Uluslararası Tarım Araştırmalarında Yenilikçi Yaklaşımlar Dergisi
International Journal of Innovative Approaches in Agricultural Research, Vol. 10 (2026), e8915
https://doi.org/10.29329/ijiaar.2026.1423.1

Original article

Selection of Forest Tree Species for Sustainable Forestry Production in the Future - Case Study: Price of Linden Planting Material as a Factor in Afforestation Species Selection

Selma Vejzagić *

Management Department, Faculty of Economics and Social Sciences, International Burch University, Ilidža, Bosnia and Herzegovina

Abstract

This paper investigates the potential of using linden (*Tilia spp.*) as an alternative commercial species in afforestation and plantation production in Bosnia and Herzegovina, with a particular focus on the impact of planting material prices as a potential limiting factor. The research includes a qualitative analysis of data from forestry company bulletins on the occurrence of pathogens associated with climate change, as well as a quantitative analysis of planting costs and market relations of wood product prices. A linear regression model was used to analyze the relationship between the prices of oak and beech wood products. The results indicate that the price of planting material is not a key factor in the selection of species for afforestation. Also, linden shows certain advantages over traditional species, including a shorter production cycle and greater resistance to the negative impacts of climate change. The results suggest that linden has significant potential for wider application in future sustainable forest management strategies. The research provides a basis for further research and development of recommendations regarding the introduction of this species into commercial production.

Keywords: *Tilia spp.,* Afforestation, Climate Change, Drought Resistance, Forestry Economics, Planting Material Price, Species Selection, Plantation Production, Wood Products Market, Sustainable Forest Management

Received: 15 September 2025 * **Accepted:** 23 March 2026 * **Published:** 27 March 2026

* **Corresponding author:**

Selma Vejzagić, Management Department, Faculty of Economics and Social Sciences, International Burch University, Ilidža, Bosnia and Herzegovina.
Email: selma.vejzagic@stu.ibu.edu.ba

INTRODUCTION

Climate change threatens to jeopardize the sustainable economic flows of forestry as an industrial branch (Kumar, 2021). The need for the production of safe quantities of wood mass, as well as other forest products, is growing. Society, which includes numerous stakeholders who expect forestry companies to fulfill their requirements in terms of selling the highest quality wood mass in the shortest possible time, also demands respect for biological principles of forest management (Manrique & Franco, 2020). This means that forestry companies must pay attention to the sustainable use of forest resources, which are increasingly endangered by the harmful consequences of climate change, in their management of forests and valuable plant species, from the aspect of preserving the gene pool and biodiversity. Climate change threatens the local economy, especially in small and poor countries and developing countries, where the lack of statistical data is very often a problem (Mueller & Hofmann, 2022). Namely, having adequate sources of information is crucial for developing strategies for long-term afforestation (establishing forest tree cultures), which ensures continuity of production and market stability in terms of supply of forestry products (McHenry, 2012). According to the available information from the latest national inventory of forests on large areas in Bosnia and Herzegovina, the methodology of which was developed by experts from the Faculty of Forestry in Sarajevo, there are about one million hectares of areas in Bosnia and Herzegovina that currently do not have sustainable plant communities in terms of forest stands, and these areas are dominated by either bare land or land with low or poor vegetation (Lojo et al., 2008). Afforestation of large areas of land can have not only beneficial effects on the local economy, in terms of the future of forestry production at the level of smaller local communities, but can also have extraordinary and protective effects on the local climate, in terms of ensuring favorable temperatures in areas affected by intense drought, reduced levels of retained water and generally improving the local climate of cities. Of particular importance in the context of raising forest cultures is the participation of planting resistant tree species in drought in terms of maintaining populations of beneficial insects, which find shade and resources for life support in forest tree communities (Visnjic, 2002). This Paper will present information on the benefits of raising plantations in Bosnia and Herzegovina, in terms of supplementing forest production. The need for innovative solutions in climate change mitigation is becoming an imperative for today's forestry companies, which are increasingly cooperating with the academic community and taking into account the proposals and recommendations of forestry experts and scientists when it comes to plans for the future, sustainable monitoring of the health of forest stands, as well as calculating all possible challenges in terms of supplying society with an adequate amount of wood mass, without disrupting the balance of the ecosystem or worsening local climate conditions. The most important commercial tree species in Bosnia and Herzegovina include Oak (*Quercus sp.*), European beech (*Fagus sylvatica*), hornbeam (*Carpinus sp.*), white and black pine (*Pinus spp*.), Douglas fir (*Pseudotsuga sp*.), fir (*Abies sp.*), and spruce (*Picea sp*.), while many other species, such as noble broadleaf trees, are more respected in the sense of managing biodiversity, insect

population viability, honey production, *etc*. (Mekic et al., 2006). One of the tree species with particularly unexplored potential for wider use in forestry is linden (*Tilia sp*.), which is prohibited for felling in certain parts of Europe, or its trees are extremely protected. However, this Paper will discuss the hidden potential of this species for wider use in the future, given the results obtained in recent years in the context of the genetics and distribution, or history, of this species. This paper will focus on a linear regression analysis, which should illuminate the path for future research, in terms of the cost-effectiveness of considering linden as a tree of the future for the timber market in Bosnia and Herzegovina.

MATERIAL AND METHOD

Research Design and Study Area

The research is planned to include analyses of the prices between different seedling materials and identifying whether the density in planting plays an important role in choosing species for afforestation. Quantitative analyses should include interpretation of regression model usage in assessing variation in prices variations in prices of top-grade timber products wooden products of Beech and Oak, to check whether this model can be used in the future to identify rentability of mass production of higher number of Linden wood products (for furniture industry, construction etc.). In order to create a clear picture of the real impact of planting density on the number of seedlings per hectare required for planting, and the relationship to the simple cost of planting (manual planting with a stick per individual seedling), only two-year-old linden, oak and beech seedlings will be taken into account, which would be planted on land of the same quality class (let's assume that it is the first quality class). Ignoring other factors that affect the increase in planting costs, which relate to soil preparation for planting, fertilizing seedlings, hoeing seedlings, removing weeds, thinning the culture, cutting branches and cleaning thickets, the Paper will focus only on approximating the picture of deciding on a particular tree species regardless of the price of seedlings and planting density, in relation to the benefits of planting that are potentially found in the length of the production cycle (Mekic, 2006). The reason for avoiding the unnecessary presentation of plantation establishment costs related to these activities lies in the fact that costs are calculated per hectare on a flat rate basis, regardless of whether in practice a worker works within a one-hectare plot area, for example, 600 or 2000 trees during the performance of these tasks. It will not analyze the reasons for such a calculation in this Paper, but will base it on the price of seedlings. For the purpose of leading the discussion on gotten results, the following keywords are used in the search for scientific papers: 1) forest tree pathogens, 2) linden pathogens, 3) oak pathogens, 4) spruce pathogens, 5) tree mortality, 6) forest drying, 7) forest and climate changes, 8) sustainable forestry, 9) wood production challenges. The papers are obtained from: 1) ResearchGate, 2) Google Scholar database and 3) Web site of Journal of Faculty of Forestry in Banja Luka. Other sources are: 1) Website of Federal ministry for forestry in Bosnia and Herzegovina and 2) Master plan of afforestation supported by the same type of Ministry office in the entity of Republika Srpska (Bosnia and Herzegovina). This paper

should present the results of quantitative and qualitative analysis. Namely, in order to obtain a preliminary picture of the profitability of considering linden (*Tilia sp*.) as a tree of the future for planting plantations in Bosnia and Herzegovina, a simple linear regression model will be conducted, which will examine whether regression model is enough accurate and does it describe nearly all variations in Oak wood prices based on European beech wood prices. The price of linden seedlings can be a decisive factor in the choice of tree species for planting plantations. But if lower prices on linden wood produces articles that affects choice of tree species in afforestation, if the site quality class of the wood is same or similar, then regression model on comparing prices variations of potential wood products in the future could bring adequate results if compared to variations in Oak and European beech products. According to the previous knowledge of forestry companies, planting linden was abandoned and always resorted to planting beech, oaks, or coniferous tree species such as pines or spruce, not only because these are the most frequently planted tree species, but also because the prices of seedlings are favorable. However, this research design should also help in explaining how the price of linden seedlings relates to the prices of beech and oak seedlings and to allow making recommendations on future plantation plans funded on real benefits of planting linden (respecting climate change facts).

