Features of reforestation in the longterm agricultural use of geosystems of the Tunkinskaya depression

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Abstract. The paper focuses on identifying the features of natural reforestation after abandonment of agricultural land. That was achieved by the annual monitoring (2014 to 2018) of current state of 22 fallow land sites within the most agrarian-developed areas of the Tunkinskaya depression (Republic of Buryatia). Geobotanical analysis of the species composition of woody and grass covers of fallow lands was carried out. The main options for overgrowing fallow lands were determined. This is a restoration through birch, pine or mixed undergrowth, as well as meadow succession. Natural reforestation on fallow lands flows more intensively around the perimeter of the fields. The species composition of the undergrowth is identical to the forest canopy of the adjacent forests. In the grass cover of fallow lands in most cases there is a dominance of meadow species. In the grass cover of the surrounding forests, forest species prevail. Our research confirmed the dependence of distribution intensity of tree undergrowth on the degree of remoteness from the forests surrounding the abandoned lands. A decrease in the excess growth of tree species was observed with increasing distance from the periphery of the field to its centre.

1. Introduction
Agriculture is historically the priority branch of economy in the Tunkinskii district of the Republic of Buryatia. Decline in production in the agricultural sector in the post-Soviet period was characterized by an increase in the area of abandoned agricultural land; and now the Tunkinskii district has one of the highest values for this indicator in the country. Taking into account that without any anthropogenic load, the processes of renaturalization are activated, the main purpose of this work was to analyze the current state of fallow lands with an emphasis on identifying the main directions of restoration post-agrarian successions.

2. Models and methods
Our research objects were abandoned agricultural land of the Tunkinskaya depression. We used a database of geobotanical descriptions collected at 22 annual monitoring points from 2014 to 2018 to determine a degree of transformation and orientation of reforestation processes. Taking into account that natural overgrowing is most observed along the perimeter of the fields, and the species composition of the undergrowth is influenced by the composition of the adjacent forest canopy [1-10], we considered the peculiarities of the current state of post-agrarian lands depending on the distance and specificity of the surrounding phytocenosis.
3. Results and discussion
The most agrarian-developed territories of the studied area are the central part of the depression, gentle slopes of its northern part, the eastern side along the Yelovskii Spur, and also its western and southwestern slopes. The main agricultural activity of local people of the region is aimed at the development of meat and dairy cattle breeding and the improvement of forage lands belonging to private farms. At present, small arable lands are concentrated near the villages of Tagarkhai, Khurai-Khobok, Taloye, Galbai, Tunka and Yelovka. Most of the agro-transformed lands without any anthropogenic load are at different stages of reforestation, the character of which depends on the current landscape conditions.

Depending on the dominant species in tree and ground covers of the “background” biocenoses, as well as according to the analysis of geobotanical materials in key fallow sites, four main directions of post-agrarian restoration successions, represented by pine, birch, mixed or meadow overgrowth, were identified (figure 1).

Meadow overgrowth is characteristic of fallow lands within the central part of the Tunkinskii depression, where the ambient phytocenoses are wetland and wet meadow associations with a predominance of sedges, horsetails, and reeds (see figure 1, inset a). The draining of the lake-marsh lowland in the second half of the last century with the aim of stopping the progressive waterlogging and for more extensive agricultural use of land contributed to the wide distribution of mesophytes in the grass cover. The features of land overgrowing after the cessation of agricultural activities are exemplified by grass-forb post-agrogenoses in the western part of the bottom; in the vicinity of the Ulbugai ulus (see figure 1, inset b). In the grass cover, there is a predominance of meadow species – Agrostis trinii, Carex duriuscula, Poa pratensis, Achillea millefolium, Trifolium pratense, Primula farinosa, and Potentilla anserina; weed species are represented by Plantago media, Taraxacum officinale, Sonchus arvensis, among steppe species Artemisia commutata prevails, and Trollius asiaticus dominates among forest ones. The projective cover of the stand is 90%; the average height is 12 cm. The area has been transformed by cattle grazing; there is no growth of tree species.

