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Ways of step-by-step assessments of transformation and dynamics of soils and vegetation functioning in Kazakhstan ecosystems

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Abstract: On the basis of the obtained expeditionary data, the authors performed a comprehensive analysis of the ecosystems' modern transformation in the studied area. In the course of the analysis, the authors found that at the present stage there have been quantitative changes (depletion of natural resources) in used landscapes, along with them, there are changes in qualitative characteristics (accumulation of resources). Now, against the background of vegetation and soil degradation, ways of their restoration are observed. New combinations of degraded and self-recovering ecosystems have emerged. Based on the analysis of the current state of different ecological systems and their relationships, the authors determined the possibilities of the dynamics of their combinations functioning by stages. This will make it possible to give a more reliable forecast of the ongoing processes in the ecosystems of the Republic of Kazakhstan.

Keywords: deposit, ecosystem relations, natural landscapes, spatial combinations, stages, vegetation degradation

INTRODUCTION

A significant amount of information obtained during the research on soil structure and climatic features in the steppe zone of Kazakhstan requires a more thorough assessment of ecosystems at some stages (Ryspekov, 2017). Methods for assessing the functioning of landscapes and their transformation should reveal the presence of contradictions and the reasons that create them. The possibility of obtaining different biological and primary plant mass should be considered as the basis for finding contradictions.

The reasons for the emergence of contradictions with various strengths lie in insufficient knowledge of the relationships between the functioning of landscapes over certain periods. This problem is expressed in the poor knowledge of the functioning of landscapes, their transformation, and further relationships between similar ecosystems in different years in terms of moisture. It is known that the ecosystem of the region should deteriorate annually from the impact of anthropogenic load, but this conclusion is not always true, it is often difficult to calculate quantitative changes in some years. In general, the source of the problem is the practice of obtaining unstable or poorly predictable situations that arise in modern conditions. To solve or explain the practical problem of obtaining stable forecasts, a number of other problems associated with area forecasting must be solved.

Along with the problem, the object of research is also determined, which was not previously considered in relation to the environment. Modern system connections within landscapes, their transformations and further relationships between similar ecosystems require constant analysis. The work by Delibas, Tezer and Bacchin (2021), related to the field of soil function, highlights the ability of soil to mitigate the effects of climate change.

Scott *et al.* (2018) in their paper develop a framework for better incorporating ecosystem science into policy and decision making in the context of spatial planning. With the use of new structural-dynamic analyses of used and unused lands, it became possible to study more thoroughly the patterns of vegetation and soils functioning of these ecosystems, their development dynamics over time.

Therefore, the bulk of published works on the state of ecosystems affect their degradation. So the work of Akiyanova *et al.* (2014) states: "Moreover, most of the territory with a significant degree of desertification is typical not for natural deserts, but for dry steppe and steppe zones due to the development of negative processes (deflation, erosion and salinisation) within arable lands". The work of Gunin *et al.* (2014) analyses the issues of simplifying the structure of the steppe communities of Mongolia due to the decrease in species diversity and the abundance of indigenous dominants – turf grasses, up to their complete loss from herbage composition.

A similar situation with plant communities is also described by Zakaryan (2008) who compares the vegetation of natural grasslands in 1946 and their change 60 years later. During this period, the composition of the fescue-feather grass steppes has been transformed. Zakaryan (2008) currently did not find any fescue-feather grass community in the study area.

The soil-vegetation area is considered a spatiotemporal unit that has integrity, hierarchy, structure (relationship between components), functioning, and stability of the ecosystem.

For many territories, the methodology of such a study is the basis for studying the ongoing changes from the anthropogenic impact between components and between ecosystems. So Alimaev (1989) mentions that in Kazakhstan, there are about 10% of pastures that have been desolated, and on 50% of the pasture territory, fodder vegetation is degraded (littered with inedible and poisonous plants).

It should also be noted that most of the information requires cartographic design. For this purpose, the results of aerospace monitoring with the compilation of thematic maps are widely used. The same point of view is followed in the work by Szostak, Bednarski and Wężyk (2018). The authors of the other work by Basova *et al.* (2014) note the same relevance.

The study of the initial data of spatiotemporal relations, which are the background for any comparisons in determining changes, is the main link. They are necessary when conducting a comprehensive study on the transformation and dynamics of ecosystems. Changes in the long-term and spatial volume will necessarily lead to the identification of new patterns in the functioning of ecosystems.

