

Natural Restoration of Norway Maple Stands in the Conditions of the Republic of Tatarstan

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Abstract. The article provides an analysis of changes in the areas of Norway maple stands in the forests of the Republic of Tatarstan from 1944 to 2019. According to the accounting data of the forest fund as of 01.01.2020, the area occupied by maple in the Republic of Tatarstan is 29.3 thousand hectares (2.5 % of the forest fund area), including 5.0 thousand hectares of young growth of the 1st and 2nd age class, 21.4 thousand hectares of middle-aged trees, 1.9 thousand hectares of ripening trees and 1.0 thousand hectares of ripe trees. A reliable relationship was revealed between a decrease in the area of maple after extremely low frosts of 1939–1940, 1941–1942 and 1978–1979, and an increase in its area after the drought of 2010. After the drought of 2010, there is a natural replacement of highly productive birch stands with low-quality maple stands, which will lead to a deterioration of the commodity structure of the felling fund of the Republic of Tatarstan. Maple plantations have a mixed composition and farming in them should be aimed at increasing the proportion of species valuable for these conditions – oak and birch.

1 Introduction

Norway maple (*Acer platanoides* L., 1753) is an economically valuable tree species, slightly represented on the lands of the forest fund of the Russian Federation [1–3]. Norway maple prefers fertile loamy, sufficiently moist, well-drained soils; grows most often in deciduous and mixed forests in the form of admixture and undergrowth, but it can also dominate – 90 % of pure maple forests are concentrated in Bashkiria [2, 5]. It is most widespread in oak forests, especially in forest ravines [4].

Norway maple reproduces well vegetatively and by seed, bears fruit abundantly almost every year. In the conditions of the Moscow region, in oak forests there are 60–70 thousand maple seedlings per hectare. By September, their height is about 7 cm, and by 10 years old undergrowth under the forest canopy reaches 50 cm. Maple grows much faster in clearings and in culture: at 5 years its height is 4–5 m, intensive growth continues up to 25–30 years [2]. In favorable growing conditions, maple is a tree of the first size with a slender trunk up to 1 m in diameter, 20–30 m in height and a densely leafy crown. In unfavorable conditions and at the border of the range, it is a tree of the second size or takes the form of a large shrub [2, 4]. The growth ability of maple lasts up to 40–50 years. It is quite shade-tolerant, especially at a young age, second only to linden in this respect. In central Russia, maple is periodically severely damaged by frost, which was noted in the winter of 1939/1940, 1941/1942, 1955/1956 and 1978/1979 [6]. According to

the accounting data of the forest fund as of 01.01.2020, the area occupied by maple in the Republic of Tatarstan is 29.3 thousand hectares (2.5 % of the forest fund area), including 5.0 thousand hectares of young growth of the 1st and 2nd age class, 21.4 thousand hectares of middle-aged trees, 1.9 thousand hectares of ripening trees and 1.0 thousand hectares of ripe trees [7].

2 Materials and methods

The initial material for the analysis was the data of the state accounting of the forest fund, starting from 1944. After the drought of 2010, more than 10 thousand strata of birch and maple forest stands were analyzed based on accounting data; natural regeneration was estimated on more than 100 temporary sample plots in 20 forest districts of the Republic of Tatarstan. The condition of the trees was assessed according to 6 categories, the undergrowth was calculated with division by categories of size by species.

When solving the problem, we used information technology based on the system analysis of the data of mass inventory of plantations [8]. The material was processed by standard methods using applied programs of mathematical statistics.

3 Results and discussion

Severe frosts of 1939–1940, 1941–1942 and 1978–1979, when the temperature dropped below 45 degrees, led to a

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massive drying out of Norway maple and English oak, the area occupied by maple decreased from 31 thousand hectares in 1944 to 12.6 thousand hectares in 1983. Part of the area was replaced by soft-leaved species, part of it turned into open spaces [9].

The decrease in the area of maple directly correlates to 1983 with the dynamics of the area of oak forests. Starting in 1998, the area occupied by maple (as opposed to oak) began to increase and at the moment it has recovered to its share in the forest fund in 1944 (Table 1).

