FINANCIAL IMPACT IN CASE OF INVESTMENT TO THE FOREST PROPERTY AS A RESULT OF DIFFERENT TREE SPECIES COMPOSITION IN THE CZECH REPUBLIC

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Introduction

The total area of forestland in the Czech Republic is about 2,593,923 ha, of which state owns 60.32%, 19.44% is owned by natural person, and 16.39% is owned by municipalities and the rest is owned by others legal bodies. [11]

The spruce covers the largest area – 1,138,424 ha (47.7%); the second largest area is covered by pine – 332,685 ha (13.9%). Coniferous species cover in total 67.2%. Oak and beech – among the broadleaved species – cover the largest area (7.4%) and (7.2%), respectively. Important species is also birch, a pioneer species (4.2%). Broadleaved species cover in total 32.8% of the area covered by tree species. [13]

The primacy of spruce is given both by natural conditions and by the history of forest management. "According to the analysis, the current proportion of homogeneous spruce forests in the total forest area is 20.3% (pure) and the current share of spruce-dominated forest ecosystems is 10.7% (dominant)" [10, p. 521].

"In the Czech Republic, the area of the coniferous trees is about 330,000 ha larger than is appropriate for the prescribed target tree species composition, and this area should be replaced by beech" [18, p. 33]. Decrease of Abies alba from natural 20% to critical value of less than 1% leads to disappearing of A. alba from Czech forests [6]. Ministry of agriculture wrote in the Report about condition of Czech forests from 2010 that natural representation of spruce was 11.2%, fir even 19.8% and beech 40.2% with current representation only 7.32% [12].

Additive trees grow in current spruce monocultures, which at least partly limit negative influence of spruce stands. Emission of these trees and their support possibly lowers costs on modification of species composition it the future. [16, p. 24] Frequent calamities are caused by instability of often monocultural or damaged and weakened forests whether because of their inappropriate tree composition. This is the reason for changing their current composition to their natural state.

Many scientists proved bad health condition of Czech forests and their weak resistance against biotical and abiotical factors. E.g. 31% of Czech forests are potentially endangered by honey fungus (Armillaria sp.). It has optimum from 2 to 4 fvz – forest vegetation zone in nutrient stations [8]. Čermák et al. [2] confirmed middle to high risk of Armillaria attacks in spruce stands within investigated locality in 3rd and 4th fzv and its possible deterioration simultaneously with change of external conditions.

Representation of Fagus sylvatica in the Czech forests is small, even though F. sylvatica is our one of the most important forest trees. However, less attention to its health condition is paid. Beech was and is considered as relatively healthy and resistant tree, but in last years it became endangered by bark necrosis. [7]

Change of tree composition to its natural form is supported by state. It creates tools which motivate forest management to change it according to target composition and stand conditions. Subsidies are one of the tools. They buffer part of planting costs and maintenance of ameliorating species (MZD). Bartoš et al. [1] wrote that forest regeneration with high representation

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of MZD (spruce 30, oak 30, beech 30, larch 10) was supported by financial endowment, which was about 46 thousands CZK higher than real plantation costs. This difference is five times higher than in case of forest regeneration without MZD (spruce 40, beech 30, fir 30) in minimal quantity per hectare for principal tree species.

Forest owners and managers are motivated to change their forest composition. But the change will have an economic impact on their property. Bartoš et al. calculated average price of spruce and beech assortments in real stands 1,273 CZK/m^3 spruce and 1,238 CZK/m^3 beech. They measured 520 m^3/ha in spruce stand in age of 45 years, which could correspond to site index +1 (36). [1]

Current average price of standing stale spruce wood without sorting was 1,300 CZK/m^3 (according to private information from the harvest cut in years 2011/12).

Suitable mixture of spruce with beech has a deciding factor on production and could change according to locality. Volume and quality yield of mixed spruce-beech stand does not reach yield of pure spruce stand, but not higher than sum of yields of pure beech and pure spruce stands calculated from assistant stands. [Wiedemann 1942 ex 15].

1. Aim and Hypotheses

The aim of this research is to create a model of dependency of total profit from forest stand depending on its composition and prove that if the forest composition is changed in favour of beech, the financial impact will be significantly negative. For our example pure Norway spruce (SM) stand is progressively changed to pure beech (BK) stand in 4th fvz with different site indexes. Time factor is eliminated, because all forest management activities are made at the same time in a model stand. The stand area is 100 hectares and on each hectare there is a forest group of differing age differs about 1 year from the forest besides. In one year trees are harvested, planted, maintained, protected, etc. All cash flows are related to the area of 100 ha, but all activities are done within one year. So, the results could be understood differently. The costs, revenues and profit are cash flows of 1 ha stand during 100 years.

The research is based on the three following hypotheses:

a) The model pure SM stands profit more (P_a) than pure BK stands (P_b).
   $P_a > P_b$ — P – profit
   $P_a = R_a - C_a$ — C – costs
   $P_b = R_b - C_b$ — R – revenues.
b) Decreasing of SM composition decreases revenues and silvicultural costs rises up and total profit decreases too.
   $P_a = P_b k$ — k – coefficient includes influence of stand composition to the total profit.
c) The total profit is influenced by change of stand composition. The total profit (loss) is function of stand composition change.
   $P = f(X)$ — X – share spruce.

