УДК 630*232

V. V. Nosnikov, M. Alam
Belarusian State Technological University

PROBLEMS OF REFORESTATION IN THE LEBANESE REPUBLIC

Each geographical location has its own dynamic on different levels, such as but not limited to climatological, soil, vegetation, population, economic and many more. The fast-changing paste of cultural, environmental, economic, and many other factors made it hard on the vegetation cover to heal and recover. As a result, a lot of forests have shrunk in area, in vegetation density, even disappeared. Tremendous efforts are invested towards stopping and/or reversing the deforestation occurring due its vital importance, one of it is through reforestation. All previously mention factors along other factors have affected the Lebanese context of reforestation in a way or another. Lebanese forests regressed to dramatical levels, where it became an issue of vital importance due to the big environmental role play the vegetation cover in terms of soil erosion, water conservation, animal habitat, and air purification. This article shed the light on the reforestation challenges and problems in Lebanon, where key challenges are addressed and dissected. In addition, an insight on the past and recent reforestation techniques, projects, and how international organization stepped in under the Lebanese Government umbrella and helped to render the whole pross more efficient with a higher degree of success.

Keywords: reforestation, Lebanon forests, climate change, reforestation challenges.

For citation: Nosnikov V. V., Alam M. Problems of reforestation in the Lebanese Republic. *Proceedings of BSTU, issue 1, Forestry. Nature management. Processing of Renewable Resources*, 2023, no. 1 (264), pp. 23–33. DOI: 10.52065/2519-402X-2023-264-03.

В. В. Носников, M. Alam
Белорусский государственный технологический университет

ПРОБЛЕМЫ ВОССТАНОВЛЕНИЯ ЛЕСОВ В ЛИВАНСКОЙ РЕСПУБЛИКЕ

Каждое географическое положение имеет свою собственную динамику процессов на разных уровнях, таких как климатологический, почвенный, растительный, демографический, экономический и многие другие. Быстро меняющаяся совокупность культурных, экологических, экономических и многих других факторов затрудняла восстановление растительного покрова. В результате многие леса сократились по площади, по густоте растительности, даже исчезли. Огромные усилия прилагаются к тому, чтобы остановить и/или обратить вспять обезлесение, что является следствием крайней жизненной важности данного процесса, одним из направлений которых является восстановление лесов. Все ранее упомянутые факторы наряду с другими факторами так или иначе повлияли на контекст лесовосстановления в Ливане. Леса в этой стране регрессировали до критического уровня, вследствие чего их восстановление стало проблемой жизненной важности из-за большой экологической роли, которую играет растительный покров с точки зрения эрозии почвы, сохранения воды, среды обитания животных и очистки воздуха. Эта статья описывает опыт лесовосстановления в Ливане с рассмотрением и анализом ключевых проблем. Кроме того, оценка ранее использовавшихся и современных методов лесовосстановления, государственных программ и проектов в этой области, а также роли международных организаций и степени их взаимодействия с правительством Ливана поможет сделать весь процесс восстановления лесов более эффективным и более успешным.

Ключевые слова: лесовосстановление, леса Ливана, изменение климата, проблемы лесовосстановления.

Для цитирования: Носников В. В., Alam M. Проблемы восстановления лесов в Ливанской Республике // Труды БГТУ. Сер. 1, Лесное хоз-во, природопользование и перераб. возобновляемых ресурсов. 2023. № 1 (264). С. 23–33. DOI: 10.52065/2519-402X-2023-264-03.

Introduction. Lebanon is situated in the Eastern part of the Mediterranean Basin, where three continents intersect [1]. With a total area of 10,452 km^2, the Lebanese terrain is categorized as rugged mountainous, where both Eastern mountains series known as the Anti Lebanon mountains chain, and the Western one known as Mount Lebanon mountains chain consist ¾ of the country total area [2–4].

Distinctively, Lebanon is located in a zone classified as semi-arid, and distinguished by its ecological diversity [5], where it is a habitat for 2.63% of the world species ranging from birds, to mammals and reptiles [6], and 1.11% of its plant species [7].

Lebanon's woods have been abused to an incredible level, and took advantage of through hundreds of years tracing all the way back to 7,700 BC with the Neolithic civilisations passing by a few civilisations, countries and Realms like the Phoenicians, Babylonians, Rulers of Israel, Romans, and the Ottomans [8–10]. As such, Lebanon biological variety is known to be a home of in excess of 2,600 species in spite of the multitude of anthropogenic difficulties, where 12% of subject can be tracked down just around here and delegated provincially endemic [11–13].

Lebanon was covered with enormous timberlands of conifers as indicated by verifiable records; it was assessed more that 70% of Lebanon's complete region was covered with ancient woodlands [8]. Furthermore, forests where under tension of metropolitan abuse in mountains from the seventh 100 years alongside undeniably related exercises, for example, taking advantage of timberland for rural purposes, gathering the wood for railways, kindling and livestock grazing, and all land deterioration that followed the new sloppy seaside urban communities and mountain resorts inciting land corruption what diminished the timberland inclusion and impacted the forest recovery cycle [8, 14, 15]. Moreover, notwithstanding all the threating factors referenced previously, Lebanese woodlands were impacted over the most recent 50 years by environment changes, Lebanese nationwide conflict, huge bushfires, microbes and bugs that obliterated and influenced a lot of those timberlands [8, 16–19].

Today, the forests are estimated to cover less than 13% of Lebanon's total area [20]; therefore, the Ministry of Environment (MoE) has sent off a Public Reforestation Plan meaning to expand the forest cover from 13 to 20% over a time of 30 years, upheld by regions and different neighborhood and worldwide associations [8]. On a short time period, the MoE launched with the cooperation of United Nations Development Programme (UNDP) and the Global Environment Facility (GEF) a 5-year building capacity project known as the "Safeguarding and Restoring Lebanon's Woodland Resources Project" (SRLWRP).

Results and discussion. By 2020 the forest cover in Lebanon was assessed at 143 thousand hectares addressing 13.7% of its all-out surface region [21], that extrapolating information revealed by the Food and Agriculture Organization of the United Nations FAO in 2005 [20] is dared to be framed of 32% conifers, for example, Juniperus excelsa (23%), Pinus pinea (18%), Cedrus libani (5%) and Cupressus sempervirens (3%), and 40% a blend of Pinus brutia and Pinus halepensis.

