# Economic analysis of coniferous silviculture in Poland

## Profitability comparison between Poland and Lithuania

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## Abstract

Cash flow analysis from pine and spruce stands on I and II site index was made basing on data collected from three Polish forestry districts. Data obtained from districts allowed to calculate NPV, IRR and FR economical indicators for the years 2001 and 2006. Economic outcomes were calculated by discounting costs and incomes with 3% discount rate. Additionally, calculations with administration costs were made. Furthermore, a part of the report compares Polish and Lithuanian economical outcomes in 2006 from pine and spruce stands of the same productivity. The following criteria were defined for all pine and spruce stands: the height of the pines reaches 24 meters and spruce 28 meters at the age of 100 years. Only state owned productive forests were investigated. The next accepted step was making the forest management programme as similar as possible to the forestry practice in both countries.

Project investigations revealed that pine stands in Poland on most common site index are not profitable according to NPV and IRR criterion with and without adding administration costs. However spruce profitability reaches more than 4 percent without taking into account administration costs. After adding administration costs it went down into 2.5 percent. For Polish pine and spruce stands forest rent remains positive with and without administration costs. Despite increasing prices for timber assortments, profitability did not increase significantly between years 2001 and 2006 due to increase of labour costs.

Comparison of Polish and Lithuanian silviculture regimes revealed that Polish pine stands are much less profitable than Lithuanian. The reason behind this lies in a higher number of treatments required and implemented during rotation. However Polish spruce stands with more treatments implemented but a 25 years longer rotation have a higher profitability in Poland. The main reason for this is a much higher spruce productivity in Poland than in Lithuania and higher wood prices.

Furthermore administration costs are more severe in Poland, which decreases profitability as compared to Lithuania.

In general, the report results lead to the conclusion that only those entrepreneurs which are willing to freeze their capital for a long time in bringing low interest rate investments can invest money in Polish and Lithuanian forestry.

**Keywords:** cash flow analysis, NPV, IRR, discount rate, pine, spruce

## List of abbreviations used in the text

**DCF**- Discounted cash flow

**EC**- Early cleanings

**ET**- Early thinning

**FF**- Final Felling

**FR**- Forest rent

**IRR**- Internal Rate of Return

**GDP**- Gross Domestic Product

**NPV**- Net Present Value

**LC**- Late cleanings

**Lt**- Late thinning,

**LT** - Lithuania

**PL**- Poland

**S1**- mine wood, pit wood

**S2**- pulpwood

**S3**- perches

**S4**- fuel wood

**R-** discount rate

**WA**- Large diameter timber, class A

**WB**- Large diameter timber, class B

**WC**- Large diameter timber, class C

**PLN** – Polish złoty ( Polish currency)

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# Preface

The study was conducted as a final thesis within the International MSc Program "Euroforester- Sustainable Forestry around the Southern Baltic Sea" at Swedish University of Agricultural Sciences, Faculty of Forestry, Southern Swedish Forest Research Centre, Alnarp; in cooperation with the Warsaw University of Life Sciences, Faculty of Forestry.

The project consists of two smaller projects prepared by separate persons. The Polish analysis was made by Aleksandra Bis while the Lithuanian analysis was done by Gediminas Jasinevičius (Economic analysis of normative versus practical management of coniferous in Lithuania) both theses were supervised by Vilis Brukas. The decision was to investigate economic outcomes from the identical pine and spruce stands. When comparing both countries two stands were analysed - Scots pine (Pinus sylvestris) on second site index with 24.1 m height in 100 years and Norway spruce (Picea abies) II site index on which tree in 100 years reach 29.3 m in Poland and 28 m in Lithuania. As in the case of every business activity a proper evaluation is necessary to choose the most profitable alternatives. In forestry it is usually done by choosing a proper silvicultural programme. From economical point of view just those activities which are bringing higher incomes than costs - which means bringing net profits - are worth investing. One of the criteria to evaluate investment profitability are Net Present Value (NPV) and Internal Rate of Return (IRR). In Polish and Lithuanian forestry such economical analysis is not available, therefore calculations of NPV and IRR for Polish and Lithuanian stands which are included in this report allows a new look at both countries' forestry economy.

# Acknowledgements

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I owe a separate acknowledgement to the heads of forestry districts, Waldemar Hylla from Herby district and Jacek Podoski from Namysłów district, who allowed me to use the data, and were very patient answering to all my questions.