The results could be a start point for further research by modelling risks or others influences. Risk is related to possible insurance of forest, etc.

2. Material and Methodology

Many scientists proved that progress of high growth of dominated and co-dominated species in mixed stands is the same as high growth in pure stands. Type of mixture does not influent shape of growth curves. [Weidemann1951, Weck 1955, Halaj 1968, Hladík 1978, ex 9]. Halaj based on own research stated, that forest site type trees mixed in one stand have in average comparable site index [5].

Taking the facts above into consideration a model stand was created. The stand area is 100 ha with rotation period of 100 years and it is located in 4th fvz natural beech wood stands according to the Typological classification system of ÚHÚL (The Forest Management Institute) [14]. The stand consists imaginarily of one hundred forest groups each with an area of 1 ha and different age from 1–100 years. In the whole area there will be imaginarily grown Norway spruce (SM) and all costs and revenues will be calculated within one year in the stand. In each next example it will be replaced 10% of SM by beech and continued until the stand is pure beech (BK). This presumption that was introduced above is that SM and BK on the same locality will get identical mean high in the same age meaning site index of both the trees will be the same. Regeneration period is one year. Forest regeneration will be done immediately after major harvest. The model is

used for all site indexes. Totally there are 121 different situations. For each from eleven different site indexes from +1 (36) to 9- (16) there are eleven possible species compositions from pure spruce to pure beech stand.

No calamities or other outsider factors are considered. The model stand is supposed healthy, wood is ideally without any damages and the stand is fully-stocked.

2.1 The Mensuration and Growth Tables (MGT)

Data about merchantable volume in age classes of five years is available from the Mensuration and Growth Tables (MGT) of the main tree species of the Czech Republic [3], where the left part of the tables represents the mensuration tables plus indicating the basic stand characteristics of the present stands and the right part of the tables is the growth table itself. It indicates the predicted development of selected stand characteristics for the main stand (mean height, mean diameter, merchantable volume) and the thinning (merchantable volume).

Allowable cuts (merchantable volume) are set from MGT, and from the regulation No. 84/1996 Coll., About forest planning, for their comparison [19]. The volume of cuts is used for calculation of costs and revenues for the model stand.

2.2 Costs Calculation

Necessary costs are divided into two groups: silviculture, which includes protective costs and logging, which includes cutting, crosscutting, delimbing and skidding. Wood is sold on roadside. Other costs e. g. cost of road maintenance, amelioration, management were not considered because they could be very different according to the locality.

Silviculture and logging costs were calculated from moment of stand regeneration to harvest cut. Stand is regenerated by 4,000 four-years-old plants of SM and 9,000 three-years-old plants of BK. Spruce is planted by hole planting and beech by slit planting to the full-area soil prepared. BK plants are full-area fenced up to 50% of its composition. With higher BK composition the fenced area decreases to 20% in case of pure BK stand. In the first three years the SM is scythed two times a year in lines and BK in full-area, SM is painted against pine weevil and against game browsing in autumn. Then the next three years the scything is done only once a year and protection against game browsing annually decreases by 20% in older trees. When the BK plantation is established the fence is removed and stand is tended. In the age of 10 to 15 years in the moment of canopy closure the negative selection crown thinning is executed and 30% of SM trees are removed. 30% of subdominant and co-dominant BK trees is removed.

In stands of ages 20 to 95 years thinning is executed. In pure SM stands and mixed stands with minimum composition preventive measures must be taken according to regulation No. 236/2000 Sb., which altered Decree of the Ministry of Agriculture of the Czech Republic No. 101/1996 Coll., setting forth details for securing forest protection and stating models of service badge and of forest guard certificate [20]. Basic condition of Ips typographus is observed by insect trapping (cut control spruce stems, the so called trap trees, or installation of pheromone-baited traps), which are installed in spring and summer seasons in minimum of one trap on each 5 hectares of forest stands older than 60 years with at least SM20.

Used prices of all activities are reported in appendix No. 1, there are prices of contractors including their profit margin.

$$C = n_{sm}Ap_{sm} + n_{bk}Ap_{bk} + nAp_0 + nAp_1 + \\ + nAp_2 + nAp_3 + nAp_4 + np_5 + Ac_p + n_{lp}p_{lp} + \\ + E_1Ac_{pr\ (sm,bk)} + E_2Ac_{pro\ (sm,bk)} + E_3Ac_{t\ (sm,bk)} \quad (1)$$

n_x – number of units (operations or meters of fence),

$n_{sm,bk}$ – number of plants,

n_{lp} – number of traps,

$p_{sm,bk}$ – plant price included its planting,

p_{lp} – price of traps included its control and remediation,

A – area of silvicultural or logging operation in ha,

$E_{1,2,3}$ – volume of cut with bark deduction in 1 m^3,

p_0 – price of full-area site preparation,

p_1 – price of scything in lines 50 cm for 1 ha,

p_2 – price of full-area scything for 1 ha,

p_3 – price for painting against spruce brows for 1 plant (including work and material),

p_4 – price for painting 1 ha against weevil (including work and material),

p_5 – price one running meter for a fence building and disposal,

$c_{p\ (sm,bk)}$ – costs of clearing on 1 ha (30% reduction),

$c_{pr\ (sm,bk)}$ – costs of thinning and skidding of 1 m^3 of softwood and broadleaved species in forests up to 40 years,

