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NATURAL REGENERATION OF PINE FORESTS AFTER FIRES IN THE "BURABAY" NATURE PARK

Abstract. The article presents the results of the studies on natural regeneration of pine forests after fires. The materials were obtained as a result of field researches (2010–2017), and the literature data was taken into account. The routes covered ten forest areas of the State National Nature Park "Burabay". The research works were carried out in six types of pine forests: stony forests, dead-covering-lichen forests, shrub forests, moss-and-grass dry forests, moss-and-grass wet forests, sphagnum pine forests (fresh forests). The research showed, that pine regeneration in stony and shrubby forests is poor; in sphagnum forests is satisfactory; in moss-and-grass wet and moss-and-grass dry forests is good. The reason of insufficient regeneration in stony and bushy forests is linked to the dry substrate, soil's overheating, and high insolation. Moreover, a large emergence of pine shoots in the steppe types of forest does not ensure their preservation within some time. Forest regeneration can be considered good and satisfactory in the fresh types of forests in case of favorable ecological conditions for reforestation.

Key words: Kokshetau mountain, pine forests, fires, regeneration.

Introduction. As a unique feature, the Kokshetau Mountain is situated in the steppe zone, and due to special microclimatic conditions, there formed extensive pine forests [1-5].

In the current state "Burabay", the state national nature park (SNNP), was organized in 2000 covering the area of about 130 thousand hectares [6].

L. N. Gribanova (1960) argues, that nowadays in the steppe forests it is almost impossible to find even a small area without a trace of a forest fire in the form of a charred bark on the trunks of growing trees. Some parts of the forests were affected by fire 2–3 times or more. Thus, the formation of modern pine forests in the steppe forests was influenced by the adverse effects of forest fires, dry climate and unsystematic predatory killing in the past. This opinion is also acceptable for the forests' territory under study.

In addition to the anthropogenic factor, global warming has influenced the ecosystems in recent decades, leading to an aridization and, in particular, to an increase in xerophytic vegetation [7-10].

Therefore, it was interesting to trace the regeneration processes in burnt areas of pine forests and burners situated in the steppe zone.

Objects and methods of research. The object of the research is the pine forests of Burabay National Park. The field surveys were conducted in the period of 2010 and 2017 on the territory of ten forest districts: Akylbay, Borovskoe, Katarkolskoe, Zolotoborskoe, Mirnoe, Barmashinskoe, Priozernoe, Bulandinskoe, Zhalayyrskoe, Temnoborskoe.

The classification of pine forests for this territory developed by V.N. Sukachev (1948) was employed in the research: stony forests, dead-covering-lichen forests, moss-and-grass dry forests, shrub forests, moss-and-grass wet forests, sphagnum pine forests. To the steppe types of pine forests refer stony forests, dead-covering-lichen forests, shrub forests, to the fresh pine forests - moss-and-grass dry forests, moss-and-grass wet forests, sphagnum pine forests.

The terms "burnt area" and "burner" are used in accordance with GOST 17.6.1.01-83. *Burnt area* is a forest area with the trees died in the result of a fire; while *burner* is a forest area with the trees partially killed by a fire [11].

According to the time of fire, burners and burnt areas are divided into five classes: I – fresh burners, 1-3 years after a fire; II – early-aged burners, 4-6 years; III – middle-aged burners, 7-10 years; IV – late-aged burners, 10-15 years; V – old-age burners, ≥ 15 years after a fire.

The age of fires was precised according to the reporting data. The description of a forest type was made on the research basis of V. I. Sukachev (1948), E. L. Berezin (1961), P. L. Gorchakovsky (1987). In total, there were explored more than 50 burnt areas and burners. The type of fire and the time of its re-sumption were determined on the pine forest area under study. Next to the territory, affected by a fire, in the same type of forest there was selected a control sector unaffected by a fire.

Regeneration account was carried out in trial sectors of 1 m^2. Trial sectors were situated strip-like and were made continiously after each 2 m. In experimental and control variants 200-300 sectors were made. The sectors with burnt areas and burners of the same type and age were merged. The strips were located in the middle part of a burnt area or a burner with the deviation from edges less than 50 m. In total, there were explored 9300 registration sectors, including the control area. The number of main forest-forming species (pine, birch, aspen, willow) was taken into account in each registration sector. For pine and birch were considered regeneration and young shoots of 2–15 years old and up to 1,5 m heigh [12].

