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RESTORATION OF ABANDONED LAND IN THE REPUBLIC OF TYVA

Research article

Abstract

Due to the fact that the Republic of Tyva is agrarian, animal husbandry is mainly developed, the agriculture has a short history. Studies on the self–restoration of abandoned arable lands were carried out at 5 key sites. It is revealed that self–restoration of abandoned agricultural lands after plowing proceeds naturally and deterministically. In the conditions of the sharp continentality of the climate of Tuva, with a lack of water at the I – initial stage of succession (0–4 years), weeds dominate in the plant cover of key sites. At the II – intermediate stage of succession (4–7 years), an absolute predominance of weeds is observed in the vegetation cover in all the key areas studied, but also the emergence of dominants of the native steppes. At the III – intermediate stage of succession (7–11 years) in all the studied key sites, the types of indigenous steppes become dominant. At the VI – late stage (11–25 years), terminal communities with typical combinations of species for each subtype of the steppe develop in the vegetation cover.

Keywords: agricultural lands, arable land, self–restoration, dominants, Republic of Tyva.

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ВОССТАНОВЛЕНИЕ ЗАБРОШЕННЫХ ПАШЕН В РЕСПУБЛИКЕ ТЫВА

Научная статья

Аннотация

В связи с тем, что Республика Тыва аграрная, в основном развито животноводство, земледелие имеет небольшую историю. Исследования по самовосстановлению заброшенных пашен проводились на пяти ключевых участках. Выявлено, что самовосстановление заброшенных сельскохозяйственных угодий после распашки протекает закономерно и детерминировано. В условиях резкой континентальности климата Тувы при недостатке влаги на I – начальной стадии сукцессии (0–4 года) в растительном покрове ключевых участков доминируют сорные растения. На II – промежуточном этапе сукцессии (4–7 лет) в растительном покрове всех залежных ключевых участков наблюдается абсолютное преобладание сорных растений, но и появление доминантов коренных степей. На III – промежуточном этапе сукцессии (7–11 лет) на всех исследуемых участках в доминанты выходят виды коренных степей. На VI – поздней стадии (11–25 лет) в растительном покрове развиваются терминальные сообщества с типичными сочетаниями видов для каждого подтипа степи.

Ключевые слова: сельскохозяйственные угодья, пашни, самовосстановление, доминанты, Республика Тыва.

1. Introduction

The Republic of Tyva is located in the south of Russia, in the central part of the Asian continent. The total area of the republic is 16860.4 thousand hectares. The relief as a whole is mountainous with height fluctuations from 520 to 3970 m, as a result of which there is a large landscape heterogeneity of the territory. According to the predominance of certain landscapes, the territory of Tuva belongs to two latitudinal geographical zones of Eurasia: taiga–forest and steppe [1]. The manifestation of latitudinal zonality is expressed in intermountain basins located at approximately the same hypsometric levels. The basins are occupied by flat, the wavy hills and low–mountain relief elements, including low foothills along the edges of the basins. The territory of the republic, developed in agricultural terms, is divided into dry–steppe, steppe and forest–steppe natural and climatic zones according to natural and climatic conditions. The climate of the depressions is characterized by the greatest degree of contrast. Low–snow winters, hot and dry summers, a large amplitude of absolute and daily temperatures are characteristic features of the climate of the depressions. Thus, the average temperature in January in the basin is minus 28–35°C, July 15–20°C, the average annual temperature is minus 3.7°C. The amplitude of extreme air temperature values for the year is 82–90°C, the amplitude of extreme temperature values on the soil surface is 118°C. Frost–free days last about 180 days. The annual amount of precipitation is small – it varies from 150 mm to 300 mm per year, while droughts and dry spells are often repeated, the hydrothermal coefficient (GTC) ranges from 0.4 to 1.0. The height of the snow cover is 10–20 cm.

In Russia, from 1990 to 2010, there was a reduction in agricultural land by 22.1%. The total area of abandoned fallow lands in 2003 in the country was 44,400, in Western Siberia – 4,550, and in Tuva – 2,034 thousand hectares, which corresponds to 56.9% of the former agricultural land fund in Tuva in 1990 [2], [3].