Research Objectives with Hypothesis

Considering that the Bosnian-Herzegovinian forest management is abandoning the planting of linden trees due to the discussable cost of linden seedlings, the aim is to investigate whether there is a basis for considering the price of planting material as a limiting factor for the selection of linden trees for cultivation, by comparing the prices of planting material, according to the average prices of seedlings in Bosnian-Herzegovinian nurseries (Govedar & Mataruga, 2021). In addition, the importance of linden tree cultivation is reflected in the possibility of introducing this tree as a substitute in the production of certain products (for example, wood for furniture, consumer wood) in which European beech and Oak have so far dominated. Taking into consideration that prices of wood products rise in accordance to wood quality class (European beech and Oak are considered to represent this class on the market of Bosnia and Herzegovina), it will be conducted the linear regression which should explain whether the regression model is accurate enough to explain nearly all variations (if possible) in oak wood prices based on beech wood prices. This should help to understand how the prices of wooden products of other species of trees (wood types) behave based on the site quality class (quality wood based price for a first site quality class of linden trees, and any other first class wood trees) (Cabaravdic, 2010). Considering that linden is a softer quality wood, it is necessary to conduct this preliminary research and consider the option of introducing linden wood into mass production, in order to timely start developing a future strategy for growing trees from substitute tree species for the current commercial tree species. Therefore, our goal is to investigate: 1) Does the price of linden (*Tilia sp*.) planting material represent a limiting factor for afforestation and establishment of linden plantations for the future, and does planting density or lack of knowledge of the species have more of an impact on not

considering mass planting of linden in Bosnia and Herzegovina?, 2) Also, efforts will be made to determine whether there are dangers or risks to production in the context of climate change, in terms of pathogens emerging due to increased temperatures and the recurrence of forest fires in larger areas of forests and forest lands. Accordingly, the research hypothesis is tried to be proven, according to which:

H: *"The price of planting material is statistically not decisive for the choice of tree species for afforestation, what supports the regression model of wooden products prices trend in the context of prognosing rentability of linden products increase on the market."*.

Structure of the Paper

Structure of paper follows methodology that should approach advanced knowledge on interpreting qualitative and quantitative data supporting research hypotheses. In this case, the Paper focuses on analyses of real data in the real market conditions in Bosnia and Herzegovina, by considering: 1) Market needs for wooden products, 2) Market prices of most important wooden articles sold, 3) Interpretation of further climate change correlated factors in sustainable production of biomass.

Data Collection

When considering the way of data collection, the next fact was taken into account: forestry logic assumes that deciduous tree species are planted on lands of those quality classes that correspond to more demanding deciduous tree species (what is in forestry known as first site quality class). Because of this, it was imagined to use relevant data showing real time prices of the planting material and wooden products in the real market in Bosnia and Herzegovina. It is also important to emphasize that the quantitative analysis will rely on the assumption that only the prices of two-year-old linden, beech and oak seedlings are taken into account in the calculations, while the cost of planting each individual seedling (manual planting with a stick) is calculated at 0.50 BAM per seedling. The data to be used in the quantitative analysis are taken from the planting and afforestation protocol from the Afforestation Master Plan (Govedar and Mataruga, 2021), which is valid in Bosnia and Herzegovina, and mathematical calculations will be made regarding the number of seedlings per hectare, for three tree species: beech, oak and linden. The fixed price (cost) of manual planting with a stick will always be 0.50 BAM. Data on constant variables (tree species) and diverse variables (price of seedling, price of planting) will be entered into a *"Microsoft Excel"* table, where a regression analysis will be run. Data on the length of the *minimum*, *maximum* and *typical* production cycle duration will be taken from official guidelines in the field of Forest Management and Silviculture, for the conditions of Bosnia and Herzegovina (Lojo et al., 2008). Data related to prices of 100 different wooden products of Oak and Beech wood has been collected with the help of product bulletins of forest companies in Bosnia and Herzegovina, and their partners - different firms that are producing furniture, construction facilities and interior and exterior equipment. Regression analysis will be conducted in the ***"Microsoft Excel"*** (Cabaravdic, 2010). Part of the quantitative analysis which will consider the duration of the minimum,

maximum and typical production cycle in beech, oak and linden forests, should be linked in a way of correlating results of a linear regression analysis on wooden products prices in Bosnia and Herzegovina, and also making a correlation to the qualitative analysis, but in a way that will try to explain how the influence of pathogens caused by climate change may play a role in deciding on the type of tree to be used in the establishment of plantations, that should in the same time represent one of the key factors in creating rentable prices of its wood products in the future.

Quantitative Analysis

Calculating the planting density (example given for *Tilia*) will be one of the first things to be done. It is worth noting that the number of seedlings per hectare is calculated as follows:

1 ha = 10 000 m2 => 10 000 : (X m * X m) = number of seedlings per 1ha

E.g.: the density of linden planting is 2 m * 2 m, in this case:

10 000 : (2 m * 2 m) = 2500 seedlings per 1ha (Mekic, 2006)

In addition to these, results of the linear regression, graphically shown results (chart type) and tables will be presented in order to follow up testing prices variations of wooden products made on the Bosnia and Herzegovina market of Oak and Beech wood. The duration of the minimum, maximum and typical period of the production cycle of linden, beech and oak stands will be presented after calculating simple mathematical percentages, on how longer or shorter the production cycle of certain tree species relates to other commercial species.

Qualitative Analysis

Unlike the quantitative analysis, the qualitative analysis will determine the presence and type of pathogens that attack linden, oak and beech trees due to increased temperatures, evaporation of moisture from the soil and forest fires, and will describe how these pathogens may affect production in the future. The data used for the qualitative analysis will be collected from reports by forestry academic experts in Bosnia and Herzegovina (FMPVS.gov.ba), who have identified and confirmed which forest tree pathogens are involved, where they occur, in what way and what damage they cause to forest production. This data will be the result of a review of written sources of literature, available on the official websites of forestry companies and within the framework of the forest units' draft studies (document "Afforestation Plan" and document "Forest Protection Plan"). The qualitative analysis, which refers to the interpretation of the danger of forest fires and increased tree mortality due to the appearance of various pathogens, the spread of which is associated with the intensification of climate change, aims to provide a closer picture of the vulnerability of beech and oak in the future of forest production, in comparison to linden, which does not show symptoms of vulnerability that could lead to drying out, additional fragmentation or extinction.

