DOI:10.5152/forestist.2022.22019
Forestist 2023: 73(1): 42-50

ISTANBUL UNIVERSITY
CERRAHPAŞA

Original Article

Characteristics of Plantations on Disturbed Lands in Copper Smelting Zone in Urals, Russia

Anna V. Bachurina[1], Sergey V. Zalesov[1], Sezgin Ayan[2]

[1]The Ural State Forest Engineering University, Ekaterinburg, Russia Federation
[2]Kastamonu University, Faculty of Forestry, Silviculture Department, Kastamonu, Turkey

ABSTRACT

In this research, it was aimed to investigate (i) the recultivation efficiency, (ii) to assess the plantation state via a complex estimated indicator, and (iii) to evaluate the environmental quality in disturbed lands in a zone under influence of copper smelting production. The research was carried out on Golden Mountain, located in the influenced zone of the Karabashed Joint Stock Company. In three plantations as reclamation sites established by sowing and planting, silver birch (*Betula pendula* Roth), aspen (*Populus tremula* L.), balsam poplar (*Populus balsamifera* L.), goat willow (*Salix caprea* L.) as broadleaves, and Scots pine (*Pinus sylvestris* L.) and Siberian spruce (*Picea obovata* Ledeb.) as conifers were selected. Moreover, environmental quality was rated based on the condition scores by collecting leaf samples in four different sites of silver birch forests. As a result, the fluctuating activity method of the silver birch leaf blade seems to be effectively used to assess the environmental quality. At a considerable distance of 8.0 and 13.0 km from the pollution source, the environmental quality has an average [condition score: III with .046 integral asymmetry index] and initial level (condition score: II with .041 integral asymmetry index) of deviation from the norm, respectively. In addition, silver birch can be recommended as the main species in forestry on disturbed lands in the South Ural forest steppe region.

Keywords: *Betula pendula*, industrial pollution, reclamation, recultivation

Introduction

Waste from mining and metallurgical production may cause serious changes in natural ecosystems including landscape disruption, environmental pollution, and disruption on biogeochemical cycles (Becker et al., 2019; Gabarrón et al., 2019; Zolotova et al., 2021). Environmental pollution caused by man-made emissions has been a problem since the middle of the last century in the Urals of Russia which is known to be the oldest industrial region (Zalesov et al., 2020). During the centuries, the development of ferrous and non-ferrous metallurgy, chemical industry, extraction of mineral to raw materials, and procurement and processing of wood have led to environmental degradation. The area of disturbed lands in the Russian Federation has been steadily increasing (Anonymous, 2019). Among the degraded lands common in the Urals, the areas that are the most difficult for biological reclamation are the gas-gene wastelands where non-ferrous and ferrous metals and magnetite are produced and some chemical plants are located (Makhnev et al., 1996). According to the information of Rosprirodnadzor, as of January 1, 2020, on the territory of the Chelyabinsk region, there are 18,734.939 ha of disturbed lands; of which, 284.257 ha were reclaimed in 2019. Additionally, the presence of worked-out lands (subjected to reclamation) is 3044.758 ha in Chelyabinsk region (Anonymous, 2020). However, according to the Federal Service for State Registration of Cadastre and Cartography, the area of disturbed land is 32.3 thousand ha in the Chelyabinsk Region (Anonymous, 2019). In accordance with the current legislation (p. 5 art 13 of the land code of the Russian Federation), people whose activities lead to deterioration in the quality of land (violation of the soil layer as a result of pollution) are obliged to ensure the reclamation on their own property (Anonymous, 2021a).

The city of Karabash and its surrounded areas are among the oldest Ural mining regions of the industrial development which began in the first half of the 18th century. The first ironworks on the territory of Soymanovsky valley where the city of Karabash is located in the Chelyabinsk region were built and put into operation in 1737. The founding date of the Karabash city is 1822 when rich gold-bearing deposits were discovered in the floodplain of the Sak-Elga River. The first copper plant in the city of Karabash was established in 1837. However,

Cite this article as:
Bachurina, A. V., Zalesov, S. V., & Ayan, S. (2023). Characteristics of plantations on disturbed lands in copper smelting zone in Urals, Russia. *Forestist*, 73(1), 42-50

Corresponding Author:
Sezgin Ayan
e-mail:
sezginayan@gmail.com

Received: February 22, 2022
Accepted: April 29, 2022
Available Online Date: July 26, 2022

copper-smelting production did not develop enough during that period since gold mining was more economically profitable (Anonymous, 2021b). A deposit of cuprous-gold Gold Mountain was discovered near the eastern slopes of Karabash in 1898–1899. A significant part of the reserve is still deep in the Gold Mountain (Spiridonov & Pletnev, 2021). This gold deposit is unique in terms of geological structure and mineral content. The main ore minerals that can be found in the mentioned deposit are minerals of the cuprous gold group and along with them mercury electrum and kustelit were also found. Arsenides Ni-orselid, chalcocine, cuprostibit, antimony, and copper are developed here. The old name of the deposit is Priisk No. 9. At the top of the ridge, there are numerous workings—mines, galleries, faces, and ditches with outcrops of diopside pomegranate composition ore bodies. On the eastern slope of the Golden Mountain, spoon-form deposits are washed out and they are characterized as rich in gold content (Spiridonow & Plotneb 2001).