Also, it is necessary to show the transformation of geographical categories into agronomic ones, where the cultural soil-forming process takes place. When transforming a natural landscape into an agricultural landscape, changes in energy and mass transfer should be taken into account in its entire structural and functional hierarchy (Ryspekov, 2017; Scott *et al.*, 2018; Delibas, Tezer and Bacchin, 2021).

In this regard, a comprehensive analysis of information obtained in the course of the expeditionary research and monitoring of data allows us to make predictive conclusions. They, in turn, are necessary for the active regulation of natural processes in the future.

The purpose of this work is to give an analysis of the current state of ecological systems on the basis of previous expeditionary observations, as well as current studies of the territories, to show the possibility of an accurate assessment of the dynamics of the functioning of their combinations by stages.

To achieve this goal, the following tasks have been set:
- to describe the ways of qualitative functioning of soil and ecosystem as a whole on the basis of the vegetation's development degree on them;
- to show the ways of interaction probabilities on models of currently unused territories with territories of anthropogenic impact at various stages;
- to show options for estimating the frequency of combinations of modern ecosystems according to their functioning after a change in anthropogenic load.

MATERIALS AND METHODS

The newly formed relationships of ecologically transformed objects of nature need a scientific explanation. The most suitable methods are comparative and historical. To establish the cause of vegetation change in unused territories, we used literary, statistical and expeditionary data.

Now the main objects of study are spatial relationships. In these areas, vegetation develops differently depending on the intensity of soil use. Since the number of different orders of natural, anthropogenically modified and newly restored ecosystems with new boundaries have increased. Transitional (contact) zones are formed and function as ecosystems, with newly formed interconnections and interactions. Such ecosystem functions are explained on the basis of the ecosystem approach. These functions are interdependent on geographical and ecological phenomena in space for a certain time of existence.

In the methodological plan for this work, information data on earlier expeditionary observations were used. Previous expeditionary observations were from 1984 to 1992 and from 2002 to 2005, we also used information data from current territory studies for the period from 2015 to 2020.

Based on expeditionary observations over a number of years, the authors determined the stages of step-by-step change in the landscapes of the Republic of Kazakhstan, which are structured and summarised in a table (Tab. 1).

Table 1. Scheme for studying the stages of landscape change in the Republic of Kazakhstan

Research stage variant	Main spatial condition
Stage 1 (from 1984 to 1992)	characterised by intensive use and degradation of natural vegetation of biogeocenoses
Stage 2 (from 1992 to 2002–2005)	characterised by a reduction in load and changes in former arable lands, pastures and hayfields, which differ both in the composition of vegetation and in plant residues on the surface
Stage 3 (after 2002–2005)	characterised by changes that occur with the constant use of soils; also, stage 3 is characterised by changes that have recovered to the quasi-primary state of the plant composition on landscapes

Source: own elaboration.

Scott *et al.* (2018) believe that ecosystem science is being promoted as a collective umbrella encompassing the body of work and approaches rooted in socio-ecological systems.

Cowell and Lennon (2014) suggest using methodological approaches that better combine and integrate competing theories and ideas. That is, they emphasise the importance of such approaches, and not those that create even more complexity and competition. Delibas, Tezer and Bacchin (2021) note that: "While a large amount of research has been done related to soil, climate change, and spatial planning, research on their complex interactions is limited".

In this regard, the authors propose a methodological approach, which, according to them, most fully combines and integrates competing theories and ideas at the present stage of ecosystem research. If we designate the natural ecological combination of components and complexes of the region as $E0$, then we can show the directions of their changes. With the beginning of the interpretation of temporal-spatial plant formations, data of natural formations are included, which can be denoted by $A0$, regardless of resistance to influences. Anthropogenic changes in vegetation, soils and the environment should be denoted as $B1$, which includes all changes in objects that have occurred from pasture load. The next more severe change is arable land for the cultivation of crops and we will denote them by the number $C2$. Residential areas, areas with excavation, and artificial embankments will be denoted by the number $D3$.