The objects of research were abandoned arable land, which was previously a native steppe.

The aim of the study is to study the stages of self–restoration of abandoned arable lands of Tuva, where there were previously native meadow, true, dry and deserted steppes.

2. Materials and methods of research

Five different deposits of the same origin were selected for the study. Wheat was previously cultivated on plots, and its crops were discontinued at the same time in 1994 near the deposits there were native steppes that were partially plowed, and their plant communities were terminal ecosystems in relation to the deposits. The deposits are located in three intermountain basins (table 1), which represent a range from wet to arid habitats (table 2).

Table 1 – Characteristics of research areas

Location	Coordinates	Height above sea level, m	Annual precipitation, mm	Average annual temperature, °C		
				year's	January's	July's
Northern part of Tuva	50°12'59"N 94°49'54"E	700–1100	300–400	–3,7	– 30,0	18,0
Central part of Tuva	51°12'34"N 94°17'48"E	520–1000	250–350	–4,5	–33,7	19,6
The southern part of Tuva	51°59'55"N 93°41'54'E	1000–1250	180–250	–5,7	–31,5	17,7

Table 2 – Characteristics of the studied sites

Location	The initial step	Soil	Number of species per plot (per 100 m^2)
The sub–mountain plain of the Uyuk ridge (site Hkadyn)	Meadow steppe is the most mesophilic variant of Tuva steppe vegetation	chernozem ordinary	72
The foothill plain of the Tannu–Ola ridge (site Mezhegey)	True steppe	chernozem south	54
The foothill plain of the East Tuva Highlands (site Kundustug)	Dry steppe 1	chestnut average capacity light loam	34–27
Intermountain depression (site Bizhiktig–Haya)	Dry steppe 2	Light-chestnut Low-power gravelly	25
The Foothill Plain (site Kurgalchy)	Deserted steppe	Chestnut low-power sandy	28

A full description of the species composition of communities with the allocation of dominants by weight method was carried out in early July for the 4th, 7th, 11th and 25th years of the uprising (1997, 2000, 2004, 2018, respectively).

A species was considered dominant if its share in the aboveground living phytomass (G) reached >10%. At the same time, samples of aboveground phytomass (live and dead) and underground organs were taken with the division into living and dead.

The studied recovery process was divided into four stages: the initial stage of restoration (0–4 years), and the first intermediate stage (4–7 years), second intermediate (7–11 years), later (11–25 years) stages.

3. The research results

Due to the fact that the studied key areas of fallow lands differed in hydrothermal regime, species composition of plant communities and the amount of species, it was assumed that the process of self-restoration of abandoned arable lands would proceed at different speeds. For the study, we selected several parameters to characterize the course of succession: a change in the amount of species in the plant communities of foreign lands; a change in the amount of weed species as a percentage of the total amount of species; a change in the proportion of xerophytes and terminal species; a change in the dominant species;

changes in various life forms of terminal species; changes in the structure of phytomass of 25-year-old deposits and in the native steppes of Tuva.

The research results showed a sharp increase in the II intermediate stage of succession. The number of plant species at this stage increases in all fallow areas by 2–3 times. In the course of self–restoration of abandoned fallow lands, there is a difference in the parameters of all indicators of real and desolate steppes. In the areas of the Khadyn and Mezhegey sites, where the original steppes are characterized by high species diversity, the amount of species increases by 20–30% over 7–11 years. In areas where there were previously dry steppes, only 1–2 species are added. A section of Kurgalchy (site of deserted steppe) is allocated, where 20% of the amount of species appears in the 11th year over the last period.

Consequently, a general trend has been revealed – a sharp increase in the number of species over 4–7 years.

In the course of fallow succession, the number of weed species of both 1–2 year olds and perennials decreases. For four years during in the second intermediate stage of restoration, the number of weeds is reduced by an average of 2 times in all communities. Most intense hair loss weed species typical for deposits on the Mezhegey site (native the true steppe) is a reduction in 2.5 times – and in the Kurgalchy site (site of deserted steppe) – reduction of 2.7 times. Along with 1–2–year–old weeds, the number of perennial weed species has decreased sharply in these deposits in the grass stands: from 6 to 1 in the Mezhegey site, from 5 to 1 in the Kurgalchy site.