In 1907, in the northern part of the Soymonovsky Valley, the second copper smelter was put into operation, known as the old copper plant. The plant has existed for 3 years. In 1909, the deep modern mines named South, Central, and South Mine were laid. In 1910, a new copper smelter was built and launched in Karabash equipped with advanced equipment and technology of that time. This plant has been smelting a third of all copper produced in Russia until 1915 (Anonymous, 2021b).

As known, during the beneficiation of copper-bearing sulfide ores, copper and zinc concentrates are released into the air. Copper is extracted from copper concentrates along with gold, silver, selenium, and other valuable elements. Derivatives of lead, sulfur, arsenic, and zinc are also emitted into the atmosphere in the form of dust and gaseous substances. Then pollutants are transported over the considerable distances entering the soil and water bodies causing enormous harm to human health and the environment. According to a study carried out in 2011, the distribution of heavy metals and arsenic in the air, surface waters, soil, and bottom sediments indicates an extremely unfavorable ecological situation in the city of Karabash (Kotelnikova, 2010; Zalesov et al., 2017; Zolotova et al., 2021).

Many studies have shown that reforestation and seedling propogation on the areas exposed to industrial waste has become a vital issue (Ayan and Yer, 2017; Makhniova et al., 2019; Potapenko et al., 2019; Zavyalov et al., 2018, 2019). For example; Menshikov et al., (1987) stated that mining activities adversely affect seed germination and seedling growths in their vicinities by polluting the air and soil. Seed germination capacity, survival rate, and morphometric characteristics of Scots pine seedlings grown in a magnesite-polluted soil medium were investigated in a pot experiment (Makhniova et al., 2019). The aim of this study is to establish (i) the efficiency of recultivation, (ii) to asses of the plantation state via a complex estimated indicator (CEI), and (iii) to evaluate the environmental quality in disturbed lands in the zone which is the under the influence of copper smelting production.

Methods

Material

The city of Karabash is located on the territory of the Chelyabinsk region (Figure 1), 90 km from the city of Chelyabinsk and 160 km