**Aleksandra Bis**
**30th of January 2009**

# 1. Introduction

## *1.1. Polish forestry background*

### 1.1.1.General information about forests and forestry in Poland

For better understanding of the project it is required to get familiar with Polish forestry conditions, facts and figures. Main tools of Polish forest legislation are Polish Act on Forests (1991) with amendments in 1997 and the Forest Policy of Poland (1997). In accordance with the international standard (taking account of the land associated with forest management) adopted in assessment, the area of Poland's forests as at 31.12.2005 was 9,192,000 hectares (according to Central Statistical Office – GUS, the area of forests associated with forest management is 9,200,000 ha). Poland's forest cover is 28.9% according to data from 31.12.2006.

### 1.1.2 Ownership structure of forests

Forests in Poland are mainly public-owned – 82.3%, including the forests under management of the State Forests – 78.2% of the total. In fact, the ownership structure of forests in the post-War period remained unchanged. Privately owned forests in Poland account for 1.5 million hectares, with an average size of a holding estimated at ca.1 ha. There has been a notable rise in the share of total forest area protected within National Parks – from 1.0% in 1985 up to 2.0% in 2005. State ownership of forests dominates in Poland and has centralized management and price policy, therefore investigating one forestry district can illustrate strategy and forestry trends in whole country.

### 1.1.3 Habitat and species structure in Poland

Poland mainly retains forests on the poorest quality soil which is reflected in the structure of forest habitat types. Coniferous forest habitats predominate in the habitat structure
of State Forests, accounting for 56.9% of the total forest area, while the broadleaved forest habitats cover 43.1% of which 3.9% are alder and floodplain forests.

Coniferous species dominate in Polish forests, covering nearly 75.6% of forest area (fig.1). In the lowlands the prevalent species is pine (accounting for 67.40% along with larch) where it finds the optimal climatic and site conditions within its Euro-Asiatic natural range, thus being able of developing a number of important ecotypes. In the period 1945–2005, the species structure in Poland's forests underwent substantial changes, expressed among other things, in an increase within the State Forests share of stands with the prevalence of broadleaved species from 13.0% to 23.5%. Nevertheless, the proportion of broadleaved stands is still lower than it potentially could be, which affects the geographical distribution of forest habitats (Forests in Poland 2006).

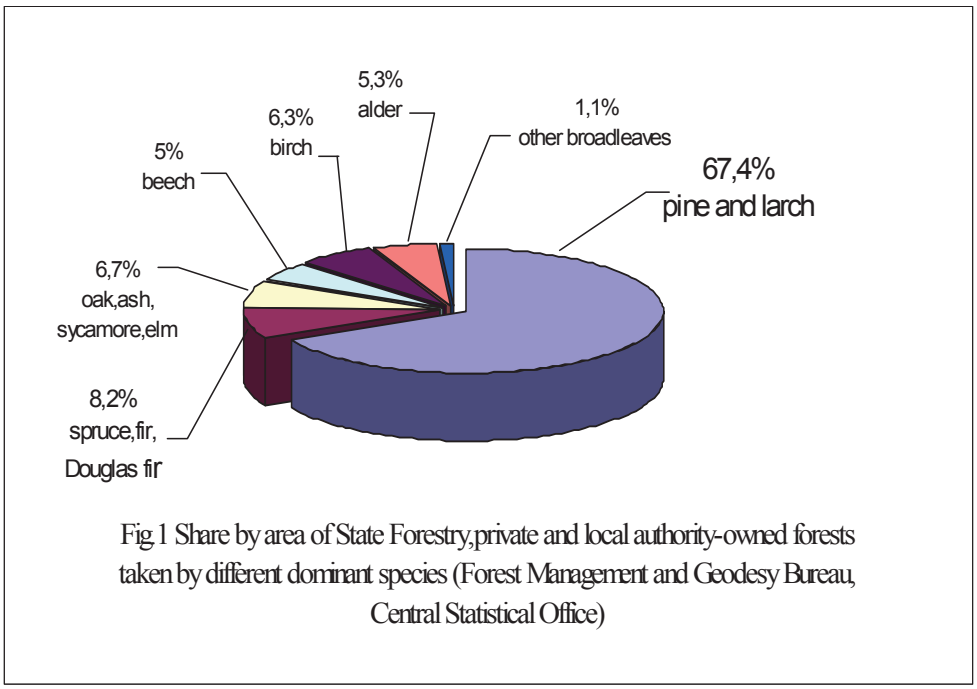


Fig.1 Share by area of State Forestry,private and local authority-owned forests taken by different dominant species (Forest Management and Geodesy Bureau, Central Statistical Office)

Fig.1 Share by area taken by different tree species.