Table 1. Dynamics in the areas of Norway maple and English oak from 1944 to 2019 in the Republic of Tatarstan, thousand hectares

Species year	1944	1966	1983	1998	2003	2008	2013	2019
High oak	109.5	160	158.2	102.7	108	102.4	102.8	97.9
Low oak	173.5	107.5	105.6	60.5	80.7	64.9	65.8	62.6
Norway maple	30.6	17.8	12.6	16.3	17.5	19.5	19.6	29.3

Norway maple in the forest-steppe zone is an integral component of oak plantations. The maple tree stand replacing the oak is characterized by low forestry-taxation indicators (height is 15 m, diameter is 14–18 cm). However, due to its high density, maple prevents the regeneration of oak, and its undergrowth, conquering free spaces formed as a result of selective sanitary felling or natural oak decay, forms a closed (up to 80%) canopy. The sustainable existence of maple is due to its shade tolerance, the presence of an abundant amount of self-seeding, resistance to frost and mechanical damage. These biological properties, the ability to grow in various environmental conditions determine the high tolerance of maple. [10]. Despite the fact that during the first 20 years it grows more intensively than oak, over time it forms a second tier in the plantings. In steppe conditions, maple has a depressing effect on oak up to the age of polewood – in the absence of timely thinning, oak decay is expected. At the same time, Norway maple is one of the most valuable components of steppe oak forests [11–13].

The share of maple stands is higher in the Elevated Trans-Volga region. Maple plantations in the Republic of Tatarstan have a mixed composition, the proportion of maple in the composition ranges from 5 to 7. The composition of forest stands in all forestries includes soft-leaved species – linden, aspen, birch, in the Predkamye (Kamsky, Kyzyl-Yulduzsky and Yelabuzhsky) there is more linden in the admixture and birch trees, in the Elevated Trans-Volga and Trans-Volga regions (Bugulminsky, Aznakaevsky, Almetyevsky, Leninogorsky and Privolzhsky), there is an oak of seed and coppice origin (Table 2).

The average age varies from 25 to 46 years, which indicates the death and recovery of maple after the frosts of 1978–1979. In the forest-steppe zone of the Republic of Tatarstan, maple, being a tree of the second size, occupies the second tier in maturing and mature stands, is inferior in productivity to the main forest-forming species, the stock per 1 hectare of stands with a

predominance of maple is 20–50 % less than that of soft-leaved and coniferous stands.

Table 2. Average inventory indicators of maple stands of forestries of the Republic of Tatarstan (based on forest inventory materials of 2014–2017)

State Public Institution “Lesnichestvo”	Composition	Bonitet	Density	Age [years]	Ripe stock [ha/m ²]	Area [ha]	Share in total forest area
Privolzhskoe	6Map2Lin 1Oak1Elm	2.4	0.70	37	115	572	2.1
Bugulminskoe	6Map 2Oak 1Bir 1Lin	3.1	0.63	42	131	1093	2.7
Aznakaevskoe	6Map1Asp 1Bir1Oak1Lin	3.0	0.67	25	72	1389	3.3
Almetyevskoe	7Map1Bir 1Oak1Lin	3.0	0.65	32	134	2043	4.7
Leninogorskoe	7Map1Lin1Bir 1Oak	2.9	0.71	38	159	2982	6.0
Aksubaevskoe	5Map3Lin 1Asp1Elm	3.0	0.61	42	144	261	1.0
Cheremshanskoe	6Map2Lin1E lm1Asp	2.7	0.62	39	105	861	2.5
Nizhnekamskoe	5Map2Lin1As p1Oak1Elm	3.0	0.67	37	99	1065	2.6
Zainskoe	6Map1Asp1Bi r1Oak1Lin	3.0	0.60	35	135	2709	4.8
Nurlatskoe	5Map1Oak1El m2Lin1Asp	2.8	0.61	34	144	1398	1.7
Alkeevskoe	6Map2Lin1As p1Bir	3.0	0.65	40	151	460	1.3
Kamskoe	6Map2Lin1El m1Bir	3.0	0.71	33	175	1328	2.6
Yelabuga	5Map2Lin1El m1Asp	3.0	0.63	40	138	820	3.0
Kyzyl-Yulduz	5Map2Lin1El m1Bir1Oak	3.0	0.69	33	162	2978	7.3
Arskoe	8Map2Bir	2.4	0.65	46	169	120	0.4

Based on the analysis of the data of mass inventory of plantations, we analyzed the change in the forest-growing regions of the Republic of Tatarstan with the age of the stand composition, density and bonitet (Table 3). Changes in the taxation parameters of forest stands with increasing age were not revealed: the share of maple in the stand varies within 5–6 units, in the forest-steppe zone, in addition to soft-leaved species, the pedunculate oak participates in all age groups.

The difference in the average diameter of maple and the main forest-forming species is considered on the example of data from the study of stands of two objects in Minnibaevskoye in the district forestry of the Almetyevskoye forestry (Table 3):

1 Object: Quarter 10, plot 45. Composition 10Bir + Lin, age 80 years, density 0.7, forest type – maple birch forest, forest site type – D₁.

2 Object: Quarter 8, plot 29. Composition 8Asp2Lin, age 50 years, density 0.7, forest type — sedge aspen, forest site type – C₂.

