PERSPECTIVES OF AUSTRIAN PINE PLANTED FOREST IN THE FOREST MANAGEMENT AREA "TESLIĆ" (BOSNIA AND HERZEGOVINA)

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Abstract: This paper presents the analysis of the condition and perspectives of Austrian pine planted forest in the forest management area "Teslić". The forest management area "Teslić" is located in the western part of the Republic of Srpska (the area of the river basin Usora and partly of the area of the river basin Ukrina). The first Austrian pine planted forest in the area were established before the end of the nineteenth century, mostly next to settlements and road communications. The excessive cutting caused degradation of forest sites. In the forest management area "Teslić", planted forests of Austrian and Scots pine are spread over the area of 5,549 hectares, which presents 18% of the total area under planted forests of Austrian and Scots pine in the Republic of Srpska. The data needed to analyze the situation in the Austrian pine planted forests were collected from the available documentation and temporary established sample plots. Five sample plots were set up in the stands that have not been thinned so far, and one sample plot was set in a stand that had an adequate silvicultural treatment. Significant differences between stands condition that have not been thinned so far and condition of the stand that had an adequate silvicultural treatment have been determined. Austrian pine planted forests in the studied forest management area are not adequately treated. Without a radical change in management aproach, planted forests have a negative future perspective.

Key words: Austrian pine, planted forest, thinning, condition.

INTRODUCTION

On the territory of Bosnia and Herzegovina gradual afforestation of barren land started after the Second World War, with the aim to expand the raw material base, enable greater exploitation of the stand production potential and environmental protection. The afforestation was mostly carried out with Austrian pine (*Pinus nigra* Arn.) and less frequently with Scots pine (*Pinus silvestris* L.), Norway spruce (*Picea abies* L.) and some types of allochthonous conifers (*Pinus strobus, Pseudotsuga menziesii, Larix decidua*). Due to its characteristics, Austrian pine has modest demands regarding the site productivity characteristics, is considered to have a wide utility value as raw material, has the ability to

grow on poor sites, grows fast and has great resistance to draught or frost, has an adaptive root, is the planting stock which is relatively easy to be produced, so accordingly, those were the determining factors for selecting Austrian pine for afforestation (Maunaga 1999).

Austrian pine planted forests have been set up on soils of all types of parent rocks, both poor and good quality. This species can grow in poor habitat conditions, especially in poor site conditions, and in poor site conditions it achieves relatively good growth and productivity results**.** Austrian pine does not efficiently use the potentials of good soils which suit other production species such as Norway spruce, European beech and others, so the question is whether the afforestation of these sites with Austrian pine is justifiable; the same question refers to the forests already planted on 'someone else's' good sites, so it is questionable whether they should be kept and managed. (Stamenković and Vučković 1988).

Intensive utilization of the forests from Usora-Ukrina area (called Teslić today) started by the end of the Ottoman rule in B&H. More extensive utilization of oak stands in this area started after the occupation by Austro-Hungarian Monarchy in 1878 (Begović, 1986). Uncontrolled cutting of oak trees which were used for the production of wooden staves for barreland clear cutting of European beech stands on large surfaces with the aim to provide sufficient amounts of European beech wood for the needs of the distillery in Teslić resulted in creating barren land or degraded stands.

According to Kesterčanek (1897), the first planted forests of Austrian pine in Usora-Ukrina region were established by the end of the nineteenth century, mostly close to settlements and road communications. Intensive work on plantingAustrian pine forests in currently called “Teslić” forest management area started after the Second World War.

MATERIAL AND METHODS

Teslić forest management area is located at a latitude of 44˚ 36' and longitude of 17°54', in the western part of the Republic of Srpska. It is located in the area of the river Usora basin and partly the Ukrina river basin. In its western part there is the mountain massif Borja, while its southern part is bordered bythe slopes of the mountain massifs Vlašić and Manjača. The highest point is 1,383 meters high (Očauš), while the lowest point is located downstream the river Usora (Tedin Han), at an altitude of 166 meters.