Natural territorial formations from year to year decreased in area from 1955 to 1992. This is formed according to the formula:

$$E0 = A0 - B1 - C2 - D3 \tag{1}$$

The developed spaces have been increasingly transformed over time, forming modified ecosystems (EI), according to the formula:

$$EI = B1 + C2 + D3 \tag{2}$$

The authors propose to study the degradation of soils and vegetation as a background cause for determining spatiotemporal combinations of self-recovering ecosystems. It should be noted that this approach of studying territory has no analogues and is pioneering since it is based on spatial observations of the state and changes in the landscapes of the Republic of Kazakhstan at key points of the stages that were carried out by the authors of this article. A stage-by-stage assessment of the transformation of ecosystems and their functioning dynamics can be studied by the presented method in other countries of the post-Soviet space. The proposed research methodology is adaptive and applicable to other similar cases of ecosystem transformation.

RESULTS

CAUSES OF LANDSCAPE DEGRADATION AND THEIR CHANGES

The authors conducted several scientific expeditions across the territory of Kazakhstan. In 1984–1985 mountainous and foothill territories were surveyed: Ile Alatau, Chu-Ili mountains. The routes of the scientific expedition passed from the foothills to desert grey-brown soils on the border with lake Balkhash. Between 1986 and 1992 kastanozems and chernozems of Northern Kazakhstan were examined. During the expeditions, the material was visually collected on the state of vegetation in these territories.

The first stage is characterised by constant human involvement of territories for using plant and soil resources. A model of a natural landscape converted to anthropogenic in pastures is shown in Figure 1, where the most affected components – biome, soil, surface and groundwater are associated with the rest of the more stable components of the landscape. The arrows indicate the interrelationships of natural components (red indicates strong, green indicates medium impacts).

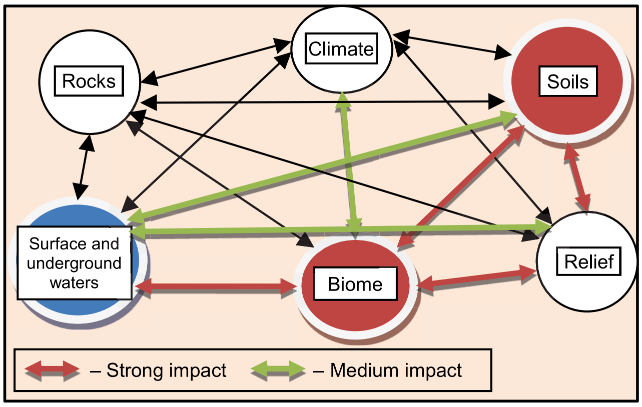

Fig. 1. Scheme of landscape functioning, systemic connections within landscapes, relationship of natural components; source: Chigarkin (1995), modified

At the same time, different ecosystems changed in different ways. The degree of decrease in vegetation degradation and soil erosion occurs with distance from the sources of impact.

We paid attention to changes in the area of arable land and the number of animals in the study area and in the Republic for the years after 1992.

In view of the foregoing, we will further note the changes in the agricultural load on pastures in the Republic of Kazakhstan. The statistical collection Agentstvo po statistike RK (2019) provides data on the number of cattle in the Republic of Kazakhstan (Tab. 2).

If we compare the numbers of large cattle and small cattle in 1990, we will understand why temporary natural territories appeared on former pastures (Tab. 2). That is, this is due to a reduction in pasture load and the beginning of the restoration of vegetation on them.

FORMATION OF NEW TEMPORARY NATURAL LANDSCAPES

Between 2002 and 2005 the authors studied the processes of vegetation restoration. Observations were carried out in the mountainous and foothill regions of south-eastern Kazakhstan. The brown soils of the semi-desert zone of Central Kazakhstan were studied. Based on the results of observations and comparison of territories, used arable lands, pastures and adjacent complexes, the state of the territories was determined in the second stage. This period is characterised by a sharp reduction in the anthropogenic load. At the same time, stage two is the functions of temporary natural landscapes that have arisen for the

Table 2. Dynamics of the number of large and small cattle (thous.) as a factor in restorative successions

Year	Large cattle	Reduced by (times)	Change regarding maximum	Small cattle	Reduced by (times)	Change regarding maximum
1990	9,757.2	–	–	35,660.5	–	–
1998	3,957.9	>2	5799.3	9,526.5	3.7	26,134.0
2016	6,413.2	1.5	3344.0	18,184.2	2	17,476.3
2019	7,522.6	1.3	2234.6	19,419.9	1.8	16,240.6

Source: own study based on Agentstvo po statistike RK (2019).

timeframe from 1992 to 2002–2005. Plots on former arable land differ both in the composition of vegetation and in plant remains on the surface.

The second stage is characterised as the period of the beginning of plant diversity's restoration in communities. During the first years of arable lands' non-use, harmful and poisonous plants predominate in the fields.