RESULTS AND DISCUSSION

Regeneration in stony forests. In the forest areas unaffected by fire, pine regeneration is low – 4,60 thousand pieces/ha.

Attention is drawn to the very low rates of regeneration in fresh, middle- and old-aged burnt areas. The amount of pine regeneration does not exceed 1 thousand pieces/ha, and in fresh burnt areas - no more than 0,1 thousand pieces/ha. Shoots and young sprouts are distributed extremely unevenly and are con-fined to the cracks in rocks, in micro-hollows filled with grass and rotten pine. Regeneration of deciduous species is also satisfactory (Table 1).

Table 1 – Regeneration and growth in burnt areas of stony forests

Age groups	Repeatability, n	Main forest species, thous. pieces/ha			
		Pinus sylvestris	*Betula pendula*	*Populus tremula*	Total
I	300	0,10±0,0	–	–	0,1
II	300	0,30±0,1	0,25±0,0	0,05±0,0	0,6
III	300	0,30±0,1	0,20±0,0	0,10±0,0	0,6
IV	600	0,60±0,1	0,20±0,0	0,20±0,0	1,00
Control	300	4,60±0,8	0,15±0,0	0,15±0,0	4,90

According to the literature data [13, 14] for such types of burnt areas regeneration is ten times higher in the plain pine forests. First of all, this is due to the orography of stony forests and the contagious placement of regeneration along cracks, splits among granite rocks and large stones.

In fresh burnt areas the proportion of pine reaches 100% (Figure 1). In early-, middle- and late-aged burnt areas in the regenerative composition appears birch and aspen. Their share in the early-aged burnt areas reaches almost 40%, but within time, drops to 20%.

Regeneration in dead-covering-lichen forests. A special feature of this type of forest is a high closeness of tree crowns and completeness reaching 0,8–1,0. In the sectors unaffected by fire, there was detected an extremely weak regeneration of both pine and other forest-forming species.

Every year a large number of sprouts appears, according to our observations up to 100 thous. pieces/ha, but almost all of them die in the first year of life. Such mass mortality of sprouts was also detected also in the pine forests with high-density in the Ob riverside forests [14]. Regeneration appears on the place of soil damage: whether it is the fall of an old tree, or a made mineral strip.

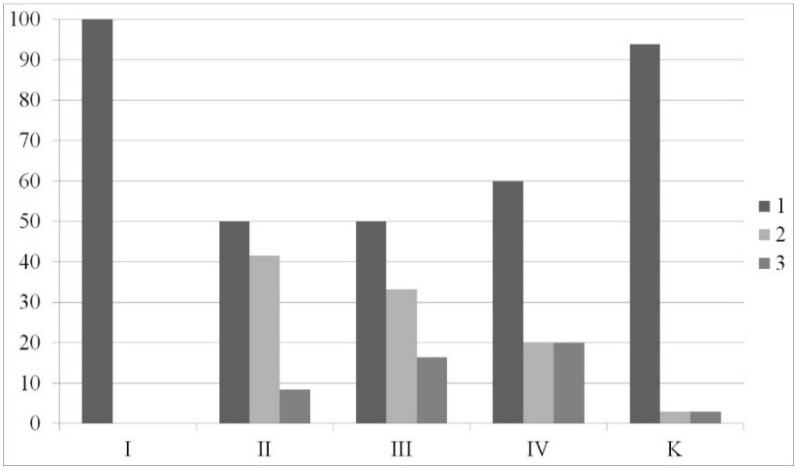

Figure 1 – Distribution of regeneration according to the burnt areas' age in % of the total number:
I, II, III, IV, V – burnt areas' age; 1 – *Pinus sylvestris*, 2 – *Betula pendula*, 3 – *Populus tremula*, 4 – species of *Salix*

Regeneration in fresh burnt areas is quite high – 10 thous. pieces/ha, but in old-aged burnt areas it is 1,3 thous. pieces/ha. This is due to the fact, that violation of the forest integrity in the case of a fire leads to a rapid meadowing and stepping. The emergence of regeneration in early- and middle-aged burnt areas is constrained by the powerful development of the cereals with long roots and, above all, by *Calamagrostisepigeios*.