RESULTS AND DISCUSSION

Review of the Literature with Main Theoretical Results

The annual permitted volume of cut timber in Bosnia and Herzegovina is slightly more than 7 million cubic meters. This timber is provided on an area of forests and forest lands of about 1.2 million hectares, where tall and coppice forest stands grow, most of which are located within the administrative borders of the Republika Srpska entity (Bosnia and Herzegovina) (Lojo et *al*., 2008). Important guidelines for future production of forest timber and the establishment of plantations are contained in the so-called "Master plans for afforestation" of the Federation of Bosnia and Herzegovina and the Republika Srpska, which are written with the help of information from individual forestry companies from all over Bosnia and Herzegovina, which manage forests and plantations that are not privately owned. The results of the comparison of areas with high (generative origin) forests and wood stocks in the period between the two national inventories on large areas in Bosnia and Herzegovina show worrying phenomena. According to these data, the level of forest cover in Bosnia and Herzegovina has indeed increased compared to the period of the first national inventory of forests on large areas (1964-1968), and in the period of the second national inventory on large areas (2006-2009) there was an increase in the percentage of forest cover from over 50% to over 60% (Lojo et *al*., 2008). However, these are areas that have become overgrown with plant vegetation in rural areas after the population moved out due to the war in Bosnia and Herzegovina (1992-1995). Due to the abandonment of private estates and agricultural areas, mainly young plant communities have appeared, which, due to the slowing down of the population's return to their properties, have the potential to grow into larger forest complexes. The devastating fact of the analysis comparing the results of two forest inventories indicates a reduction in the area under high forests (forests of seed origin or short "generative origin") by about one hundred thousand hectares. Although the number of residents in the country decreased due to increased population migration during the war and in the post-war period, due to the difficult economic situation, the needs of society as a whole for wood and forestry products are growing significantly from year to year (Mekic, 2006). Experts and students of the Faculty of Forestry in Sarajevo have been working on developing an application that can be used to report forest theft, which partially helps the process of monitoring the forest fund. A particular problem in the post-war forestry of Bosnia and Herzegovina is illegal logging, in which the leading trees are Oak, European beech, pine, spruce, fir, acacia, maple and ash, but also wild cherry, wild pear and walnut have not been spared either. The increase in prices of forest wood assortments on the market is dictated by the demand for commercial tree species, where volatility in the prices of beech and oak wood is observed in certain years, such as periods characterized by the occurrence of long-term droughts and the absence of fruiting in natural forests (Avdibegovic et *al*., 2007). European beech (*Fagus silvatica*), Oak (*Quercus sp*.), pine (*Pinus sp*.), Douglas fir (*Pseudotsuga sp.*), chestnut (*Castanea sp*.), walnut (*Juglans sp*.), fir (*Abies sp*.), spruce (*Picea sp*.), maple (*Acer sp*.), wild cherry (*Prunus sp*.), juniper (*Juniperus sp*.), poplar (*Populus sp*.) and

willow (*Salix sp.*) continue to be the most attractive tree species, not only in afforestation, furniture production, firewood production (mostly oak, beech, hornbeam), veneer production, the establishment of parks and alleys, the establishment of flood protection belts in coastal areas (mostly poplars, willows), and other tree species are less emphasized in afforestation, and are mainly used in beekeeping, horticulture and landscaping private properties. Finding a solution for sustainable wood production in Bosnia and Herzegovina is of crucial importance in the context of climate change, especially taking into account that drought is endangering oak and beech forests, which poses linden as a drought resistant species in the focus of economic analysis.

Findings on Theoretical Results Explaining the Previous Research on Plantations Fundings to Secure Biomass for the Wood and Furniture Market

The history of planting tree plantations on larger areas in Bosnia and Herzegovina has not been sufficiently researched (Govedar and Mataruga, 2021). Certain oral data on the establishment of chestnut and linden plantations exist in the area of the Cajnice municipality in Bosnia and Herzegovina, the origin of which is linked to the expansion of the Austro-Hungarian monarchy in the territory of Bosnia and Herzegovina. In general, more intensive planting of trees for the needs of furniture production and additional quantities of wood began to take place during the 1920s, when certain studies or results of research on Bosnian and Herzegovinian forestry were already published in local documents. The exploitation of Bosnian and Herzegovinian wood during the annexation of the Austro-Hungarian monarchy in Bosnia and Herzegovina, in addition to exports to other parts of the monarchy, largely enabled the construction of roads, railways and other infrastructure in Bosnia and Herzegovina, and the planting of plantations took off mainly at the beginning of the 20th century (Mekic, 2006). However, during the 1960s, certain trends were also present in the former common state, the Socialist Federal Republic of Yugoslavia, when pine plantations became extremely popular. Namely, there was a great need for pine wood in Europe, especially in the northern European countries, and the production of furniture from coniferous wood experienced an expansion. The wood market in some countries promoted coniferous wood more than hardwood (e.g. Oak and European beech), but hardwoods still remained the focus of firewood production. Solid Oak and beech wood remained primarily in the wood products market for furniture production, and the sale of veneers “L” (glued veneer) and “F” (peeled veneer) became one of the most current topics of economic research by local forestry companies and wood processors and furniture manufacturers for homes, offices and schools. The most famous furniture company that buys and processes wood for the purpose of making extremely high-quality furniture is SIPAD (Avdibegovic et *al*., 2007) from Sarajevo, Bosnia and Herzegovina. The company employed tens of thousands of workers, and furniture was exported to many countries in Europe and the world. Depending on the hardness qualities of the wood, it is possible to make different objects or semi-products. Each forest area, which is characterized by the presence of large complexes of natural high forests, has certain tree species that can be called primary or dominant in these areas. The transport of

wood over greater distances has greatly influenced the total costs of hauling and processing wood mass, and products made from this wood have certainly had a higher price. However, with the establishment of plantations in different areas, as well as by supplementing forest cultures, it is possible to reduce costs and thus influence the total price (Mueller and Hofmann, 2022). Certainly, the design of a strategy for mass afforestation in the future should be thoroughly analyzed and evaluated from various aspects, and one of them is finding a solution for selecting species that are estimated to have primacy in the future in the production of furniture and other products (DBU.de, 2021).

Theoretical Findings on Bosnian-herzegovinian Actual Issues Regarding Climate Change context

The biggest problem that arises for forestry in Bosnia and Herzegovina in the context of climate change is the drying of forests, both due to attacks by calamitous insects whose inoculums (centers of infection) appear after forest fires, and due to the drying of individual trees due to the complexity of the health status of trees (Andrianjar et *al*., 2021). Namely, the weakest trees in plant communities are usually the first to become infected with certain pathogens. Micro-localities of habitats that are affected by soil drying do not only become poorer in terms of reducing the amount of moisture in the soil, but the problem is also complicated by the evaporation of useful chemical elements and compounds from the soil. The evaporation of useful chemical elements from forest soil can ultimately cause an imbalance in the proportions of organic and inorganic matter in the soil, which can result in a disruption in the development of vegetative and reproductive parts of plants. In addition to high air temperatures, the long-term absence of adequate moisture in the soil, and the occurrence of forest fires on large areas can irreversibly damage the habitat (primarily the quality of the soil, its chemical and physical properties) and even result in the succession of forest tree species. It is known that so-called pioneer tree species, such as those from the *Populus* and *Betula* genera, usually appear first on burned soils, which can only later, in the future, help improve the soil quality and repopulate previously existing tree species in that habitat (Kaul et *al*., 2010). Therefore, one of the challenges for forestry production is preserving the quality of soil in forest complexes and striving to improve the quality of forest soil, both through bio-technical measures of planting adequate tree species, removing (felling) infected trees, and through various land reclamation measures (depending on profitability, financial resources and goals of the forestry company) (Kumar, 2021). A special challenge in the context of forestry is the care of so-called honey-bearing species in forest ecosystems, which are important for biodiversity and the preservation of insect populations. An example of a honey-bearing species is linden (*Tilia spp.*), which is widely used in apiculture, which is based on beekeeping, honey production for the local and regional market with honey and products related to beekeeping, but also products that have a wide use in pharmacy and medicine (Kusiak et *al*., 2022). The honey market is one of the most important agricultural markets in Bosnia and Herzegovina, where honey has been traditionally used for centuries in everyday nutrition, alternative and official medicine (teas, tinctures, pharmaceutical raw materials) but also in gastronomy