From observations, the authors made the following conclusions: the end of the second stage can be characterised as the formation time of the quasi-root state of the plant composition. However, they are all preceded by intermediate stages of plant development, which are characteristic of each soil-climatic zone.

Starting from 1992, natural territorial formations have ceased to decrease, that is, modified ecosystems (*EI*) has decreased by 2–4 times. Then, from year to year, self-healing territories began to appear. According to the data (Tab. 2), the beginning of the natural restoration of vegetation and soils will be expressed as:

$$E0 = A0 - \frac{B1 - C2 - D3}{2 - 4} \tag{3}$$

The knowledge systematisation about the developed lands is carried out regularly. For example, data on vegetation cover transformation as the pasture load increases are given in the work of Kaysagaliyeva (2001). In this article, the authors used the method proposed by Kaysagaliyeva (2001) as a background pattern of vegetation degradation for our work.

According to the forecast of vegetation cover transformation, as the pasture load decreases or ceases, the content of this newly functioning territory will be built in the opposite direction by Ryspekov (2015) (Tab. 3).

The natural vegetation of these territories has changed in composition over the years. The transformation of the vegetation cover on former arable land is completely different due to agrotechnical measures than on pastures and meadows.

MODERN COMBINATION OF ECOSYSTEMS ON LANDSCAPES OF A VERY DRY STEPPE

The time aspect in the study must be taken into account for the post-Soviet period, when unused fields, meadows, pastures and their associations appeared. For the period from 2015 to 2020, we observed the condition of plants over a large area. The path of the expeditions ran from the northern slopes of the Iliysky Alatau to the northern borders of ordinary chernozems. We noted that a new spatial situation is emerging on the territory of Kazakhstan, which should be singled out as the third stage. These are combinations of new ecosystems on landscapes. At the same time, the third stage is the accounting of the permanently used and temporarily restored natural landscapes after 2002–2005.

The proposed method for evaluating new combinations of soil and vegetation areas is recommended taking into account their impact on the environment. This influence depends on the amount of diversity of the state, and the volume of territories. An increase in combinations increases the dynamics of ecosystem functioning. Such an assessment will reduce the unpredictability of the behaviour of some natural disasters, for example, the possibility of locust accumulation, snow accumulation, and others.

So in the work of Kurbatova and Tarko (2012) a mathematical model of the global carbon cycle is shown and the problem of offsetting carbon dioxide absorption by countries in the Kyoto

Table 3. Forecast table of vegetation cover transformation as pasture load is reduced or terminated for fescue kinds on meadow-kastanozem soils

Time of pasture load's absence	Stage and characteristics of the transformation of vegetation of phytocenoses
"Failure" – zero term	1st stage; the surface is devoid of vegetation, occasionally knotweed is found
Short term	2nd stage; the role of rhizomatous grasses decreases, turf grasses appear in the herbage, forked *Potentilla bifurca* drops out
Moderate	3rd stage; layering appears; not all plants are concentrated in a layer of 5–10 cm, the role of rhizomatous grasses decreases
Significant	4th stage; the top layer is being restored; alfalfa and bedstraw appear in herbage
Long	quasiclimax; restoration of natural composition and structure

Source: own elaboration based on Ryspekov (2015).

Protocol is considered. We see that temporary landscapes absorb CO_2 from atmospheric air and synthesise plant mass. Vegetation in these landscapes changes step by step to the level of natural cenoses. Here every year the organic mass in the soil and on its surface increases. As we can see, the consequences of changes in agricultural pressure are changes in the composition of vegetation and improvement in the functioning of soils in these areas. Further, these changes in the composition of vegetation lead to changes in soil functions in these and adjacent territories. Therefore, a new method is proposed for taking into account the actions in a certain space of a combination of such ecosystems. Since in recent years, there has been a positive trend in the development of "reserve lands" for agricultural and other uses. For example, in 2005–2017, the area of "reserve lands" decreased by 28.5 mln ha.

Hence, it is necessary to take a new approach to assess the functioning of the territories at the third stage. Many agricultural lands have been used for over 30 years. Some of them are temporarily in natural conditions, which can be reused at any time. It should be borne in mind that temporary natural landscapes differ from "deposits" by the period of non-use. For example, individual fields with perennial grasses have reached the age of 30 years. They can occupy large or small areas, and in comparison with natural areas, they are characterised by the absence of sod, various groups of vegetation, and improved aggregate composition of the soil. The area of projective soil cover by plants on formerly arable lands reaches 50–60, 70–90%.