In late- and old-aged burnt areas pine regeneration is constrained by a rapid formation of small-leaved species (birch and aspen), the number of which increases significantly in the burnt areas over 10 years old (Table 2).

Table 2 – Regeneration in burnt areas and burners in dead-covering-lichen forests

Age groups	Repeatability, n	Main forest species, thous. pieces/ha			
		Pinus sylvestris	*Betula pendula*	*Populus tremula*	Total
II	300	10,10±1,6	0,60±0,11	0,10±0,00	10,80
III	300	6,10±1,10	0,40±0,13	0,10±0,00	6,60
IV	300	1,20±0,78	4,10±0,46	1,30±0,19	6,60
V	300	1,30±0,34	3,70±0,32	0,80±0,16	5,80
Control	600	3,60±0, 38	0,05±0,00	0,15±0,10	3,80

In control of this type of forest, the proportion of pine reaches more than 90%, as well as in early- and middle-aged burnt areas. This is due to the fact, that in early years, when burnt trees are preserved, environmental conditions favor the emergence of pine shoots, but after the dead and damaged trees are removed from the burnt section, a large part of regeneration becomes lost, both from direct insolation and from the soil damage caused by heavy technics while cleaning. In the middle-aged burnt areas, the formation of a dense grass cover prevents the appearance of pine regeneration, its share decreases, while the share of birch regeneration increases. In late- and old-aged burnt areas the share of birch more than 60% (Figure 2).

Shrub forests. Estimating the regeneration in shrubby forests according to the scale of V. G. Nesterov (1948) [15], it should be assessed as weak in control, and satisfactory in burners (Table 3). Pine regeneration occurs unevenly: most of the shoots and young sprouts appears in the areas with damaged soil, birch also settles there. Regeneration of aspen is more even over the burnt area, basically there are sprouts. A small amount of regeneration is associated with a rapid covering of the burnt surface by the shoots of *Calamagrostis epigeios*. In these conditions, the seedlings of the pine practically do not appear. With an insignificant number of regeneration in conditions of climate warming, it is possible that the pine forest will be transformed into the birch and aspen plantations. In the areas damaged by fire the under-

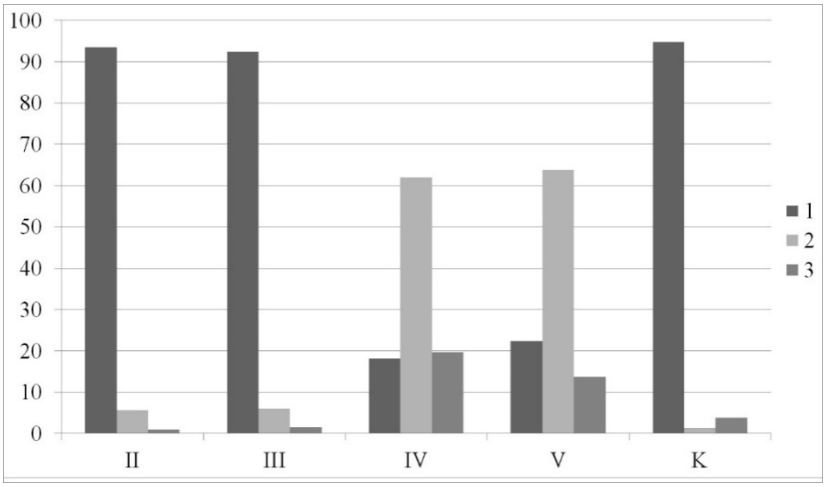

Figure 2 – Distribution of regeneration according to the ages of burnt areas and burners in dead-covering-lichen forests (see Figure 1 for the designations)

Table 3 – Regeneration in burners of bush forests

Age groups	Repeatability, n	Main forest species, thous. pieces/ha			
		Pinus sylvestris	*Betula pendula*	*Populus tremula*	Total
I	300	1,10±0,17	0,40±0,07	0,10±0,06	1,60
II	200	1,8±0,16	0,20±0,03	1,50±0,40	3,50
III	300	0,45±0,02	0,11±0,03	0,90±0,30	1,46
IV	300	0,30±0,06	0,20±0,10	0,70±0,11	1,20
Control	300	0,20±0,06	0,05±0,01	0,15±0,01	0,40

growth of bushes develops intensively *(Caraganafrutex, Cerasus fruticosa, Cotoneastermelanocarpus, Crataegussanguinea, Rosaacicularis, R. majalis, Salixcaprea, Spiraeacrenata, Spiraeahypericifolia*), many of which are steppe species. Regeneration of shrubs to a lesser extent consists of seed plants, and mostly of partial vegetative shoots.