(sale of honey-related products in service industries), which is why linden is listed as one of the focus trees in planning future plantations on private properties (Bartsha, 1995., Barker et *al*., 2016, Barker et *al*., 2022). Finding also implicate appearance of pathogens on the forest species *Picea* (spruce wood), *Pinus* (pine wood), *Fagus* (beech wood) and *Quercus* (oak wood) which cause drying of the trees, what was in detail reported by Mekic (2006), who also named forest area around Vares as an example of pine forests drying. Something similar was spotted in the pine standings in the Konjic area (Ovcari), after the thermophilous pathogen *Viscum album* (white mistletoe) infected many trees. Exactly these pathogens, with some additional fungi and bacteria, cause increased mortality ratio.

Presentation of Quantitative Results

In this subchapter of the Paper, quantitative results will be presented first, followed by qualitative results. The quantitative results relate directly to the analysis of planting material prices and how the price of planting material of the commercially dominant species of beech and oak compares to the proposed substitute tree species, namely linden. The results will be immediately followed by a discussion, which should help clarify the results.

Context of Planting Density and How it Affects Species Choice

Analyzing data on recommended planting densities of forest tree species within the "Afforestation Plan" documents, which are an integral part of technical-technological (implementation) projects of forestry companies (which are part of broader *Forest Management Regulatory Studies*, which are adopted for a period of at least 10 years/10 years from the production period of the forest), the following results were obtained: **I. -** The recommended planting density for the European beech (*Fagus silvatica*) tree species in Bosnia and Herzegovina is 4m x 4m, which means that the distance between neighboring beech trees is at least 4 meters in all directions, if maximum wood production is to be achieved with minimal damage to the physiological development of the trees, **II. -** The recommended planting density for the oak tree species (*Quercus petraea*) in Bosnia and Herzegovina is 3m x 3m, which means that the distance between neighboring oak trees is at least 3 meters in all directions, if maximum wood production is to be achieved with minimal damage to the physiological development of the tree. It must be noted here that in Bosnia and Herzegovina, two types of oak dominate in oak wood production, namely *Quercus petraea* (sessile oak) and *Quercus robur* (pedunculate oak). In cases where the soil is richer in water, pedunculate oak fits better into the production agenda, since it is a tree species that tolerates the presence of groundwater, wetland ecosystems and generally a higher percentage of moisture, without having negative consequences for the quality of the wood produced, **III. -** The recommended planting density of lime trees (*Tilia sp*.) is 2m x 2m, which means that the distance between neighboring lime trees is at least 2 meters in all directions, if maximum wood production is to be achieved with minimal damage to the physiological development of the trees. It is worth noting that three main types of lime trees grow naturally in Bosnia and Herzegovina, namely the small-leaved lime

tree (*Tilia cordata*), the large-leaved lime tree (*Tilia platyphyllos*) and the silver-leaved lime tree (*Tilia tomentosa*). Since the silver-leaved linden tree, due to its habit, has the potential to occupy a larger space, and that, proportionally to its much larger leaves (compared to the small-leaved and large-leaved linden trees), it can absorb a higher concentration of CO2 from the air and produce a larger wood mass, it is assumed that a higher planting density of 2m x 2m can be calculated in some other (future) analyses, even up to a planting density of 7m x 7m, which could greatly reduce the cost of purchasing planting material, which in that case becomes more than 300% more cost-effective (cheaper) compared to the cost of purchasing planting material if the planting density of 2m x 2m (which would be more suitable for the small-leaved linden tree) were to be maintained. Next table shows how the planting density relates between the three types of linden.

Table 1. Comparison between trees planting density among three suggested species.

Species	Planting Density	Trees per Hectare
Linden (Tilia spp.)	2 meters x 2 meters	2500
European Beech (F. silvatica)	4 meters x 4 meters	625
Oak (Quercus spp.)	3 meters x 3 meters	667

It is observed that, according to the given planting density, the most trees must be used to plant one hectare of forest land with quality planting material (2500 plants). Based on the mathematical relation (Mekic, 2010):

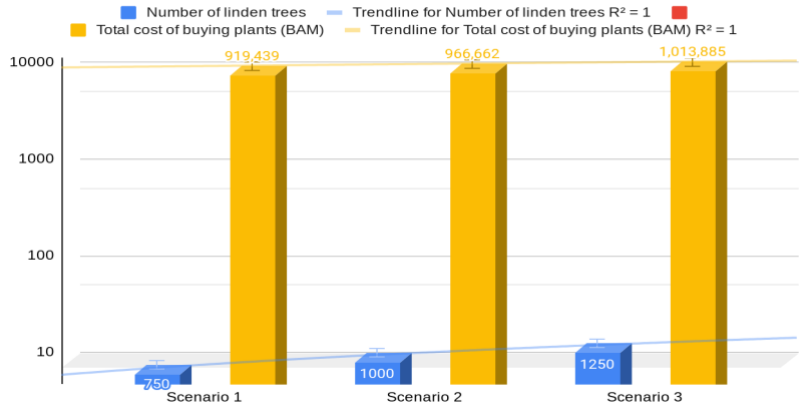
Percentage increase = [(Number of linden trees - Number of beech trees) : Number of beech trees] x 100

,calculation arrives at the result of 300% more linden trees than beech trees, which are needed to plant one hectare of forest land. In general, guided by this planting density for all three tree species, it is observed that the most space is needed for the beech crown, and the least for the linden crown (graph 1).

Graph 1. Proportion of forest soil surfaces needed to handle the healthy tree crown area (in square meters) for each tree species.