$c_{pro\ (sm,bk)}$ – costs of thinning and skidding of 1 m^3 of softwood and broadleaved species in forest older than 40 years,

$c_{t\ (sm,bk)}$ – costs of harvest cut and skidding of 1 m^3 of and softwood and broadleaved species.

2.3 Revenues Calculation

Revenues from the model stand were calculated as a product of cubic capacity harvested assortments and its price on roadside, which is recorded by the Czech statistical office to the roadside place [4].

$$R = M_1 A p_6 + M_2 A p_7 + M_3 A p_8 \quad (2)$$

$p_{6\text{-}8}$ – wood price according assortments,

M_1 – volume of timber of assortments of III. A/B quality class according to the Czech state norm (ČSN),

M_2 – volume of timber of assortments of IV. quality class according to the ČSN,

M_3 – volume of timber of assortments of V. quality class according to the ČSN (fuel wood),

A – area of species in model stand.

2.4 Profit from the Model Stand

The total profit does not include any tax or forest administration costs. For the research the profit means difference between costs and revenues. In case that result is negative there is loss and not profit.

$$P = R - C \quad (3)$$

3. Results

Firstly values of cuts were set up for calculations of revenues and costs. Actual prices for year 2012 were used, which could differ from one contractor to another one and which includes their profit margin. For wood assortments an average price for wood for the third quadrant last year 2012 were used. It is publicly available from the Czech statistical office (ČSÚ) webpage [4]. This price is of wood on roadside.

3.1 Allowable Intermediate Cut

According to regulation No. 84/1996 Coll., on forest management planning, for pure spruce and beech stands of higher site index there is percentage value of allowable intermediate cut including natural mortality for each decennial period and for full stocking (see Tab. 1 and 2). In the tables below there are values from the Mensuration and Growth Tables (MGT), which were summed for 10 years period for better comparison because in the MGT there are five-year periods stated. The values from the MGT for spruce up to 70 years are higher and then mainly lower according to the regulation for site index +1. In average the volumes are almost equal. Volumes are compared without that of age of 20 years because there is no data for allowable intermediate cut for spruce till the age of 30 years in the MGT. For beech both volumes are almost equal at sum. The volumes in the MGT are lower than regulation ones and they were used for the calculations. In this way overvaluation of incomes is potentially avoided.

3.2 Harvested Timber and Its Assortments

Volume of timber harvested from model stands were established according to real timber supply from the MGT as well as intermediate cut. All cuts were sorted by their diameter at breast height according to the Assortment tables [17 with groundwork by Dejmal 1986]. Bark deduction was made differently according to their diameter at breast height were used different coefficient. Example of calculation is in appendix No. 2. In case of spruce the used category was: standard for stacked and healthy wood with average technological quality standards. In case of beech followed category was used – standard for stacked and healthy wood with average technological quality standards including branch wood. Shares of assortments in the model stand are shared as followed (Tab. 3).

Tab. 1: Comparison of allowable intermediate cut for pure spruce stand with site index +1 (36)

Age	Timber to the top of 7 cm o.b. (in m³/ha)	An allowable intermediate cut according to the regulation		An allowable intermediate cut according to the MGT (in m³/ha)
		Timber to the top of 7 cm o.b. (in %)	Timber to the top of 7 cm o.b. (in m³/ha)	
30	294	24	70.6	77.0
40	423	17	71.9	77.0
50	534	12	64.1	71.0
60	628	10	62.8	63.0
70	716	8	57.3	58.0
80	785	7	55.0	54.0
90	847	6	50.8	52.0
100	900	6	71.4	50.0
Total			503.9	502.0

Source: Calculated form the MGT and regulation No. 84/1996 Coll., About forest planning.

Tab. 2: Comparison of allowable intermediate cut for pure beech stand with site index +1 (36)

Age	Timber to the top of 7 cm o.b. (in m³/ha)	An allowable intermediate cut according to the regulation		An allowable intermediate cut according to the MGT (in m³/ha)
		Timber to the top of 7 cm o.b. (in %)	Timber to the top of 7 cm o.b. (in m³/ha)	
20	118	-	-	-
30	220	21	46.2	70
40	303	21	63.6	75
50	381	18	68.6	68
60	454	16	72.6	60
70	527	13	68.5	56
80	591	11	65.0	54
90	655	10	65.5	56
100	711	9	64.0	55
Total			514.0	494

Source: Calculated form the MGT and regulation No. 84/1996 Coll., About forest planning.