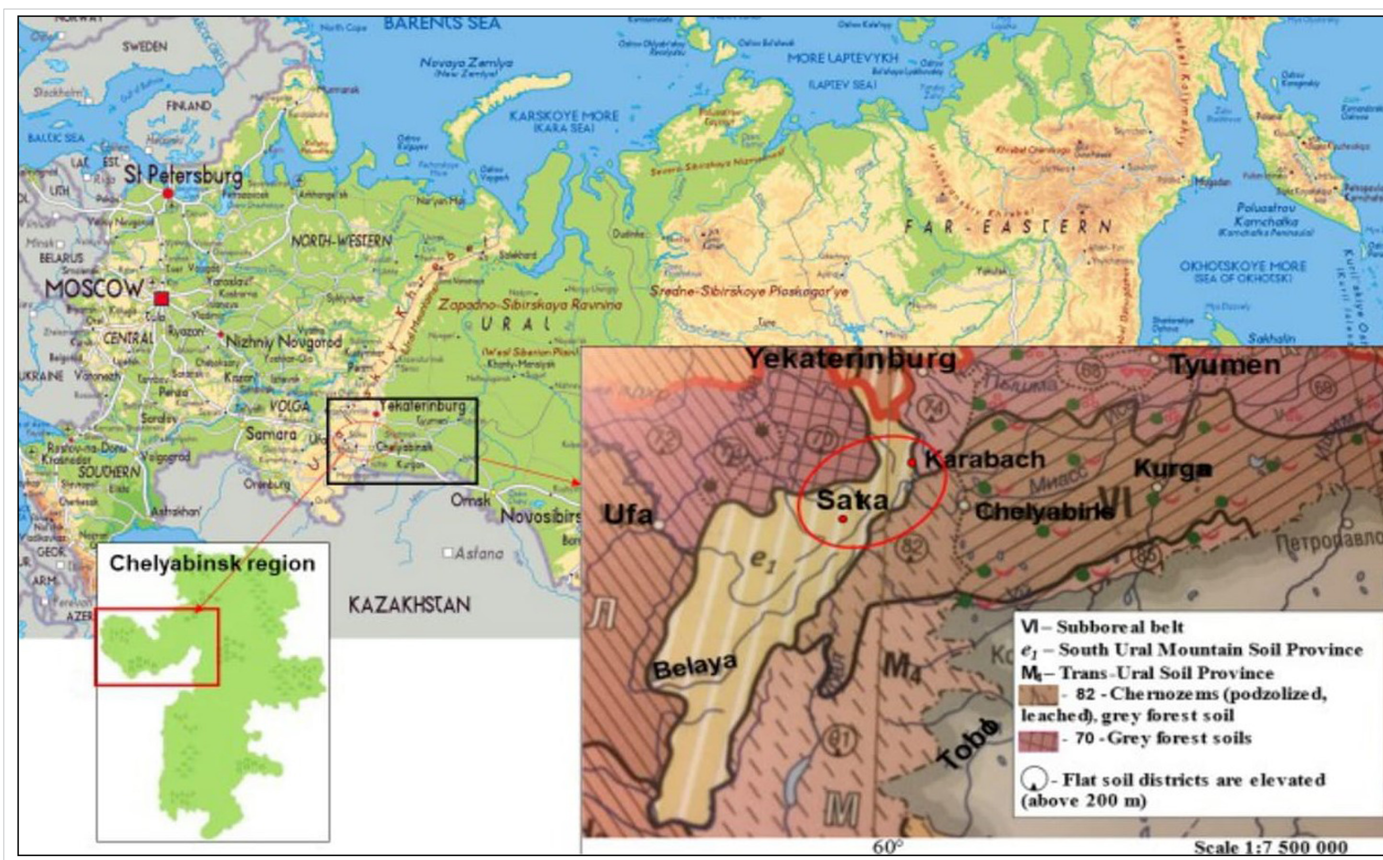

Figure 1.
Location of the Research Area.

from the city of Yekaterinburg. The geographic position of the research area is determined by 55° 20″–55° 40″ north latitude and 60° 00″–60° 30″ east longitude. The temperate continental climate prevails in Karabash. Winters are long and frosty. The coldest month is January with an average temperature of 12.5°C below zero. Summer is short and warm. The warmest month is July with an average temperature of +19.4°C. The average annual precipitation is 540 mm. Winds from the western, south-western, and north-western directions prevail. The relief of the research area is a combination of relatively low slopes (with heights rarely more than 400–600 m) with inter-ridge depressions. Mountain gray forest soils are widespread in the research area. According to their genetic characteristics, mountain soils have a great similarity with the soil analogs of lowland territories but differ in low power and skeletality. Such soils are more susceptible to destruction when vegetation is destroyed or partially disturbed (Bachurina et al., 2020).

The research area is the disturbed lands of the Golden Mountain slopes located in the zone of the enterprise Joint-Stock Company "Karabashmed" (named Karabash Copper Smelting Plant until 2004) which produces 150,000 tons of rough copper per year. Despite the repeated modernization and restrictions on the plants, the volume of the industrial emissions amounted to 14.4 mln tons between 1907 and 2007. Moreover, the emission of sulfur dioxide amounted to 19.3, copper oxide to .5, dust inorganic (SiO_2 <20%) to 4.7, lead and their compounds to .9, arsenic to .7, zinc oxide to 1.6, and other substances to .4% (Zalesov et al., 2017).

As mentioned above, long-term industrial emissions had led to the degradation of vegetation in the research area. On the windward side, the slopes of the Golden Mountain completely lost their native biota. After that, intensive erosion processes was begun. Since the natural reclamation of mountain slopes is extremely hard, in 1993, workers of the Kyshtym Forestry Enterprise under the leadership of its director "A.N. Batin" began reclamation work by terracing the slopes and creating artificial plantations on the terraces being created. Three experimental plots with a total area of 4.87 ha were laid. The total length of the terraces was 9.42 km. The terracing of slopes was carried out with a TC-2.5 terracer and aggregated with a DT-75 tractor (Zalesov et al., 2017).

On the first reclamation site with an area of 1.32 ha, 17 terraces were created. The slope where the first eight terraces were laid reached 40^0 whereas remaining nine terraces were $10–20^0$. At the same time, there were erosion gullies up to 1.5 meters deep every 2–3 meters. The soil of the terraces was consisted of rock (30%) and dense clay with stone (70%). The second site with an area of 1.03 ha included 16 terraces on a slope with a gradient of $21–30^0$. The soil of the created terraces in second plot was a mixture of 80% crushed stone and 20% of heavy loam. On the third, the largest in the study site (2.5 ha), 26 terraces have been created. At the same time, the soil on these terraces was comprised of crushed stone with the exit of monolite rock (Bachurina et al., 2020).

In the spring of 1994, seeds of silver birch (*Betula pendula* Roth) were sown on all the terraces with sawdust and followed by covering them with snow. The amount of the sown seeds was 16, 12, and 6 kg for the first, second, and third plots, respectively.

In 1997, at the first reclamation site, .8 thousand seedlings of small-leaved linden (*Tilia cordata* Mill.), .1 thousand seedlings of yellow acacia (*Caragana arborescens* Lam.), .1 thousand of Double cinnamon rose (*Rosa majalis* Herrm.), 1.0 thousand of Siberian spruce (*Picea obovata* Ledeb.), and 1 thousand of silver birch were planted. On the second reclamation site, 1500 balsam poplar (*Populus balsamifera* L.) cuttings and 1.0 pieces of silver birch seedlings were planted. On the third reclamation site, 3000 pieces of silver birch were hand-planted in the same year.

In addition, four sites were also selected for collecting materials in places of natural growth of silver birch by the method of fluctuating asymmetry of leaves. They were located in a northeastern direction, and their distances to the source of industrial pollution were .8, 2.2, 8.0, and 13 km for the sites 1, 2, 3, and 4, respectively. The sites No. 1 and No. 2 were located on the territory of the Karabash urban district, whereas No. 3 and No. 4 were on the lands of the forest fund of the Karabash district forestry.

