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Broadleaved Species Admixtures in Composition of Greenish Spruce Stand as Their Stability Index.

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ABSTRACT

The last decades has been marked the spruce stands drying up problem in different countries of the world. We have established earlier that the stand species composition strongly affects spruce trees drying up. The research purpose is in establishing the dependence between the share of different broadleaved species participation in stand composition and the area of spruce stands. The spruce stands of greenish forest type of the Permsky kray has served as the research object. As the result, it has been established that when the admixtures share in composition of greenish spruce stands is rather high, then spruce stability for drying up is increasing. In particular, spruce stands of the greenish forest type with birch admixture of more than 50 % and aspen admixture of more than 30 % are characterized by maximal stability for drying up. The fact revealed is explained by the fact that under spruce stands, which stock constitutes mainly broadleaved, at the expense of yearly folia attrition more fertile soils than in pure coniferous stands are formed. Spruce stability to drying up in dependence on broadleaved participation share in stands composition should be taken into account under improvement felling and in artificial stands creating.

Keywords: coniferous-broadleaved (mixed) forest zone, drying up, broadleaved, greenish spruce stands, stand composition.

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INTRODUCTION

Lastly in different countries of the world, the problem of spruce stands drying up has been sharply worsened [1-5]. Unfortunately, the authors have not succeeded in finding a single opinion as concerns the reason of this phenomenon.

Admixtures in spruce stands of various wood species indicate definite soil condition availability. In particular, it means that under spruce stands, the main part of which is broadleaved, more fertile soils are formed at the expense of yearly leafage, i.e. the soils that are more fertile than in pure coniferous stands. In other words, in the first case, soddy is dominate, but in the second one is the podzolic type of soil-forming. A significant part of broadleaved species admixture testifies to the favorable soil condition for spruce growth.

In coniferous-broadleaved (mixed) forests of Permsky kray, it is registered ever growing number of spruce stands dried up seats that calls for necessity of this phenomenon cause determining and ways to minimize the damage caused. We have established in our previous works that stands composition rather strongly influences spruce drying up [6]. However, the problem should be thoroughly studied, this problem brought us to determine the trend of our investigations.

The purpose of our research is to establish the dependence between the share of different broadleaved participation in the forest stands composition and the area of greenish spruce stands drying up in condition of the coniferous-broadleaved (mixed) zone in Permsky kray forests (European part of the Russian Federation).

MATERIALS AND METHODS

Spruce stands of the greenish forest type growing on the territory of the Ochersky forest district of Permsky kray (European part of the Russian Federation) served as an object of our research.

In the process of our research, the greenish spruce stands distribution according to types of stands composition was carried out. Altogether, 5 forest stands composition types were picked out: the pure spruce stands; the mixed coniferous – spruce stands with coniferous trees admixtures (pine, larch, fir tree); the mixed coniferous broadleaved –stands with dominating in composition of coniferous stands, including spruce and broadleaved species admixture); mixed spruce broadleaved –stands with dominating in stands composition spruce trees and with broadleaved species admixture; some others stands when spruce does not occur in stands composition. Distribution according to stands composition type was carried out as a whole for the forest district as well as for drying up seats.

Forest management materials and the acts of pathologic inspection of Ochersky forest district for the period 2010-2016 served as the source of information.

In forest pathologic investigations sample plots have been laid according to generally used and approved methods [7]. When the amount of current attrition has appeared lower than that one of natural attrition in stands of analogous composition and age, then the stand was considered to be healthy.

To clear out dependence of availability between areas of distribution as a whole for the forest district and in dried up stands, then the correlation coefficient r [8] has been applied.

The term stability we understood as a tree capacity to retain viability under different types of negative anthropogenic and natural impact.

RESULTS AND DISCUSSION

According to the data coming from the Ochersky forest organization, the area of greenish spruce stands constitute more than 29 thousand ha. For the period 2010-2016, spruce stands of greenish type drying up registered on 2051.2 ha, and 120 stratum were included (table 1).