The difference in the number of beech and oak seedlings per hectare is 42 trees, or 6.56% more oak seedlings than beech. However, the value of the coefficient of determination ($R^2 = 0.172$) indicates a weak correlation between the observed variables, which means that the model explains a relatively small part of the variability and that the results should be interpreted with caution. For the purpose of additional quantitative analysis, a comparison of different scenarios of planting mixed linden and oak crops was performed. The total number of seedlings per hectare varies between approximately 1528 and 1806 seedlings, depending on the share of individual species. Also, increasing the share of linden in the composition of the crop leads to an increase in the total number of seedlings needed, which directly affects the costs of planting. The analysis of planting material costs shows that, despite the higher number of linden seedlings, the total costs do not increase proportionally due to the lower price of seedlings compared to oak. For example, in the scenario with 30% linden and 70% oak, the total planting material costs are lower compared to the scenario with a higher share of oak, which indicates the potential economic justification of including linden in mixed stands. Additionally, it can be observed that increasing the share of linden leads to an increase in planting density, but also to potential long-term benefits in terms of climate change resilience and shorter production cycles. These results indicate that the price of planting material is not the decisive factor in itself, but that a combination of ecological and economic parameters should be taken into account when making decisions on the selection of species for afforestation. "Further research should include more advanced statistical models and a larger data set to more precisely assess the relationships between variables." In forestry and in general in the establishment of plantations (cultures) of forest trees for the production of a wide range of wood products, cultures consisting of one species (so-called pure or monospecific tree cultures) and mixed cultures (multispecific forest tree cultures) can be established (Lojo et *al*., 2008). Accordingly, a forestry engineer can influence the economic profitability and even save on the costs of establishing forest plantations. For example, if the density of linden planting (2m x 2m) is a major economic problem for a forestry company, because for afforestation or establishment of a culture consisting of linden trees, as much as 300% more plants need to be planted than if it were done only with beech (or oak), and the price of linden and beech seedlings is identical (0.50 BAM), while oak seedlings are somewhat more expensive (0.70 BAM). In order to establish a sustainable tree plantation from the aspect of climate change mitigation, a forestry engineer may propose, for example, a proportion of planting linden and beech together, in the ratio of 20% to 80%. In that case, 20% of the forest land area on one hectare would be planted (20% of the area of one hectare is 2000 m2, which is divided by 4m2 of space per linden tree crown) with linden seedlings, the purchase cost of which would be "500 linden seedlings * price of one seedling", and 500 beech seedlings would be planted (the remaining 80% of the area of one hectare is 8000 m2, which is divided by 16m2 of space per beech tree crown), which would make the total number of linden and beech seedlings in one mixed culture 1000. From the aspect of ecology and biology, and referring to dendrochronological research, i.e. the history of the settlement of European habitats by forest tree species, this proportion of species, i.e. their trees in the establishment of cultures, would have

relatively sound foundations for the growth and development of a healthy and competitive mixed forest stand, because these are two species that can equally well thrive in a shared habitat (Mekic, 2006). What would be left for forest experts to consider is certainly the method of mixing, or rather, the mixing of trees (whether linden trees, which are fewer in number, would be planted individually or in groups next to beech trees, which are more numerous). Research into competition would be interesting for forest scientists, and perhaps a certain evolutionary pattern of behavior of these two species in the case of sharing a common space could be observed. If the recommendations of German experts (Heinrichs et *al*., 2021), which were previously written for the conditions of Romanian forestry, were to be accepted, that linden trees should be planted together with oaks on lands where there is potential for this, and in order to successfully mitigate climate change, the proportion of linden trees compared to the proportion of oak could be greater, and perhaps even equal to the proportion of oak. For example, if one adult tree (full form of developed crown) of linden requires 4 m2, and one adult tree of oak (full form of developed crown) requires 9 m2, then: **a. -** in scenario 1 (example) around ca. 30% of linden trees (3000 m2 : 4 m2 = 750) + 70% of oak trees (7000 m2 : 9 m2 = 777.77) comes to the figure of 1527.77 linden and oak trees for afforestation of one hectare, **b. -** in scenario 2 (example) around ca. 40% of linden trees (4000 m2 : 4 m2 = 1000) + 60% of oak trees (6000 m2 : 9 m2 = 666.66) comes to the figure of 1666.66 linden and oak trees for afforestation of one hectare, **c. -** in scenario 3 (example) around ca. 50% of linden trees (5000 m2 : 4 m2 = 1250) + 50% of oak trees (5000 m2 : 9 m2 = 555.55) comes to the figure of 1805.55 linden and oak trees for afforestation of one hectare. When taking into account, for all three reforestation scenarios according to the recommendations for Romania (Radoglou et al., 2009), the prices of planting material according to the Master Plan for Reforestation in Bosnia and Herzegovina, 0.50 BAM for linden and 0.70 BAM for oak, we arrive at the following results (graphs 2).



Graph 2. Costs for buying the total plant material for planting 1 hectare decreases with higher proportion of linden trees in the mixture proportions between linden-oak mixture scenarios.

To understand how the cost of buying trees aimed for funding a plantation changes, as the percentage of linden trees increases in the mixture, it is necessary to observe that in all the three scenarios linden trees take a new 10% of the total proportion (at the same time oak decreases equivalently). By adopting the second scenario, linden percentage increases:

40% -30% = 10%,

so for each 10% increase in the linden tree percentage, the cost increases by ca. 4.66% or 47,223 BAM (for value R2 = 1.0). So, it can be observed that the mathematical relation:

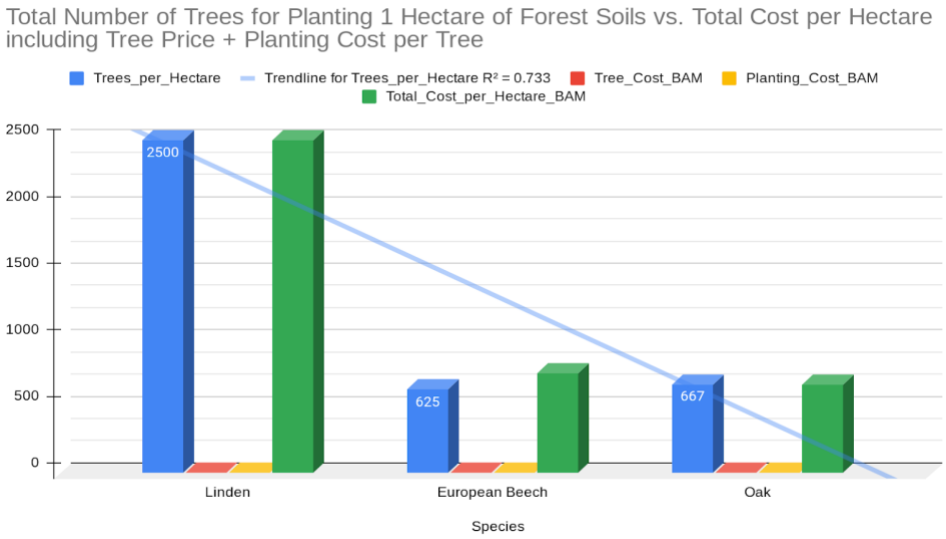
Percentage = (Cost increase : Total cost) x 100

(Lojo et al., 2008) was used.

However, the presented results of the mathematical analysis of percentages and proportions and the progressive growth of the cost of purchasing seedlings in all three scenarios remain the responsibility of the forestry engineer or forestry company, who should decide what the needs of society and stakeholders are in terms of the assortment, quantity and quality of wood products or plantations. Therefore, these three scenarios represent simple models for calculating the cost of purchasing seedlings if different models of mixed planting of forest tree seedlings were to be considered. It is worth noting that the prices of beech seedlings are lower than the prices of oak seedlings, and that one beech tree requires 16 m2 of space compared to an oak tree that requires 9 m2. This would certainly significantly affect the cost of planting in terms of the cost of purchasing seedlings, but due to the lack of recommendations from current studies in Europe, scenarios for planting mixed beech and linden cultures are not considered, due to competition. Due to the past of Europe, which until the beginning of the Ice Age was characterized by large expanses of linden, whose habitats were taken over by linden after the cold snap, it is observed that linden pollen (Pigott, 2002, Klug et *al*., 2000) is present everywhere. A justified research question arises as to whether linden planting material would enter into sharp competition with beech trees. On the other hand, there is already research indicating that the presence of linden in oak stands improves the growth of oak forests, which is why scenarios for planting mixed stands of linden with beech will not be considered in this Paper.