The data needed for the analysis of the condition of Austrian pine planted forests were collected by summarizing the information from the available planning documentation (Forest Management Plans, commission reports of the accomplished sulvicultural work) and by setting up sample plots in the stands which belong to the oldest represented age class (51 to 60 years). Out of the total number of six temporary sample plots which were set up, five sample plots (OP2-OP6) were set up in the stands which haven't been appropriately treated (thinned), while one sample plot was set up in the stand where tending measures wereapplied (OP1).

The stand (MU “Donja Velika Usora”- compartment 208), in which Sample plot 1 (OP1) was set up, is the only stand in the studied age class in „Teslić“ forest management area which was thinned several times in recent years (1970, 1986, 1998 and 2005). In this

research the thinned stand is used as an optimal structure stand model for the observed age with which the structure of the unthinned stands is compared.

Three sample plots were set up in the stands which were established in the site of Sessile oak mountain forest (*Quercetum petraeae-daleschampii serpentinicum Stef.*), the others in the stands set up on the following sites: one in a Sessile oak and winter heath mountain forest (*Erico-Quercetum petraeae Ht. 59*.), one in a fir and common hornbeam forest (*Carpino betuli-Abietetum*), and one in a European beech and common hornbeam forest (*Rusco hypoglossi-Fagetum subpannonicum, subas*. *Carpinetosum betuli Stef*.).

In each selected stand was set up one square-shaped sample plot with the dimensions 30 m x 30 m (900 m^2).The diameter and height of all trees were measured and, according to Pintarić (1991), it was also determined whether they belonged to certain classes according to IUFRO Tree Classification. Extracted core samples were taken from 12 trees on each sample plots with the aim to estimate the vitality of the stands.

RESULTS AND DISCUSSION

According to the data from the Forest Management Plans (FMP), on the territory of "Teslić" forest management area planted forests spread on 5,838.4 ha, which is 10% of the planted forest area in the Republic of Srpska. Austrian pine and Scots pine planted forests spread on the surface of 5,549.3 ha, which is 18% of the surface under Austrian pine and Scots pine planted forests in the Republic of Srpska.

The overview of the wood stock distribution according to diameter classes in Austrian pine and Scots pine planted forests in "Teslić" forest management area is given in Table 1. 569,913 m^3 (79%) of Austrian pine wood stock i.e. 102.7 m^3/ha belong to diameter classes of 11-20 cm and 21-30 cm. The growing stock in Austrian pine and Scots pine planted forests on the surface of 5,549.3 ha is 715,854 m^3. According to Forest Management Plans for "Teslić" forest management area, pine forests were put in six management units. Table 2 shows the overview of the growing stock and the forest areas under Austrian pine and Scots pine forests according to their age classes.

Table 1. Distribution of growing stock according to diameter classes in Austrian pine and Scots pine planted forests in "Teslić" forest management area

Diameter class(cm)	**6-10**	**11-20**	**21-30**	**31-50**	**51-80**	**>80**	**Total**
m^3 ha^{-1}	11.5	65.2	37.5	13.8	1.0	0.0	129.0
%	9	50	29	11	1	0	100

In the first years after the war (World War II) the territory of Teslić municipality was characterized by extensive afforestation which was carried out with limited funds and without recruiting enough professional staff. Afforestation activities were often in the form of unplanned work and the recruitment of a large number of workers. Large surfaces were treated and due to the lack of funds unpaid workforce was recruited (so-called work drives), which later proved to be quite inadequate for such professional activities.

Afforestation activities were carried out without having previously prepared technical documentation.

Table 2. The area and volume of the growing stock in Austrian pine and Scots pine planted forests in "Teslić" forest management area

Age class						Total
1-20	21-40	41-60	61-80	81-100	101-120	
			Area (ha)			
1,808.6	3,571.0	169.7	-	-	-	5,549.3
			Growing stock (m^3)			
58,921.0	616,081.5	40,852.0	-	-	-	715,854.5

In the period from 1947 to 1951 the afforestation of substantial surfaces of barren landwas carried out mostly with Austrian pine and Scots pine seedlings, but in their records, commissions often reported minimal results. Because of these specific reasons (unprofessional approach), the results of the work on planting forests were often very bad. Pine forests were established with the planting density of 10,000 trees per ha, sometimes up to 12,000 seedlings per hectare (on degraded land).