Table 3. Distribution of maple stands by taxation indicators depending on the age group

Age	Forest growing zone	Composition	Density	Bonitet
0–20	Forest-steppe zone	5Map2Lin1Oak 1Asp1Bir+Elm	0.65	2.9
	Coniferous-deciduous forest zone	6Map2Lin1Elm1Bir +Asp+Spr	0.56	2.9
20–40	Forest-steppe zone	6Map2Lin1Asp1Oak+Bir+Elm	0.67	3
	Coniferous-deciduous forest zone	5Map2Lin2Elm1Bir +Asp+Spr	0.6	2.9
41 and older	Forest-steppe zone	6Map2Lin1Asp1Oak+Bir	0.61	3
	Coniferous-deciduous forest zone	5Map2Lin2Elm1Bir +Asp+Oak	0.57	3

Table 4. Average diameter of species at sites (cm)

Object No.	Birch	Aspen	Linden	Maple
1	35.2±1.6		22.9±0.8	10.0±0.3
2		33.7±1.5	23.1±1.0	12.4±0.5

Table 5. Change in the area of maple and birch stands in the forestries of the Republic of Tatarstan after the drought in 2010, ha*

Species/Forestry	Bugulminkoe	Zainskoe	Leninogorskoe	Almetyevskoe	Aznakavskoe
Norway maple	434	1022	1256	1191	1026
Silver birch	-1659	-951	-978	-1463	-745

* difference between forest inventory data for 2004-2005 and 2014–2017 (minus means area reduction)

From 2013 to 2019, there was a sharp increase in the acreage of Norway maple in the forest fund of the

Table 7. Characteristics of the stand before drying out and undergrowth in the areas of drying out of silver birch in the forestries of the Republic of Tatarstan

State Public Institution "Lesnichestvo" district forestry	Quart. No.-Plot No.	Area [ha]	Characteristics of the stand before drying out		Undergrowth characteristics	
			Age [years]	Composition	Composition	Quantity [ths. pcs./ha]
Privolzhskoe, Chulpanikhinskoe	64–28	1.7	6	5Bir5Lin	4Map3Lin3Bir	5.0 ± 0.52
"Nurlatskoe", Mamykovskoe	69–29	0.7	40	6Asp 4Bir	10Map+Lin+Asp	9.6 ± 1.68
"Nurlatskoe", Mamykovskoe	73–20	64.9	30	6Bir3Asp1Lin+Map+Oak	4Asp2Map2Lin1B1Bir	4.7 ± 0.5
Almetyevskoe, Maktaminskoe	10–45	1.7	80	10Bir+Lin	3Map3Bir2Asp 2Lin	9.8±1.21
"Kaleykinskoe", Butinskoe	73–23	4.9	40	10Bir forest cultures	7Map2Lin1Bir+Oak	7.0±0.93
"Bugulminkoe", Yutazinskoe	131–15	10.0	70	10Bir	10Map+Oak+Bir	8.8 ± 0.83
"Bavlinskoe", Bavlinskoe	362–9	14.7	60	10Bir+Oak	9Map1Oak	14.9 ± 1.22
"Bavlinskoe", Bavlinskoe	67–7	0.4	70	6Bir2Oak2Bir	7Map3Bir	7.5 ± 0.94
"Alkeevskoe", Chuv.Brodskoe	32–48	4.7	50	5Bir3Asp2Lin	6Asp3Map1Bir+ Lin	15.4± 1.12

Republic of Tatarstan. An increase in the share of maple areas in the state forest fund directly correlates with a decrease in the area of birch forests. The dynamics is explained by the natural renewal of maple in the areas of drooping birch after the drought of 2010 [14, 15] (Table 5). If present in the composition of the stand, maple is able to displace other species – abundant self-seeding and good preservation of the undergrowth ensure its distribution in the plantation [16].

According to forest inventory data for 2014–2017. In most of the forestries of the forest-steppe zone, under the canopy of mature and over-mature stands of birch, there is undergrowth of various species. In the categories of large and medium undergrowth, maple prevails; in small undergrowth, low oak. After the birch dries up, maple replaces these species. Studies have shown that on a part of the areas of birch-oak stands, weakened by drought, the amount of oak undergrowth up to 1.5 m in height is quite sufficient for the formation of oak stands, but it significantly decreases with age as a result of damage by frost or lack of light under the canopy.

Table 6. Composition of undergrowth in birch plantations (based on forest inventory materials)

Forestry	Undergrowth category		
	Large	Medium	Small
Bugulminkoe	5Map2Asp 1Oak1Lin 1Bir	7Oak2Bir 1Asp	5Oak4Bir 1Asp
Leninogorskoe	10Map	8Map2Oak	-

The studies carried out at the sites confirm the forest management data—with a decrease in the density of birch and aspen stands after the drought of 2010, under the canopy, a large amount of undergrowth with a predominance of maple appears, which, after drying out or cutting down the main stand, completely replaces birch (Table 7).