The share of pine in regeneration is the highest in fresh burners, there it reaches almost 70% (Figure 3). Further, the proportion of pine is reduced to 25%, and the share of birch regeneration grows to 60%.

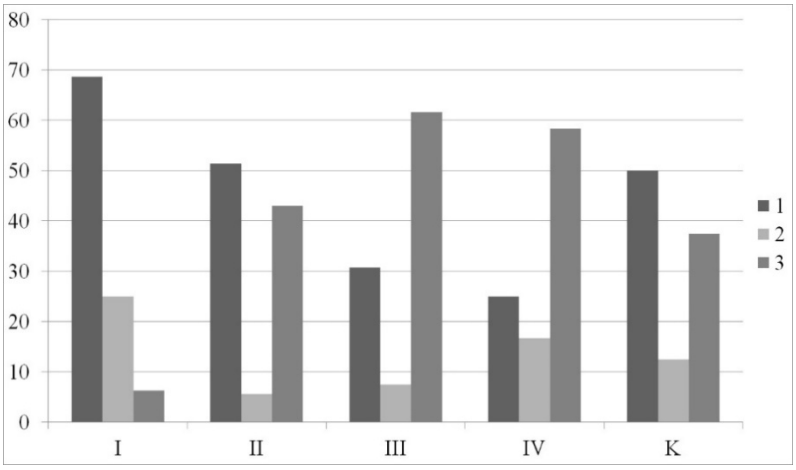

Figure 3 – Distribution of regeneration according to the age of burners in shrubby forests (see Figure 1 for designations)

Moss-and-grass dry forests. The regeneration in the control is 13,5 thousand pieces/ha, which is a very satisfactory result for pine forests in the steppe zone. The greatest amount of regeneration appears in fresh burnt areas due to the mass emergence of sprouts on the soil mineralized after fire (Table 4). Pine regeneration is many times larger than deciduous trees. But most of the pine shoots die, not reaching the state of young adolescence. Within the time of burnt areas' and burners' overgrowing, the amount of pine regeneration gradually decreases, and in old-age burnt areas its quantity practically coincides with the control. In addition to pine, in the burnt areas of dry moss-and-grass forests, birch and aspen regeneration appears intensively, which is a typical example of the burnt areas' overgrowth in the southern forest-steppe and steppe zones [13, 16-18]. The share of pine in the regeneration of this type of forest in the burners of different ages, and in the control is about 90%, the share of birch and aspen regeneration is insignificant, and, in sum, they are no more than 10% (Figure 4).

Table 4 – Regeneration in the burners of moss-and-grass dry forests

Age groups	Repeatability, n	Main forest species, thous. pieces/ha			
		Pinus sylvestris	*Betula pendula*	*Populus tremula*	Total
I	500	124,43±10,17	11,70±1,67	0,23±0,04	136,39
II	300	22,40±0,93	1,90±0,12	0,75±0,03	25,05
III	300	11,20±1,21	0, 80±0,19	0,38±0,12	12,38
V	300	12,20±1,24	1,30±0,24	0,17±0,10	13,67
Control	300	13,50±0,28	0,47±0,19	0,34±0,39	14,31