Data was got from the MGT as values of total cuts from major harvest and allowable intermediate cuts. The Tab. 4 below presents example of the volumes for site index 36 and 16 for pure spruce stand and pure beech stand and equally mixed stand. Situation is similar in others site indexes. Total volume is almost the same for another species composition. There is a difference between volumes in various stand growth stages. Whereas the major harvest is in any situation higher in case of pure spruce stand, opposite situation is in all cuts before major harvest in case of pure beech stand or its mixtures.

Tab. 3: Assortment shares of different site indexes in case of spruce and beech

Assortment	Assortment shares of different site indexes										
	spruce										
	36	34	32	30	28	26	24	22	20	18	16
III. A/B grade	0.8510	0.8317	0.8054	0.8057	0.7773	0.7139	0.7219	0.6168	0.6156	0.6109	0.6102
V. grade	0.1219	0.1414	0.1684	0.1679	0.2034	0.2669	0.2588	0.3639	0.3650	0.3699	0.3706
Fuel wood	0.0272	0.0269	0.0262	0.0263	0.0193	0.0192	0.0193	0.0192	0.0194	0.0192	0.0192
	beech										
III. A/B grade	0.6645	0.6384	0.6360	0.6414	0.6414	0.6549	0.6371	0.6699	0.6538	0.6425	0.6213
V. grade	0.2828	0.3110	0.3140	0.3139	0.3139	0.3001	0.3179	0.2847	0.3020	0.3192	0.3408
Fuel wood	0.0526	0.0506	0.0500	0.0447	0.0447	0.0450	0.0450	0.0454	0.0442	0.0383	0.0379

Source: Calculated form the Assortment tables and the MGT used methodology above.

Tab. 4: Volume of cut in model stands of site index 36 and 16

Items with bark deduction	Volume of cut in site index 36 in m^3			Volume of cut in site index 16 in m^3		
	SM100	SM50	BK100	SM100	SM50	BK100
Volume of cut up to age 40 years (E_1)	146.94	149.08	151.22	0.00	0.00	0.00
Volume of cut over 40 years (E_2)	350.08	404.27	458.46	64.80	94.71	124.63
Major harvest (E_3)	820.62	745.54	670.47	240.97	183.00	125.03
Total	1,317.64	1,298.89	1,280.15	305.77	277.71	249.66
Volume of III. A/B grade of quality (M_1)	1,121.28	985.99	850.70	186.57	170.83	155.10
Volume of V. grade of quality (M_2)	160.55	261.31	362.07	113.32	99.20	85.09
Volume of fuel wood, VI. grade of quality (M_3)	35.81	51.595	67.38	5.88	7.67	9.47

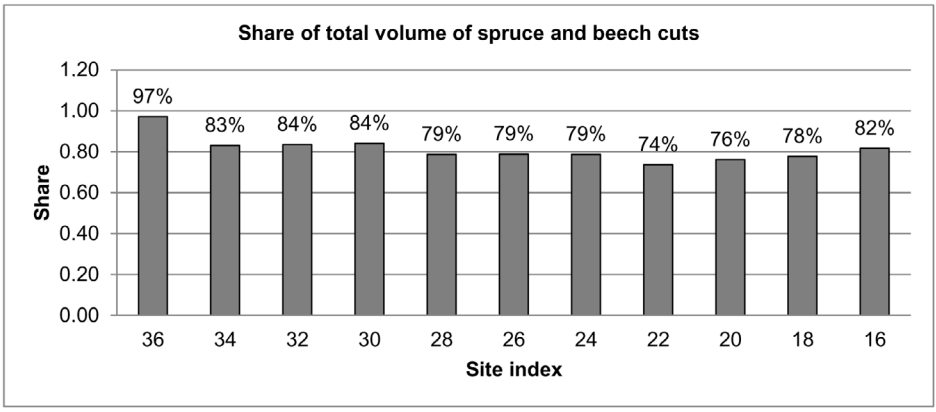
Source: Results from calculations according to the methodology.

Share of total volume of spruce and beech harvested timber is shown in the Fig. 1. In the model stand the amount of beech harvested timber does not decrease fewer than 74% of spruce harvested timber. In average beech harvested timber comprises about 81% of spruce harvested timber.

3.3 Costs and Revenues Calculations

Using the previous results of harvested timber and its assortments the costs and revenues for model stand in all site indexes and mixtures of spruce and beech were calculated (tab. 5 and 6).

Fig. 1: Share of total volume of spruce and beech cuts



Source: Results from calculations according to the methodology.