Note that the site No. 1 was located in close proximity to the industrial zone of the Joint Stock Company (Karabashmed) and the site No. 2 was on a mountain slope. It was at the foot which lies on Lenin street. The vegetation on this site was represented only by silver birch (Bachurina & Zalesov, 2020).

Method

During the research in 2018, an inventory of the surviving species of woody, shrubs, and herbaceous plants was carried out on the terraces of three experimental plots. Studies were performed by the method of continuous enumeration and measurement of all preserved plants as well as the plants that grew naturally. Simultaneously, with the recalculation, the species composition was determined not only of the planted and sown woody plants but also the self-sowed plants as well as the measurement of the heights and diameters at a height of 1.3 m (Bunkova et al., 2011).

For assessing the state of plantings, a CEI proposed by Vysotsky (1962) called the growth intensity coefficient was used. The calculation was carried out according to the formula below:

$$CEI = \frac{H*100}{G}$$

where H is the average height of the stand, in m. G is the cross-sectional area of an average tree at a height of 1.3 m, in cm^2.

To evaluate the state of the environment in the zone of the Joint Stock Company Karabashmed, including the reclaimed sites, the fluctuating asymmetry method recommended by the Ministry of Natural Resources of the Russian Federation was applied (Anonymous, 2003). In silver birch, leaves were taken only from shortened shoots from the lower part of the crown with the maximum number of branches evenly around the tree. The collection of material was carried out after the end of the growth of leaves (starting at the end of July). For each sample, ten leaves from ten plants were collected. The asymmetry value in the plants for dimensional traits was calculated as the difference in the measurement on the left and the right referred to the sum of the measurement on two sides. To assess the indicators of fluctuating asymmetry of silver birch leaf blades, the following five indicators were used (Figure 2):

1) The width of half of the leaf;
2) The length of the second vein of the second order, second from the base of the leaf;
3) The distance between the bases 1 and 2 veins of the second order;

Figure 2.
Disturbed Lands of the Slopes of the Golden Mountain, Located in the Influenced Zone of the Karabashed Joint Stock Company.

4) The distance between the endings of the first and the second of the second-order veins;
5) The angle between the main vein and the second from the leaf base of the second-order vein.

The length of the veins and the distance between them were measured with an accuracy of .1 mm, and the angle of attachment of the second vein to the main one was measured with an accuracy of .5^0. At the last stage, the integral indicator of developmental stability was calculated as the value of the average relative difference between the sides per feature.

To assess the degree of identified deviations from the norm, a point scale has been developed (Zakharov et al., 2000). The range between these thresholds is ranked in ascending order of the indicator values: I point (to .040), II (.040–.044), III (.045–.049), IV (.050–.054), and V (more than .054). In this study, these values are referred to as condition scores. The quality of the environment deteriorates, as the value the scores increases. That is, if I point corresponds to the conditional norm, then in the fifth point environmental conditions are characterized as critical. The collected materials were processed by statistical mathematical methods using the Microsoft Office Excel software package.

Results and Discussion

Menshikov et al., (2019) specified that the dynamics of transformation of forest plant communities play a very important role in the stability of forest ecosystems in terms of the assessment of the negative impact of anthropogenic stress. They also remarked that the ability of self-purification of biogeocenoses on reducing emissions originating from industrial pollution takes a special place in the constancy of forest ecosystems.

This study showed that broadleaf plantations were formed with a slight admixture of coniferous in all experimental plots. As for the plot No. 1, the density of broadleaved trees was 595 pieces per hectare while the density of coniferous was 24 pieces per hectare (Table 1).

Table 1.
Characteristics of the Stand for at the Reclamation Site No. 1

No.	Species		Average Diameter, cm	Average Height, m	Number of Seedling, ps/ha	CEI, cm/cm^2	Average Age, years
	Latin Name	English Name					
1	*Betula pendula* Roth	Silver birch	4.42 ± .10	4.55 ± .06	530	29.7	21
2	*Populus tremula* L.	Aspen	2.99 ± .26	3.17 ± .14	42	45.2	16
3	*Populus balsamifera* L.	Balsam poplar	2.08 ± .39	3.04 ± 0.35	9	89.5	14
4	*Salix caprea* L.	Goat willow	2.14 ± .22	2.83 ± .16	14	78.7	17
Total broadleaves			2.91 ± .24	3.40 ± .18	595	51.1	
5	*Pinus sylvestris* L.	Scots pine	2.95 ± .24	2.6 ± .09	20	38.1	16
6	*Picea obovata* Ledeb.	Siberian spruce	2.68 ± .52	2.68 ± .16	4	47.5	21
Total conifers			2.82 ± .38	2.65 ± .13	24	42.5	

Table 2.
Characteristics of the Stand Formed at the Reclamation Site No. 2

No.	Species	Average Diameter, cm	Average Height, m	Number of Seedling, ps/ha	CEI, cm/cm^2	Average Age, years
1	*Betula pendula* Roth.	5.36 ± .11	5.11 ± .06	1111	22.7	21
2	*Populus tremula* L.	2.13 ± .09	3.37 ± .06	319	94.6	16
3	*Populus balsamifera* L.	1.59 ± .18	3.15 ± .14	56	158.7	20
4	*Salix caprea* L.	1.74 ± .07	3.20 ± .06	188	134.6	17
Total broadleaves		2.70 ± .11	3.71 ± .08	1674	64.8	
5	*Pinus sylvestris* L.	3.29 ± .31	3.22 ± .15	39	37.9	18
6	*Picea obovata* Ledeb.	2.23 ± .21	3.23 ± .25	6	82.7	10
Total conifers		2.76 ± .26	3.23 ± .20	45	54.0	

The table also indicates that 24 years after sowing of silver birch and 21 years following planting of Siberian spruce seedlings, only a part of silver birch and Siberian spruce seedlings survived among the composition formed by silver birch, small-leaved linden, yellow acacia, and double cinnamon rose. It was shown that all samples of the small-lived linden, yellow acacia, and double cinnamon rose were perished.