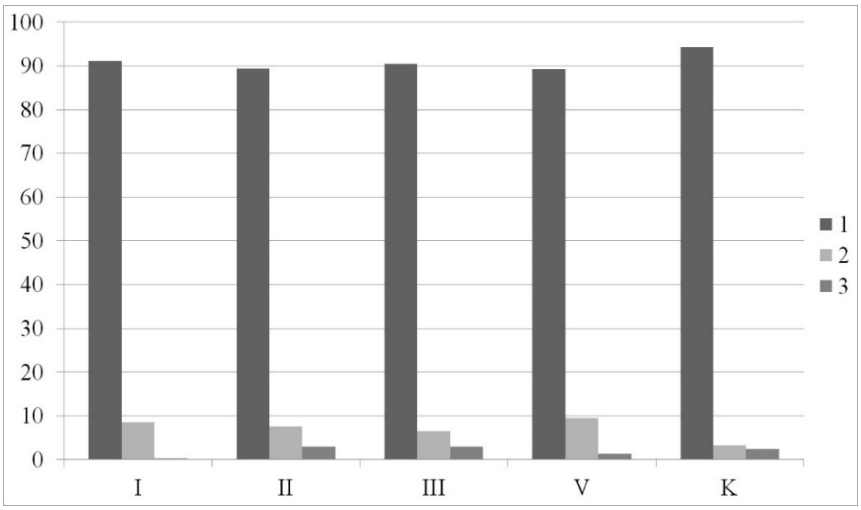

Figure 4 – Distribution of regeneration according to the age of burners in moss-and-grass dry forests, % (see Figure 1 for designations)

Regeneration in moss-and-grass wet forests. Pine regeneration after strong grassland fires in moss-and-grass wet forests makes up 62,27 thousand pieces/ha in fresh burnt areas and decreases to 21,34 thousand pieces/ha in old-aged burnings (Table 5). It should be noted, that in the control pine regeneration is quite abundant – 27,8 thousand pieces/ha. The obtained results confirm the data obtained for the Zaural forests [19, 20]. P. I. Chudnikov (1931) showed that new generations of pine undergrowth appear, as a rule, in the first five years after a fire, and then the amount of sprouts decreases.

The share of pine in the pine regeneration in the moss-and-grass wet forests in the burnt areas and in the control is overwhelming, it is more than 90% (Figure 5). First of all, this is due to the fact that the grassland fires significantly reduce the area of the moss cover and contribute to the emergence of a large number of sprouts, despite the fact that the amount of pine and birch seeds, as well as of willow species, is extremely great.

Table 5 – Regeneration in burnt areas and burners of moss-and-grass wet forests

Age groups	Repeatability, n	Main forest species, thous. pieces/ha				
		Pinus sylvestris	*Betula pendula*	*Populus tremula*	*Salix* sp.	Total
I	300	62,27±0,18	2,90±0,42	1,33±0,04	0,37±0,06	66,87
III	300	20,87±0,20	1,20±0,55	0,76±0,28	0,25±0,10	23,08
V	300	21,34±0,26	1,06±0,31	0,70±0,12	0,14±0,03	23,24
Control	300	27,80±0,35	0,86±0,09	0,65±0,29	0,10±0,09	29,41

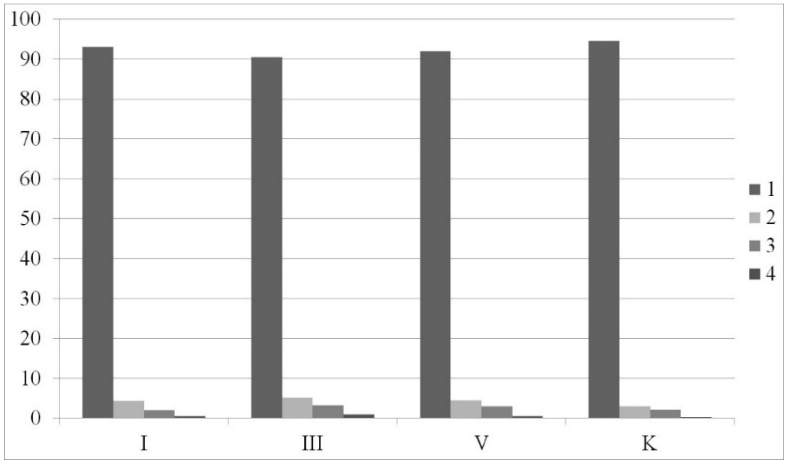

Figure 5 – Distribution of regeneration according to the age of burners in moss-and-grass wet forests, %
(see Figure 1 for designations)

Regeneration in sphagnum forests. As a rule, sphagnum forests are found on the overgrown shores of lakes, along the stream valleys. They are quite wet, with high-density and unformed vegetation.

Fires are quite rare here and are represented by a grassland quick, rarely sustainable fire. Burnt areas are not large in depth, nor in area. The spotting of the area affected by the fire influences the equability of regeneration (Table 6).