Figure 2 shows the features of unused landscapes. We characterise the functional place of temporarily natural landscapes in the currently valid facts:
- reduction of water and wind erosion;
- soil structure is restored under natural vegetation;
- the supply of above-ground and underground plant mass is growing;
- precipitation water is more absorbed and stored in the soil;
- soil biodiversity increases;
- options rise for alternating the use of territories for agricultural needs.

The functions of unused landscapes were studied in detail on kastanozem soil. We observed their connections between the components, the fields used and the environment on the territory of the Arkalyk experimental station. We attribute such a situation

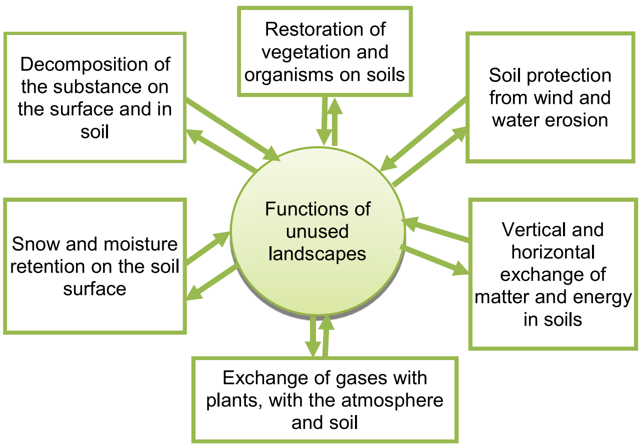

Fig. 2. Scheme of the unused landscapes' function and their relationship between the components and the environment; source: own elaboration

as protection of soil from wind and water erosion to the function of unused fields. After the beginning of deposits' usage, the effect of soil mulching is observed. We can present this in the Photo 1 after tillage with a flat cutter.

Photo 1. The field after tillage with a flat cutter as a way to protect soil from wind and water erosion, the effect of soil mulching
(phot.: *T.R. Ryspekov*)

As climatic conditions worsen, the role of temporary natural landscapes increases. That is, the lower the stability of the ecosystem, the higher the role of self-restoring vegetation on these landscapes. The least degraded and the most restored territories in terms of vegetation are located in places remote from large settlements. In their work, the authors Delibas, Tezer and Bacchin (2021) present the mainstreaming of ecosystem science in the practice of spatial planning using a hybrid opportunity.

MODERN LANDSCAPE DYNAMICS (MATHEMATICAL MODELLING) OF THE SUBZONE OF KASTANOZEM SOILS IN THE SOUTHERN PART OF KOSTANAY REGION

Expeditionary research in the intervals from 2005 to 2019 showed that part of the unused territories again began to be involved in agricultural production.

For the period of intensive development of landscapes until 1992, geosystems consisted of conjugated areas:

$$A0 + B1 + C2 + D3 \tag{4}$$

where: $A0$ = natural formations' data, $B1$ = all changes of the objects due to grazing load, $C2$ = arable lands for crop cultivation, $D3$ = residential areas, dredging areas, artificial embankments.

There the frequency of location of the used objects and their functioning were taken into account. This was the main background for the combination and functioning of landscapes. Now from 1992 to 2001 the number and space of the territories used have decreased.

That is, in the same space, a self-restoring part of the "soil-vegetation" system was added on pastures, arable lands, and man-made areas:

$$B1_c + C2_c + D3_c \tag{5}$$

where: $B1_c$ = self-recovering part of the "soil-vegetation" system in pastures, $C2_c$ = self-recovering part of the "soil-vegetation" system in arable land, $D3_c$ = self-recovering part of the "soil-vegetation" system in man-made areas.

Their total functioning after the termination of the load (Z) is denoted as:

$$Z = B1_c + C2_c + D3_c \tag{6}$$

The beginning of new combinations and new functions of landscapes have become altered ecosystems, which can be expressed by the formula:

$$EI_c = B1 - B1_c + C2 - C2_c + D3 - D3_c \tag{7}$$

These new used ecosystems (EI_c) appeared in 1992, increasing until 2001, which indicates new stages in the functioning of many associated ecosystems. Therefore, it is necessary to take into account the frequency of location of used (A), self-restoring (Z) objects in a new way. If there is an anthropogenic load on the territory, then:

$$A = B1 + C2 + D3 \tag{8}$$

and after the termination of the load in some areas:

$$EI_c = A - Z \tag{9}$$

As we observed in field expeditions, after the appearance of self-healing areas, the process simultaneously occurs:

$$B1 - B1_c \tag{10}$$

It turns out that the new site occupies part of the pasture or the entire pasture. That is, a combination of $B1_c$ of different sizes appears in the area. The same thing happens in areas with arable land:

$$C2 - C2_c \tag{11}$$

where: $C2_c$ has different values over the area.