On the site No. 1, species of woody plants, aspen, balsam poplar, goat willow, and Scots pine have been formed as a result of self-sowing. The density of these species is low, and they do not significantly affect the composition of the stand. Makhniova et al., (2019) emphasized that seed germination and seedling growth reduced significantly as the levels of pollution increased. These negative effects of the pollution tend to increase as the seedling gets older.

It should be noted that the formation of woody plants in the site No. 2 proceeded more successfully than in the first site (Table 2, Figure 3). Table 2 indicates that the total stand density was 1719 pieces per hectare 21 years after the addition of silver birch crops by planting of balsam poplar cuttings and silver birch seedlings. In this case, the stand composition in terms of density can be described by the following formula 6,4B1,9Oc1,Iv(к)0,3T0,2C0,1Lts. In other words, 65% of all trees among the young trees are represented by silver birch, 19% by aspen, and 11% by goat willow and balsam poplar.

The aspen, goat willow, Scots pine, and Siberian spruce were formed as a result of self-sowing in reclamations sites. Soil remediation can positively affect the natural regeneration process of Scots pine. Moreover, seed supplementation can play a major role in successful natural regeneration (Mohnachev et al., 2018).

The lowest indicators of the growing stand density were recorded at the sites. The total density of the growing stands on these sites after 21 years did not exceed 214 pieces per hectare with the composition formula in terms of density 9,3Б0,5Ос0,1И(к)0,05Т0,05С (Table 3).

Due the low frequency and height (Figure 4), birch stand could not create a forest ecosystem.

According to the data of Shulga et al., (2007), the value of the CEI is practically the same for all the main forest forming species of Russia in normal plantations for each age class. Thus, for a plantation at the age of 20 years, CEI is 20.6 for pine, 19.9 for spruce, and 22.1 cm/cm^2 for birch. Zalesov et al., (2020) stated that the plantations of Scots pine showed good adaptability and growth in the ash dump areas of Reftinskaya Power Plant in Russia. The annual emission of this power plant is about 400 tons. The main components of the emissions are sulfureous anhydride (up to 40%), solid stuff (up to 50%), and nitric oxides. However, Zavyalov et al., (2018) showed that silver birch and Scots pine trees were more severely impacted by magnesite dust pollution compared to Sukachyov's larch (*Larix sukaczewii* Dylis) trees. Soil remediation is needed in adversely affected areas. In addition, Potapenko et al., (2019) examined the changes in the state of the pine stands after the Chernobyl accident, and they found that these changes were characterized by their strong weakening. Ambiguous trends were also observed in the stability of stands depending on the type of forest and land relief.

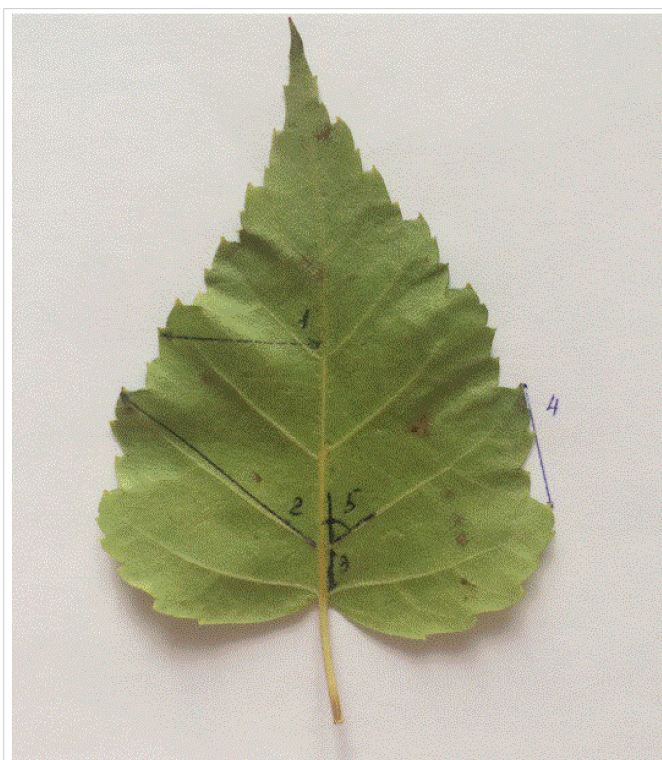

Figure 3.
Indicators of Silver Birch Leaf Blades Used to Determine Fluctuating Asymmetry.