In Poland, a vast share of the area taken by pine is connected using a clear cutting system and artificial regeneration (Białobok et.al, 1993). As a result, pine took not just the sites typical for itself but also large areas of mixed deciduous and deciduous forests. Only 49.5% of pine forests area are typical pine sites. The direct effect of favouring pine is the creation of huge even-aged pine stands in which fighting pests is very difficult (Tomanek, 1997). Number of planted pine trees per ha according to the forest principles legally binding in Poland in 1988-2002 was 10,000-16,000 per ha (Zasady Hodowli Lasu, 1988). Since year 2003 the number of planted pines is 8,000-10,000 per ha (Zasady Hodowli Lasu, 2003). There were economical reasons to decrease the number of planted pine

seedlings. Stands managed by clear cutting silvicultural system covered 5.4 mln ha and 78% of them have a rotation age of 100 years, 17% has a 110 years rotation age just 5% 120 years and others (Poznański, 2005).

Minimum cutting age for pine and spruce can be 80 years but only in stands which cannot reach a normal management goal (Dziennik Ustaw, 2005). Therefore choosing a 100 years rotation age for the project calculations is ideal for describing a typical Polish situation. The current annual pine increment on I site quality is 7.9 m³/ha and 2.6 m³/ha in the poorest sites (Jaworski, 1995). Pine II stand index is an average for Polish pine stand.

In Polish lowlands Norway spruce occurs mainly in mixed stands, rarely as a single species stand (Żybura, 1990). In Polish mountains spruce share in tree species distribution is taking 80%-90% which is making this species the most important in those areas (Boratyński, 1998). In total it is occupying approximately 6% of area in Polish forests. According to the newest State Forestry report spruce together with fir and Douglas fir is covering 8.2% of Polish forests area. Spruce in Poland can reach 50 m height and 1.5-2.0 m diameter at breast height. Total volume during whole rotation is around 1,200 m³ for stocking index 1.0.

### 1.1.4 Structure of timber resources by volume and harvested volume

In 2001 about 23.4 million m³ of net merchantable timber was harvested in State Forests while in 2006 the number grew to 31 million m³. About 74% of timber resources are coniferous and 26% deciduous.

Table 1. Harvests of timber by utilisation types in year 2001 and 2006.
(in million m³ net merchantable timber)

| **Utilisation type** | **2001** | **2006** |
|---|---|---|
| Clear felling | 24% | 19.7 % |
| Complex felling | 11.7 % | 19.2 % |
| Incidental felling during final felling and other prescribed | 3.6 % | 5.3 % |
| Incidental intermediate felling | 12.9 % | 12.3 % |
| Improvement cutting | 47.8 % | 43.5 % |

In 2001 about 29% of timber was cut via clear felling system and just 19.7% in 2006. This was the lowest level in the last 15 years (Table 1). The reduction in the size of clear-cut area is indicative of the progress in the 'ecologisation' of forest management. Recently, the value of timber harvest in net merchantable timber volume per hectare in the State Forests has been constant (3.88 m3/ha in 2003, 4.08 m3/ha in 2004 and 4.00 m3/ha in 2005).

Average stand volume within the State Forests was at the level of 226 m3/ha (as at 01.01. 2005). According to numbers from 1.01.2006 the average stand volume in State Forests was 231 m³/ha. Increase in volume is in every age class (Forests in Poland 2006), (Forests in Poland 2007).

The volume harvested in sanitation felling in year 2006, amounted to 5.7 million m³, or 19.9% of the total harvest of merchantable timber.

### 1.1.5 State forestry economical and financial situation and activity in 2001-2006

In the beginning of 90ties there were 103,000 workers employed in State Forestry. When the privatization of forest operations started in 1997 there were 37,000 employees in State Forests (Dawidziuk, 2002).