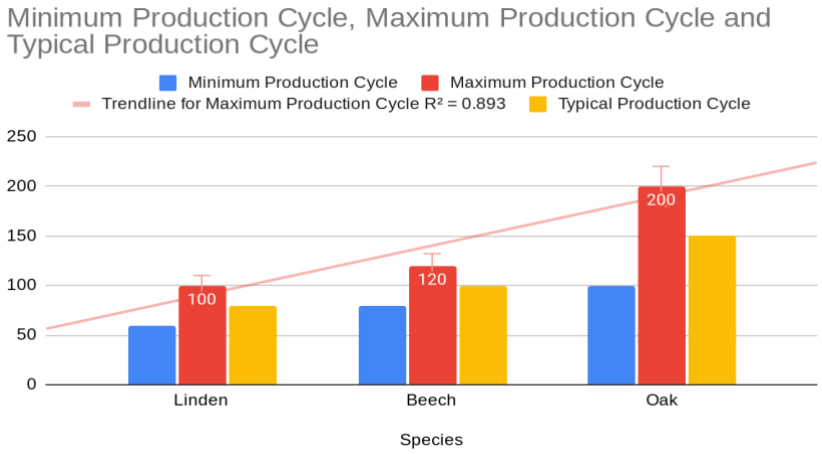
Prices of Individual Seedlings and Production Cycle Duration of Tree Species

In this case, a simple percentage calculation was performed, in order to investigate whether the price of the seedling itself statistically has a significant influence on the selection of the tree species for afforestation. Since the introductory considerations of the Paper state that the calculation is made with two-year-old seedlings of three broadleaf tree species that can equally grow and develop on land of the same quality and credit rating class, and that the price of seedlings taken from the Afforestation Master Plan (Govedar and Mataruga, 2021) in force in Bosnia and Herzegovina is the same for beech and linden (0.50 BAM) and slightly higher for oak (0.70 BAM), it will be analyzed whether the price of the seedlings themselves can statistically represent a decisive factor for the selection of the tree species. By comparing prices and durations of production cycles of Oak, Linden and Beech, we come to next results:



Graph 3. Trend of planting cost decrease (increase) in comparison to total number of trees planned in the afforestation of 1 hectare

By comparing it to the duration of production cycles among three species, we come to next graph:



Graph 4. Trend of percentage increase in production cycle in three plant species.

Following the gotten data from Forestry Elaborate Methodology by Lojo et *al*. (2008), Linden plantations have shortest production cycle duration (60 years minimum, 100 maximum, 80 years typical), while beech is being planted for minimally 80 years, maximally 120 years and typically for 100 years. Having oak plantations being planted for minimally 100 years, maximally 200 years, and typically 150 years, Linden seems to be most rentable species for cultivating, with its minimal production period 100 percent shorter than beech typical production cycle duration and more than 300 percent shorter than maximal oak production cycle duration.

Regression Analysis on Wood Article Prices of Beech and Oak in Bosnia and Herzegovina

By conducting the regression analysis in the “Microsoft Excel”, it came to the next results:

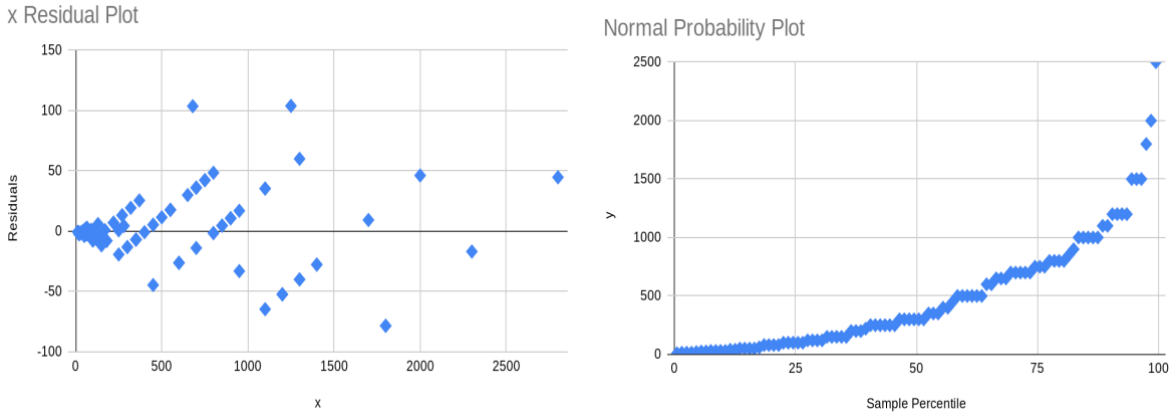
Table 2. Statistical analysis results on beech-oak prices in Bosnia and Herzegovina

Multiple R	0.9991258016
R Square	0.9982523675
Adjusted R Square	0.9982347146
Standard Error	28.92027093
Observations	100

ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	47296623.17	47296623.17	56549.0639	0	
Residual	99	82801.82501	836.3820708			
Total	100	47379425				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0					
x	0.87686350	0.003687391	237.8004708	0	0.869546918	0.88418008

When explaining strength of the relationship, it is possible to observe next: a) Multiple R of 0.9991 means that the correlation coefficient is showing almost a perfect linear relationship, b) R^2 (R-squared) of 0.9983 is meaning that 99.83% of the variation in the dependent variable (oak wood prices) can be explained by the independent variable (beech wood prices), while c) Adjusted R^2 of 0.9982, as slightly lower than R^2, is still very high, confirming the strong explanatory power of the tested model, which is similar to the Cabaravdic (2010) models explained in comparing deciduous and conifer species products for construction. Explaining the model significance by conducting ANOVA analysis means next: a) F-statistic of 56,549.06 is extremely high, indicating that the model is statistically significant, and b) Significance F (p-value) of 0 means there is almost no chance that the relationship is random, which compares to Avdibegovic (2007) statements for perfect forest market models. Explaining the regression coefficients it comes to next interpretations: a) Intercept of 0 means that the model does not include an intercept term (which means if beech prices were 0, oak prices would also be 0), b) Slope (x coefficient) of 0.8769 means that for every unit increase in beech wood price, the oak wood price increases by 0.8769, c) Standard Error of x coefficient of 0.0037 is pretty small, indicating a precise estimate, d) t-Statistic of 237.8 is very large, meaning the coefficient is highly significant, and e) P-value of 0 means that the predictor variable is highly significant.v Explaining the model accuracy and residual analysis means next: a) Standard Error of 28.92 is the average deviation of the actual prices from the predicted prices, b) Residuals - most of them are small, but a few larger residuals (e.g., -78.35, 103.92) suggest possible outliers, and c) Normality of residuals shows in a way that they appear relatively small and balanced between positive and negative values, suggesting a good model fit., which again agrees with Cabaravdic (2010) findings in scope of explaining error values in the monograph. As a conclusion it came to next: 1) The used regression model is highly accurate and explains nearly all variations in oak

wood prices based on beech wood prices, 2) The coefficient (0.8769) shows a strong proportional relationship, and 3) The residual analysis suggests minor outliers, but the overall fit is excellent.