Table 3.
Characteristics of the Stand Formed at the Reclamation Site No. 3

No.	Species	Average Diameter, (cm)	Average Height, m	Number of Seedling, ps/ha	CEI, cm/cm²	Average Age, years
1	*Betula pendula* Roth	5.17 ± .14	4.57 ± .06	199	21.8	21
2	*Populus tremula* L.	3.05 ± .34	2.84 ± .14	10	38.9	16
3	*Populus balsamifera* L.	1.47 ± .30	2.23 ± .07	1	131.5	14
4	*Salix caprea* L.	1.35 ± .25	2.35 ± .16	3	164.3	16
Total broadleaves		2.76 ± .26	3.00 ± .11	213	50.2	
5	*Pinus sylvestris* L.	3.20	2.10	1	26.1	15
Total conifers		3.20	2.10	1	26.1	

Our results showed that CEI value in all plots for all species significantly exceeds the optimal value for normal plantations, which in turn indicates a high intensity of tree growth and their unfavorable condition.

To assess the environment quality, we also collected materials for research using the methods of leaf-blade fluctuating asymmetry on the territory of the Karabash urban district and adjacent forest plantations in August and September 2018 (Table 4).

Figure 4.
Formation of the Forest Environment at the Reclamation Site No. 2.

Table 4.
Integral Indicators of Silver Birch Stable Development in the Vicinity of Karabash City

Collection Area	Distance from Sources of Pollutants, km	Integral Asymmetry Index	Condition Score	Quality of Development
No. 1 (city line)	.8	.050	IV	Significant deviations from the norm
No. 2 (city line)	2.2	.053	IV	Significant deviations from the norm
No. 3 (north-east direction)	8.0	.046	III	Average deviation rate from the norm
No. 4 (north-east direction)	13.0	.041	II	Initial (minor) deviations from the norm
Reclamation site No. 1. The western slope of the Golden Mountain	3.1	.047	III	Average level of deviation from the norm
Reclamation site No. 2. The western slope of the Golden Mountain	3.0	.054	IV	Significant deviations from the norm
Reclamation site No. 3. The Eastern slope of the Golden Mountain	3.3	.053	IV	Significant deviations from the norm

Figure 5.
Reclamation Site No. 3.

The integral indicators presented in Table 4 indicated that the quality of the Karabash urban district environment as well as its environments did not meet the standards. Within the city limits, there were significant deviations from the norm, but with distance from the Joint Stock Company Karabashmed, the state of the environment significantly improved. The integral indicator of developmental stability for silver birch growing at a distance of 8.0 km from a source of industrial pollutants was .046, at a distance of 13.0 km, it was .041, corresponding to the III and II points according to the operating scale (Anonymous, 2003) (Figure 5).

Figure 6 indicates that the dependence was linear. As can be seen from figure 6; With distance from the enterprise as a source of emissions, the condition of the studied birch trees improves, bilateral symmetry of leaf blades approaching the norm.

The leaves obtained in the areas of forest recultivation indicate average and significant deviations from the norm of the integral asymmetry indicator. On the reclamation site No. 1, located on the western slope of the Golden Mountains, the integral indicator of development stability corresponds to the III point, in the other two to the IV point. It is quite consistent with factors influencing the growth of woody vegetation assessed visually. Unlike plots 2 and 3, where the soil is completely absent, in the first plot on the terraces, there is a soil cover of low thickness and as a result, such components of forest plantations as undergrowth, underwood, and living ground cover are formed.

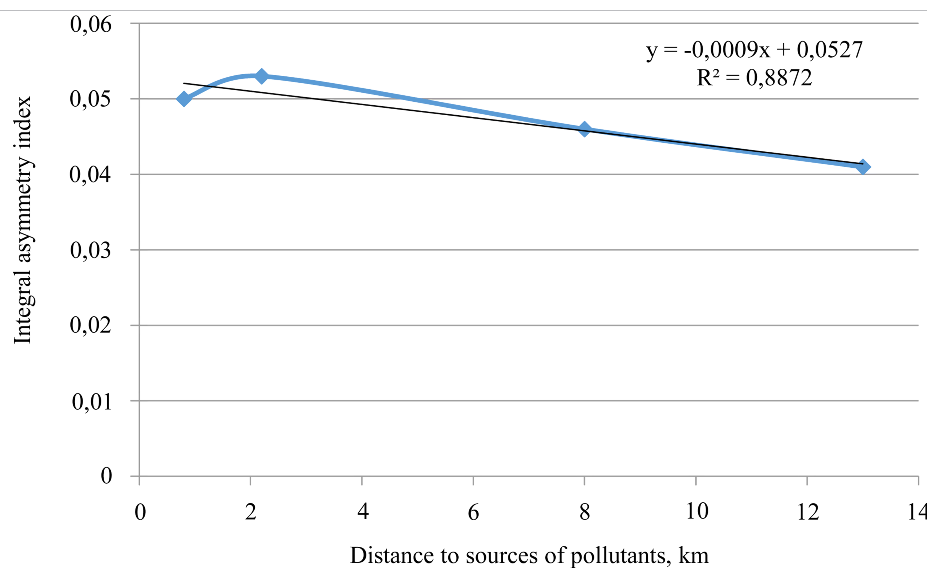

Figure 6.
The Integral Asymmetry Index of Silver Birch According to the Distance from the Source of Pollution.