The average monthly level of employment in the State Forests in 2001 was 32,294 employees, around 870 people less than in year 2000. The Forest Districts employed 29,554 including 15,675 personnel in the forest service, 6,617 in non-manual posts outside the forest service and 7,262 in manual jobs. State forests owned in 2001, 50,000 apartments and first time in State Forestry history there was minus income – 83 mln zł. Average monthly salary for 2001 was 2879.20 zł. Nowadays there are 27,000 employees (15,000- forest service, 6,000 in administration and 6,000- workers); an average salary is 4,045.2 zł. By examining this data and comparing it to other European countries we can say that Poland has a leading position in the reduction of work force but the trend is similar in all former planned economy countries. What is more the number of districts decreased from 439 in year 2002 to 428 in year 2006 (GUS, 2006). The Polish labour market amounting for ca.30 million people is one of the biggest in Central Europe. Poland at the end of 1980s had around 1 million unemployed people; in the years 1994-1999 that number was rapidly declining but in the year 2002 the unemployment level rose again and reached 3.2 million people. It is important to mention that big unemployment rates are observed in these regions of Poland where huge forest areas are located and there is a

small potential for developing industry production. In 2002 the wood industry, furniture industry and pulp and paper industry accounted of 2% of the national GDP, the forestry sector accounted for 0.23%. Polish wood market is shaped by exports on a large scale, especially by furniture exports. In 2002 the value of wood products exports (including furniture, pulp, and paper) accounted for 5.5 billion USD and it constituted 14% of Poland's exports.

Percentage share of incomes from selling the timber was developed in the years 1994- 2006 as presented in the table 2.

Table 2. Share of incomes during years 1994 – 2004 from selling the timber

| Item number | Year | Share of incomes from selling the timber |
|---|---|---|
| 1 | 1994 | 79.4 % |
| 2 | 1995 | 77.2 % |
| 3 | 1996 | 78.6 % |
| 4 | 1997 | 80.1 % |
| 5 | 1998 | 80.1 % |
| 6 | 1999 | 81.7% |
| 7 | 2000 | 81.1 % |
| 8 | 2001 | 79.4 % |
| 9 | 2002 | 83.1 % |
| 10 | 2003 | 83.4 % |
| 11 | 2004 | 83.4 % |
| 12 | 2005 | 84.0 % |
| 13 | 2006 | 84.4 % |

Those figures show that selling timber has a fundamental role in forestry economy and it is steadily increasing with small stagnation in 2001 (Lasy w Polsce 2007).

In 2006 the costs of districts accounted for 98% of all State Forestry costs. Harvesting and extracting costs were the most important – in 2001-829 mln zł, 51.8%; and in 2006 -1,110 mln zł, 55%; silvicultural costs in 2001- 407,2 mln zł, 25.5%; and in 2006 – 395 mln zł, 19.5%; and forest protection costs – in 2001- 181,7 million zł, 11.4%;

and in 2006 -141 mln zł, 7.0%. In years 2001 and 2006 incomes and costs level in the State Forests was:

1. Total incomes- 2001- 3,709,000,000 zł
   2006- 4,887,453,700 zł
2. Total costs – 2001- 3,789,000,000 zł
   2006-4,690,105,900 zł

(Forests in Poland 2002; 2006)

In 2006 State Forests achieved a positive financial result of 185.4 million zł net income, compared with 125 million zł in 2005 and minus 82.8 million zł in 2001.

In 2001 the financial result was negative but we can observe that in the years 2001-2006 the employment level decreased significantly and expenses for administrative activity costs decreased from 41% in 2001 to 33.7% in 2006. What is more forest protection costs decreased from 11.4% in 2001 to 7% in 2006. Those changes and a high demand for timber had a positive influence on the State Forests economy.

In 2001 the average price for 1 cubic metre of timber was 120.3 zł, (34.4 €) 3.3% less than a year before, and 133.7 zł (38.2 €) in 2006, 1.4% more than in 2005. The average prices for the main assortments are described in table 3.

Table 3. Wood assortment prices in Poland.

| | Wood assortment prices [ €/m³] | | |
|---|---|---|---|
| **Assortment** | **2001** | **2006** | **2007** |
| Softwood saw timber | 54.5 | 53.6 | 58 |
| Hardwood saw timber | 56.3 | 62.4 | 65.7 |
| Pine and larch pulpwood | 23.7 | 29.5 | 32 |
| Spruce and fir pulp wood | 26.6 | 30.2 | 32.3 |
| Deciduous pulp wood | 20.8 | 26.6 | 28.6 |
| Coniferous fuel wood | 15.7 | 18.3 | 19.7 |
| Deciduous fuel wood | - | 22.6 | 24 |

In the tables 3 and 4 the author uses the term hardwood to describe deciduous tree species and softwood for coniferous tree species. From 1996 to 2001 wood prices for assortments were not even according to inflation.