It should be borne in mind that the more $B1_c$ and $C2_c$, the less $B1$ and $C2$.

Due to changes in the size and time of operation of the plots, a new background of combinations in the landscape ($B2$) can be designated as follows:

$$B1 - B1_c \text{ mark as } B2, \text{ meaning } B2 = B1 - B1_c \tag{12}$$

Same in the next case $C2 - C2_c$ we can mark the value as $C3$, which is new functioning of smaller by area arable plots in the landscape:

$$C3 = C2 - C2_c \tag{13}$$

At present, both the space and the time of existence of natural-anthropogenic combinations play an important role in a correct assessment of the occurring situations on any studied landscape. Alternation of $B1$, $B1_c$, $C2$, $C2_c$, $D3$, $D3_c$ creates diverse dynamics of the functioning of the natural environment.

To assess the role of plants and soils in new spatio-temporal combinations, it should be taken into account that the largest territories were allocated for pastures. This leads to the greatest spatial and temporally diverse combinations of $B1$, $B1_c$, $B2$. All areas of the steppe zone, which were inconvenient for cultivating crops, were allotted for pastures.

It should also be taken into account that according to Jaiymbetov *et al.* (2016), kastanozem soils have an area of 20,650 thous. ha, of which 10,196.6 thous. ha are agricultural land, and 1,785.6 thous. ha of area are arable land. These combinations can be predicted by comparing the same indicators by area of use for 1992. Then we will find new combinations for $B1$, $B1_c$, $B2$, $C2$, $C2_c$, $C3$ and describe phenomena and processes using mathematical or natural models of ecosystems.

MODERN SYSTEM CONNECTIONS WITHIN THE LANDSCAPE DURING THEIR TRANSFORMATION ON KASTANOZEM SOILS OF THE ARKALYK AGRICULTURAL EXPERIMENTAL STATION (AAES)

We recorded vegetation on pastures and fields of AAES not used for arable farming. For example, Photo 2 shows natural vegetation where wheatgrass from neighbouring crop plots is found. Plants, which are located on the surface of the soil in spots, have a difference in botanical composition. This emphasises the presence of areas with a high salinity of kastanozem soil and the presence of solonetzes. The vegetation consists mainly of *Artemísia*, *Leymus ramosus*, *Bassia scoparia*, *Festuca*, *Stipa* and other plants. The projective cover of the area is about 60–80%. The function of the soil in natural conditions in any year, at