Late examinations feature the basic overall impact of climatic changes notwithstanding habitat loss on biodiversity [22, 23]. Recent research done in the 21st century has demonstrated that these progressions are progressively influencing the biological systems of backwoods and forest [23–30], where dieback numbers and additionally grow rates decline became huge and related with, occasional and outrageous climate variance connected with declination in precipitation and temperature increment overall for long windows of time [24–27, 29–35]. Current researchers are assessing that a ton of the environment changes will be tending either to increment or become the new typical, what will enhance the unsettling influence saw of woodland's biological system [26, 27, 30, 36, 37]. Specialists guarantee that environment changes will affect contrastingly the biological systems and individual species all over the planet [18, 27].

Lebanon lies within a recognized core of plant diversity that is known as a global hotspot because of its biogeography, geology, topography, and early human settlements unique to the Mediterranean basin [12, 38], where it is considered a habitat for more than 9,119 species of animals and plants [39].

Lebanese woodlands are situated in one of the most vulnerable regions to climatic changes on the planet, what is affecting timberlands as well as their species dissemination [40]. Research have noted that mind to final part of the twentieth century precipitations has diminished in wintertime in the Mediterranean area, where Lebanon keeps on confronting dry spell related with impacts of anthropogenic climatic changes through the 21st century classifying the ongoing dry season period of getting the opportunity by 98% to be thought of as the drier one than any beyond ones over the most recent 500 years. Outstandingly, a new report for Mahfouz et al. classified 2014's colder time of year as driest one contrasted with the recorded data of the past 56 years [4].

It has been noted thought data analyses from 1951–1975, the occurrence of extreme drought conditions rose twice in the period from 1976–2000 compared with 1950–1982, the period 1983–2014 saw a 60% rise in the occurrence of severe drought conditions [4]. What's more, between the years 2006–2015, Lebanon showed an average estimated ascent of 0.75–1.5 °C contrasted with 1850–1900 throughout the colder time of year season. In the late spring season, it was accounted for a more outrageous ascent of around 1.5–2.25 °C. Specialist has noted between the years 1960–2003 a surmised increment of warm evenings by 27 evenings and abatement cool ones by 23 evenings. Besides, as per the UNDP environmental change profile and the

MOE, an ascent of almost 0.21 °C has been recorded every decade between the years 1970–2006 [4].

With high instability, Lebanon exhibits low precipitation. Soil moisture instability in the summer season is driven mainly by spring rainfall, which leads it to be vulnerable to droughts. These observations well outweigh the predicted natural variability from the North Atlantic Oscillation and are compliant with other research that indicate signs of drought linked to anthropogenic climate change [4].

Through a study that covered the Cedrus Libani forests in Syria, scientists have found a notable correlation between the precipitation's quantity, fluctuation in temperatures, and growth of vegetation [40]. It is a continuous dynamic between various factors, where rainfall levels and temperature fluctuation will influence the dry season severity, which at its turn will affect simultaneously how species are distributed and forest development [41]. In addition, by analyzing the dendrochronological data in the Mediterranean, scientists were able to understand the dynamic between tree growth and climatic changes [42–46].

One of the interesting research projects conducted on Cedar forest in Lebanon had reviewed the past present and future of those forest. The study was done through a collection of past geographic, meteorologic, soil and climate data that was processed with the help of the CARAIB model. Finally, the results obtained by the CARAIB model helped predict the future distribution of the C. Libani forest where 3 scenarios of atmospheric CO^2 where tested to mimic potential future global CO^2 emissions until year 2100. The 3 climate changing scenarios predicted that although the Cedar forest potentially will be growing near same geographical location as current ones, except that it will migrate to higher altitudes. The Lebanese Cedar forest borders expansion, and geographical altitudes migration will depend not only on the Cedars migration potential that is influenced mainly by the abiotic and biotic interventions, but also on the climatic change rhythm that will be taking place in the Mediterranean area especially Lebanon until the end of the 21st century [47]. This study is a clear demonstration on climatological impact on forest distribution, where it highlights Cedar forest migration to higher altitudes, altitudes that will provide these trees with needed temperature to exist and expand.

The climatological changes impacted Lebanese forests allowing speeches to dominate and expand. More specifically, a study covering Bekaa valley was conducted using an interesting approach to understand the biotic response in correlation to climatic changes that were occurring during the past interglacial-glacial phase through paleoenvironmental remodeling. This study concluded that during the transition phase at a given point tree population such as C. Libani were dominant and expanding with existence of temperate deciduous species during favorable climatic conditions rich with precipitation, while this expansion stopped due to inclination of rainfall, impacting coniferous leading to a declination in their population. In addition, the study highlights the re-expansion of conifers at a later stage is probably related to increase in precipitation, yet not enough to allow the revival of temperate deciduous species [48].

As with many countries of the East Mediterranean, climate change affects Lebanon with frequent droughts and intensive desertification, thus the country's forests are highly vulnerable to anthropogenic pressure from urban expansion, agricultural encroachment on forested spots, quarrying, uncontrolled logging, forest fires, invasive species, pollution and soil erosion, as stated by Khater [49]. Most of the region lacks irrigation and nutrients due to erosion processes, and presence of several native species such as the Cedrus libani is so reduced that it is currently assessed as Vulnerable in the Red List of Threatened Species [1, 50–52].

The SRLWRP and Lebanon Reforestation Initiative (LRI) projects have addressed this degradation and deforestation challenge since 2012, testing reforestation techniques from United States and Europe to solve issues related to nursery practices and outplanting while evaluating their suitability to Lebanese conditions [16, 53]. Traditional reforestation practices in Lebanon focused on using whatever plant materials were available, completing full payment of seedlings to nurseries upon successful three-year survival of seedlings, outplanting in the post-winter season and employing large-scale mechanical site preparation to loosen rocks and a hoe for the planting hole, making this an intensive labor, economically non-viable and low efficient scheme [54].

These techniques are the outcome of using the target plant concept (TPC) aimed at enhancing survival and growth of seedlings, by emphasizing how seedlings perform on the outplanting site rather than on nursery performance, by establishing a close work between the nursery and the client to determine the target plant based on site characteristics and feedback regarding performance of initial crops, and employing post-planting monitoring information to improve subsequent plant materials [5, 54].

Al-Idrissi was an arabic geographer who lived in 12th century noted pine forest around the Lebanese capital covering an area of more than 3,000 Ha. Later this forest known today as 'Beirut forest' was expanded by Emir Fakhreddine the 2nd, who lived

between the 14–15th century, in addition to his remarkable reforestation efforts that covered different areas of Mount Lebanon [16].