Table 4. Shares of the more important assortment categories on sale in year 2001 and 2006.

| Assortment | 2001 | 2006 |
|---|---|---|
| softwood pulpwood | 30.7 % | 31.3 % |
| hardwood pulpwood | 13.9 % | 12.4 % |
| pitwood | 3.1 % | 2.1 % |
| hardwood saw timber | 7.4 % | 7.6 % |
| softwood saw timber | 28.7 % | 32 % |
| other merchantable timber | 1.9 % | - |
| slash | 6.8 % | 6.7 % |
| fuelwood | 5.9 % | 7 % |
| „valuable" assortments | 1.6 % | 0.9 % |

Among all important assortments on sale in 2001 and 2006 the share of softwood saw timber was the highest (table 4).

About 40% of harvested wood is used in the production of saw goods, 25% in the production of wood-based panels and 30% in pulp and paper manufacturing with an increasing tendency. Poland harvests about 50–60% of the increment. Fuel wood market is rather stable and lack of this material is noticed only locally. Slash is used exclusively for heating purposes on a local basis. According to the State Forests information profitability in selling is constantly increasing and in 2006 was 3.59%, in 2005- 2.62% and in 2004 - 1.68 % (Lasy w Polsce, 2006).

Among all important assortments on sale in 2001 and 2006 share of softwood saw timber was the highest. Profitability in selling according to the State Forests information is constantly increasing and in year 2006 was 3.59% in 2005- 2.62% and in 2004- 1.68%.

## *1.2 Hypotheses*

Forestry activity is a unique holding with a long production period, income widely spread in time and full of free of charge non productive services. All of the above-mentioned factors are probably lowering the forestry practise profitability. The aim of this project is to find out what is the current Polish and Lithuanian forestry profitability according to IRR, NPV and FR criterion.

Before making appropriate calculations the following hypotheses were formulated.

1. Scots pine and Norway spruce stands on I and II site indexes have a higher profitability according to IRR, NPV and FR in 2006 than 2001.

   Such hypothesis was formulated during observations which took place in 2001 and 2006 i.e wood prices increase (table 3) and decrease in the required number of planted seedlings per hectare.

2. Spruce and pine stands in the same year on the same site index but in different forest districts will have the same profitability according to IRR.

   Such hypothesis was formulated because

   - there are equal yields in the same site index
   - silvicultural requirements are the same in the whole country, and respectively in all districts
   - labour costs should not differ much in the country
   - State Forests have the same price policy

3. Administration costs will severely decrease profitability according to IRR and FR in Scots pine and Norway spruce stands compared to stands indicators without administration costs.

   The above hypothesis was formulated according to state forests information from a 2006 report, which stated that basic activity accounted for the biggest share in the costs, (managing the forest, harvesting costs etc.) 49.5% 2001 and 54.2 % in year 2006 and administrative activity in 2001 took 41 % and 33.7% in 2006.

4. Scots pine and Norway spruce on II site index in Lithuania are having a higher profitability according to IRR and NPV than Scots Pine and Norway spruce on II site index in Poland.

It was believed that in Poland there are higher rotation ages for both pine and spruce species. Additionally, labour costs are higher in Poland than in Lithuania.

5. According to IRR and NPV, in 2006 pine and spruce stands administration costs decreased profitability more severely in Poland than in Lithuania.

   Administrative costs in Lithuania in 2006 correspond to 11% and it means around 31 Euro per hectare every year (Jasinevičius, 2008). In Poland in 2006 administrative activity took 33.7 % of all costs, around 80 Euro per ha.

# 2. Materials and Methods

## *2.1 District description*

Data for calculations was collected from three Polish forestry districts: Namysłów (Appendix 2) and Herby (Appendix 1) both placed in south-western Poland and Starachowice (Appendix 3) placed in southern Poland.

Descriptions of the selected districts are a result of a series of interviews with the head foresters of those districts, analysing management plans from a ten year period, SILP computer financial programme and from official web pages of the districts.

### 2.1.1 Herby forest district


Fig.2. Herby district location

Herby district is a part of Katowice Regional Directorate of State Forests. Its total area is about 17,697.97 ha. Coniferous forest types cover 56.69% of forests and the rest 43.31% is taken by deciduous forest types. Dominant species in district species composition is pine which takes 88.01% (14,825.13 ha ) of area, 3.36% (611.13 ha ) takes alder, 4.56% (768.82 ha ) birch, oak 2.43% (410.40 ha ) and spruce just 1.0% (176 ha ). In the district stands conversion is made on a large scale which results in decreasing share of coniferous stands not appropriate to their habitats. Constant increase of deciduous stands can be observed. Annually Herby district is harvesting about 69,846 m³ large

diameter timber from which 45,900 m³ comes from final felling activities and the rest 24,000 m³ from thinning.