The results obtained supplement and refine the results of earlier studies on the problem of creating and maintaining the stability of plantations created on disturbed lands (Zalesov et al.,, 2017, 2020). The use of the method for determining the state of environment by the asymmetry of silver birch leaf blades makes possible to quickly determine the ecological situation in the region and carry out ecological monitoring of the environment state. The uniqueness of the method along with its use easiness is explained by the possibility of its using in condition of negative anthropogenic impact of various types on the environment.

In the industry complexes in the present period of global and local climate changes, green spaces are considered a very important factor in making the situation better, especially in polluted areas. The results of the research are in function of prioritizing both reclamation measures and selection of woody species suitable for revitalization and improvement of the disturbed lands, that is, whereas copper pollutes the ecosystem directly, air and soils in particular.

Conclusion and Recommendations

This research is, in a way, for the measure of adaptability, sensitivity, and resilience of certain pioneering tree species after the emissions of the smelter that may certainly have some affection on them over a period of time. Particularly, the silver birch native to the investigation area is very important not only for the country where they are inhabited but also for global hygrometric habitats, too. In addition, in the high altitude forest zones in the present period of global and local climate changes, tree species are considered a very important factor in finding mitigation measures, especially in alpine and pre-alpine areas where the shift of tree-line is noted. By the observations and evaluations of the data the following conclusions and recommendations can be expressed.

1. Terracing followed by planting or sowing of forest cultures on created terraces is an effective way for forest reclamation of mountain slopes near copper smelting enterprises.
2. When reclamation is carried out, it is possible to create forest crops both by sowing seeds and by planting 2-year-old seedlings.
3. Silver birch can be recommended as the main species on disturbed lands in the South Ural forest steppe region.
4. To increase the safety of forest crops, it is advisable to cover terraces with a layer of sewage sludge. The latter, in addition to forest reclamation accelerating, ensures the release of treatment and improves the environmental situation in the area of reclamation work.
5. To accelerate the formation of soil and forest environment on reclaimed slopes, it is possible to recommend, in addition to creating forest cultures, sowing seeds of the undergrowth species: broom Russian (*Chamaecytisus ruthenicus* (Wol.) Klask), buckthorn (*Rhamnus* L.), and blue honeysuckle (*Lonicera caerulea* L.).
6. To assess the environmental quality, the fluctuating activity method of the silver birch leaf blade is recognized as quite effective. The asymmetry of birch leaves is in direct proportion to the distance to the Karabashmed Joint-Stock Company. In the state of environmental quality on the territory of the Karabash urban district, there are significant deviations from the norm. At a considerable distance from the Karabashmed joint-stock company—8.0 and 13.0 km—the environmental quality has an average and initial level of deviation from the norm, respectively.
7. The state of the environment in the territory of the Karabash urban district despite the attempts to modernize production remains unfavorable.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – A.V.B., Z.V.Z.; Design – A.V.B., S.V.Z., S.A.; Supervision – S.V.Z., S.A.; Materials – A.V.B., S.V.Z.; Data Collection and/or Processing – A.V.B., S.V.Z.; Analysis and/or Interpretation – A.V.B., S.V.Z., S.A.; Literature Review – A.V.B., S.V.Z., S.A.; Writing – A.V.B., S.V.Z., S.A.; Critical Review – S.V.Z., S.A.

Declaration of Interests: The authors declare that they have no competing interest.

Funding: The authors declared that this study has received no financial support.

