On the issue of involving abandoned agricultural land in crop rotation

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Abstract. In the nineties of the last century due to the known economic stress experienced in this time in Russia there were more than fifty million hectares of arable lands withdrawn from the Russian agricultural turnover. There are more than one million hectares of such arable deserted lands in the Amur Region of the Russian Federation (The Far Eastern part of Russia). These arable lands have turned into deteriorating lands in abeyance being colonized by weeds and periodically attacked by fires. As a result of this, these promising agricultural lands, being used for the food supply and forage resources production, have lost their primary purpose of use. It has become a serious national economic problem. Nowadays there is a gradual inclusion of such arable lands into soya and wheat production. The conduction of agrochemical and geo-botanical research needed for suitability evaluation of such arable lands for soya and wheat species cultivation is to a certain degree very expensive and time-consuming procedure. Our research work suggests implementing resources-evaluating method which implies one-time route study in the period of mass flowering of plants and identifying the plants of the arable lands that have resource value. If the number of these plants exceeds eighty percent in relation to the whole species composition, then such arable lands are considered to be suitable for crop rotation. If this ratio is less than sixty percent, then it is necessary to take extra measures in order to reduce the number of weeds and woody plants on such arable lands.

1 Introduction

In the 90s of the last century more than 50 million hectares of arable land were taken out of the agricultural turnover in Russia [1]. In 2005, according to the regional Ministry of Agriculture in Amur region, 1781.8 ha were allocated for agricultural use, including 1143.3 ha for arable land, which is much less than in 1997, when the total number of such lands was 2682.2 ha, of which 1783.7 ha were arable lands [2]. At the same time, according to the data of the Federal State Statistics Service, in 2005 the actual cultivated area in Amur Oblast was only 576.4 ha. [3]. If we compare the data of the Ministry and given statistics, it turns out that by 2005 more than one million hectares of arable land in the Amur region had been taken out of circulation. These lands were essentially abandoned and fell out of the field of peasants' activity for more than 20 years. It is known that agricultural land not ploughed or inhabited

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for more than one year should be designated as fallow lands [4;5].

In the beginning of 2010, according to Amur Region statistics, the gradual return of abandoned lands to agricultural turnover is taken place. In 2018 the total area of arable lands in the region has already made up to 1514.2 thousand hectares. There were 216.8 thousand hectares of arable land in the deposits, i.e. the number of uncultivated arable land decreased almost 5 times. [6]. Nevertheless, this number is also large enough, which requires close attention to this problem.

In the Amur Region, this important national economic problem is aggravated by the fact that there are about 1500 forest and meadow fires annually during early summer and autumn droughts, which cover on average 800.000 to several million ha [7]. As a result, these abandoned and essentially derelict lands are constantly burned out, degraded and overgrown with "weed" (*a common name for high weed grasses*). If the deposits do not burn out, they begin to overgrow with bushes and trees [2;6]. Apparently, this is why abandoned agricultural lands do not fall into the category of deposits and, accordingly, cannot perform the function of fallow lands, which is to increase the fertility of agricultural lands. It is known that in the swidden system of arable farming, arable land is left in the deposit in order to give it "rest", accumulate humus and other nutrients.

At present, there is an intensive involvement of previously abandoned arable land in agricultural turnover. The bulk of this land is used to increase soybean production. The condition of these allegedly "rested" agricultural lands is not taken into account at all. There is no history of their presence in the fallow state, the role of fires is also not taken into consideration. If the fields are overgrown with shrubs, then there is excavation, associated with the removal of soil turf horizon, etc.

Research objective: to study possibilities of return of abandoned agricultural lands to soybean crop rotations and recommend methods of evaluation of fallow lands condition.