Table 1: Greenish spruce stands of the Ochersky forest district with available seats of drying up.

| Sectional forest district | Number and area of investigated stratum per years, pcs/ha | | | | | | | Total, pcs/ha |
|---------------------------|---|-----------|-----------|-------------|-------------|-------------|-------------|---------------|
| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | |
| Bolshesosnovsky | - | - | 2 45 | 9 181 | 2 24.1 | 13 242 | 12 251.8 | 38 743.9 |
| Okhansky | - | 3 18.3 | 4 40.6 | 14 202.8 | 25 423.8 | 15 241.9 | 19 350.9 | 80 1278.3 |
| Ochersky | 1 11 | - | - | - | - | 1 18 | - | 2 29 |
| Total | 1 11 | 3 18.3 | 6 85.6 | 23 383.8 | 27 447.9 | 29 501.9 | 31 602.7 | 120 2051.2 |

The table 1 data testifies to the fact that the seats of spruce stands drying up area in greenish forest type is constantly increasing. In such a way, if it constituted 11 ha in 2010, then it was 602.7 ha in 2016. It makes clear the necessity of silvicultural measures to be carried out in order to minimize the damage caused.

As for composition, in the Ochersky forest district, the mixed coniferous-broadleaved stands are prevailing. The stands of above mentioned stands composition type occupy 76.44% of the total greenish spruce area. The share of mixed coniferous-broadleaved in the total area of drying up seats does not exceed 61.01%. The share of mixed coniferous stands constitutes 14.07%. For all this, the mixed coniferous stands share in seats of drying up constitutes 38.4%.

Mixed spruce-broadleaved stands where spruce grows together with broadleaved species occupy nearly 8% on the territory of the forest district in forest type greenish spruce stand. However, seats of drying up with the given above stands composition type have not been registered for the whole period of our research. The correlation coefficient $r = 0.87$. It reaffirms the close ties between the distributions cited in table 2.

Table 2: The area of greenish spruce stands distribution in the forest district as a whole and in seats of drying up according to composition types (comparative characteristic).

| Type of stand composition | The occupied area in forest district | | The occupied area in seats of drying up | |
|------------------------------|--------------------------------------|-------|---|-------|
| | ha | % | ha | % |
| Pure spruce | 332.0 | 1.14 | 12.2 | 0.59 |
| Mixed coniferous | 4097.9 | 14.07 | 787.6 | 38.4 |
| Mixed coniferous-broadleaved | 22265.3 | 76.44 | 1251.4 | 61.01 |
| Mixed spruce-broadleaved | 2327.5 | 7.99 | - | - |
| Others | 106.8 | 0.37 | - | - |
| Total | 29129.5 | 100 | 2051.2 | 100 |

In such a way, there observed a distinct tendency of broadleaved species admixtures in greenish spruce stands with positive influence on spruce stability.

Spruce stands of greenish forest type have in their composition, beside spruce, 8 more woody species, five of them are broadleaved (table 3). Drying up in stands with lime, willow, and alder have not been registered.

Table 3: The greenish spruce stands area with accompanying species in stands composition in the forest district generally and in the seats of drying up (comparative characteristic).

| Accompanying species | The occupied area in forest district | | The occupied area in seats of drying up | |
|----------------------|--------------------------------------|-------|---|-------|
| | ha | % | ha | % |
| Pine | 21196.1 | 72.77 | 1861 | 90.73 |
| Fir | 17791.0 | 61.08 | 1540.3 | 75.09 |
| Larch | 117.6 | 0.40 | - | - |
| Birch | 22598.6 | 77.58 | 959.6 | 46.78 |
| Aspen | 16207.0 | 55.64 | 665.5 | 32.44 |
| Lime | 587.5 | 2.02 | - | - |
| Willow | 701.6 | 2.41 | - | - |
| Alder | 81.4 | 0.28 | - | - |

The data presented in Table 3 testify to the fact that if the birch is available in 77.58% of greenish spruce stands (on the whole in the forest district), then in the registered dried up seats, stands share with birch in stands composition does not exceed 46.78%. Analogous situation is observed in stands with aspen participation, as a whole in the forest district aspen grows in 55.64% of greenish spruce stands, but in seats of drying up the share of stands with aspen participation constitutes 32.44%.