The dynamics of the increase of the surfaces under planted forests in the territory of "Teslić" forest management area for the period from 1 January 1965 to 1 January 2005 is shown in Figure 1. According to the cadastre data, on 1 January 1965 the total surface of planted forests in this territory was 1.110 ha or 2.2% of the total forest area in "Teslić" forest management area, on 1 January 1995 it was 6,127 ha and 5,838 ha on 1 January 2005. Primarily due to the changes of the boundaries of the area, the surface covered with planted forests in "Teslić" forest management area was reduced by 289 ha, compared to the situation in 1995.

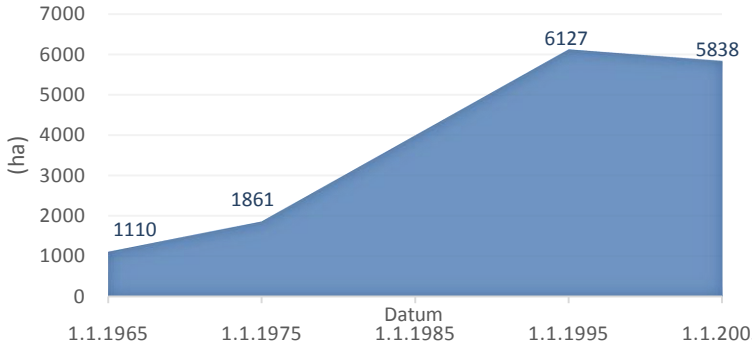

Figure 1. Overview of the surfaces covered with planted forests according to the data from the Forest Management Plans (According to the data from FMP for the periods 1975-1994, 1995-2004 and 2005-2014)

Although the Forest Management Plans require thinning after 15 years of stand age, in practice it was not the case. The lack of tending and management measures for

planted forests can be registered in control records i.e. the development of pine cultures was left to the action of natural factors.

Table 3 shows the basic stand structure elements established on sample plots (Figure 2) set up in the oldest represented age class (51-60 years). Great deviation of stand structure elements was determined on the thinned sample plot OP1 compared to the determined elements on other sample plots OP2-OP6**.** Unthinned stands at a particular age have a considerably higher number of trees and a smaller mean diameter than the thinned stand i.e. than the optimal structure of stands.

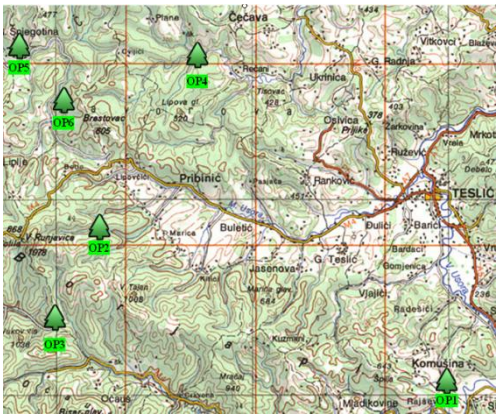

Figure 2.The sample plots (OP1-OP6) locations in the forest management area "Teslić" (Jović et al. 2012)

Table 3. Basic stand structure elements (number of trees – N, root mean square of trees dbh - DBH, basal area - G, stand height - h_L, volume – V, current annual increment – I_V)

Sample plots	N	DBH	G	h_L	V	I_v
	ha^{-1}	cm	m^2ha^{-1}	m	m^3ha^{-1}	
OP1	389	32	31.3	26.4	354	6.35
OP2-OP6	1282	21	43.7	19.8	387	4.8

In order to analyze and assess the structural characteristics of the stand from the sulvicultural aspect, IUFRO classification of trees, which has a dual character – biological and management, was applied according to Pintarić (1991). The obtainedpercentage share of individual classes in the total number of trees in the thinned (OP1) an unthinned stands (OP2-OP6) is shown in Table 4.