Size of silviculture activities taken by Herby district annually:

- Regeneration of cutting area – 101- 153 ha
- Productive under planting area- 4.1 ha
- Early cleanings area 247 ha
- Late cleanings area 218 ha
- Agro technical melioration area 220 ha
- Forest hydro melioration area 83 ha

District is employing 53 full time workers, 36 in forest services, 14 office workers and 3 labourers mainly working with building renovations and meliorations not connected to forestry production. Herby district is not using harvesters for forest activities and it is self financed.

### 2.1.2 Namysłów forest district


Fig. 3. Namysłów district location

Namysłów district is under the jurisdiction of Katowice Regional Directorate of State Forests. It is placed in south-western Poland. The forest area managed by this district covers 16,487.18 ha. In the Namysłów forest district there are 10 lowland types of forest. Coniferous forests take up 44.5% of district forest area and mixed forests 38%. The biggest share in tree species composition is pine with 67.8%. Black alder is second with 10.1% and oak with 9.3%. Birch accounts for 4.4%, larch 2%, beech

1.9%, and spruce 1.6% and common ash 1.5%. The rest of the species like fir, maples, hornbeam and lime altogether account for 1.4%. The terrain form is extensive flatland with small hills. Good quality soils allowed establishing mixed deciduous forests. Annually Namysłów forest district is harvesting 75,000.00 of cubic metres of large diameter timber. Harvested wood is sold to domestic and foreign buyers. Described district has harvested last year about 17,500 m³ of dead wood. The priority in multifunctional forest management of Namysłów district is to create more natural stands destroyed by previous wrong management. This process is made by converting pine monocultures into mixed stands by complicated and long selective cutting systems. Pine monocultures are usually converted into pine - oak stands. District also has problems with labour workers therefore it is not able to make two early thinnings in two intervals. Therefore just 8% out of 38% of planned early thinnings which need to be done twice were actually done. Most of the workers prefer well paid jobs in Wroclaw's building industry rather than working for lower salaries in forestry. What is more young people emigrate to other EU countries in search of well paid jobs. The Namysłów district has a big problem with windstorms coming regularly every second year. In year 2000 -30,000 m³ trees were broken by wind and two years later a windstorm destroyed another 30,000 m³. In January 2007 50,000 m³ of trees were destroyed. Therefore, harvester help is absolutely necessary. In the damaged open stands many insects are coming and regeneration is not possible without chemical treatments in some areas. Game browsing damages are also a problem and district is spending around 200,000 zł annually for preventing game and insect related damages. Namysłów in year 2006 spend 4,472,462.17 zł for administration, for Regional Directorate, forest management and 4,687,458.07 zł in year 2007. District in 2006 send to forest fund 2,254,417.00 zł but got support in amount 217,500.00 zł. In year 2007 support was 20 times smaller than money district gave to forest fund.

Size of silviculture activities taken by Namysłów district in year 2006 and 2007:

- Regeneration of cutting area – 2006;105.06 ha
  2007;107.36 ha

  In that included
  - Clear felling - 2006; 28.1 ha
    2007; 37.2 ha
  - Complex felling – 2006; 76.96 ha
    2007; 70.16 ha

- Productive under planting – 2006;0.0 ha
  2007; 0.0 ha
- Replanting and filling up – 2006; 23 ha
  2007; 14 ha
- Forest restoration - 2006; 7.93 ha
  2007; 2.21 ha
- Early cleanings 2006; 153 ha
  2007; 140 ha
- Late cleanings 2006; 220 ha
  2007; 240 ha
- Agro technical melioration 2006; 85 ha
  2007; 51 ha
- Forest hydro melioration - 2006; 7.0 ha
  2007; 0.0 ha
- Soil improvement (mowing etc.) - 2006; 435 ha

District was employing in year 2006 -54 full workers, and 6 labourers and just two of them working in managing the forest.

### 2.1.3 Starachowice forest district


Fig. 4. Starachowice district location

Starachowice forest district is located in southern Poland 160 km from Warsaw and almost the same distance from Krakow. District area is 14,500 ha and it consists of two working parts with separate management plans. Pine is the dominating tree species and it has very good quality and growth. Pine covered 86% of district forest area: 6% is covered by fir, oak takes 4% next is birch with 2% and 1% of spruce.

Annually Starachowice forest district is harvesting around 72,000 cubic metres of large diameter timber, in which 42,000 m³ in final cutting and 30,000 m³ in intermediate cutting. Timber is sold mainly to domestic buyers. Starachowice district doesn't have problems with lack of labour workers and all tending is done according to the plan, also there are no harvesters working in this district. It is self sufficient and doesn't need support from the forest fund.