So, the fact of reduced share of dried up stands with broadleaved species participation has been established.

The latter put in claims to analyze in more details the cause of spruce stands with broadleaved species in composition drying up.

The data in the table 4 testifies to the fact that the share of birch participation in spruce stands of greenish forest type varies from 2-5 to 100%.

Table 4: The greenish spruce stands distribution in the Ochersky forest district according to the birch admixture share in stands composition, ha/%

| Age class | Birch participation in stands composition, % | | | | | | | | | | | Total |
|-----------|--|--------|--------|--------|-------|-------|-------|-------|-------|-------|------|---------|
| | 2-5 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | |
| I | 26.5 | 43.5 | 307.3 | 362.9 | 333.6 | 169.9 | 141 | 36.7 | 33.6 | - | 3.3 | 1458.3 |
| | 1.82 | 2.98 | 21.07 | 24.89 | 22.88 | 11.65 | 9.7 | 2.52 | 2.3 | - | 0.2 | 100 |
| II | 37.3 | 135 | 319.7 | 186.4 | 120.9 | 87.7 | 33.2 | 72.3 | 34.2 | 30.4 | 5 | 1062.1 |
| | 3.51 | 12.7 | 30.1 | 17.6 | 11.4 | 8.26 | 3.13 | 6.81 | 3.22 | 2.86 | 0.5 | 100 |
| III | 863.2 | 2491.1 | 1885 | 736 | 585.9 | 293.6 | 233.6 | 156.3 | 105.2 | 64.5 | 18.6 | 7433 |
| | 11.61 | 33.51 | 25.36 | 9.9 | 7.88 | 3.95 | 3.14 | 2.1 | 1.42 | 0.87 | 0.25 | 100 |
| IV | 1063.6 | 3499.3 | 3000.8 | 1055.3 | 652.3 | 417.5 | 303.8 | 264.4 | 152.5 | 26.2 | 4.5 | 10440.2 |
| | 10.19 | 33.52 | 28.74 | 10.11 | 6.25 | 4.0 | 2.91 | 2.53 | 1.46 | 0.25 | 0.04 | 100 |
| V | 552 | 566.4 | 525.4 | 272.8 | 75.6 | 21.4 | 47.2 | 45.8 | 8.9 | - | - | 2115.5 |
| | 26.1 | 26.77 | 24.84 | 12.9 | 3.57 | 1.01 | 2.23 | 2.16 | 0.42 | - | - | 100 |
| VI | 18 | 12.8 | 6.3 | 9.9 | 1.6 | - | - | - | - | - | - | 48.6 |
| | 37.04 | 26.34 | 12.96 | 20.37 | 3.29 | - | - | - | - | - | - | 100 |
| VII | 4.7 | 5.7 | - | 1.6 | 26.1 | 2.8 | - | - | - | - | - | 40.9 |
| | 11.49 | 13.94 | - | 3.91 | 63.81 | 6.85 | - | - | - | - | - | 100 |
| Total | 2565.3 | 6753.8 | 6044.5 | 2624.9 | 1796 | 992.9 | 758.8 | 575.5 | 334.4 | 121.1 | 31.4 | 22598.6 |
| | 11.35 | 29.89 | 26.75 | 11.62 | 7.95 | 4.39 | 3.36 | 2.55 | 1.48 | 0.54 | 0.14 | 100 |

Spruce stands of greenish forest type mostly has the birch admixture of one (29.89%) and two (26.75%) units in composition formula.

According to forest pathologic acts of inspection, in condition of the Ochersky forest district, drying up process in stands with birch participation is registered only in stands of III and IV age classes (Table 5).