Table 6 – Regeneration and sprouting in sphagnum forests

Age groups	Repeatability, n	Main forest species, thous. pieces/ha				
		Pinus sylvestris	*Betula pendula*	*Populus tremula*	*Salix* sp.	Total
I	300	9,12±0,08	3,06±0,65	0,63±0,09	0,24±0,07	13,05
I	200	4,32±0,17	1,48±0,57	0,56±0,43	0,71±0,11	7,07
II	300	8,38±0,16	2,14±0,18	0,49±0,24	0,79±0,25	11,80
IV	300	1,80±0,23	1,46±0,16	0,67±0,39	0,26±0,06	4,19
Control	300	3,15±0,65	0, 98±0,26	0,77±0,21	0,22±0,07	5,12

The number of regenerations is the largest in fresh burners – 9,12 thous. pieces/ha, which is almost three times more than in the control (Table 6). In middle-aged burners, the share of pine regeneration is 58% of the control.

Attention is drawn to the quantity of birches in the regenerated composition – in fresh burnt areas it is 23%, and in medium-aged burners is 35% (Figure 6). In approximately similar sectors of pine forests in the Middleob forests [14], the amount of regeneration is approximately the same as in the explored parts of the national park.

For the forest-steppe zone V. G. Nesterov (1958) developed a scale for estimating natural regeneration, which is quite suitable for special conditions of the Kokshetau forests. The regenerated density of forest plantations is considered good with the number of a reliable undergrowth at the age of 1–5 years –

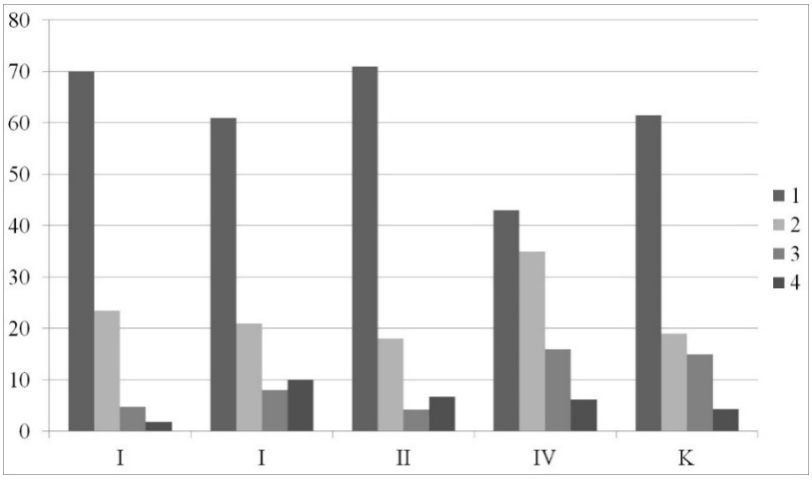

Figure 6 – Distribution of regeneration according to the age of burners in sphagnum forests, %
(see Figure 1 for designations)

more than 10 thousand pieces/ha; satisfactory at 5–10 thousand/ha; weak – from 3 to 5 thousand/ha and poor – with a number of undergrowth less than 3 thousand pieces/ha. Applying this scale of **assessments**, it can be stated that the regeneration at the first two age stages of burnt areas and burners (fresh and early-aged burnt areas) is poor in stony and bushy forests; satisfactory in sphagnum ones; good in moss-and-grass wet and in moss-and-grass dry forests (Table 7).

Table 7 – Qualitative assessment of pine regeneration (according to V. G. Nesterov, 1958)

Forest type	Burnt areas' age					
	I	II	III	IV	V	Control
Stony forest	bad*	bad	bad		bad	bad
Dead-covering-lichen forest	good	satisfactory	bad	–	bad	weak
Bushy forest	bad	bad	bad	bad	–	bad
Moss-and-grass dry forest	good	good	good	–	good	good
Moss-and-grass wet forest	good	–	good	–	good	good
Sphagnum forest	satisfactory	satisfactory	–	bad	–	weak

Conclusion. Forest regeneration can be considered good and satisfactory in fresh types of forest. In the steppe forest types even a large emergence of pine shoots does not ensure their preservation with time. High summer temperature of the soil surface, high insolation and rapid overgrowth of the burnt areas and burners prevent the process. In the fresh types of forest, pine regeneration is satisfactory.