In the thinned stand all the trees are in the upper storeyand they are considerably more vital compared to the trees from the unthinned stands. 74.3% of trees are of extremely high vitality and 97.1% of trees have been selected for their sulvicultural role.Also, the thinned stand has the best quality of tree trunks (88.6% of trees have excellent quality trunks) due to the fact that most phenotypically bad trees were removed from this surface through silvicultural operations. Austrian pine trees in this stand have considerably longer crowns (62.9% of trees are with longer crowns), compared to the tress from the unthinned stands, which directly correlates with tree vitality.

Table 4. Number of trees (%), byIUFRO classification system

Characteristics	IUFRO class	Sample plots	
		OP1	OP2-OP6
Stand layer	upper layer	100	83.2
	middle layer	0	15.9
	lower layer	0	0.9
Vitality	strong	74.3	19.8
	normal	25.7	51.7
	weak	0	28.5
Growth tendency	advanced	78.4	17.0
	accompanying	8.4	54.2
	lagging	13.2	28.8
Silvicultural role	future tree	97.1	41.5
	useful	2.9	24.7
	harmful	0.0	33.8
Stem quality	excellent quality	88.6	41.3
	medium quality	8.6	33.9
	bad quality	2.8	24.8
Crown length	long	62.9	11.2
	medium	37.1	86.4
	short	0	2.5
Tree health	healthy	97.1	86.5
	slight damaged	2.9	8.1
	heavy damaged	0.0	5.4

By applying tending measures (thinning), this stand was brought into an optimal state from biological and management aspects relating the assessed parameters. Contrary to the thinned stand, the unthinned stands are characterizes by smaller vitality of trees and greater presence of trees which are harmful for the selected trees considering their silvicultural role. Trees from the unthinned stands have trunks of much worse quality.

As a measure for assessing the stability and growth potential of one stand, slenderness ratio can also be used - the smaller the vitality ratio is, the bigger is the capacityof the stand to resist the effects of snow or storms (Preuhsler 1991). The established values of slenderness ratio for all trees in the stand (h/d), for the thinned stands (h/d = 82) and for the unthinned stands (h/d = 96) are shown in Figure 3. Based on the established slenderness ratio and contrary to the thinned stand, the condition in the unthinned stands is unfavorable i.e. the stands are unstable which means that, while performing the potential thinning process on these sample stands, there is a considerable risk of the influence of snow and wind (snow break and windfall wood), so considerable caution is needed.

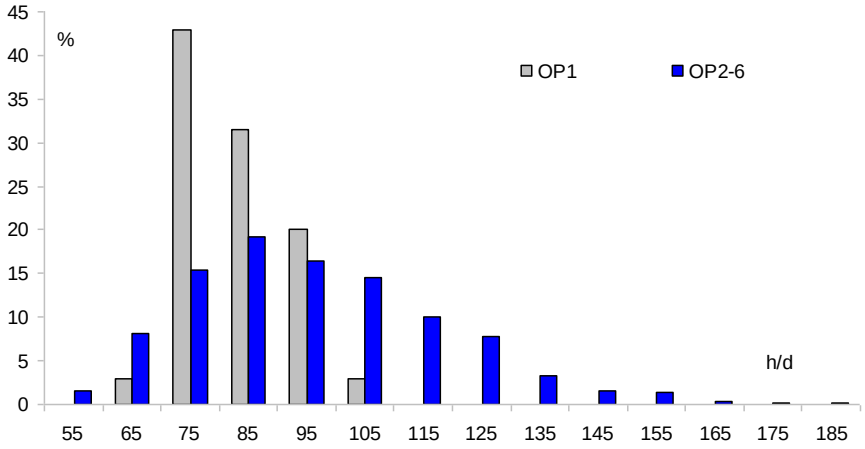

Figure 3. Number of trees (%), by slenderness ratio

Tree vitality of Austrian pine was tested on diameter increment i.e. the width of increment rings. The analysis of the diameter increment presents a significant base for assessing the vitality and a reliable prognosis of the future development of trees and stands. The trees in the stand are divided into three biological positions following the instructions from the Faculty of Forestry in Belgrade (Stamenković and Vučković 1988), and then 4 trees were drilled to the pith on each sample plot and in every biological position. To minimize the effect of age, i.e. to have a better insight into the reaction of trees to the effect of exogenous factors on diameter increment the growth ring indexes for trees from all three biological positions were calculated:

$$I = \frac{i}{\hat{i}_r}$$

(I - growth ring index, i - actual width of the ring and $\hat{i}_r$ - estimated width of the ring)

The annual ring width estimate related to specific functions didn't give satisfying results, so the moving average method was used (for periods of 5 years). All trees which have growth ring index lower than 1 in the studied period show hidden symptoms of loss of vitality (Table 5). Trees with low growth ring index don't have enough capacity for water and nutrients transmission, which, in the case of dominant trees and due to developed crowns and great 'transport distance', often results in an imbalance between the inflow and waterconsumption, i.e. the loss of vitality and dieback (Vučković et al. 2005).

Based on the ratio of the trees with hidden symptoms of loss of vitality and vital trees, it can be concluded that the trees from the thinned sample plot are considerably more vital than the trees from those sample plots which were not thinned and consequently, that refers to the whole stand. The stands which were not thinned during their development have low vitality.

Table 5. Share of vital and devitalized trees in thinned and unthinned stands

Sample plots	structure of stands		vital trees		with hidden symptoms of loss vitality	
	biological position of trees	(%)	n	(%)	n	(%)
OP1	I	81	4	100	0	0
	II	18	4	100	0	0
	III	1	3	75	1	25
	∑	100	11	92	1	8
OP2-OP6	I	48	15	75	5	25
	II	47	13	65	7	35
	III	5	7	35	13	65
	∑	100	35	58	25	42

CONCLUSIONS

More intensive work on planting Austrian pine forests in currently called "Teslić" forest management area started after the Second World War. Planted forests of Austrian pine and Scots pine in this area cover the surface of 5,549 ha, which is 18% of the surface under Austrian pine and Scots pine planted forests in the Republic of Srpska. Although thinnings are planned to be done starting from 15 years of age according to the Forest Management Plans, in most cases tending measures of planted forests were left out. The development of pine planted forests was left to the actions of natural factors. Great deviations of the established stand structure elements in the unthinned stands compared to the situation in the thinned stands are evident. The unthinned stands at the studied age have a considerably larger number of trees and smaller mean diameter than the thinned stand i.e. than the optimal structure of stands at the studied age.

Following the IUFRO classification of trees, and compared to the thinned stand, unthinned stands are characterized by low vitality of trees and a considerable number of trees which are by their silvicultural role harmful for the selected trees. The trees from the unthinned stands have a considerably worse quality of bolewood. Based on the established slenderness ratio, in the unthinned stand the situation is unfavorable i.e. the stands are unstable, so during carrying out potential thinning activities in these stands there is a considerable risk of the influence of snow and wind (snow break and windfall wood) and great caution is necessary. Testing tree vitality on diameter increment i.e. the width of growth rings showed that, contrary to the thinned stand which has very good vitality, the stands which were not thinned during their development have bad vitality.

There are numerous reasons for inadequate treatment but they can't be an excuse i.e. unfavorable current condition of Austrian pine forests in the territory of "Teslić" forest management area (high cost of harvesting during sulvicutural activities in the forests, fragmentation of plots where the forests were planted, unresolved property matters on the considerable part of the surfaces...). In order to improve the condition when Austrian pine planted forests in the studied area are in question, it is urgent to

intensify work on tending the stands i.e. carrying out thinning activities. Further afforestation without carrying out thinning activities, especially on the stands which are suitable for other production species is unjustifiable and leads to the aggravated condition of the forests in this area.

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