Before Lebanon took its independence in 1943, the reforestation activities were limited to small initiatives done on an individual level by planting some Pine trees. The Lebanese Government initiated the 'Green Plan', in order to preserve and regenerate Lebanese forests, where it succeeded to restore a lot of green spaces by planting different types of conifers and hardwoods mainly during the 60S and mid 70S, and by creating national nurseries. In addition, a special consideration was given to Lebanese Cedars in the Shouf mountains [13]. In the early 90s, the Ministry of Environment (MoE) in an effort to creat a momentum in reforestation launched what is known by the largest reforestation plan called the National Reforestation Plan (NRP), where in a later stage the Ministry of Agriculture (MoA) played a key role, explicitly managing safeguarded woods and foundation of new timberlands since 2001.

The NRP was divided to short- and long-term plan, ending up covering 100,000 Ha of land where the forest cover will reach a total of 20% [16]. MoE have executed the reforestation of 580 Ha of degraded areas between 2002–2006, by selecting specific sites that are suitable for reforestation according to a set of standards derived from maps that helped with the decision making, in addition to request for reforestation submitted by municipalities. During that time, the reforestation process was monitored by the MoE, but allocated to private firms, including sites maintenance that followed reforestation. The MoE ensured that a variety of Lebanese indigenous species to be used for the reforestation, and selection of species to be determined depending on each site soil, climate, elevation and many other factors [16].

The NRP have established guidelines for reforestation where the seedling used for reforestation must be a minimum of 12–24 month old, planted in nylon bags that holds a volume 1 L of soil, then planted in 50 cm^3 holes; In addition, seedlings were irrigated twice within one year of their plantation, and weeding also was done twice a year for the first 2 years of plantation time [16].

Funded by the Global Environment Facility (GEF), the MoE initiated a project that aimed to complement and add more value to the NRP under the name of Safeguarding and Restoring Lebanon's Woodland Resources Project (SRLWRP). The SRLWRP added more value to the ongoing NRP by using a more efficient management approach, implementation of innovative technologies, reforestation cost reduction approaches, continuous monitoring, and evaluation in addition to other steps taken towards improving the whole reforestation experience by creating a modern approach under the NRP [16].

Phase 3 of the NRP project was launched in 2010 under the supervision of the MoE with the support of the SRLWR where in order to further develop execution in this stage, the SRLWR proposed another contracting methodology, in view of a participatory methodology of contracting straightforwardly intrigued municipalities to achieve reforestation works in their particular areas, as opposed to contracting private firms and 3rd parties, giving the government a strong grip on the reforestation process. The MoE would choose among municipalities who submitted reforestation requests that aligned with selection criteria set by the SRLWR and MoE, where later on the MoE trained and monitored the bodies who carried the reforestation efforts in each municipality [16]. The MoE with the assist of the SRLWR managed to get on board 48 municipalities between 2010–2011 restoring an area of nearly 200 Ha planted mainly with Pinus pinea due to its economic value deriving from selling the pine fruit; In addition not only light was shed inside the Lebanese community on the importance of forests, but also some members where trained on the reforestation methodologies [16].

Reforestation is carried out nowadays through either individual with small initiatives, and official big, organized bodies, such as the Ministry of Agriculture, Ministry of environment, local and international organizations.

The Lebanese Reforestation Initiative (LRI), funded by the United States Agency for International Development (USAID) developed and published a manual under the name of: "A guide to reforestation best practices" in 2014. The target behind publishing that manual is to set the guidelines for best practices in order to implemented in future reforestation activities. Since then, reforestation was carried out in a more effective way. In parallel, 2 technical reports published under the LRI supported by USAID, one in 2015 under the name of "Outplanting monitoring and inspection practices and results" summarizing the results of reforestation efforts done between 2011 and 2014, followed by another one titled "Lebanon reforestation initiative outplanting monitoring report phase2" published in 2019 stating the results of reforestation efforts done in Lebanon between 2016 and 2018.

All reforestation efforts done after 2010 shaped the modern approach of best practices in restoring the forest cover.

Reforestation process starts by a decent site determination system comprises the most important move towards fruitful reforestation. Sites to be chosen and assessed based on ecological, social, and economic factors.

Site determination can begin preceding visiting the site by picking expected areas from a reforestation appropriateness guide, for example, accessing and analyzing data with the help of GIS, a step that can give a better understanding of potential sites in terms of soil composition, climatical conditions, along other data that plays a key role in site selection process. Subsequently, destinations displayed on the maps are those where reforestation can find lasting success from a feasible and scientific perspective. Nonetheless, it is critical to take note of that those guidelines are not definitive, where in some cases the opinion of local people with deep knowledge relative to reforestation can be taken into consideration and in specific situation, they can assist the reforestation chief with looking further into best species to plant [55].

Mainly, the LRI make sure that reforestation is done in either governmental owned locations or religious one, a strategy to better secure the manageability and conservation of the reforested land as well as ensuring that this effort will reflect a public benefit on the whole community within the reforested area [53].

After site selection and verification of ownership, a technical field assessment should follow. The field assessment will be tailored based on the reforestation goals, where it can be done to increase the forest cover, for community strengthening purposes, to restore mine sites, for keep up with the impact of climate changes, and many other objectives [16, 53]. The technical field assessment then will measure the potential site's suitability based on set of standards such as:

− soil depth, where it is important to plant in deep soil (minimum of 0.4 m), otherwise the seedling mortality rate will spike;

− soil types and texture;

− water availability;

− security related matters related to presence of military activity, land mines, or any other factor that may be considered as a security concern for reforestation implementation;

− local community level of interest and degree of engagement, where it is considered as a key factor contributing to the success and sustainability of the reforestation project;

− area accessibility in case any machinery is needed, for irrigation purposes, and for workers' transport;

− the land assessed is preferably to have a relatively big area (>25 Ha);

− land geography in terms of slops, elevation, and aspect;

− potential human activities that may threaten the seedlings;

− risk of fire in that area;

− grazing pressure, where if any it is important to mitigate that risk by for example putting a fence around the reforested area [16, 53, 55].

The step that follows is species selection, where the choice depends on the outcome from the field assessment, in addition to other factors such as but not limited to economical value, symbolic value, availability at the nurseries and many other [55].