2 Research objects and methods

Field studies were conducted on abandoned fields of various farms in Blagoveshchensk, Arkhara and Shimanovsk districts of Amur Region. The study areas are located in the south of the Amur-Zeya plain and in the Arkhara lowland, which occupies the extreme south-eastern part of the Zeya-Bureya plain. The age of the investigated deposits varied from 4 to 16 years. More than 30 deposits were studied. On the investigated fields test sites with the size not less than 25x25 m were allocated. The phytocoenotic characteristics of plant communities were studied using classical methods of geobotany [8;9]. At the trial sites species belonging was taken into account, the total number of species was calculated, ecological groups of plants were determined in relation to their moisturization, the confinement of species to vegetation types, the nature of growth of individual species, characteristics of species abundance (density, degree of projective coverage), periods of mass flowering and change of aspects were taken into account, observations of fluctuations were made. Absolute accounting of tree plants was made at the sites where trees were present. In order to study the soil condition at the studied sites the soil sections were laid down according to the methods generally accepted in soil science. At their description the profile method was applied [10]. Species composition of phytocoenoses of investigated deposits has been estimated on an accessory of plants to aspects of resource value that was based on possibility of their use in various branches of a national economy (medical, fodder, food, decorative) [6;11].

3 Results and discussion

The results of studies conducted over 10 years on abandoned agricultural lands revealed that in condition of favorable situation in these fields there is a gradual formation of plant communities corresponding to the type of phytocoenoses characteristic of the area. It was found out that in the development of secondary succession on deposits in the conditions of the southern agricultural zone of Amur Region three stages of 5 years each can be distinguished.

The first or initial stage of plant community formation is characterized by slow growth of species composition. Species diversity at this stage does not exceed 70 species. Ubiquitous dominance of wormwoods (*Artemisia spp.*) is observed, which on former arable lands is an identifier of phytocoenosis. *Artemisia spp.* creates a pyrogenically dangerous situation for fallow lands. As a result, fallow lands are often burned out, which significantly hinders the development of the plantcommunity.

The second stage is initially characterized by a sharp increase in species composition (up to 160 species). In communities on former arable land wormwood continues to dominate. Where they have been used as pasture or hayfields after the end of field ploughing, they are dominated by bean and cereal families. There is a mosaic of vegetation distribution in the area. There are only 130 species of herbaceous plants in 11 summer deposits. The deposits begin to be actively covered by woody plants and bushes, which leads to changes in ecological conditions and, as a result, the end of the second stage is characterized by a slight reduction in species diversity. The third stage is characterized by the onset of saturation in the species composition of the vegetation inhabiting the deposits. By this time, the number of species in deposits can reach 180. Wooden plants start to play the role of edifiers in some deposit zones. Deposits are tightened with shrubs. The mosaic manifests itself more clearly in the territorial distribution of plants.

The forest-steppe zone is characterized by overgrowth of deposits with woody and bushy species and restoration of the forest shrub community. The role of forest vegetation in the formation of phytocoenosis in the deposits is significant. The development of a deposit among the forest leads to the formation of overgrowth of shrubs or herbaceous vegetation, which are later replaced by secondary forest [12]. For example, a deposit in the former state farm of Novogorгиеvskii Shimanovskii district is surrounded from all sides by coniferous-broadleaved forest, the main representatives of which are *Pinus sylvestris* L., *Betula platyphylla* Sukacz. and *Populus tremula* L. Population of the deposit with pine trees is quite intensive (Table 1).

Table 1. Characteristics of *Pinus sylvestris*, on deposits in the forest zone (v. Novy Trud, Shimanovskiy district, Amur Region).

Age of the deposit, years	10 m from the forest wall		25 m from the forest wall		50 m from the forest wall	
	Plant height, m	Density, pcs./ha	Plant height, m	Density, pcs./ha	Plant height, m	Density, pcs./ha
14	1.8±0.2	450	1.2±0.1	300	0.6±0.1	70
16	2.3±0,2	480	1.7±0,2	350	1.1±0,1	280

There is a clear trend of increasing planting density and plant height when approaching a forest area. During two years, the height of plants increases by more than 0.5 m. If at the beginning of the research the teenage pine trees were traced at the distance of 50 - 75 m

from the forest edge, then in 2 years the teenage pine trees penetrate the deposit up to 200 m.