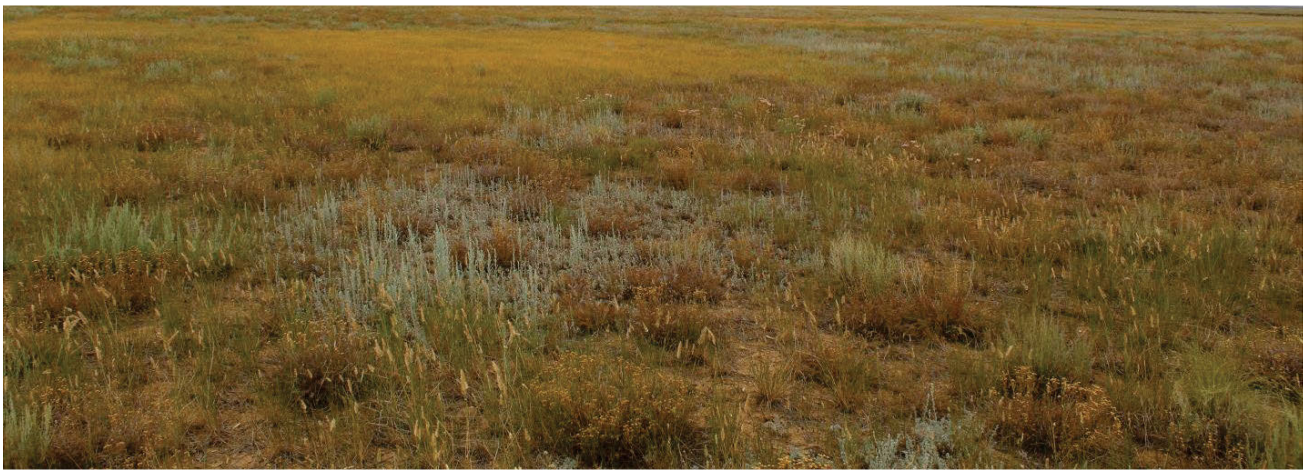

Photo 2. Self-restoration of vegetation in the area of the former pasture ($B1_c$) subzone of kastanozem soils (phot.: *T.R. Ryspekov*, *M.A. Balkozha*)

different frequencies of precipitation and temperature jumps, is synthesising phytomass.

Also, in order to assess the change in the state of the former arable kastanozem soil, we made an inspection of the vegetation in the middle of summer. To assess the change in $C2_c$ of kastanozem soil, the authors of this article, during the period of expeditionary observations, dug up the soil in the middle of summer on the former arable land. The vegetation shown here has developed naturally on the soil (Photo 3), it is a field without cultivation for more than six years. Vegetation over 60–70 cm high was observed in *Erysimum cheiranthoides*, for *Sonchus arvensis* – up to 60–70 cm, and *Bassia scoparia*, – from 10 to 60 cm. *Convolvulus arvensis* was observed in significant numbers. *Lactuca serriola* was from 10 to 60 cm tall. Projective cover area (S) was 50–60%.

Photo 3. Reflection of the soil-plant systemic relationship ($C2_c$) (phot.: *T.R. Ryspekov*, *M.B. Balkozha*)

The Photo 3 clearly shows the presence of roots, above-ground litter, density and height of vegetation. If such territories are involved in agriculture under arable land, the vegetation replenishes the organic matter of the soil. These sites change the functions used to receive products.

In autumn, in this field with vegetation that has been growing here for more than six years, a soil section was dug up to a depth of 110 cm (Photo 4). Carbonates are visible at depth on the front wall of the soil section. There is a horizontal layer of gypsum deeper than 90 cm. In the photograph, it is a white strip of crystalline gypsum up to 2 cm thick. Gypsum goes with carbonates in streaks from 90 to 110 cm and deeper (Photo 4).

Photo 4. Structure of kastanozem soil ($C2_c$) (phot.: *T.R. Ryspekov*)

During the annual use of the soil, the upper part was looser, and less structured soil than it is now. This is a 0–20 cm layer of soil that was under cultivation, grey, homogenised, loose, moist, with plant roots. The soil layer from the surface to a depth of 5–7 cm has become more structured than before. That is, the options for pairing $C2$, $C2_c$, and $C3$ in terms of spatial and temporal combinations both among themselves and with other objects will be more dynamic than combinations with pasture areas.

With a long time of no load, self-developing landscapes approach the root state $B \geq A0$. In this case, the natural ecological combination of the components and complexes ($E0$) of the subzone will be aimed at restoring the former changes.

$$E0 = A0 - B2 - C3 - D4 + B \tag{14}$$

where: $D4 = D3 - D3_c$.

At the same time, different ecosystems changed in different ways depending on internal and external relationships.

DISCUSSION

According to the authors, Kazangapova *et al.* (2017), land degradation is observed in a large area of the Republic of Kazakhstan, that is, the process of depletion of ecosystems through the loss of soil fertility and biomass productivity.

We believe that they should consider temporary natural landscapes. In their work, Yu *et al.* (2019) note that after the collapse of the former Soviet Union in 1991, a huge area of agricultural land was abandoned. This has changed landscapes and water cycles over a large area (Yu *et al.*, 2019). Yu *et al.* (2019) believe that the identification of spatial and temporal patterns of land use change in the future may allow for a better balance of regional development. As we see from this work, a direction, such as ours, attracted the attention of Yu *et al.* (2019) earlier. Zhang *et al.* (2018) provide an analysis by vegetation. They confirm the ongoing restoration processes of vegetation on territories that we study.

Zhang *et al.* (2018) correctly allocate the spatial scale of the "recovery project" of the study areas. As we understood from the scientific article of these authors, the study was preceded by the scientific processing of literature data, which formed an approach for studying the spontaneous restoration of the steppe on abandoned arable lands. Jiang *et al.* (2019) associate vegetation with climate change, i.e., the decrease in vegetation is considered to be associated with an increase in dryness in the region (Jiang *et al.*, 2019). The authors come to the same conclusions that we made on the basis of expeditionary and field experiments – summer and remote pastures were abandoned, and overgrazing was facilitated in these areas.