Tab. 5: Example of costs calculation for model stand in site index +1 (36) and SM100, BK0

C =	Costs of	Calculations	
$n_{sm}Ap_{sm}$	planting of spruce	4,000*1*(10 + 5)	60,000
$n_{bk}Ap_{bk}$	planting of beech	9,000*0*(8 + 4.8)	0
np_0	full-area site preparation	1*2,000	2,000
nAp_1	scything in lines	1*7*5,000	35,000
nAp_2	full-area scything	0*7*8,000	0
nAp_3	painting against spruce brows	4,000*(1+1+0.8+0.6+0.4)*1*1.2	18,240
nAp_4	painting against weevil	1*2,620*3	7,860
np_5	building and disposal of a fence	0*90	0
Ac_p	clearing – 30% reduction	1*9,600	9,600
$n_{lp}p_{lp}$	traps including control and remediation	16*1*600	9,600
$E_1Ac_{pr\ (sm)}$	thinning and skidding (age < 40 years)	146.94*1*1,020	149,879
$E_1Ac_{pr\ (bk)}$		151.22*0*780	0
$E_2Ac_{pro\ (sm)}$	thinning and skidding (age > 40 years)	350.08*1*660	231,053
$E_2Ac_{pro\ (bk)}$		458.46*0*660	0
$E_3Ac_{t\ (sm)}$	harvest cut and skidding	820.62*1*660	541,609
$E_3Ac_{t\ (bk)}$		670.47*0.684	0
Total costs (C)			**1,064,841 CZK**

Source: Calculation according to the equation (1)

Tab. 6: Example of costs calculation for model stand in site index +1 (36) and SM100, BK0

R =	Revenues of	Calculation	
M_1 A p_6	timber of assortments of III. A/B quality class	1,121.277*1*2,098	2,352,439
M_2 A p_7	timber of assortments of IV. quality class	160.557*1*860	138,079
M_3 A p_8	timber of assortments of V. quality class	35.807*1*784	28,073
Total revenues (R)			**2,518,591 CZK**

Source: Calculation according to the equation (2)

Profit from model stand in site index +1 (36) and SM100, BK0 is:

P = 2,518,591 – 1,064,841 = 1,453,750 CZK

In the table 7 below you can see some other results for next two site indexes and different species compositions. Average costs for established plantation are 133,000 CZK per hectare in pure spruce stand and 237,000 CZK per hectare in pure beech stand.

Tab. 7: Profit from model stands in different site index and species compositions

Item	Cash flows for site index 36 (CZK)			Cash flows for site index 26 (CZK)			Cash flows for site index 16 (CZK)		
	SM100	SM50	BK100	SM100	SM50	BK100	SM100	SM50	BK100
Costs up to ten-year old forest with scything	132,700	184,750	237,232	132,700	184,750	237,232	132,700	184,750	237,232
Harvesting costs	932,141	905,640	879,139	487,403	432,300	377,198	211,408	189,591	167,773
Total costs	1,064,841	1,090,390	1,116,371	620,103	617,050	614,430	344,108	374,341	405,005
Total revenues	2,518,591	2,104,007	1,689,422	1,234,116	984,492	734,867	493,492	409,238	324,984
Profit (Loss)	1,453,750	1,013,617	573,051	614,013	367,442	120,437	149,384	34,897	-80,021

Source: Results from calculations according to the methodology.

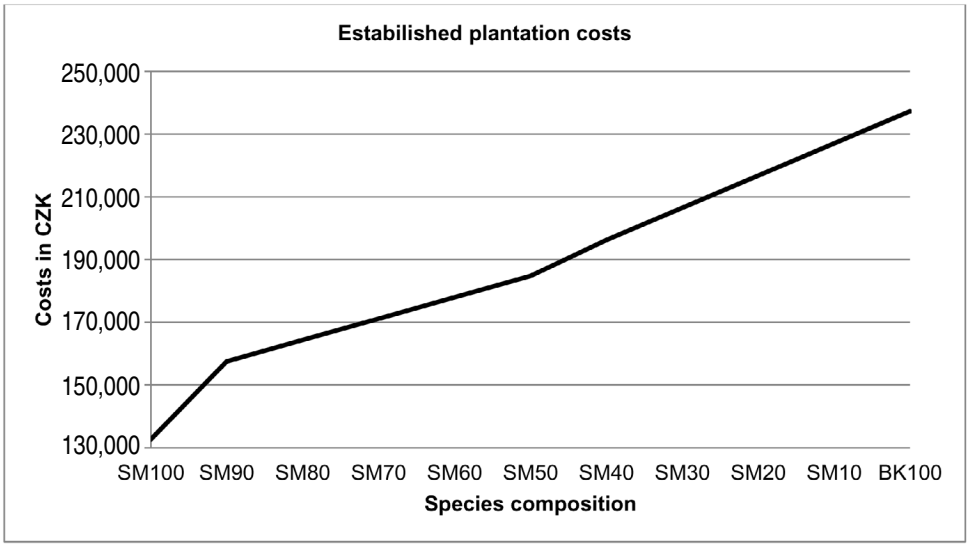
Established plantation costs grew 6% in average with growth 10% of beech in species composition. The main growth of the costs is between pure spruce stand and composition of SM90 and BK10, as seen in Fig. 2.

With calculation of weight average price of wood for spruce and beech stand using both the data from Tab. 3 and from profits from stands it is possible to confirm that the average is decreasing with site index of tree especially in spruce stands, whereas this decrease is not so noticeable in case of beech stand. The average price of spruce wood ranges in the highest site index (36) from 1,991 CZK/m^3 to 1,614 CZK/m^3 for the lowest site index (16) and in case of beech wood from 1,319 CZK/m^3 to 1,302 CZK/m^3. Relative change is in Fig. 3.