In terms of the number and size categories of the undergrowth that appeared after drying out in the forest-steppe zone of the Republic of Tatarstan, Norway maple competes with aspen, a change of species occurs—the formation of young stands with a predominance of aspen and maple (Figure 1). According to forest inventory data, the main cause of death of coniferous forest cultures is damping by soft-leaved species and Norway maple. The undergrowth of maple and soft-leaved species, appearing in large numbers in forest areas after clear felling, in the first years grows faster than coniferous crops created in these areas, in particular, spruce, drowning them out. The growth of spruce after the closure of the upper canopy decreases sharply, the crown acquires an umbrella-like shape. Forest cultures of spruce and other conifers, once under a canopy, die in the absence of care by the age of 20–40.

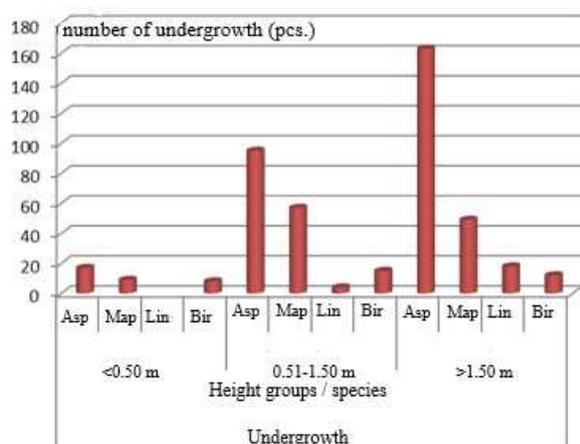


Fig. 1. Distribution of undergrowth by size categories by species in the plantation after birch drying (Alkeevskoe forestry)

Let us consider this on the example of studying a plantation with spruce crops of different ages at 3 objects in the Zainskoye forestry—differences in diameter (Table 8).

1 Object: Quarter 21 unit 8. Composition 6Lin4Bir of the culture under the canopy 10E, age 33 years, density 0.5, forest type – grassy linden stand, forest site type – D₂.

2 Object: Quarter 13, unit 13. Composition 4Lin3Map2Asp1Bir culture under the canopy 10E, age 30 years, density 0.7, forest type – grassy linden stand, forest site type – D₂.

3 Object: Quarter 10, unit 12. Composition 5Spr3Bir1Lin1Map+Asp, age 20 years, density 0.9, forest type – oak spruce, forest site type – D₂.

Table 8. Average diameter of species at objects, (cm)

Objects/ species	Spruce	Maple	Linden
1 object	9.6±0.56	10.1±0.59	18.8±0.88
2 object	1.7±0.07	12.4±0.58	15.4±0.85
3 object	6.7±0.29	15.7±0.58	15.2±0.96

Characteristics of seed-origin maple undergrowth vary in height and quantity depending on the distance

from the forest wall. The largest number of undergrowth over 1.51m high grows at a distance of up to 20 m from the forest wall, the smallest number at a distance of over 50 m. There is no undergrowth at a distance of more than 100 m (Figure 2).

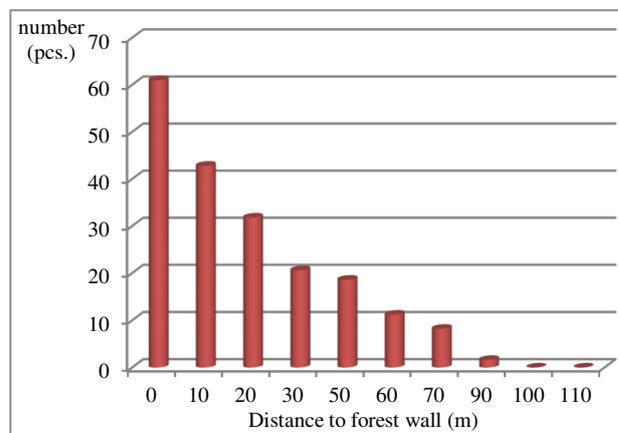


Fig. 2. Distribution of maple undergrowth at different distances from the forest wall (Bugulma forestry)

4 Conclusion

The decrease in the area of maple was associated with damage to it by extremely low temperatures of 1939–1940, 1941–1942 and 1978–1979. Possessing a high ability to regenerate by seed and vegetative means, maple, by 2019, restored its share in the forest fund of the Republic of Tatarstan. Until 2010, the restoration of maple took place in mixed plantations with the participation of pedunculate oak in the composition. After the drought of 2010, high-productivity plantations of birch are replaced by low-quality maple stands, which leads to a deterioration in the commodity structure of the felling fund of the Republic of Tatarstan. Maple plantations have a mixed composition and farming in them should be aimed at increasing the proportion of such species valuable for these conditions as oak and birch in the composition.

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