The process of demutation on the fallow lands, surrounded by mixed larch-birch-pine with admixture of Siberian pine herbaceous-subshrub forests, is considered on the example of the surroundings of the Khurai-Khobok village. Under the canopy of “background” vegetation, the crown density of which reaches 0.6, the shrub layer is well developed, represented by Rhododendron dauricum and Vaccinium uliginosum (see figure 1, inset c). The projective cover of the grass stand is low – 30-40%; the dominant species are Carex pediformis, Lathyrus humilis and Pyrola asarifolia. Vaccinium vitis-idaea is the most common of shrubs. Green mosses are also common.

Just 80 m from the edge of the forest, the composition of the undergrowth on the post-agrarian lands is also mixed – Betula pendula is mixed with the dominant Pinus sylvestris (see figure 1, inset d). The height of the trees at the time of observation in July 2016 reached 3-5 meters. In the undergrowth, the average height of which was 80-90 cm, Pinus sylvestris prevails, occasionally mixed with Betula pendula and Larix sibirica. Grass stand here is subject to grazing and haying; projective cover is 90%, and average height is 35-40 cm. Species composition is represented mainly by meadow phytocenosis with prevalence of Linaria vulgaris, Trifolium pratense, Vicia cracca, Achillea millefolium, Poa pratensis, Ranunculus propinquus, Potentilla tanacetifolia, Astragalus adsurgens, Melilotus suaveolens, Bupleurum scorzonerifolium and Schizonepeta multifida of the steppe species dominate here; Taraxacum officinale, Plantago media and Elytrigia repens of weed species, Fragaria orientalis, Artemisia commutata and Sanguisorba officinalis are more common of the forest species.

In the surroundings of the settlement Zaktui village we investigated the features of reforestation on fallow lands that are as close as possible to the wall of pine with the inclusion of birch and larch of herbaceous forest (see figure 1, inset e). Just 20 m from it, overgrowing with larch-pine young stands is observed. The undergrowth is represented by the abundant Pinus silvestris, with infrequent undergrowth of Larix sibirica (see figure 1, inset f). The average height of the stand is 2 m; the average height of the undergrowth is 70-80 cm. Meadow species dominate in the ground cover,
namely *Poa pratensis*, *Agrostis trinii*, *Achillea millefolium*, *Trifolium pratense*, *Vicia cracca*, *Leymus chinensis*, *Fragaria orientalis*, *Artemisia camphorata* and *Anemone sylvestris* of the forest species are presented; *Astragalus adsurgens*, *Melilotus suaveolens*, *Potentilla anserina*, *Dianthus versicolor*, *Bupleurum scorzonerifolium* and *Schizonepeta multifida* of the steppe species, *Plantago media* and *Sonchus arvensis* of weeds. The projective cover of the grass stand is 60%; the average height is 35-40 cm. In general, the ground cover is quite diverse, while the grass stand adjacent to the “background” tree stands is poor and is represented exclusively by forest species – *Carex pediformis*, *Geranium pseudosibiricum*, *Lathyrus humilis* and *Actaea erythrocarpa*.

Figure 1. The main scenarios of the overgrowing of fallow lands in the Tunkinskaya depression, depending on the surrounding biocenoses. *Meadow scenario*: a – marsh and wet meadow natural associations, not subject to agricultural activities, b grass-forbs post-agrocenoses; *mixed scenario*: c – “background” larch-birch-pine with the inclusion of Siberian pine herbaceous-subshrub forest, d – small-leaved/coniferous young forest on falls in the surroundings of the settlement Khurai-Khobok village; *scenario with overgrowing with pine*: e – “background” pine with the inclusion of birch and larch herbaceous forest, f – young light coniferous forest on the post-agricultural lands of the surroundings of the settlement Zaktui village; *scenario with overgrowing mainly with Betula pendula*: g – “background” larch-birch with the inclusion of pine subshrub-herbaceous forest, h – coniferous/small-leaved young growth on falls in the surroundings of the settlement Yelovka village.