So, the simultaneity of weed species (1–2 perennials in total) is typical for the second intermediate stage of restoration. In in the first intermediate and later stages, the speeds and even the direction of the processes differ significantly in different deposits. Thus, there were more weeds on the dry land (by the 7th year) than there were in the 4th year, and on the Kundustug site (dry steppe 1) at the same time, the share of weed species decreased by more than 2 times. In the late stage, the amount of weed species remained unchanged for the Mezhegey site and decreased by 4 times for the Kundustug site. Note that the amount of weed species reaches four in the native dry steppe, and no weed species were found in the native dry steppe 1. Hkadyn differences affect the shape of the weed species loss curve, but do not affect the instantaneous maximum loss.

As in the case of species accumulation, we observe a phase of synchronous manifestation of the restoration trend, which is replaced by a phase of specific behavior of species belonging to different types of steppes.

One of the main features of the species is belonging to a certain bioecological group that characterizes its moisture–loving nature. On the basis of the types are divided into mesophytes, mesoxerophytes, xeromesophytes and xerophytes. The ratio of environmental groups describes a community that is usually stacked with data groups in different proportions. Since our objects are steppe sites, we chose a group of xerophytes as a mirror of the aridity of the soil and climate. Does the share of xerophytes change during the restoration?

Already at the very beginning (the 4th year of restoration), deposits are allocated that occur on the site of the dry steppes. The share of xerophytes in their heritage varies about 50%. Sites that develop on wetter soils are characterized by a 27–33% share of xerophytes by the 4th year of success. Every year, the share of xerophytes in all sites increases. Major shift in the direction of the processes carried out at the first intermediate stage of success. At the next stage, the rate of increase in the share of xerophytes decreases.

One of the most controversial characteristics in success theory is the rate at which the species composition of the grass stock reaches the species structure of the terminal ecosystem – the native steppe. In our case, we have an amount of steps that have been used for crops for no more than 20 years after plowing. Due to the short duration of the agricultural period in the soil, we believe that the bank of seeds of steppe plants was preserved, which was constantly replaced with seeds brought by the wind from the nearby steps. The original seed bank also contained seeds of weeds that grew in agrocenoses. The wind could bring seeds from meadow forest ecosystems to areas of land and the Mezhegey site, because these sites were located in the forest–steppe zone. Dry steppes could receive seeds from mountain steppe ecosystems located in the nearby.

The conditions for restoring the steppes were almost perfect. A diverse fund of seeds is stored in the soil, which almost did not change during the period of their agricultural use. The most changed was the soil on the Bizhiktig–Haya site (dry steppe 2), since plowing turned the top layer and the surface stonyness turned into the skeletal structure of the top layer of soil. The conditions of species survival were violated due to changes in the rough structure of the soil. Otherwise, all sites had the opportunity for rapid recovery.

As the observations showed, the restoration of steppe vegetation was proceeding at a high rate and naturally. In the first four years, the share of terminal species reached 20–25% (with the exception of dry steppe 2). At the first intermediate stage, the introduction of terminal species slowed down somewhat, and their share in the herbage increased by an average of 15%. The next period (7–11 years) on four sites was a time of rapid progress to the terminal state. The amount of native steppe species increased by an average of 45%. The only exception was the plant communities of the deposit, which was developing towards the dry steppe 1. On this deposit, the maximum share of terminal species (33%) appeared in the last period of recovery. In the late winter, the dry steppes significantly outstripped the meadow and common steppes. By the 25th year of succession, deposits on chestnut soils had between 93% and 100% of terminal species in their composition and were actually variants of the dry steppes of Tuva.

Coherence in the self–organization of a community, when the bulk of terminal species are introduced into the grass stands of deposits, is manifested in initial and second intermediate stages of recovery.