Size of silviculture activities taken by Starachowice district in year 2007:

- Regeneration of cutting area – 109 ha
- Replanting and filling up – 9.13 ha
- Early cleanings - 92.50 ha
- Late cleanings - 310.72 ha
- Soil improvement (mowing etc.)- 523.68 ha
- Soil preparation – 141.68 ha
- Forest meliorations- 138 ha

District is employing 43 full workers, 31 in forest services, 11 office workers and 1 labourer mainly working for forestry production. Average salary in 2006 was 3889.9 zł; it is about 3 times higher than the lowest national salary.

### 2.1.4 Comparison of districts.

All three districts have similar managing conditions and the size of silvicultural activities is very much the same. They have almost the same annual harvesting levels ranging from 69,000 m³ in Herby to 72,000 m³ in Starachowice and 75,000 m³ in Namysłów. In addition the size of districts does not differ a lot. Herby cover an area of 17,697.000 ha, and Namysłów 16,487.000 ha. Starachowice is the smallest district with 14,500.000 ha. In all districts there are around 3 full time workers employed per 1000 ha. Additionally in all investigated districts pine is the dominant species. This species has the lowest share in Namysłów 67.8 % of area, while in Starachowice it occupies 86 % of the area and 88 % in Herby. While spruce is playing a minor role in all districts' silviculture

management, it is not an important species in the district from the economic point of view as it is covering just 1% of area. Certainly it would be more appropriate to gather data from districts in which spruce is more economically important but it was only possible to get access to data from those three districts. However similarity between districts is positive aspect for cash flow analysis comparison.

A more detailed description of the named districts is done in the subsequent chapters. Calculations were made for pine and spruce cutting age 100, I and II site indexes with prices from years 2001 and 2006.

Deciding on the site index average for Polish conditions was crucial for this work. After consultations with Polish supervisor and studying the literature it was decided to use for pine II site index where pine in 100 years is reaching 24.1m height when strong silviculture programme is implemented and 25.3 m height with light silviculture programme.

Pine on I site index where tree reach 28.7 m in 100 years with light silviculture programme and 28 m height with strong silviculture programme was also taken into calculations.

For spruce calculations II site index was chosen where spruce is reaching 29.3m in 100 years. For spruce I site index tree reach 33.3 m in age 100.

The next important step of the project was the creation of silvicultural pine and spruce programmes as similar as possible to modern forestry practice and typical for studied districts. It was achieved after long conversations with forestry district representatives.

## 2.2. Silvicultural regulations

### 2.2.1 Stand treatments during whole rotation.

In the project all stands were artificially regenerated, since this is the common way to regenerate stands in Poland. Normally, soil regeneration is preceded by preparation. There are several methods of that treatment applied in specific habitats but the method used for pine and spruce in studied districts was ploughed furrow in distance between furrow from 0.7 – 1.5m depend on machine used. Distance between seedlings according to rules should not be wider than 1.5 m and usually nowadays pine is planted in spacing 1.5 m * 0.75 m and spruce 1.5m*1.5m. Nowadays the required number of planted pines per ha is between 8,000- 10,000 seedlings, spruce number of seedlings should be between 3,000-5,000. Prices for seedlings are given for 1,000 items. However it is interesting that before 2003 the norm was to plant 10,000-16,000 pine seedlings per ha and 4,000-6,000 spruce seddlings per ha (Zasady Hodowli Lasu 1988).

The next important early treatment for pine seedlings is using repellents which are implemented in 1$^{st}$ and 2$^{nd}$ year occasionally in third year because in the beginning pine tops are endangered by browsing. The next obligatory treatment is mowing. A common practice is to perform mowing 2-3 times, sometimes even 2 times in one season.

Early cleanings are the next obligatory treatment for pine and spruce cultures in Poland. They are playing an important role in helping thinning reach their tending role in the management system. It is necessary to prepare stand for those treatments and it can happen by implementing early cleanings and late cleanings. This preparation role by cleanings is to eliminate wolf trees and if it is possible in normal stand density (no gaps). Early cleanings are recommended to be done before 10 year of forest culture life, usually there are 2-3 cuttings in 3- 4 year intervals. They should be moderate to help stand reach the crown closure consequently it is obvious that it is not preferable to make only one cleaning. Also important fact about which Polish foresters do not forget is that between 8$^{th}$ and 12$^{th}$ year no treatments are done in pine stands because this is the time when stand is susceptible to tapping so it is recommended not to make stand more accessible for game by opening it.