Main step that affects the reforestation process is the quality of the seedling provided by nurseries, where several elements ensure the production of high-quality seedlings such as:

− container selection, where using a Deepots allowed a better management of seedlings, better root system development without swirling, more uniform seedlings, and better management;

− growing media used, where it's a mix of coco-peat and peat most known its water holding capacity, characterized with a specific pH ranging between 5–5.5, and considered cost effective;

− sowing period, where choosing the perfect time for sowing will result in a health strong seedling, and a high percentage of seeds germination;

− a well-managed irrigation system;

− a well-managed fertilization system ensuring that the seedling is strong and healthy and equipped with all nutrients needed for the reforestation process [53].

All the previous steps are followed by holes preparation, where it can be effected manually or with the help of machinery, but what is matters the hole dimensions that is mention previously, and both density seedling density and spacing based on the target of reforestation and geographic nature of the land [53, 55]. Seedling will be placed at the hole center and after filling 1/3rd of the hole with soil, it is important that the soil is hand tamped and the process is repeated in thirds and finished by a foot tamped, a way of compacting the soil ensuring no air pockets around the root system and keeping the seedling in place [56]. Watering at this stage or in monitoring stage will depend on soil moisture availability for planted seedlings, but most of the seedlings in Lebanon used for reforestation are watered either by water trucks or a water irrigation system which is better cost-effective option [53, 55].

Final stage, where monitoring and maintenance take place. In this stage, weeds controlling, and irrigation will be done for the first 2 years. In addition, seedling survival will be monitored and will be used as an indicator of the reforestation overall degree of success or failure. At this stage also there will be a lot of lessons learned, a way improves approaches that will be made in future reforestation projects.

NRP reforestations adopted method compared to SRLWRP reforestation enhanced methods [56]

Parameter	NRP reforestation guidelines	SRLWRP reforestation guidelines
Seedling age	12–24 months old	8 months old
Container specs	Nylon bags with a volume of 1 L	Reusable plastic container with a volume of 0.35–0.45 L
Hole dimensions	50 cm^3	20 cm^3
Weeding	Weeding twice a year for first 2 years	Weeding twice a year for first 2 years

Conclusion. It became obvious that climate changes in Lebanon have affected the vegetation cover where it was observed the increase in temperatures, and decrease in precipitations. It is noted that the past of climate change is disturbing the balance or forest ecosystem, where trees became more susceptible to die from insects' attacks, drought, and their slow adaptability past compared to the quickly rising climatic challenges. Based on the Lebanese reforestation experience, it is obvious that reforestation is not an easy task, where a lot of factors are involved and interact together leading to success or failure of the process. It is important to give high attention to details through each step, starting by choice of land, then choice of seedling, followed by planting phase and maintenance for the couple following year. Everything should be done with high degree of professionalism and great managerial approach to harness successful results of reforestation. In addition, it is important to take into consideration lessons learned from previous reforestation experiences, while keep an open mind to implement and try new promising reforestation techniques that may decrease the seedling mortality rate and bring the whole process to a better cost-efficient level compared to current or old approaches. The level of approached mentioned before will need economic stability, legislation protection, absence of political interfering, and a high level of community awareness and engagement, and till the day Lebanon still faces many of these challenges.

References

1. El-Hajj R., Varese P., Nemer N., Tatoni T., Khater C. Mediterranean ecosystems challenged by global changes and anthropogenic pressures: Vulnerability and adaptive capacity of forests in north Lebanon. *Revue D Ecologie*, 2015, no. 70, pp. 3–15.

2. Merlo M., Croitoru L. Valuing Mediterranean forests: Towards total economic value Wallingford, UK, CABI International, 2005. 406 p.

3. Verner D. Adaptation to a Changing Climate in the Arab Countries: A Case for Adaptation Governance and Leadership in Building Climate Resilience. MENA development report. Washington, DC, World Bank, 2012. 445 p. Available at: https://openknowledge.worldbank.org/handle/10986/12216 (accessed 18.08.2022).

4. Naameh S. Anthropogenic Climate Change in Qadisha Valley and Horsh Arz el Rab, Lebanon. Available at: http://dx.doi.org/10.13140/RG.2.2.28106.59843 (accessed 14.09.2022).

5. Kildisheva O., Aghai M., Bouazza K., Davis A. Improving restoration success through research-driven initiatives: Case studies targeting pinus pinea reforestation stock development in Lebanon. *Plant Ecology*, 2017, vol. 218 (1), pp. 39–53. DOI: 10.1007/s11258-016-0632-7.

6. State and trends of the Lebanese environment. Available at: http://www.undp.org/lebanon/publications/state-trends-lebanece-enviroment (accessed 18.08.2022).

7. Tohmé G., Tohmé H. Illustrated flora of Lebanon. Kesrouwan, CNRS Publ., 2014. 612 p.

8. Haroutunian G., Chojnacky D. C., El Riachy R., Chojnacky C. C. Reducing reforestation costs in Lebanon: Adaptive field trials. *Forests*, 2017, vol. 8 (5), pp. 1–18. DOI: 10.3390/f8050169.

9. Marvin W. Mikesell. The Deforestation of Mount Lebanon. *Geographical Review*, 1969, vol. 59 (1), pp. 1–28. DOI: 10.2307/213080.

10. Yasuda Y., Kitagawa H., Nakagawa T. The earliest record of major anthropogenic deforestation in the Ghab Valley, Northwest Syria: a palynological study. *Quaternary International*, 2000, vol. 73, pp. 127–136. DOI: 10.1016/S1040-6182(00)00069-0.

11. El-Hajj R., Al-Jawhary D., Moukaddem T., Khater C. Forest Sustainability in North Lebanon: A Challenging Complexity in a Changing Environment. *International Journal of Forestry Research*, 2014, vol. 1, pp. 1–12. DOI:10.1155/2014/212316.

12. Médail F., Quezél P. Biodiversity hotspots in the Mediterranean basin: Setting global conservation priorities. *Conservation Biology*, 1999, vol. 13 (6), pp. 1510–1513. DOI: /10.1046/j.1523-1739.1999.98467.x.

13. Talhouk S. N., Zurayk R., Khuri S. Conservation of the coniferous forests of Lebanon: Past, present and future prospects. *Oryx*, 2001, vol. 35 (3), pp. 206–215. DOI: 10.1046/ j.13653008.2001.00180x.