The species and dominant composition of the community have different dynamics. The species composition fluctuates due to weather conditions – the species may disappear and soon reappear. The appearance and disappearance of 1–3 species is an important process, but not decisive. Restoration of deposits is manifested in a constant change in the species composition of plant communities. New species appear, some of them fall out, but some remain in the herbage. Species that appeared, then preserved, and create a late-stage plant communities are the leading fallow species successions. The regularities of changes in the species composition of plant communities are the same for all studied deposits. At all sites, the number of species that appeared in the first intermediate stage of succession exceeds the sum of the fallen and preserved species. On the second intermediate sometimes there are differences between meadow and real steppes, on the one hand, and dry steppes, on the other.

In the first pair of deposits, the number introduced species exceeds the number dropped, on all other deposits of the number of precipitated species to or greater than the number of new or almost equal to the last.

At all sites, the first intermediate phase is the period of maximum appearance of species, and the second intermediate phase is the period of maximum loss of species. The amount of preserved species increases during the succession, and the late phase is the time of their maximum accumulation.

Analysis of the appearance of terminal species of different life forms confirms the uniformity of the development of plant communities of steppe deposits. Analyzed the wettest deposit in the ordinary chernozem and the driest on light chestnut soils.

At the I initial stage of recovery, only weed species and two types of perennial grasses appear: *Artemisia glauca* and *Heteropappus altaicus*, which do not they fall out of the grass stand during recovery and are present on all deposits.

By the end of the first intermediate stage, the amount of perennial grasses increases. Rhizomatous grasses (*Bromopsis inermis*) appear on the dry land deposits, which immediately become dominant and remain the forming grasses. In turn, the first terminal cereal species, *Cleistogenes squarrosa*, appears on the deserted Kurgalchy site and will dominate throughout the recovery.

At the II intermediate stage, as noted earlier, the maximum number of "new" terminal species vegetates in the herbage (for the entire period). The real steppe is represented by 13 species of new perennial grasses that are not included in the Poacea and Ciperaceae families. On the Kurgalchy site there are no new types of grass.

One species of sedge was identified on both deposits (*Carex pediformis* on dry deposits and *C. duriuscula* on Kurgalchy site). Sod grasses (*Agropyron cristatum, Phleum phleoides, Koeleria cristata*) and three species of grasshoppers are introduced massively into the grass beds. On the Kurgalchy site there are three types of the same turf grasses: *A. cristatum, K. cristata* and *Stipa krylovii*. Half–shrubs sprout, of which there are especially many (5 species) on the deserted Kurgalchy site.

The late stage of succession is marked by the appearance of new terminal species, including 4 and 3 sod grasses on the Hkadyn and Kurgalchy sites, respectively. Five Poa species are simultaneously recorded on Land deposits, three of which are rhizomatous and two of which are turf. On the Kurgalchy site Poa is not included in the amount of terminal types, there appear to be *Festuca valesiaca* and *Stipa orientalis*. On both sites in the last period, the herbage simultaneously includes the sod grass *Helictotrichon altaicum* and the shrub *Caragana pygmaea*.

Probably, each species has its own time of mass germination of seeds. It is surprising that this time is almost independent of the soil and its moisture content. Coherence of an amount of succession processes was found in deposits with different hydrothermal regimes [4], [5].

Species composition and dominance structure are extremely important indicators of the degree of maturity of the system. But there is another indicator, which indicates the degree of development of the biotic cycle in the ecosystem. This indicator is the structure of phytomass (stocks of organic matter in components). Each ecosystem is characterized by its own specific structure of phytomass. Restoration on all sites fairly quickly (25 years) leads to communities that are similar in species composition and to a lesser extent in the structure of dominance to the original steppe plant communities.

The structure of phytomass develops more slowly, which is especially pronounced in the underground sphere. It takes a long time (probably at least 30 years) for a complete network of the biotic cycle to develop and exchange processes between the components of the ecosystem to come to a stationary state.

4. Conclusions

Based on the study of five deposits located along the moisture gradient, we identify certain stages of succession. In arid conditions of Tuva, the initial stage of succession is almost identical and can be called weed.

The first intermediate stage is transitional. It is characterized by absolute dominance of Wheatgrass and the appearance of dominants characteristic of certain types of steppes – *Bromopsis inermis* for sites leading from the meadow and real steppes; *Cleistogenes squarrosa* for the desolate steppe.

