporary barriers that lead to little river degradation with a decrease of water quality, undermining of fish resources and waterfowls;

2.3. Forage lands degrade due to increased livestock and overgrazing in the settlements' outskirts and undergrazing of remote areas.

3. Threats conjugated with industrial activity:

3.1. Open cut mining leading to a loss of zonal steppe soils and their lithogenic basis;

3.2. Spontaneous mining of small quarries of public natural resources accessible for general use;

3.3. Expansion of technical and road infrastructure in rural landscapes;

3.4. A loss of valuable agricultural lands due to placement of solar power's objects on the best soils.

4. Threats conjugated with vital functions of residential places:

4.1. Withdrawal of valuable agricultural lands for low-rise suburban house building;

4.2. Movement of solid domestic waste by wind and water from unequipped rural dumps to agricultural areas and the river network;

4.3. Unauthorized discharge of solid domestic waste and formation of spontaneous dumps in quarries, ravines, on agricultural lands, forests, and windbreaks, on the banks of water bodies, in the outskirts of the populated locality;

4.4. Reduction of biological resources, first of all, hunting and biodiversity under the influence of stray dogs and cats.

5. Threats conjugated with other use of steppe bioresources:

5.1. After-Kyoto protocol for steppe is absent;

5.2. The principal title species of steppes not having high economic significance are under danger of extinction;

5.3. Unsystematic burn of steppe vegetation;

5.4. Spontaneous construction and destruction of earth dams on small stream flows;

5.5. Poaching and extermination of rare species of vegetation;

5.6. A lack of old-aged forests, degradation of the zonal natural agro-forest amelioration framework, invasion of problem "weedy" arboreal - shrub species.

We consider the ecological threats to steppe nature management and stability of steppe landscapes listed above as an attempt to systematize risks of worsening not only conditions of socio-economic, but the medicine-economic situation in regions of the steppe zone despite depopulation of local inhabitants.

We assume it is necessary to pay special attention to a threat of a loss of steppe soils and their lithogenic basis, which intensifies a carbon sink [15] and deepens the crisis of title biological objects of the steppes. Liquidation or lessening of this threat is the most complicated problem, which acts as the most potent factor for the desertification of the total agricultural belt of North Eurasia. The global mission of grassy turf in the steppe of Eurasia is conservation and preservation as fertile loess-like fine
material accumulated in cryochrons as organic matter held in thermochrons. The cover strata of loess and loess-like rocks, loess-soil bands were collected by the enormous creative work of Nature on the Earth. The most fertile zonal steppe soils – the principal tool of agricultural industry were generated on these strata. Removing the steppe turf in a million hectares to cultivate crops, humans turned into the most powerful destructive geological force. Increased carbon emission and farming that promote climate warming, including in the Arctic, hastens the destruction of loess-ice bodies and methane discharge from them that, in one's turn, increases a tendency to warming [16].

A well-known example of degradation and aridization of the largest loess country on the planet is the Loess plateau in the Hwan Ho river basin. The most ancient agricultural civilization in China had transformed the former forest-steppe country into an eroded and desertified hilly area with fanciful shapes of natural-anthropogenic weathering for four thousand years [17]. On the whole, loess-like loamy soils are the most significant strategic resource of humanity, on an equal basis with oil and gas. First of all, the principal agricultural regions of the world-steppes operate thanks to loess-like loam. Simultaneously, the human's transforming activity has such scales that we can consider the modern epoch as a separate geological period – the Anthropocene [2]. Concerning the grasslands of the world and Eurasian steppes, it is rather the agro-Anthropocene of the steppe as the principal reformer and factor of desertification in the steppe belt of Inner Eurasia is agriculture.

5. Conclusion
The agro-Anthropocene consequences in Steppe Eurasia are the global challenge for stable development in North Eurasia's agricultural regions. Signs of approaching an ecological catastrophe in Steppe Eurasia are as critical reduction of resources of title steppe biological species as three-level loss of fine material due to erosion of various geneses. As a result of extensive and soil-exhausting agriculture, steppe soils of the Holocene formed for thousands of years have vanished. Due to linear water erosion and ravine formation, the loess-like lithogenic basis formed for ten thousand years has been lost. Under the critical erosion, including erosion by wind, there is a danger of liquidation of the loess strata, and loess-like bands had formed during the entire Pleistocene and the Holocene.

A hardly reversible loss of the loess lithogenic basis has a character of a more severe challenge than a loss of soil. If soils are possible to be restored, a loss of the loess-like strata makes soil restoration impossible even in a costly way. It leads to a collapse of the whole areas of agriculture and rural cultures developed on them.

Simultaneously, it is necessary to note that in a line of south-east regions in European Russia, in the post-virgin land Trans-Volga-Urals region, the potential for restoration of soil and biological diversity has remained thanks to peculiarities of the landscape structure and short-term period of plucking of black steppe earth (chernozem and chestnut soil). This process can be noticed in fallow lands and left pieces of land unplowed. It is allotments of such lands which must organize a reserve fund of the forming system of the landscape-ecological framework [18, 19].

A sign of the new epoch in the steppe history - the agro-Anthropocene is a rate of destruction of steppe soils and their lithogenic basis that exceeds soil accumulation rates during the natural processes many times. The climatic description of this epoch in the steppe history is more imbalances of the weather and climate than in the Holocene, more unpredictability of climatic changes with an evident trend to stronger winds as storms, tornados, whirlwinds, etc. These phenomena have already been noticed in the Trans-Volga-Urals steppe region [20]. These agro-Anthropocene features in the steppe resemble, likely, the cryo-arid wind of the late Pleistocene when fine material had been intensively blown out the open surfaces, then deposited on the ground in other climatic conditions.

On the opening phase of the agro-Anthropocene in Steppe Eurasia, we should consider a necessity to preserve and restore turf on the possible vast space of the steppe zone. Besides the cover (protective) function, it would be deposited carbon.

If an algorithm and the steppe nature management model are not changed to preserve turf in the modern climatic changes, humanity will risk losing the steppe itself and the possibility of its restoration.

Based on the results of the previous study by the Institute of Steppe UB RAS, we can conclude that at this stage, there is an opportunity to give an adequate response to the challenge mentioned above.
the agricultural sector of the steppe zone, it is necessary to realize the principle of "long grass," culture of land use with long-term support of steppe turf, to introduce the strategic priority of agriculture in elite soils, pasture, and hunting land use in other agricultural areas, to provide the importance of the system of nature-similar technologies, first of all, soil-preserving in agriculture, to diversify agriculture in the steppe zone. The principal solution of the problem is seen through the development of the innovative industry of agricultural products with a transition from large-scale areas under crops to compact super-productive lands in the open soil, including the format of a system of autonomic megalopolises.

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