14. Zurayk R., El Moubayid L. Land Degradation and Mitigation in the Lebanese Mountains: The Breakdown of Traditional Systems. Research Paper no. 9. New York, UNDP/DHA, 1994. 92 p. Available at: https://erc.undp.org/evaluation/documents/download/19920 (accessed 17.08.2022).

15. Mediterranean Environmental Technical Assistance Program. Available at: https://cordis.europa.eu/project/id/94-USA-B21-PT-00978-MED (accessed 18.08.2022).

16. Lebanon reforestation initiative. Outplanting monitoring report – phase II. Jdeideh, LRI, 2015. 90 p. Available at: outplanting-monitoring-report-2019.pdf (accessed 18.08.2022).

17. Sattout E., Nemer N. Managing climate change effects on relic forest ecosystems: A program for lebanese cedar. *Biodiversity*, 2008, vol. 9, pp. 122–130. DOI: 10.1080/14888386.2008.9712917.

18. Hansen A., Neilson R., Dale V., Flather C., Iverson L., Urrie D., Shafer S., Cook S., Bartlein P. Global change in forests: Responses of species, communities, and biomes. *Bioscience*, 2001, vol. 51 (9), pp. 765–779. DOI: 10.1641/0006-3568(2001)051[0765:GCIFRO]2.0.CO;2.

19. Stolte K. W. Forest health monitoring and forest inventory analysis programs monitor climate change effects in forest ecosystems. *Hum. Ecol. Risk Assessment: An International Journal*, 2001, vol. 7, pp. 1297–1316.

20. National forest and tree assessment and inventory: Final report. FAO, 2005. 112 p. Available at: http://www.fao.org/forestry/15565-0f921641e230ef06f11d15b8856f2ff07.pdf (accessed 23.08.2022).

21. Global forest resources assessment 2020: Main report. FAO, 2020. 186 p. Available at: http://www.fao.org/3/ca9825en/CA9825EN.pdf (accessed 18.08.2022)

22. Mantyka-Pringle C. S., Martin T. G., Rhodes J. R. Interactions between climate and habitat loss effects on biodiversity: a systematic review and meta-analysis. *Glob. Change Biol.*, 2012, vol. 18, pp. 1239–1252.

23. Brouwers N., Mercer J., Lyons T., Poot P., Veneklaas E., Hardy G. Climate and landscape drivers of tree decline in a Mediterranean ecoregion. *Ecology and Evolution*, 2013, vol. 3, pp. 67–79. DOI: 10.1002/ece3.437.

24.Van Mantgem P. J., Stephenson N. L. Apparent climatically induced increase of tree mortality rates in a temperate forest. *Ecol. Lett.*, 2007, vol. 10, pp. 909–916.

25. Van Mantgem P. J., Stephenson N. L., Byrne J. C., Daniels L. D., Franklin J. F., Fule P. Z., Harmon M. E., Larson A. J., Smith J. M., Taylor A. H., Veblen T. T. Widespread increase of tree mortality rates in the western United States. *Science*, 2009, vol. 323, pp. 521–524.

26. Phillips O. L., Aragao L. E. O. C., Lewis S. L., Fisher J. B., Lloyd J., Lopez-Gonzaalez G. Drought sensitivity of the Amazon rainforest. *Science*, 2009, vol. 323, pp. 1344–1347.

27. Allen C. D., Macalady A. K., Chenchouni H., Bachelet D., McDowell N., Vennetier M., Kitzberger T., Rigling A., Breshears D. D., Hogg E. H., Gonzalez P., Fensham R., Zhang Z., Castro J., Demidova N., Lim J., Allard G., Runningr S. W., Semercis A., Cobbt N. A global overview of drought and heat-induced tree mortality reveals emerging climate change risks for forests. *For. Ecol. Manage*, 2010, vol. 259, pp. 660–684.

28. Barbeta A., Penuelas J., Ogaya R., Jump A. S. Reduced tree health and seedling production in fragmented Fagus sylvatica forest patches in the Montseny Mountains (NE Spain). *For. Ecol. Manage.*, 2011, vol. 261, pp. 2029–2037.

29. Carnicer J., Coll M., Ninyerola M., Pons X., Sanchez G., Penuelas J. Widespread crown condition decline, food web disruption, and amplified tree mortality with increased climate change-type drought. *Proc. Natl. Acad. Sci.*, 2011, pp. 5. DOI: 2010.1073/pnas.1010070108.

30. Peng C., Ma Z., Lei X., Zhu Q., Chen H., Wang W., Liu S., Li W., Fang X., Zhou X. A drought-induced pervasive increase in tree mortality across Canada's boreal forests. *Nature Climate Change*, 2011, vol. 1, pp. 467–471.

31. Huang C.-Y., Anderegg W. R. L. Large drought induced aboveground live biomass losses in southern Rocky Mountain aspen forests. *Glob. Change Biol.*, 2012, vol. 18, pp. 1016–1027. DOI: 10.1111/j.1365-2486.2011.02592.x.

32. Jump A. S., Mátyás C., Peñuelas J. The altitude-for-latitude disparity in the range retractions of woody species. *Trends in Ecology & Evolution*, 2009, vol. 24 (12), pp. 694–701. DOI: 10.1016/j.tree.2009.06.007.

33. Sarris D., Christodoulakis D., Korner C. Impact of recent climatic change on growth of low elevation eastern Mediterranean forest trees. *Climatic Change*, 2011, vol. 106, pp. 203–223.

34. Dulamsuren C., Hauck M., Leuschner C. Recent drought stress leads to growth reductions in Larix sibirica in the western Khentey, Mongolia. *Glob. Change Biol.*, 2010, vol. 16, pp. 3024–3035.

35. Vila-Cabrera A., Martınez-Vilalta J., Vayreda J., Retana J. Structural and climatic determinants of demographic rates of Scots pine forests across the Iberian Peninsula. *Ecol. Appl.*, 2011, vol. 21, pp. 1162–1172.

36. Parry M. L., Canziani O. F., Palutikof J. P., Van Der Linden P. J., Hanson C. E. Climate Change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press, 2007. 976 p. Available at: https://www.ipcc.ch/site/assets/uploads/2018/03/ar4_wg2_full_report.pdf (accessed 24.08.2022).

37. Solomon S., Qin D., Manning M., Chen Z., Marquis M., Averyt K. B., Tignor M. M., Miller H. L. Climate Change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press, 2007. 996 p. Available at: https://www.ipcc.ch/site/assets/uploads/2018/05/ar4_wg1_full_report-1.pdf (accessed 24.08.2022).