The second intermediate stage is the phase of formation of future steppes. All sites are dominated by types of initial terminal communities.

Although there are still many weed and "alien" species in the herbage, the transition to the indigenous community is clearly marked.

The late stage is characterized by the fact that all deposits located on the former dry steppes are already variants of dry steppes. Meadow and dry steppe deposits are close to their source in terms of species, but differ in their dominance.

Studying individual deposits, the majority of authors came to the conclusion that the fallow succession proceeds naturally and is directed to the terminal state of the ecosystem. Taking this conclusion and taking into account our results of simultaneous study of a number of steppe deposits from meadow to deserted, we came to the following conclusion: fallow succession is self-organized and proceeds according to certain rules; in a number of deposits located along the moisture gradient, most processes are simultaneity; the appearance of various plant life forms occurs simultaneously regardless of the moisture content of the plant communities; plant communities of deposits that are least provided with moisture come to the terminal state earlier than plant communities of deposits that are located in more favorable hydrothermal conditions, which is probably due to the lower species diversity of dry steppes compared to grasslands.

We believe that any system has the potential for self–organization, i.e. the gradual construction or reconstruction of all systems of biogeocenosis moving to the terminal state. In our opinion, the mechanism of self–organization is a network structure of the biotic cycle, which provides organisms with several options for introducing or returning to the biogeocenosis during the primary or secondary succession.

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Conflict of Interest

None declared.

Конфликт интересов

Не указан.

References

1. Носин В.А. Почвы Тувы / В.А. Носин. – М.: Изд–во АН СССР, 1963. – 342 с.
2. Бигон М. Экология. Особи, популяция и сообществ / М. Бигон, Дж. Харпер, К. Таунсенд. – М.: Мир, 1989. – Т. 2. – 477 с.
3. Люри Д.И. Динамика сельскохозяйственных земель России в XX в. и постагрогенное восстановление растительности и почв / Д.И. Люри, С.В. Горячин, Н.А. Краваева и др. – М.: ГЕОС, 2010. – 415 с.
4. Титлянова А.А. Биологический круговорот углерода в травяных биогеоценозах / А.А. Титлянова. – Новосибирск: Наука, 1977. – 219 с.
5. Титлянова А.А. Залежная сукцессия в Туве [Электронный ресурс] / А.А. Титлянова, А.Д. Самбуу // Современные проблемы науки и образования. 2013. № 5. – URL: http://www.science–education.ru/111–10438 (дата обращения: 10.02.2022).

References in English

1. Nosin V.A. Pochvy Tuvy [Soils of Tuva] / V.A. Nosin. – M.: Publishing House AN SSSR, 1963. – 342 p. [in Russian]
2. Bigon M. Ekologiya. Osobi, populyaciya i soobshchestv [Ecology. Individuals, populations and communities] / M. Bigon, Dzh. Harper, K. Taunsend. – M.: Mir, 1989. – Vol. 2. – 477 p. [in Russian]
3. Lyuri D.I. Dinamika sel'skohozyajstvennyh zemel' Rossii v XX v. i postagrogennoe vosstanovlenie rastitel'nosti i pochv [Dynamics of agricultural lands in Russia in the XX century and postagrogenic restoration of vegetation and soils] / D.I. Lyuri, S.V. Goryachin, N.A. Kravaeva et al. – M.: GEOS, 2010. – 415 p. [in Russian]
4. Titlyanova A.A. Biologicheskij krugovorot ugleroda v travyanyh biogeocenozah [The biological succession of carbon in the grassland ecosystems] / A.A. Titlyanova. – Novosibirsk: Nauka, 1977. – 219 p. [in Russian]
5. Titlyanova A.A. Zalezhnaya sukcessiya v Tuve [Fallow succession in Tuva] [Electronic resource] / A.A. Titlyanova, A.D. Sambuu // Sovremennye problemy nauki i obrazovaniya [Modern problems of science and education]. 2013. № 5. – URL:http://www.science–education.ru/111–10438 (accessed: 10.02.2022). [in Russian]