Graph 5. (a - left, b - right). Relation between *x* residual plot and normal probability plot

Presentation of Qualitative Results

Identification of Main Pathogens in the Context of Planting Under the Droughts

On the basis of Federal Ministry office for forestry administration, based on the previous reports of the federal forestry companies, main illnesses affecting the sustainable production of Oak, Beech and Linden forests are: a) disease of grey leaf in Oak species, which causes drying and destruction of the oak plantations, b) disease of the black core in European beech, that devastate beech ecosystems and destroys complete plantations up to 90 percent of juveniles, and c) wilting disease in Linden, which appears as a result of combined natural and anthropogenic factors such as fertilization. The sources announced that mass drying of the beech and oak forests had been identified in certain parts of the country, but that it is still under control. Source announces no mortality cases in Linden. Compared to Kumar (2021) it is visible that forest pathogens represent everywhere in the world a real danger for forest production, because they combine with negative effects of wild forest fires in the large ecosystems and suppress natural juvenile populations to fight. Most of the diseases correspond to those described by Avdibegovic (2007), as main risks for the forestry firm's management. It is very important to point out to the wider academic community the importance of afforestation in the country, especially in those habitats where there is a potential for planting tree species that would be highly resistant to high temperatures and long-term droughts. Consideration of the price of planting material, possibly a large number of seedlings per hectare of area, as well as a smaller planting distance (density) should not be a decisive factor in limiting future cultivation, cultures (plantation) supplementation and afforestation to the most frequent tree species so far, but rather that it is necessary to give a chance to the application of current research results and the search for solutions for climate change mitigation. In this analysis, we should not lose sight of the harmful consequences of climate change, which includes an increased level

of tree mortality in forests, and the appearance of pathogens and harmful insects, the spread of which is correlated with increased temperatures and the frequency of forest fires.

Knowledge Gaps in Understanding Potential of Healthy Linden Plantations in the Context of Drying Typical Commercial Species Such Oaks and Beech

A complex study of the morphological, phenological and genetic characteristics of three species of lime tree in Bosnia and Herzegovina has shown that the genus *Tilia* is very important for the process of climate change mitigation (Vejzagic et *al*., 2021). In earlier studies in Bosnia and Herzegovina, linden (in literature also named as "lime") tree has been characterized as a tree of the future, due to its high resistance to drought, but also due to its distribution in almost all habitats where forests naturally grow. Certain linden tree populations in Bosnia and Herzegovina are characterized by different morphological characteristics of their fruits, which enable them to be dispersed by wind over greater distances, due to the greater number of bracts (Vejzagic, 2022). Linden trees were studied much more extensively on the European continent about 100 years ago, but the study of this tree finally intensified again in the 2010s. A major contribution to linden research and the analysis of pollen maps of Europe was made by the author Pigott, who pointed out the potential for linden to return to ancient habitats, since linden pollen is widespread throughout Europe, including in European forest habitats where linden currently dominates (Pigott, 1969, 1991, 1992, 1997, 2002). The onset of the Ice Age led to significant changes in the proportion of forest tree species in Europe, as well as to glacial retreats of entire plant populations (Klug et *al*., 2000). However, thousands of years later, researchers are witnessing an intensification of climate change, which brings with it high temperatures and long-term droughts, which necessitates the need for in-depth research on species that once, before the onset of the Ice Age, had primacy in forest plant communities (Logan et *al*., 2015). A great contribution to the study of linden, as well as its application in the establishment of plantations, the establishment of gardens, planting alleys and parks, was made by Scandinavian countries, followed by Germany, the Netherlands and the United Kingdom, where the largest number of studies on linden (Baxandall, 1995, Becker, 1920, Bengtsson, 2005, Binder, 2016, Christensen, 1981, De Jaegere et *al*., 2016, Engler, 1969, Huntley and Birks, 1983, Hyde and Williams, 1945, Karling, 1931, Lindberg, 1956, 1957, Svoboda, 1953, 1957, Wicksell and Christensen, 1999) come from. The potential of linden for planting in the future is supported in the deciduous forests of Europe, such as Romania, where it is possible to plant linden with oaks and beech (Heinrichs et *al*., 2021). A Ukrainian study has shown that linden trees are extremely long-lived and much more resistant to diseases and temperature turbulence. If seedlings costs and sustainable afforestation strategy are met, the potential of sustainable biomass production for future, including rentable prices of wooden products for society, the potential crisis on the wood market could be prevented. Unfortunately, negative reports on drying in the Oak and Beech stand structures are not bringing positive news to the wood and furniture market, which implies additional potential for the healthy linden plantations to be used more intensively in the future.

CONCLUSIONS

Respecting the quantitative and qualitative results gotten in the research, it is possible to identify several crucial findings: - forest species have to be chosen in scope of the afforestation lans not only on the fundament of expenses for buying seedlings or planting material, but also by respecting the benefits from planting cultures with drought resistant trees, - in comparison to first two commercial species in wood market in Bosnia, which are oak and beech, the linden tree can also be produces on a high soil quality class soil, and with enough biomass produces in the cultures it an provide similar quality of certain wood products for the society, - the production cycle duration is crucial in the context of the climate change, because focusing on production of linden, whose minimal duration of the production cycle is more than 300 percent shorter than maximal oak production, can prevent drying of forest plantations caused by drought resistant pathogens, and help provide sustainable and production with less risk of drying, - regression model can be used to compare prices of same or similar quality wooden products of linden, since it is shown to be ideal in analyses of variation of prices between oak and beech products. Respecting the gotten results, we failed to reject the null hypothesis of the research that "*The price of planting material is statistically not decisive for the choice of tree species for afforestation, what supports the regression model of wooden products prices trend in the context of prognosing rentability of linden products increase on the market."*. It is needed to conduct further investigation on the linden wood products market and to explore further danger for the linden plantation funding, if any indicators for the health of the species exist.

REFERENCES

Andrianjar, I., Bordenave-Jacquemin, M., Roy, V., Cabassa, C., Federici, P., Carmignac, D., Marcangeli, Y., Rouhan, G., Renard, M., Nold, F., Lata, J.-C., Gene, P. & Planchais, S. (2021). Urban tree management: Diversity of *Tilia* genus in streets and parks of Paris based on morphological and genetic characteristics. *Urban Forestry & Urban Greening*, 66, December. https://doi.org/10.1016/j.ufug.2021.127382

Avdibegović, M., et al. (2007). Sumarska ekonomika. Sumarski fakultet u Sarajevu, Katedra za ekonomiku i politiku u sumarstvu, Univerzitet u Sarajevu.

Bartha, D. (1995). *Tilia tomentosa* MOENCH. In: Schuett, P. et al. (Hrsg.): Enzyklopädie der Holzgewächse. 1. Ergänzungslieferung 3/95.

Barker, C., Ashton, M. & Ashton P.A. (2016). Segregation of *Tilia cordata* and *T. platyphyllos* (*Malvaceae*) along environmental gradients. *New Journal of Botany. Journal of the Botanical Society of Britain & Ireland* 5:157-163. https://doi.org/10.1080/20423489.2015.1123968

Barker, C., Davis, M.L. & Ashton, P. (2022). Reproductive strategy of a temperate canopy tree *Tilia cordata* Mill. (*Malvaceae*) is related to temperature during flowering and density of recent recruits. *Tree Genetics & Genomes*, 18:22 . https://doi.org/10.1007/s11295-022-01553-y

Baxandall, M. (1995). *The Limewood Sculptors of Renaissance Germany*. New Haven and London.

Becker, G.A. (1920). Private haver, in Denmarks havebrug og gartneri til aaret 1919, S. Bruun og. A. Lange (ed). Kopenhagen og Kristiania (Copenhagen and Oslo). (in Danish)

Bengtsson, R. (2005). Variation in common lime (*Tilia* x *europaea* L.) in Swedish Gardens of the 17th and 18th centuries. Fakulteten för landskapsplanering, trädgårds- och jordbruksvetenskap, Institutionen för landskaps- och trädgårdsteknik, Alnarp - Doctoral thesis, Swedish University of Agricultural Sciences, Alnarp 2005.