38. Regato P., Asmar F. Analysis and evaluation of forestation efforts in Lebanon: Expert report. Beirut: Lebanese Ministry of Agriculture, 2011. 59 p.

39. Fourth national report of Lebanon to the convention on biological diversity. Available at: https://www.cbd.int/doc/world/lb/lb-nr-04-en.pdf (accessed 24.08.2022).

40. Mahfoud I., Jabbour B., Soulaiman R. Study of long-term climatic changes effects on cedar of Lebanon (Cedrus libani a. Rich) stands (Syria) using remote sensing techniques. *Am. J. innov. res*., 2019, vol. 8 (3), pp. 84–92. Available at: https://american-jiras.com/Ilene-ManuscriptRef.1-ajira010319.pdf (accessed 18.08.2022).

41. Jalab A., Mahfoud I., Ismaiel F. Temperature and rainfall changes in Lattakia, Kasaab and Slenfeh during 1978-2011. *Tishreen Univ. J. for Res. and Sc. Stud.*, 2014, vol. 36 (3), pp. 286–303. Available at: https://shamra.sy/academia/show/57e2e150d8bf2# (accessed 17.08.2022).

42. Andreu L., Gutie'rrez E., Macias M., Ribas M., Bosch O., Camarero J. J. Climate increases regional tree-growth variability in Iberian pine forests. *Global Change Biol.*, 2007, vol. 13, pp. 1–12.

43. Bogino S. M., Bravo F. Growth response of Pinus pinaster Ait. to climatic variables in central Spanish forests. *Ann. For. Sci.*, 2008, vol. 65 (5), pp. 1–13.

44. Linares J. C., Tíscar P. Climate change impacts and vulnerability of the southern populations of Pinus nigra subsp. salzmannii. *Tree Physiol.*, 2010, vol. 30, pp. 795–806.

45. Gea-Izquierdo G., Cherubini P., Canellas I. Tree-rings reflect the impact of climate change on Quercus ilex L. along a temperature gradient in Spain over the last 100 years. *For. Ecol. Manag.*, 2011, vol. 262, pp. 1807–1816.

46. Río M., Rodríguez-Alonso J., Bravo-Oviedo A., Ruíz-Peinado R., Cañellas I., Gutiérrez E. Aleppo pine vulnerability to climate stress is independent of site productivity of forest stands in southeastern Spain. *Trees*, 2014, vol. 28 (4), pp. 1209–1224. DOI:10.1007/s00468-014-1031-0.

47. Hajar L., François L., Khater C., Jomaa I., Déqué M., Cheddadi R. Cedrus libani (A. Rich) distribution in Lebanon: Past, present and future. *Comptes Rendus Biologies*, 2010, vol. 333 (8), pp. 622–630. DOI: 10.1016/j.crvi.2010.05.003.

48. Jeffers D., Willis K. J. Vegetation response to climate change during the Last Interglacial–Last Glacial transition in the southern Bekaa Valley, Lebanon. *Palynology*, 2014, vol. 38(2), pp. 195–206. Available at: https://doi.org/10.1080/01916122.2014.880958 (accessed 24.09.2022).

49. Khater C., El-Hajj R. Terrestrial biodiversity in Lebanon. *Review and perspectives of environmental studies in Lebanon*: *National Council for Scientific Research*, 2012, pp. 141–169. Available at: https://www.researchgate.net/publication/257374942_Terrestrial_Biodiversity_In_Lebanon (accessed 23.09.2022).

50. Haktanir K., Karaca A., Omar S. M. The prospects of the impact of desertification on Turkey, Lebanon, Syria and Iraq. *Environmental challenges in the Mediterranean 2000–2050*. Springer Dordrecht, 2004, pp. 139–154.

51. IUCN red list of threatened species: Cedrus libani. Available at: https://www.iucnredlist.org/en (accessed 25.09.2022).

52. Zdruli P., Pagliai M., Kapur S., Faz Cano A. Land Degradation and Desertification: Assessment, Mitigation and Remediation. Springer Publ., 2010. 660 p. DOI:10.1007/978-90-481-8657-0.

53. Native tree nurseries culturing practices and results. USFS/LRI, 2014, 23 p. Available at: https://api.lri-lb.org/Content/uploads/resourcepublications/Native-Tree-Nurseries-Culturing-Practices-and-Results.pdf (accessed 24.09.2022).

54. Dumroese R. K., Landis T., Pinto J., Haase D., Wilkinson K., Davis A. Meeting forest restoration challenges: Using the target plant concept. *Reforesta*, 2016, no. 1, pp. 37–52. DOI: 10.21750/REFOR.1.03.3.

55. A Guide to Reforestation Best Practices. USFS/LRI, 2014. 43 p. Available at: https://project.lri-lb.org/sites/default/files/AGuidetoReforestationBestPractices.pdf (accessed 23.09.2022).

56. Safeguarding and restoring Lebanon's woodland resources: technical report. UNDP, 2014. 109 p. Available at: https://www.lb.undp.org/content/lebanon/en/home/library/environment_energy/safeguarding-and-restoring-lebanons-woodland-resources-technical.html (accessed 24.09.2022).

Список литературы

1. Mediterranean ecosystems challenged by global changes and anthropogenic pressures: Vulnerability and adaptive capacity of forests in north Lebanon / R. El-Hajj [et al.] // Revue D Ecologie. 2015. No. 70. P. 3–15.

2. Merlo M., Croitoru L. Valuing Mediterranean forests: Towards total economic value. Wallingford, UK: CABI International, 2005. 406 p.

3. Verner D. Adaptation to a Changing Climate in the Arab Countries: A Case for Adaptation Governance and Leadership in Building Climate Resilience. MENA development report. Washington, DC: World Bank, 2012. 445 p. URL: https://openknowledge.worldbank.org/handle/10986/12216 (date of access: 18.08.2022).

4. Naameh S. Anthropogenic Climate Change in Qadisha Valley and Horsh Arz el Rab, Lebanon // ReseachGate. URL: http://dx.doi.org/10.13140/RG.2.2.28106.59843 (date of access 14.09.2022).

5. Improving restoration success through research-driven initiatives: Case studies targeting pinus pinea reforestation stock development in Lebanon / Kildisheva O. [et al.] // Plant Ecology. 2017. Vol. 218 (1). P. 39–53. DOI: 10.1007/s11258-016-0632-7.