Basova *et al.* (2014) write about the development of landscapes under desertification. However, works on landscape-based zoning will not be complete if the areas of temporary natural landscapes are not taken into account.

Such situations and combinations of similar territories are also noted in Russia by Lashchinskiy, Tishchenko and Korolyuk (2019). We believe that this work is suitable for characterising local areas.

Chibilyova *et al.* (2015) describes the value of ecosystem services. The authors do not estimate the cost of restoring the soil structure, as well as the accumulation of biomass in these areas. Lazarev and Vinogradov (2008) write about the degradation of forage lands in Russia and the overgrowth of natural and old sown meadows.

The article by Kuznetsov (2021) shows a fallow that was studied for the carbon content of microbial biomass in comparison with other sites. Popov, Rusakov and Simonova (2021) compare the data of arable land and arable land that has been in fallow land for 40 years. Szostak, Bednarski and Wężyk (2018) state: "More than three times as much forest and the wooded area was found in the study area than was recorded in official databases."

Han *et al.* (2021) believe that the succession of vegetation significantly affects the physicochemical properties of the soil and, consequently, its quality.

Authors of the work by Podgornaya *et al.* (2021) write about a fallow area. Similar attention is paid by the authors of Dobryanskaya (2020), Ryspekov *et al.* (2021). Now the combination of fallows and crops is given in the work by Trubnikov *et al.* (2019).

Delibas, Tezer and Bacchin (2021) write that the interaction between spatial planning and ecosystem science is explored as a theoretical space. The study of Khorchani *et al.* (2021) confirms the need to consider continuity after abandoned lands for water conservation.

Rozenberg (2014) writes: "A more detailed description of some ecosystems, their services, and general assessment problems can be found in 'Nature's Services' ". Delibas, Tezer and Bacchin (2021) write about soil ecosystems, about how little attention is paid to them. Delibas, Tezer and Bacchin (2021) state: "…the ongoing lack of global cooperation in soil research and the lack of a comprehensive and consistent set of soil management rules put soils under increasing threat".

An analysis of the listed works of authoritative authors allows us to conclude that the interaction of ecosystems with unused territories has been little studied. In many articles and scientific directions, there are no interpretations for new combinations of ecosystems. Most of the works give a conclusion about the widespread degradation of vegetation and soils. Quite recent publications provide comparative data on long-term fallows with arable land. There is no information about the succession stages in these fields. There are no articles showing how the functions of unused landscapes are reflected in the environment.

That is, in many studies, there is no complete picture of the state and changes in landscapes. This is because now many studies are of a stationary nature, and expeditionary studies of territories are not enough.

We have received visual data from all the studied territories during expedition trips. Comparative data on the vegetation of mountainous and foothill areas are clearly expressed. In many places the pastures looked like mowed lawns. Other territories were deprived of the main vegetation, but only those that were not eaten and little eaten by cattle grew well.

Therefore, we have proposed objects, both under anthropogenic load, and after the termination or reduction of the load. Now part of the territory is characterised as self-developing landscapes for a long time (*B*). The functions of these territories and their interconnections between the formed *A–Z–B* and *A–B* ecosystems have distinctive dynamics. This is expressed in the form of a new method, which is to evaluate the functioning of combinations of different territories. This approach is very important when comparing information data obtained at different times from satellites, aircraft and other remote methods.

CONCLUSIONS

It is necessary to strive for using new soil and plant combinations in landscapes to assess the ecosystems' functioning. To assess the ecological qualities of the landscape, it is necessary to compare self-restoration, if possible, with areas close to the natural (primary) state. At the present stage, the water and air basins of these objects have quantitative material relationships. The dynamics of these objects differ from the period that was before 1992. The given functions of unused landscapes and their connections between the components and the environment, which are long in time and in area, are very important. The modern transformation of territories, their dynamics and stages will make it possible to give a more reliable forecast of the ongoing processes in the territory of Kazakhstan. This line of research makes it possible to create new approaches to fixing gradual changes in ecosystems in the countries of the Commonwealth of Independent States (CIS). In other CIS countries for ecological systems there is a possibility of improvement and also formation of worse ones. It should also be used in this way by compiling assessment-inventory, geoecological, soil and plant maps.

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