Table 5: Seats of drying up distribution in greenish spruce stands according to the share of birch participation in stands composition, ha/%.

| Age class | Share of birch participation in stands composition, % | | | | | | Total |
|-----------|---|-------|-------|------|------|------|-------|
| | 2-5 | 10 | 20 | 30 | 40 | 50 | |
| III | 9.6 | 238.4 | 70.0 | 10.5 | 16.7 | - | 345.2 |
| | 2.78 | 69.06 | 20.28 | 3.04 | 4.84 | - | 100 |
| IV | 16.1 | 352.1 | 206.0 | 29.2 | - | 11.0 | 614.4 |
| | 2.62 | 57.31 | 33.53 | 4.75 | - | 1.79 | 100 |
| Total | 25.7 | 590.5 | 276.0 | 39.7 | 16.7 | 11.0 | 959.6 |
| | 2.68 | 61.54 | 28.76 | 4.14 | 1.74 | 1.15 | 100 |

The data from table 5 visually testifies to the fact that there observed no drying up process when more than 50% of birch admixture is available in greenish spruce stands. Greenish spruce stands with 10% of birch admixture in stands composition are characterized by the maximum drying up share. Their share constitutes 61.54% of the total area of drying up seats, registered in spruce stands of above mentioned forest type. It should be especially accentuated that spruce stands with birch admixture 10% in the Ochersky forest district does not exceed 29.89%. With birch participation in stands composition of 20% in the Ochersky forest district, the share of dried up spruce stands of greenish forest type constitutes 28.76%. By the way, the share of spruce stands with birch admixture 20% in the Ochersky forest district does not exceed 26.75%. When the birch admixture of 30% and more, the inversed situation is observed: the share of registered seats of drying up does not exceed the analogous share as a whole in the forest district. So, with share of birch participation in greenish spruce stands composition increasing the stands stability to drying up is also increasing. The correlation coefficient r between the area of greenish spruce stands in the forest district as a whole and in seats of drying up according the share of birch participation in stands composition constituted 0.92, testifying to the very high ties between them.

According to the forest organization materials in the Ochersky forest district, the share of aspen in greenish spruce stands is varied from 2-5 to 90% (Table 6).

The most part of greenish spruce stands has admixtures of aspen 10% (44.21%) in stands composition. Pathologic investigation acts testify to the fact that drying up in stands with aspen participation has been registered in stands of III, IV, and V age classes (Table 7).

As for the Table 7 information, drying up has not been registered in stands when the aspen share of greenish spruce stands constitutes more than 30%. It deserves devoting special attention to the fact that greenish spruce stands with the aspen admixture share in stands composition of 2-5% constitutes 13.65% and the share of the above mentioned composition stands constitutes 16.18% of seats in the drying up area. Greenish spruce stands with aspen participation in stands composition of 10% are characterized by the maximum share of drying up, they constitute 68.73 % of the total area.

It should be accentuated that spruce stands share with aspen participation in stands composition of the Ochersky forest district does not exceed 44.21%.

Greenish spruce stands with aspen admixture 20 and 30% (10.43 and 4.66% accordingly) are characterized by the less share of drying up. With that stands, the share with aspen admixture of 20 and 30% in the forest district achieves 27.6% and 6.98%, correspondently.

Table 6: The distribution of greenish spruce stands in the Ochersky forest district according to the aspen admixture in stands composition, ha/%.