On the north-western slopes of the exposure of the left bank of the Khamnaganskaya river (left tributary of the Yelovka river) fallow lands are surrounded by larch-birch forests with the inclusion of subshrub-herbaceous forests (see figure 1, inset g). Closeness of crowns is 0.7 to 0.8; due to abundant leafy litter, the projective cover of the stand is 50%. The composition is represented by forest species, dominated by *Equisetum sylvaticum*, *Pyrola asarifolia*, *Actaea erythrocarpa*, *Lathyrus humilis*, *Geranium pseudosibiricum*, *Fragaria vesca*, *Carex pediformis*, *Vaccinium vitis-idaea* from shrubs. On falls adjacent to these forests, 80 m away from the periphery, reforestation occurs through the overgrowth of small-leaved trees. Tree stand, 2-4 meters high, is represented by *Betula pendula* (see figure 1, inset h). *Larix sibirica* and *Pinus sylvestris* are occasionally found of coniferous species. The
undergrowth equally consists of *Larix sibirica* and *Betula pendula*. The species composition of the grass cover is represented mainly by the meadow phytocenosis with a predominance of *Trifolium pratense*, *Vicia cracca*, *Achillea millefolium*, *Agrostis trinii*, *Poa pratensis*, *Carex pediformis*, *Astragalus adsurgens*, *Bupleurum scorzonerifolium*, *Melilotus suaveolens* and *Potentilla tanacetifolia* are dominant of the steppe species, *Taraxacum officinale* and *Plantago media* are the most common of the weed species; *Fragaria orientalis* *Equisetum arvense*, *Artemisia commutata* and *Tanacetum vulgare* of the forest species. Projective cover is 90%.

Thus, these examples of fallow land overgrowing confirm the dependence of the specific features of the species composition of restorative successions on the state of the surrounding post-agrarian lands of biocenoses. Generally, according to the results of geobotanical studies conducted at 22 key sites, it was found that within the Tunkinskaya depression the most common type of overgrowing is meadow, noted at 9 key sites, drawn to the center of the depression and river valleys. *Poa pratensis*, *Agrostis trinii*, *Elytrigia repens*, *Ranunculus propinquus*, *Potentilla tanacetifolia*, *Trifolium pratense*, *Vicia cracca*, *Linaria vulgaris* and *Achillea millefolium* prevail among the meadow species of grass stand; *Potentilla bifurca*, *Astragalus adsurgens*, *Bupleurum scorzonerifolium*, *Schizonepeta multifida* and *Artemisia commutata* are the most common of the steppe species. On two sites, due to remoteness from populated areas, mowing and grazing are not carried out, and six sites are natural pastures.

On six sites, overgrowth with *Pinus Sylvestris* is observed, the abundance of which tends to decrease with the distance from the periphery of arable land to the center. The grass cover is represented by forb-grass meadows, dominated by *Poa pratensis*, *Agrostis trinii*, *Bromus inermis*, *Vicia cracca* and *Trifolium pratense*. The territories of the four sites are used as natural pastures. The forest environment of the fallow lands under study is represented mainly by birch-pine herbaceous-subshrub forests.

On four observation sites, overgrowth with mixed vegetation was noted - pine-birch associations prevailed at 2 sites, and birch-pine associations dominated in the second half. Agricultural activities in these territories were discontinued more than 15-20 years ago; in the undergrowth under the canopy of mixed forests, the same species prevail that dominate in the tree layer. In the herbaceous cover *Fabaceae* prevail, namely *Astragalus adsurgens*, *Potentilla tanacetifolia* and *Trifolium pratense*; besides, *Poa pratensis Agrostis trinii* and *Achillea millefolium*, etc. are common. On one site, fallow land is used as natural pasture. No signs of grazing or mowing were observed on the remaining sites.

On three sites, overgrown with birch was noted. Herbaceous cover is represented by forbs with the dominance of *Fabaceae* – *Vicia cracca*, *Trifolium pratense*, *Potentilla tanacetifolia*, *Astragalus adsurgens*, besides *Agrostis trinii*, *Bromus inermis* and *Poa pratensis* are widespreads. Also, *Achillea millefolium* and *Sanguisorba officinalis*, etc. are common. In two cases, the sites are used as natural pasture. The fallow lands under study are surrounded mainly by pine-birch with the inclusion of aspen and larch subshrub-herbaceous forests.

### 4. Conclusions

The long period of agricultural activities contributed to the significant widespread of agar lands, most of which, being abandoned, are at various stages of renaturalization. As a result of the study, four scenarios for overgrowing of fallow lands were identified: reforestation through birch, pine or mixed undergrowth, or meadow succession. Secondary succession in the fallow lands is directed to a state, physiognomically close to the “background” forests surrounding the abandoned lands. This process is most actively manifested at the perimeter of fallow lands, as the distance from which the heights and abundance of tree undergrowth change.

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