The reason for the low amount of regeneration in stony and bushy forests is probably due to the general warming of the climate, which leads to the death of the whole forest ranges of coniferous species [21]. Perhaps, with further warming, the pine forests regeneration in dry forest types (stony forest, dead-covering-lichen forest, bushy forest) will slow even more, and small-leaved forests and steppe communities will form in their place.

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«БУРАБАЙ» ТАБИҒИ ПАРКІНДЕГІ ӨРТТЕН КЕЙІНГІ ЖАС ҚАРАҒАЙЛАРДЫҢ ТАБИҒИ ОРМАНДЫ ҚАЙТА ҚАЛПЫНА КЕЛТІРУІ

Аннотация. Мақалада өрттен кейінгі жас қарағайлардың табиғи орманды қайта қалпына келтіруін зерттеудегі нәтижелер келтірілген. Материалдар далалық зерттеулер (2010–2017 жж.) нәтижесінде алынып, әдебиет көздері есепке алынды. Маршруттармен «Бурабай» Мемлекеттік ұлттық табиғи паркінің он орман-шаруашылығы қамтылды. Зерттеу қарағайлы ормандардың алты түрінде: тасты қарағайлы ормандар, өлі жабынды-қыналы қарағайлы ормандар, мүкті-шөпті құрғақ қарағайлы ормандар, бұталы қарағайлы ормандар (орманды қарағайлы ормандар деп аталатын),мүкті-шөпті ылғалдықарағайлы ормандар, сфагнумді жас қарағайларда (жас қарағайлы ормандар) жүргізілді. Зерттеу көрсеткендей, қарағайлардың қайта қалпына келтіруі тасты және бұталы қарағайлы ормандарда нашар; сфагнумді қарағайлы ормандарда қанағаттанарлық; мүкті-шөпті ылғалды және мүкті-шөпті құрғақ ормандарда – жақсы. Тасты және бұталы қарағайлы ормандарда қайта қалпына келтіру санының жетіспеу себептері субстраттың құрғауымен, топырақтың ысуы, жоғары инсоляциямен байланысты. Орманның далалы түрінде қарағайлардың көктеуінің көп пайда болуы алдыңғы уақытта олардың сақталуын қамтамасыз етпейтіндігі анықталынды. Орманның қайта қалпына келуі үшін қолайлы экологиялық жағдайлар болатын болса орманның қайта қалпына келуі орманның жас түрінде жақсы және қанағаттанарлық болуы мүмкін деуге болады.

Түйін сөздер: Көкшетау қыраты, қарағайлы ормандар, өрттер, қайта қалпына келтіру.

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ЕСТЕСТВЕННОЕ ЛЕСОВОЗОБНОВЛЕНИЕ СОСНЯКОВ ПОСЛЕ ПОЖАРОВ В ПРИРОДНОМ ПАРКЕ «БУРАБАЙ»

Аннотация. В статье приведены результаты изучения естественного лесовозобновления сосняков после пожаров. Материалы получены в результате полевых исследований (2010–2017 гг.), учтены литературные данные. Маршрутами были охвачены территории десяти лесничеств Государственного национального природного парка «Бурабай». Исследования проводились вшести типах сосновых лесов: каменистые боры, мертвопокровно-лишайниковые боры, мшисто-травяные сухие боры, кустарниковые боры, мшисто-травяные влажные боры, сфагновые сосняки (свежие боры). Исследования показали, что возобновление сосны в каменистых и кустарниковых борах плохое; в сфагновых борах удовлетворительное; в мшисто-травяных влажных и в мшисто-травяных сухих борах – хорошее. Причиной недостаточного количества возобновления в каменистых и кустарниковых борах связано с сухостью субстрата, перегреванием почв, высокой инсоляцией. Отмечено, что в степных типах леса даже большое появление всходов сосны не обеспечивает их сохранности со временем. Лесовозобновление можно считать хорошим и удовлетворительным в свежих типах леса, где складываются благоприятные экологические условия для лесовозобновления.

Ключевые слова: Кокшетауская возвышенность, сосновые леса, пожары, возобновление.

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