Sorting process influences profit from spruce stands more than beech stands because of significant differences in assortment prices.

The average price of spruce wood reached 77% of III. A/B quality classification price and the average price of beech wood reached 90% of III. A/B quality classification price in the lowest site index. It responds to price differences between grades, where spruce wood price of fuel wood compared to III. A/B grade comprises 37% and 75% in case of beech.

Fig. 2: Established plantation cost for different species composition



Source: Results from calculations according to the methodology.

Fig. 3: Relative change of average wood price according to site index

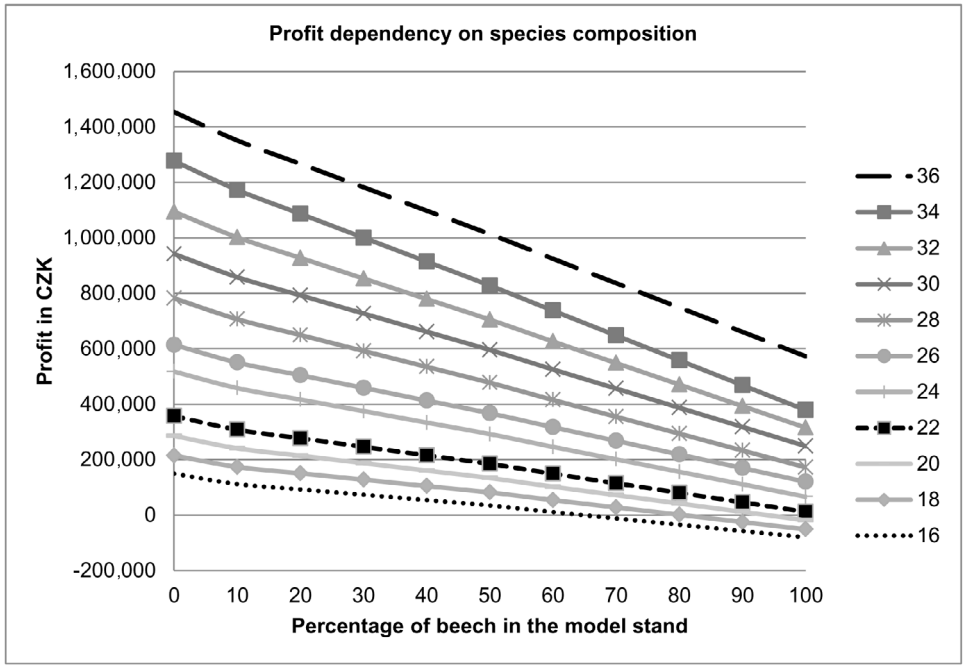
Source: Results from calculations according to the methodology

3.4 Profit Dependency on Species Composition

With the previously calculated prices results show that in stand with the highest site index the differences between profits in pure spruce stand and pure beech stand will be about 900,000 CZK, whereas in stands with the lower site index it will be 230,000 CZK.

The profit is decreasing linearly with dependency on species composition from SM100 to BK100. In lower site indexes this decrease is not so steep. In stands with composition BK80 with index 20 and lower there is loss. The Fig. 4 shows absolute values for all 121 model situations.

Fig. 4: Dependency of profit from forest on species composition



Source: Results from calculations according to the methodology.

Absolute relation between profit and species composition for various site indexes:
$y = px + n.$
E.g. for site index 36: y = -8713x + 1,445,667. For others site indexes coefficients are in Tab. 8.

Tab. 8: Coefficients for different site indexes

Site index	p	n
36	-8,713.0	1,445,667
34	-8,885.9	1,268,901
32	-76,917.0	1,085,997
30	-68,338.0	933,855
28	-60,036.0	774,034
26	-48,418.0	605,929
24	-44,193.0	509,601
22	-33,573.0	348,967
20	-29,479.0	277,641
18	-25,661.0	206,535
16	-22,001.0	141,301

Source: Results from calculations according to the methodology.

n – profit from the model stand,

p – differences between profit from pure spruce stand and pure beech stand divided by beech composition.

In case of mixture SM40 and BK60 at site index 36 the profit is approximately:

y = 60x(-8,713)+1,445,667 = 922,877 CZK

Tab. 9: Coefficients for different site indexes

Site index	p	n	R^2
36	-0.0083	2.3427	0.9989
34	-0.0088	2.0330	0.9987
32	-0.0085	2.2327	0.9987
30	-0.0087	2.1992	0.9986
28	-0.0085	2.1124	0.9982
26	-0.0077	1.9676	0.9978
24	-0.0080	1.9175	0.9975
22	-0.0068	1.7036	0.9966
20	-0.0066	1.6182	0.9958
18	-0.0063	1.5109	0.9946
16	-0.0006	1.3892	0.9922

Note: R^2 – coefficient of determination

Source: Results from calculations according to the methodology.

It is possible to express the graph (Fig. 4) relatively as a relation between profit and species composition for various site indexes:

$y = px + n$

E. g. for site index 36:

$y = -0.0083x + 2.34$

Conclusion

Nowadays matters about forest stability are very important related to the climate changing, which could be met by owner or manager. Many scientists show an alarming condition of some of our forests and possible threats caused by biotic and abiotic agents.