References

- Anonymous (2003). Methodological recommendations for assessing the quality of the environment by the state of living beings (assessment of stability of living organisms by the level of asymmetry of morphological structures). Approved by the order of Rosecolog from 16.10.2003 (p. 460). Retrieved from https://base.garant.ru/2159808/
- Anonymous (2019). *State (national) report on the state and use of land in the Russian Federation in 2019*. M.: 2020. Retrieved from https://rosreestr.gov.ru
- Anonymous (2020). *Reporty on the environmental situation in the Chelyabinsk region in 2019, Chelyabinsk*. Retrieved from http://mineco174.ru
- Anonymous (2021a). *Land code of the Russian Federation of 25.10.2001* (p. 136). Retrieved fromhttp://www.consultant.ru/document/cons_doc_LAW_33773/
- Anonymous (2021b). Karabash urban district. Historical background. URL. Retrieved from http://karabash-go.ru/about/
- Ayan, S., & Yer, E. N. (2017). A review on the species used in the remediation of contaminated soils due to different mining operations in Turkey, 4–7 September, 2017, International Conference on the Biological Reclamation of Disturbed Lands, Proceedings (pp. 371–380). Ekaterinburg, Russia.
- Bachurina, A. V., & Zalesov, S. V. (2020). The use of the bioindication method for assessing the quality environment quality in industrial cities of the Urals. *Forestry Bulletin*, *24*(3), 11–17.
- Bachurina, A. V., Zalesov, S. V., & Tolkach, O. V. (2020). Forest reclamation efficiency of disturbed lands in the zone of copper smelting production influence. *Ecology and Industry of Russia*, *24*(6), 67–71. [CrossRef]
- Becker, F., Eser, R. A., Hoelzmann, P., & Schütt, B. (2019). The environmental impact of ancient iron mining and smelting on Elba Island, Italy – A geochemical soil survey of the Magazzini site. *Journal of Geochemical Exploration*, *205*, 106307. [CrossRef]
- Bunkova, N. P., Zalesov, S. V., Zoteeva, E. A., & Magasumova, A. G. (2011). *Phytomonotoring bases* (p. 89). Ekaterinburg: Ural State Forest Engineering University.
- Gabarrón, M., Zornoza, R., Acosta, J. A., Faz, Á., & Martínez-Martínez, S. (2019). Mining environments. In *Advances in Chemical Pollution, Environmental Management and Protection* (Vol. *4*, pp. 157–205). [CrossRef]
- Kotelnikova, A. L. (2010). On the mobilization of components of copper smelting slag by model soil solutions [in Russian]. *Trudy IGG Uro Ran*, *157*, 142–145.
- Makhnev, A. K., Menschikov, S. L., & Terin, A. A. (1996). Problems of biological reclamation of phytotoxic distrurbed lands in the Urals and Siberia. Biological Reclamation of Disturbed Lands: Abstr. Rep. of Intern. Confer (pp. 99–101). Yekaterinburg: Ur. Br. RASc.
- Makhniova, S., Mohnachev, P., & Ayan, S. (2019). Seed germination and seedling growth of Scots pine in technogenically polluted soils as container media. *Environmental Monitoring and Assessment*, *191*(2), 113. [CrossRef]
- Menshikov, S. L., Srodnykh, T. B., & Terekhov, G. G. (1987). Peculiarities of the chemistry of soils and anatomic-morphological structure of the assimilation apparatus of pines and birch under the conditions of magnesite dust [in Russian]. *Russian Journal of Ecology*, *5*, 84–87.
- Menshikov, S., Kuzmina, N., Ayan, S., & Özel, H. B. (2019). Effects of mining, thermal, industrial plants on forests land and rehabilitation practices in Ural region in Russia. *Fresenius Environmental Bulletin*, *28*(2A), 1511–1521.
- Mohnachev, P., Menshikov, S., Makhniova, S., Zavyalov, K., Kuzmina, N., Potapenko, A., Ayan, S., & Laaribya, S. (2018). Scotch pine regeneration in magnesite pollution conditions in South Ural, Russia. *South-East European Forestry*, *9*(1), 55–60. [CrossRef]

- Potapenko, A., Bulko, N., Kozlov, A., Mohnachev, P., Zavyalov, K., Kuzmina, N., & Ayan, S. (2019). Influence of Scotch pine (*Pinus sylvestris* l.) plantations on near and far territories of Chernobyl anthropogenic factors. *Forestry Ideas*, *25*(2) 58, 301–313.
- Shulga V. D., Gustova A. I., & Terekhina, D. K. (2007). Features of obligatory intensive silvicultural maintenance for recreational stands of the arid zone. *Arid Ecosystems*, *13*(33–34), 81–88.
- Spiridonov, E. M., & Pletnev, P. A. (2021). Cuprous gold deposit of Gold mountain (on «gold rodingite» formation). M.: Scientific world, 217 p. Retrieved from https://www.rfbr.ru/rffi/ru/books/o_249
- Zakharov, V. M., Baranov, A. S., & Borisov, V. I. (2000). Environmental health: Assessment methods. M.: Russian Centre for Environmental Policy, *68*
- Zalesov, S. V., Ayan, S., Zalesova, E. S., & Opletaev, S. A. (2020). Experiences on establishment of Scots pine (*Pinus sylvestris* L.) plantation in ash dump sites of Reftinskaya power plant, Russia, *Alınteri J. of Agr. Sci*, *35*(1), 7–14. https://doi:10.28955/alinterizbd.696559
- Zalesov, S. V., Bachurina, A. V., & Bachurina, S. V. (2017). Condition of forest plantations exposed to the influence of industrial pollutants of the closed joint stock company «Karabashmed» and the reaction of their components to renewal felling. Ekaterinburg: Ural state forest engineering university. Retrieved from https://elar.usfeu.ru/handle/123456789/6620
- Zavyalov, K. E., Ivanova, N. S., Potapenko, A., & Ayan, S. (2019). Influence of soil fertility on the ability of Scots pine (*Pinus sylvestris* L.) to adapt to technogenic pollution. *CERNE*, *25*(4), 326–331. [CrossRef]
- Zavyalov, K., Menshikov, S., Mohnachev, P., Kuzmina, N., Potapenko, A., & Ayan, S. (2018). Response of Scots pine (*Pinus sylvestris* L.), Sukachyov's larch (*Larix sukaczewii* Dylis), and Silver birch (*Betula pendula* Roth) to magnesite dust in Satkinsky industrial hub. *Forestry Ideas*, *24*(1) 55, 23–36.
- Zolotova, E. S., Ivanova, N. S., Ryabinin, V. F., Ayan, S., & Kotelnikova, A. L. (2021). Element mobility from the copper smelting slag recycling waste into forest soils of the taiga in Middle Urals. *Environmental Science and Pollution Research International*, *28*(1), 1141–1150. [CrossRef]