Inhabitation of woody species of deposits in the area dominated by meadow- steppe vegetation is slower. On 5-year-old deposits in this area no wood species has been found yet. It is only after 10 years that separately growing shrub forms of willows (*Salix spp.*) are detected in these fields. Areas of 15-year-old deposits are already more actively populated by representatives of willow and birch families (Table 2).

Table 2. Species composition and density of woody plants on the 15-year-old deposit in the zone of meadow-steppe vegetation (Tselinny state farm, Arkhara Region, Amur Oblast).

Name of plants	Density, pcs./ha
<i>Salicaceae</i> Mirb.	
<i>Salix miyabeana</i> Seem.	821
<i>Salix abscondita</i> Laksch.	124
<i>Betulaceae</i> S. F. Gray	
<i>Betula platyphylla</i> Sukacz.	60

Deposits in the forest-steppe zone begin to be inhabited by woody plants after 5 years. The first to appear are shrubs and trees of *Salix nipponika* Franch. et Savat., *S. miyabeana* Seem and *S. abscondita* Laksch. By the age of ten, *Salix miyabeana* curtains are already forming in the deposits, while *Salix miyabeana* and *Salix abscondita* grow as freestanding trees in different parts of the deposits.

On the one hand, if the deposits are actively overgrown with wood and bush species it indicates the positive dynamics of secondary succession, the protection of such fields from fires. On the other hand, it should alert land users, because in order to return these lands to agricultural turnover, it is necessary to clean the field from wood and shrub plants. In doing so, the fertile horizons of the soil are either destroyed or ploughed into sub-powered horizons.

The pyrogenic factor has a more significant influence on the development of vegetation in the deposits. Fires contribute to phytocoenosis changes both in forests and in meadows and steppes [13]. Usually in 5 years after cessation of use on arable lands a large amount of phytomass rags of weedy grasses is accumulated, which promotes rapid spread of grassroots fires [14]. Fires for a certain type of vegetation are a natural factor of renewal and do not bring any serious violations, provided that they do not occur annually [15]. At the same time, fires simplify and unify the species composition of open ecosystems, promoting the development in them of pyrogenically resistant communities [6]. Studies of deposits in the Amur Region that were burned out as a result of fires have shown that these fields subsequently exhibit very poor species diversity. In such fields in 3-5 years after the fire, no more than 10 plant species grow (Table 3).

Artemisia predominates in these fields. There are no teenage tree species. Phytocoenoses formed on these lands begin to develop practically from scratch. The presence of a large number of wormwoods on deposits creates an extremely dangerous situation for repeated fires during spring and autumn drought periods.

The greatest damage fires cause to fallow lands is the destruction (burning out) of leafy and grassy opal, with which the layer of turf burns out as well. If the horizon of the turf can reach 6 cm in the soil cross-sections in the deposits that have not been burned out, the destruction (burning out) of leafy and herbaceous opal, with which most of the turf is burned out, occurs in pyrogenic deposits.

It is believed that over time, soil fertility is restored and accumulated in the deposits. The soil seems to "rest" from the anthropogenic impact. But, on the one hand, fifteen years is clearly not enough for this, in a difficult pyrogenic situation, in most of the southern agricultural zone in the Amur region. On the other hand, this puts this point of view into

question. As it is said above, fires destroy not only vegetation but also sod horizon formed on the surface of the soil, decomposition of which in the future should lead to accumulation of soil fertility, to formation of humus horizons replacing arable ones. Therefore, it is difficult to use the presence of fertile horizon in the soils of fallow lands as a marker of the direction of restoration succession.

Table 3. Total number of species and species with resource value in deposits of different species in a single survey in July.