The owner or manager can change species composition and influence the future profit from cut wood. From this point of view this profit is interesting gain from economic forest function because the others functions (as ecological and social) are not enough profitable yet in the Czech Republic.

The aim of this research was to prove that natural species composition is not as profitable as spruce monoculture in example of 4th fvz (forest vegetation zone in nutrient stations). The profit from pure spruce stand is higher, so that beech stands are not lucrative for owners. Any state subsidiaries or other motivation tools for changing species composition were not considered.

On the model stand possible costs and revenues for all possible site indexes and various species compositions from pure spruce forest through mixtures of beech to pure beech forests were calculated. The cash flows were compared. The model stand includes 100 groups differ in age of one year. The same rotation period of 100 years and regeneration period of one year were considered for spruce and beech stands.

It was set up a number of silviculture and logging activities and the costs were calculated. Total volume of cuts was used from MGT (Mensuration and Growth Tables) for all site indexes with bark deduction. Revenues were calculated for wood assortments. There are used prices of forestry contractors including their profit margin and average price for wood assortments for the third quarter last year 2012 publicly available from the Czech statistical office related to the roadside.

The research was based on three hypotheses. Firstly the profit from the pure spruce stand is

higher than the profit from pure beech stand. **The revenues from spruce stand were 2,518,491 CZK, which is 1.5 times higher** than beech ones, which were 1,689,422 CZK in site index +1 (36). The costs for establishing plantation did not differ in absolute values so much. The difference between the revenues is caused mostly by **different price for species** assortments according to their quality. **The volume of harvested SM and BK wood does not differ so significantly** mainly in higher site indexes in pure stands or their mixtures too. In case of SM100 the volume of total cut was 1,317.64 m^3, SM50, BK50 it was 1,298.89 m^3 and BK100 it was 1,280.15 m^3 (for site index 36). The volume of cuts is almost the same, there is a difference between the volume of wood harvested in forest group with age up to 40 years, older than 40 years and major harvest, where the major harvest is in any situation higher in case of pure spruce stand. Opposite situation is in all cuts before major harvest in case of pure beech stand or its mixtures.

Profitability of potential investment, which presents costs to the pure spruce stands with the highest site index +1 (36) is 234%, whereas profitability of beech stand in the same site index is only 151%.

The second hypothesis was confirmed only partly. It is true that lower SM composition causes lower profit. However, this is not caused by rising costs for established plantation, which are twice times higher in case of beech. **Price differences of wood assortments have a bigger impact on the profit.** Wood price is affected by various factors, which could be target for future research. The calculated average price for site index +1 (36) in case of SM is 1,990 CZK/m^3 and for BK 1,319 CZK/m^3. In comparison to Bartoš et al. [1], results from this research do not differ so significantly in case of BK. They got beech wood price 1,238 CZK/m^3 and spruce price 1,273 CZK/m^3 which differs more, whereas the differences between used prices were not so big. It could be influenced by various damages which could lower price and which were not taken in consideration in the model situation. Level of risk of lower profit could be next topic for following research.

Average costs for established plantation including the first 30% clearing were 132,700 CZK in case of pure spruce stand and 237,232 CZK in case of pure beech stand. It could be decreased by lower amount of silviculture operations, but main cost comprises of planting. All the cash flows are related to the area of 100 ha, but all activities are done within one year. So, the results could be understood differently. The costs, revenues and profit are cash flows of 1 ha stand during 100 years.

The third hypothesis confirmed that **amount of profit is influenced by species composition** with certain amount of silviculture operations. Profit is a linear function of changing species composition. Intensity of silviculture operations could lower costs, but on the other hand it could lower volume of felling too. But this was not object of this research.

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Appendix 1: Price list of operations and wood

Operations*	Price in CZK
p_0 – full-area site preparation (1 ha)	2,000
p_{sm} – plant price SM (12-25 cm) and Whole planting price for one plant	10 + 5
p_{bk} – plan price BK (36-50 cm) and Slit planting price for one plant	8 + 4.8
p_1 – price of scything in lines 50 cm for 1 ha	5,000
p_2 – price of full-area scything for 1 ha	8,000
p_3 – price for painting against spruce brows for 1 plant	1.2
p_4 – price for painting 1 ha against weevil – SM – work (1,000 CZK); material (Primor, 1 kg on one ha; 1,620 CZK)	2,620
p_5 – price of running meter of fence and disposal	80 + 10
c_p – costs of clearing on 1 ha (30% reduction)	9,600
$c_{pr,sm}$ – costs of thinning and skidding of 1 m3 of softwood	660 + 360
$c_{pr,bk}$ – costs of thinning and skidding of 1 m3 of broadleaves	420 + 360
$c_{pro,sm}$ – costs of thinning and skidding of 1 m3 of softwood in forest older than 40 years	300 + 360
$c_{pro,bk}$ – costs of thinning and skidding of 1 m3 of broadleaves s in forest older than 40 years	300 + 360
p_{lp} – price of one trap includes its control and sanation (one piece is required two times a year on each 5 hectares in forests younger then 40 years)	600
$c_{t,sm}$ – costs of harvest cut and skidding of 1 m3 of and softwood	300 + 360
$c_{t,bk}$ – costs of harvest cut and skidding of 1 m3 of and softwood and broadleaved species	324 + 360
Wood grade of quality**	
p_6 – SM – III. A/B quality classification according to the Czech state norm (ČSN)	2,098
p_7 – SM V. quality classification according to the ČSN	860
p_8 – SM VI. quality classification according to the ČSN – fuel wood	784
p_6 – BK – III. A/B quality classification according to the ČSN	1,453
p_7 – BK V. quality classification according to the ČSN	1,050
p_8 – BK VI. quality classification according to the ČSN – fuel wood	1,086