6. State and trends of the Lebanese environment // UNDP. Lebanon. URL: http://www.undp.ordlebanon/publications/state-trends-lebanese-enviroment (date of access: 18.08.2022).

7. Tohmé G., Tohmé H. Illustrated flora of Lebanon. Kesrouwa: CNRS, 2014. 612 p.

8. Reducing reforestation costs in Lebanon: Adaptive field trials / G. Haroutunian [et al.] // Forests. 2017. Vol. 8 (5). P. 1–18. DOI: 10.3390/f8050169.

9. Marvin W. Mikesell. The Deforestation of Mount Lebanon // Geographical Review. 1969. Vol. 59 (1). P. 1–28. DOI: 10.2307/213080.

10. Yasuda Y., Kitagawa H., Nakagawa T. The earliest record of major anthropogenic deforestation in the Ghab Valley, Northwest Syria: a palynological study // Quaternary International. 2000. Vol. 73. P. 127–136. DOI: 10.1016/S1040-6182(00)00069-0.

11. Forest Sustainability in North Lebanon: A Challenging Complexity in a Changing Environment / R. El-Hajj [et al.] // International Journal of Forestry Research. 2014. Vol. 1. P. 1–12. DOI: 10.1155/2014/212316.

12. Médail F., Quezél P. Biodiversity hotspots in the Mediterranean basin: Setting global conservation priorities // Conservation Biology. 1999. Vol. 13 (6). P. 1510–1513. DOI: 10.1046/j.1523-1739.1999.98467.x.

13. Talhouk S. N., Zurayk R., Khuri S. Conservation of the coniferous forests of Lebanon: Past, present and future prospects // Oryx. 2001. Vol. 35 (3). P. 206–215. DOI: 10.1046/j.13653008.2001.00180x.

14. Zurayk R., El Moubayid L. Land Degradation and Mitigation in the Lebanese Mountains: The Breakdown of Traditional Systems. Research Paper no. 9. New York: UNDP/DHA, 1994. 92 p. URL: https://erc.undp.org/evaluation/documents/download/19920 (date of access: 17.08.2022).

15. Mediterranean Environmental Technical Assistance Program. URL: https://cordis.europa.eu/project/id/94-USA-B21-PT-00978-MED (date of access 18.08.2022).

16. Lebanon reforestation initiative. Outplanting monitoring report – phase II. Jdeideh: LRI, 2015. 90 p. URL: outplanting-monitoring-report-2019.pdf (date of access: 18.08.2022).

17. Sattout E., Nemer N. Managing climate change effects on relic forest ecosystems: A program for lebanese cedar // Biodiversity. 2008. Vol. 9. P. 122–130. DOI: 10.1080/14888386.2008.9712917.

18. Global change in forests: Responses of species, communities, and biomes / A. Hansen [et al.] // Bioscience. 2001. Vol. 51 (9). P. 765–779. DOI: 10.1641/0006-3568(2001)051 [0765:GCIFRO]2.0.CO;2.

19. Stolte K. W. Forest health monitoring and forest inventory analysis programs monitor climate change effects in forest ecosystems // Hum. Ecol. Risk Assessment: An International Journal. 2001. Vol. 7. P. 1297–1316.

20. National forest and tree assessment and inventory: Final report. FAO, 2005. 112 p. URL: http://www.fao.org/forestry/15565-0f921641e230ef06f11d15b8856f2ff07.pdf (date of access: 23.08.2022).

21. Global forest resources assessment 2020: Main report. FAO, 2020. 186 p. URL: http://www.fao.org/3/ca9825en/CA9825EN.pdf (date of access: 18.08.2022)

22. Mantyka-Pringle C. S., Martin T. G., Rhodes J. R. Interactions between climate and habitat loss effects on biodiversity: a systematic review and meta-analysis // Glob. Change Biol. 2012. Vol. 18. P. 1239–1252.

23. Climate and landscape drivers of tree decline in a Mediterranean ecoregion / N. Brouwers [et al.] // Ecology and Evolution. 2013. Vol. 3. P. 67–79. DOI: 10.1002/ece3.437.

24. Van Mantgem P. J., Stephenson N. L. Apparent climatically induced increase of tree mortality rates in a temperate forest // Ecol. Lett. 2007. Vol. 10. P. 909–916.

25. Widespread increase of tree mortality rates in the western United States / P. J. Van Mantgem [et al.] // Science. 2009. Vol. 323. P. 521–524.

26. Drought sensitivity of the Amazon rainforest / O. L. Phillips [et al.] // Science. 2009. Vol. 323. P. 1344–1347.

27. A global overview of drought and heat-induced tree mortality reveals emerging climate change risks for forests / C. D. Allen [et al.] // For. Ecol. Manage. 2010. Vol. 259. P. 660–684.

28. Reduced tree health and seedling production in fragmented Fagus sylvatica forest patches in the Montseny Mountains (NE Spain) / A. Barbeta [et al.] // For. Ecol. Manage. 2011. Vol. 261. P. 2029–2037.

29. Widespread crown condition decline, food web disruption, and amplified tree mortality with increased climate change-type drought / J. Carnicer [et al.] // Proc. Natl. Acad. Sci. 2011. P. 5. DOI: 2010.1073/pnas.1010070108.

30. A drought-induced pervasive increase in tree mortality across Canada's boreal forests / C. Peng [et al.] // Nature Climate Change. 2011. Vol. 1. P. 467–471.

31. Huang C.-Y., Anderegg W. R. L. Large drought induced aboveground live biomass losses in southern Rocky Mountain aspen forests // Glob. Change Biol. 2012. Vol. 18. P. 1016–1027. DOI: 10.1111/j.1365-2486.2011.02592.x.

32. Jump A. S., Mátyás C., Peñuelas J. The altitude-for-latitude disparity in the range retractions of woody species // Trends in Ecology & Evolution. 2009. Vol. 24 (12). P. 694–701. DOI: 10.1016/j.tree.2009.06.007.

33. Sarris D., Christodoulakis D., Korner C. Impact of recent climatic change on growth of low elevation eastern Mediterranean forest trees // Climatic Change. 2011. Vol. 106. P. 203–223.

34. Dulamsuren C., Hauck M., Leuschner C. Recent drought stress leads to growth reductions in Larix sibirica in the western Khentey, Mongolia // Glob. Change Biol. 2010. Vol. 16. P. 3024–3035.