Binder, F. (2016). Kurzportrait Silberlinde (*Tilia tomentosa*). https://www.waldwissen.net/assets/FVA/Waldwirtschaft/Artensteckbriefe_2.0/Silberlinde.pdf

Cabaravdić, A. (2010). Sumarska statistika. Sumarski fakultet u Sarajevu. Univerzitet u Sarajevu.

Christensen, A. (1981). Frederik V's hobby: Haven ved Fredensborg Slot. (The hobby of King Frederik: The gardens at Fredensborg palace). I: Fra Kvangård til Humlekule. Meddelelser fra Havebrugshistorisk Selskab. Nr. 11, s. 35-50: Ill. (In Danish)

Communication with S. Brewer. http://www.pierroton.inra.fr/Cytofor/Maps/index.html

`De Jaegere, T., Hein, S. & Claessens, H. (2016). A Review of the Characteristics of Small-Leaved Lime (*Tilia cordata* Mill.) and Their Implications for Silviculture in a Changing Climate. Liege university, Gembloux Agro-Bio Tech. Gestion des Ressources forestieres.

DBU.de (2021). Morphologische, phänologische und genetische Merkmale von Lindenbestandstrukturen (*Tilia cordata* Mill., *Tilia platyphyllos* Scop. und *Tilia tomentosa*). Abschlussbericht. https://www.dbu.de/moe-fellowship/30020-888/

Engler, V. (1909). Monographie der Gattung *Tilia*. Breslau. (in German)

FMPVS.gov.ba (2025). Patogeni sumskog drveca. Izvjestaj preduzeca sumarstva u Federaciji Bosne i Hercegovine.

Govedar, L et *al*. (2021). Master plan posumljavanja Republike Srpske, Bosna i Hercegovina. Sumarski fakultet u Banjoj Luci. Univerzitet Banja Luka.

Heinrichs, S., Oeder, V., Indreica, A., Bergmeier, E., Leuchner, C. & Walentowski, H. (2021). The influence of *Tilia tomentosa* Moench. on plant species diversity and composition in mesophilic forests of western Romania - A potential tree species for warming forests in Central Europe. Sustainability, 13, 7996.

Huntley, B. & Birks, H.J.B. (1983). An atlas of past and present pollen maps for Europe: 0 - 13,000 B.P. . Cambridge University Press, Cambridge, United Kingdom.

Hyde, H. A., & Williams, D. A. (1945). Pollen of Lime (*Tilia spp*.). Nature, 155, 457.

Karling, S. (1931). Trädgårdskonstens historia i Sverige intill Le Notre Stilens genombrott. Stockholm. (in Swedish)

Kaul, M., Mohren, G., & Dadhwal, V. (2010). Carbon storage versus fossil fuel substitution: a climate change mitigation option for two different land use categories based on short and long rotation forestry in India. Mitigation and Adaptation Strategies for Global Change, 15, 395-409. https://doi.org/10.1007/S11027-010-9226-1.

Klug, P., Engels, J., & Kastner, R. (2000). Arbolex-Fachwörter der Baumpflege. Steinen - 2000, ISBN: 3-934947-00-X.

Kumar, P. (2021). Climate Change and Cities: Challenges Ahead. Front. Sustain. Cities, Sec. Climate Change and Cities, 3-2021. DOI: https://doi.org/10.3389/frsc.2021.645613.

Lindberg, A. (1956/57). Linden i Jonsboda. Det Linneska vårdträdet. Svenska Linnesallkapets arsskrift 39/40:95-105. (in Swedish)

Logan, S.A., Phuekvilai, P. & Wolff, K. (2015). Ancient woodlands in the limelight: Delineation and genetic structure of ancient woodland species *Tilia cordata* and *Tilia platyphyllos* (*Tiliaceae*) in the UK. *Tree Genetics & Genomes*, 11 (3) 1-12.

Lojo, A., et *al*. (2008). Metodika druge inventure suma na velikim povrsinama u Bosni i Hercegovini. Sumarski fakultet, Katedra za Uredjivanje suma. Univerzitet u Sarajevu.

Manrique, S., & Franco, J. (2020). Tree cover increase mitigation strategy: implications of the "replacement approach" in carbon storage of a subtropical ecosystem. Mitigation and Adaptation Strategies for Global Change, 25, 1481 - 1508. https://doi.org/10.1007/s11027-020-09930-5.

McHenry, M. (2012). Practicalities of establishing forestry carbon sequestration projects in the agricultural sector: A technical and economic analysis with implications.

Mekić, F. (2006). Uzgajanje suma. Sumarski fakultet u Sarajevu, Katedra za Uzgajanje suma. Univerzitet u Sarajevu.

Mueller, D., & Hofmann, M. (2022). Impacts of climate change on agriculture and recommendations for adaptation measures in the Western Balkans. Leibniz Institute of Agricultural Development in Transition Economies (IAMO). With support from the Federal Ministry of Food and Agriculture by decision of the German Bundestag.

Pigott, C.D. (1969). The status of *Tilia cordata* and *T. platyphyllos* on the Derbyshire limestone. *Journal of Ecology*, 57, 491-504.

Pigott, C.D. (1991). Biological flora of the British Isles. *Journal of Ecology* 79: 1147-1207.

Pigott, C.D. (1992). The clones of common lime (*Tilia* x *vulgaris* Hayne) planted in England during the seventeenth and eighteenth centuries. New Phytologist 121, 487-493.

Pigott, C.D. (1997). Two proposals to maintain the names *T. cordata* and *T. platyphyllos* (*Tiliaceae*) in their current use. *Taxon*. 46: 352-353. (proposal accepted).

Pigott, C.D. (2002). A review of chromosome numbers in the genus *Tilia* (*Tiliaceae*)", *Edinburgh Journal of Botany* 59 (02): 239-246. DOI: 10.1017/S0960428602000057.

Radoglou, K., Dobrowolska, D., Spyroglou, G. V., & Nicolescu, V. N. (2009). A review on the ecology and silviculture of limes (*Tilia cordata* Mill., *Tilia platyphyllos* Scop. and *Tilia tomentosa* Moench.) in Europa. Die Bodenkultur – Band 60, Heft 3, S. 10-19.

Vejzagić, S., Ballian, D., & Memisevic-Hodzic, M. (2021). Preliminarna istrazivanja morfoloskih svojstava lista srebrnolisne lipe (*tilia tomentosa* moench) u bosni i hercegovini i srbiji / Preliminary research of morphological traits of silver linden (*tilia tomentosa* moench) leaves in Bosnia and Herzegovina and Serbia. *Glasnik Sumarskog fakulteta* Univerziteta u Banjoj Luci 31, 65-77. DOI: 10.7251/GSF213106SV. UDK 582.795:581.47/48(497.11)(497.6).

Vejzagić, S. (2022). On the discovery of the multibracteate silver-leaved linden (*tilia tomentosa* moench.) in Mostar, Bosnia and Herzegovina / O pronalasku multibraktealne srebrne lipe (*tilia tomentosa* moench.) iz Mostara, Bosna i Hercegovina. *Glasnik Sumarskog fakulteta* u Banjoj Luci 32, 87-90. DOI: 10.7251/GSF2232007V. UDK 630*17(497.6):[582.795:581.54].

Visnjić, G. (2002). Sjemenarstvo i rasadnici. Sumarski fakultet. Katedra za uzgajanje suma. Univerzitet u Sarajevu