Note: *Prices of contractors includes its profit margin; ** Average prices in third quarter of year 2012 (ČSÚ) as a price on roadside [4].

Appendix 2: Example of the SM sorting, site index +1 (36)

Age	Stock (m^3)*	Cut (m^3)*	$d_{1,3}$ with bark (cm)*	Bark deduction**	Cut with bark deduction (m^3)	Volume of harvested assortments with bark deduction (m^3)						
						III. A				III.B	pulp wood	fuel wood
15	82.00					1.b	2.a	2.b	3.	1.b		
20	152.00		11.90							0.00	0.00	0.00
25	223.00	34.00	14.30	0.8777	29.84					6.57	22.98	0.30
30	294.00	43.00	16.50	0.8826	37.95					17.08	20.12	0.76
35	358.00	45.00	18.60	0.8872	39.92					17.97	21.16	0.80
40	423.00	44.00	20.70	0.8914	39.22	0.78	16.87			8.63	12.16	0.78
45	477.00	42.00	22.70	0.8951	37.59	0.75	16.16			8.27	11.65	0.75
50	534.00	39.00	24.60	0.8979	35.02	0.35	23.46			4.20	6.30	0.70
55	582.00	37.00	26.40	0.9005	33.32	0.33	22.32			4.00	6.00	0.67
60	628.00	35.00	28.10	0.9026	31.59		15.48	9.79		2.21	3.48	0.63
65	674.00	33.00	29.90	0.9049	29.86		14.63	9.26		2.09	3.28	0.60
70	716.00	31.00	31.50	0.9061	28.09		13.76	8.71		1.97	3.09	0.56
75	753.00	30.00	33.10	0.9073	27.22		4.63	7.89	10.62	1.36	1.91	0.82
80	785.00	29.00	34.70	0.9084	26.34		4.48	7.64	10.27	1.32	1.84	0.79
85	821.00	28.00	36.10	0.9091	25.45		4.33	7.38	9.93	1.27	1.78	0.76
90	847.00	28.00	37.60	0.9098	25.47		3.82	5.60	12.74	1.27	1.27	0.76
95	879.00	27.00	39.00	0.9108	24.59		3.69	5.41	12.30	1.23	1.23	0.74
100	900.00	28.00	40.40	0.9118	25.53		3.83	5.62	12.77	1.28	1.28	0.77
Major harvest	900.00	900.00	40.40	0.9118	820.62		123.09	180.54	410.31	41.03	41.03	24.62
TOTAL		1,287.00	-	-	1,317.64	2.21	270.55	247.84	478.92	121.73	160.55	35.81

Note: * Values from the MGT [3]; **Bark deduction was interpolated so that it responds the best to the $d_{1.3}$ (diameter at breast height) [17].

Abstract

FINANCIAL IMPACT IN CASE OF INVESTMENT TO THE FOREST PROPERTY AS A RESULT OF DIFFERENT TREE SPECIES COMPOSITION IN THE CZECH REPUBLIC

Pavlína Köhler, Vlastimil Vala

The spruce covers the largest area 44.7% in the Czech Republic, but its natural representation was 11.2%. Forest owners and managers are motivated to change their species composition. But the change will have an economic impact on their property. The aim of this research is to create a model of dependency of total profit from forest stand depending on its composition and prove that if the species composition is changed in favour of beech, the financial impact will be significantly negative. The model has area 100 ha with 100 forest groups which differ in age of one year. All the silviculture and logging activities were done within one year for eleven site indexes. Total volume of cuts was used from the Mensuration and Growth Tables. Prices of contractors including their profit margin and wood price from the Czech statistical office were used for revenues and costs calculations related to the roadside. The profit from the pure spruce stand is higher than profit from pure beech stand. The costs for establishing plantation did not differ in absolute values so much. The difference between revenues is caused mostly by different price for species assortments according to their quality. The profitability of potential investment, which presents costs to the pure spruce stands with the highest site index +1 (36) is 234%, whereas profitability of beech stand in the same site index is only 151%. Profit is a linear function of changing species composition. The localities with the lowest site index was it the red.

Key Words: *Profit, spruce, beech, profitability, cost, revenues.*

JEL Classification: *C20, Q23, L73.*

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