| Age class | Share of aspen participation in stands composition, % | | | | | | | | | | Total |
|-----------|---|-----------------|-----------------|----------------|----------------|---------------|--------------|--------------|--------------|-------------|---------------|
| | 2-5 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | |
| I | 38 4.02 | 135.8 14.35 | 431.5 45.59 | 106.2 11.22 | 164.6 17.39 | 37.3 3.94 | 19.4 2.05 | - | 13.6 1.44 | - | 946.4 100 |
| II | 75.8 13.13 | 124 21.48 | 118.6 20.55 | 54.9 9.51 | 185.9 32.21 | 5.4 0.94 | 5.5 0.95 | 3.4 0.59 | 3.7 0.64 | - | 577.2 100 |
| III | 706.3 14.11 | 2395.9 47.88 | 1259 25.16 | 262.2 5.24 | 178.1 3.56 | 141.8 2.83 | 26.3 0.53 | 28.7 0.57 | 4.4 0.09 | 1.3 0.03 | 5004 100 |
| IV | 1184.5 14.39 | 3911.2 47.51 | 2274.1 27.62 | 515.4 6.26 | 197.8 2.40 | 85.4 1.04 | 25.2 0.31 | 19.5 0.24 | 19.9 0.24 | - | 8233 100 |
| V | 199.8 14.06 | 587.2 41.33 | 388.7 27.36 | 192.7 13.56 | 18.3 1.29 | 33.9 2.39 | - | - | - | - | 1420.6 100 |
| VI | - | 10 62.89 | 1 6.29 | - | - | - | 4.9 30.8 | - | - | - | 15.9 100 |
| VII | 8.2 82.83 | 1.7 17.17 | - | - | - | - | - | - | - | - | 9.9 100 |
| Total | 2212.6 13.65 | 7165.8 44.21 | 4472.9 27.6 | 1131.4 6.98 | 744.7 4.59 | 303.8 1.87 | 81.3 0.5 | 51.6 0.32 | 41.6 0.26 | 1.3 0.01 | 16207 100 |

Table 7: Seats of greenish spruce stands drying up distribution according share of aspen participation in stands composition.

| Age class | Share of aspen participation in stands composition, % | | | | Total |
|-----------|---|----------------|---------------|------------|--------------|
| | 2-5 | 10 | 20 | 30 | |
| III | 37.7 16.88 | 148.1 66.29 | 37.6 16.83 | - | 223.4 100 |
| IV | 70 17.32 | 271.3 67.14 | 31.8 7.87 | 31 7.67 | 404.1 100 |
| V | - | 38 100 | - | - | 38 100 |
| Total | 107.7 16.18 | 457.4 68.73 | 69.4 10.43 | 31 4.66 | 665.5 100 |

The correlation coefficient r between the distribution area of the greenish forest type spruce stands in the forest district as a whole and in seats of drying up, according to the aspen participation in stands composition, constitutes 0.87, which testifies to the strong ties between them.

The above mentioned visually testifies to the dependence of spruce stands on aspen admixture in stands composition.

So, a significant share of broadleaved species admixture in stands of greenish spruce influences positively on spruce stands stability.

The most part of the scholars believes [9, 10, 11, 12] that the mixed stands are characterized by the increased stability against unfavorable natural and anthropogenic factors, as compared with the pure stands. It should not be forgotten that the creation of mixed stands results in biodiversity increasing, which guarantees the increasing recreation attractiveness [13, 14]. However, this point of view is not of a single meaning. E.G. Malakhova and A.M. Krylov [15] point out that the drying up spruce stands are observed mainly when the spruce trees share in stands composition is more than 50%.

The positive effect of the admixture of broadleaved species on the stability of spruce stands to root rot in the conditions of Belarus was noted by N.I. Fedorov [16]. The author notes that the prevalence of stands

by root rot reduces with the increase of the participationshare in spruce stands of broadleaved species (birch, alder, oak, ash, maple etc.) in 3-3.5 times in comparison with the pure spruce stands.

Thus, the mixed spruce stands with an admixture of broadleaved species are characterized by an increased sustainability to unfavorable factors.

CONCLUSION

1. In condition of coniferous-broadleaved forests in the zone of Permsky kray for the last 7 years, it is observed that the seats of drying up are increasing in the greenish spruce stands.
2. The mixed coniferous and mixed coniferous-broadleaved stands, the share of which constitutes 99.41 % of the whole area of drying up seats, are characterized by minimal stability.
3. Under the significant part of broadleaved species admixture in greenish spruce stands composition in condition of coniferous-broadleaved (mixed) stands, spruce stability to drying up increases.
4. The spruce stands of greenish forest types, with the birch admixture of more than 50 % and with the admixture of aspen of more than 30%, are characterized by the maximal stability to drying up.
5. A significant spruce stands drying up are observed in stands with the birch admixture of 10 and 20 % and with the aspen of 2-5 and 10%, as concerns their reserves.
6. The broadleaved impact on spruce stability to drying up should be taken into account when improvement felling carrying out and in forest cultures creating.

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