35. Structural and climatic determinants of demographic rates of Scots pine forests across the Iberian Peninsula / A. Vila-Cabrera [et al.] // Ecol. Appl. 2011. Vol. 21. P. 1162–1172.

36. Climate Change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change / M. L. Parry [et al.]. Cambridge: Cambridge University Press, 2007. 976 p. URL: https://www.ipcc.ch/site/assets/uploads/2018/03/ar4_wg2_full_report.pdf (date of access 24.08.2022).

37. Climate Change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change / S. Solomon [et al.]. Cambridge: Cambridge University Press, 2007. 996 p. URL: https://www.ipcc.ch/site/assets/uploads/2018/05/ar4_wg1_full_report-1.pdf (date of access: 24.08.2022).

38. Regato P., Asmar F. Analysis and evaluation of forestation efforts in Lebanon: Expert report. Beirut: Lebanese Ministry of Agriculture, 2011. 59 p.

39. Fourth national report of Lebanon to the convention on biological diversity. URL: https://www.cbd.int/doc/world/lb/lb-nr-04-en.pdf (date of access: 24.08.2022).

40. Mahfoud I., Jabbour B., Soulaiman R. Study of long-term climatic changes effects on cedar of Lebanon (Cedrus libani a. Rich) stands (Syria) using remote sensing techniques // Am. J. Innov. Res. 2019. Vol. 8 (3). P. 84–92. URL: https://american-jiras.com/Ilene-ManuscriptRef.1-ajira010319.pdf (date of access: 18.08.2022).

41. Jalab A., Mahfoud I., Ismaiel F. Temperature and rainfall changes in Lattakia, Kasaab and Slenfeh during 1978-2011 // Tishreen Univ. J. for Res. and Sc. Stud. 2014. Vol. 36 (3). P. 286–303. URL: https://shamra.sy/academia/show/57e2e150d8bf2# (date of access: 17.08.2022).

42. Climate increases regional tree-growth variability in Iberian pine forests / L. Andreu [et al.] // Global Change Biol. 2007. Vol. 13. P. 1–12.

43. Bogino S. M., Bravo F. Growth response of Pinus pinaster Ait. to climatic variables in central Spanish forests // Ann. For. Sci. 2008. Vol. 65 (5). P. 1–13.

44. Linares J.C., Tíscar P. Climate change impacts and vulnerability of the southern populations of Pinus nigra subsp. salzmannii // Tree Physiol. 2010. Vol. 30. P. 795–806.

45. Gea-Izquierdo G., Cherubini P., Canellas I. Tree-rings reflect the impact of climate change on Quercus ilex L. along a temperature gradient in Spain over the last 100 years // For. Ecol. Manag. 2011. Vol. 262. P. 1807–1816.

46. Aleppo pine vulnerability to climate stress is independent of site productivity of forest stands in south-eastern Spain / M. Río [et al.] // Trees. 2014. Vol. 28 (4). P. 1209–1224. DOI: 10.1007/s00468-014-1031-0.

47. Cedrus libani (A. Rich) distribution in Lebanon: Past, present and future / L. Hajar [et al.] // Comptes Rendus Biologies. 2010. Vol. 333 (8). P. 622–630. DOI: 10.1016/j.crvi.2010.05.003.

48. Jeffers D., Willis K. J. Vegetation response to climate change during the Last Interglacial – Last Glacial transition in the southern Bekaa Valley, Lebanon // Palynology. 2014. Vol. 38 (2). P. 195–206. DOI: 10.1080/01916122.2014.880958.

49. Khater C., El-Hajj R. Terrestrial biodiversity in Lebanon // Review and perspectives of environmental studies in Lebanon: National Council for Scientific Research, 2012. P. 141–169. URL: https://www.researchgate.net/publication/257374942_Terrestrial_Biodiversity_In_Lebanon (date of access: 23.09.2022).

50. Haktanir K., Karaca A., Omar S. M. The prospects of the impact of desertification on Turkey, Lebanon, Syria and Iraq // Environmental challenges in the Mediterranean 2000–2050. Springer Dordrecht, 2004. P. 139–154.

51. IUCN red list of threatened species: Cedrus libani. URL: https://www.iucnredlist.org/en (date of access: 25.09.2022).

52. Land Degradation and Desertification: Assessment, Mitigation and Remediation / P. Zdruli [et al.]. Springer Publ., 2010. 660 p. DOI: 10.1007/978-90-481-8657-0.

53. Native tree nurseries culturing practices and results. USFS/ LRI, 2014. 23 p. URL: https://api.lrilb.org/Content/uploads/resourcepublications/Native-Tree-Nurseries-Culturing-Practices-and-Results.pdf (date of access: 24.09.2022).

54. Meeting forest restoration challenges: Using the target plant concept / Dumroese R. K. [et al.] // Reforesta. 2016. No. 1. P. 37–52. DOI: 10.21750/REFOR.1.03.3.

55. A Guide to Reforestation Best Practices. USFS/LRI, 2014. 43 p. URL: https://project.lrilb.org/sites/default/files/AGuidetoReforestationBestPractices.pdf (date of access: 23.09.2022).

56. Safeguarding and restoring Lebanon's woodland resources: technical report. UNDP, 2014. 109 p. URL: https://www.lb.undp.org/content/lebanon/en/home/library/environment_energy/safeguarding-and-restoring-lebanons-woodland-resources-technical.html (date of access 24.09.2022).

Information about the authors

Nosnikov Vadim Valer'evich − PhD (Agriculture), Associate Professor, Assistant Professor of the Department of Forest Plantations and Soil Science. Belarusian State Technological University (13a, Sverdlova str., 220006, Minsk, Republic of Belarus). E-mail: nosnikov@belstu.by

Alam Michel – postgraduate student, the Department of Forest Plantations and Soil Science. Belarusian State Technological University (13a, Sverdlova str., 220006, Minsk, Republic of Belarus). E-mail: michelalalam@gmail.com

Информация об авторах

Носников Вадим Валерьевич − кандидат сельскохозяйственных наук, доцент, доцент кафедры лесных культур и почвоведения. Белорусский государственный технологический университет (220006, г. Минск, ул. Свердлова, 13а, Республика Беларусь). E-mail: nosnikov@belstu.by

Alam Michel – аспирант кафедры лесных культур и почвоведения. Белорусский государственный технологический университет (220006, г. Минск, ул. Свердлова, 13а, Республика Беларусь). E-mail: michelalalam@gmail.com

Received 13.10.2022