Type of deposit	Age of the deposit, years								
	3-5			10			15		
	total pcs	resource-significant pcs	resource-significant %	total pcs	resource-significant pcs	resource-significant %	total pcs	resource-significant pcs	resource-significant %
Pyrogenic deposit	10	8	61.5	-	-	-	-	-	-
Former arable land	17	10	58.5	25	13	52.0	28	19	67.8
Arable land served as hayfields and pastures	13	11	84.6	22	19	86.3	30	26	86.6

The species composition of fallow lands and its phytocoenotic features can serve as a marker of the direction and success in the development of regenerative succession. The richness of species composition in deposits is distributed in ascending line as follows: pyrogenic deposits, former arable lands, former arable lands used as pastures and hayfields (Table 3). Such distribution can be established by single surveys during the period of mass flowering. However, the differences in the total number of species revealed by single surveys are not significant. Pyrogenic deposits are less distinguished, and former arable lands and arable lands used as pastures and hayfields differ slightly in this respect.

Essential differences in the phytocoenotic features of fallow lands can be established only during long-term studies, taking into account seasonal dynamics and fluctuations by year [2]. Carrying out such studies is rather laborious and time- consuming work.

However, there are many species in deposits that have resource value aspects. These are plants that are used in official and folk medicine (medicinal), are of interest as fodder crops for animal husbandry and beekeeping (fodder), as food resources for gathering (food), which can be used as flower crops in ornamental horticulture (ornamental), as well as a source of conservation of biological diversity of the territory (rare and declining numbers).

A list of resource significant plants was compiled from plants found on fallow lands in Amur Region [2;6]. More than 130 species were included in this list. Among which nine plants are included in the medicinal registers of Russia and are used in official medicine for the production of medicines, three are full analogues of official (pharmacy) medicinal plants. About 100 species of plants are used in traditional medicine. More than 30 herbaceous plants growing on the studied deposits are fodder crops. More than 100 can be referred to the category of ornamental crops. Sixteen species of herbaceous plants should be considered as aspects of food value. Fourteen species are of interest as a resource to preserve the species richness of the area.

Even single examinations at different deposits will identify the plants on this list. The

presence and quantitative relation to the total species composition of plants with aspects of resource value in different types of deposits shows a direct dependence on the success and direction of the regeneration succession. In periodically burning out deposits, which are mainly overgrown with wormwood and have a scarce species composition, plants with resource value are detected no more than 60% of the total number of species. Former arable land is also characterized by widespread overgrowth with weedy plants. *Artemisia* dominate on these fields for a long period of time.

The abundance of wormwood reduces the presence of plants of resource value. After 5 years of development, the deposits of plants with a resource value of only 52%. Their number does not increase in 10 years' deposits either. Even by 15 years the number of such plants on deposits hardly reaches 67%.

In the fields, which after cessation of ploughing were converted into hayfields and pastures, were sown with forage herbs in 5 years the number of valuable plants in resource terms exceeds 80%, and in 10-15 years it reaches 86%.

4 Conclusion

Thus, as a result of one-time route surveys in the period of mass flowering of plants, when no more than 30 species are identified on the investigated deposits, it is quite possible to predict the direction and success of the secondary succession of agrophytocoenosis by the ratio of plants with resource value to the total number of identified species. So, if after 10-15 years on the abandoned agricultural land more than 80% of plants have resource value, it can be assumed that the field in the deposit went not immediately after the cessation of plowing, and some time was used as hay or grazing for livestock, in the process of its development did not burn out and it is not observed complete dominance of weedy plants. Such fields are quite suitable for their reuse in soybean crop rotations. If on fallow lands the number of plants with resource value does not exceed 60%, the success of secondary succession development can be questioned and recommended before introducing such fields into crop rotations to promote recovery processes. Firstly, the assistance should be provided to protect deposits from fires. Secondly, the representation of weedy and woody plants species should be reduced.

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