Late cleanings are recommended to be done before 20$^{th}$ year of forest culture and 2-3 treatments with 3-5 year intervals. Number of seedlings after early and late cleanings for pine should be around 5,000 trees/ha and spruce around 2,000 trees/ha.

Next obligatory step in managing the stand is to implement early thininngs. In pine stands in I a and I stand site index is required to make first thinning when the average height is about 10 m, according to tables it should be implemented in age 20. In stands on II and III stand quality when stand has an average height 8m, so before 25th year. In stands on IV and V stand quality first thinning should be made when the height is 6-7 m. In other species stands first thinning should be made when stand reach 10-12 m height, for spruce it should be done for first site index in age 25, in II site index before 35th year of life. Early thinning treatments should be repeated when it is needed but common and recommended early thinning intervals are 5-7 years because usually in 3-5 years after thinning crowns density is coming back to stage before thinning. More often thinnings should be done on fertile sites in mixed fast growing species stands. Crown length in pine and deciduous trees in early thinning period shouldn`t be less than 1/3 of trees height and in spruce from 1/2 to 2/3 of height. Early thinning phase should be finished before 40$^{th}$ year of stand. Early thinning intensity should not be too high and it can not exceed 10-20% of standing volume. The practical opinion is to make two intervals in 5 years, so two times during one management period.

Late thinnings are the last tending activity and should be carried out in 8-10 year intervals and started after 40$^{th}$ year of stand life. In general thinnings have positive influence on stand structure and production quality, and most of thinnings experts are unanimous about that, but increase in volume due to thinnings programmes is not so clear. It is proved that thinnings can increase volume periodically (Brzeziecki, 2005).
Minimum cutting age for pine and spruce can be 80 years but just in stands which can't reach the normal management goal, in the project final felling for pine and spruce is in age 100 which is most common (Dziennik Ustaw, 2005). In Poland it is required to make land reclamation after the cutting. Unfortunately Polish wood chips market is just developing and it is non existent on the national level so in most cases residues need to be collected on the side of felling area before making soil preparation for the next generation. Before receiving FSC certificate felling residues were burnt but since certification they are collected on the side of felling area. Recommendations for silvicultural programme were taken from "Zasady Hodowli Lasu" (Forest silviculture rules) from year 2003 approved by Director-general of State Forests edict Number 99 from day 24 December year 2002.

### 2.2.2 Estimations of removed volume in thinnings and fellings

Main tool for volume estimations are Szymkiewicz's growth tables. Scots pine (Pinus sylvestris) is a major tree species in Polish forests, so the models for the growth of this tree species are the most developed. Szymkiewicz (1949) created yield tables based on the Schwappach`s ones and other previous studies. In his research, he discovered that in Poland, there are stands which grow faster than those described by the German forester. He added a new superior site index class to the Schwappach `s tables by means of extrapolation (Zasada, 2004). "Tablice zasobności i przyrostu drzewostanów "created by Szymkiewicz in 1949 already had many editions and are still in use in Polish forestry. The tables were constructed for main species of Polish forestry, like: Scots pine, fir, spruce, larch, beech, oak, alder, birch aspen and ash. The tables for Scots pine are divided into A and B tables. The first one is for management regimes with heavy thinnings (Starachowice district is applying heavy thinnings programme) and second one is used for stands, where treatments with lower intensity are done. Table A is based on models created by Schwappach, with 5 site index classes and I a class added by Szymkiewicz. The tables for fir and spruce include five site index classes, and are also based on Schwappachs` studies. For all species, tables are divided into five parts. The first includes information about growing stock in the stand, like: average diameter and height, number of stems per ha, basal area, shape figure for; whole tree and merchantable timber, volume per ha for; merchantable and small dimension timber. The second gives information about removed trees, like: volume of merchantable and small dimension timber and volume of timber taken out from the stand in thinnings. In the third part, the volume of the timber whole rotation, with the percentages of volumes taken out from the thininngs, is presented for all stands. The fourth and fifth parts include increments: mean annual increment and current annual of whole volume for: merchantable and small-dimension timber. All those values are presented for five or ten year trees` age intervals. The tables for pine and spruce include graphs of average height and current annual increment of merchantable timber of the individual tree (Skręta, 2006).

Szymkiewiczs` tables are old, but they are still in use in practical forestry for site index determination. In this report no measurements of volume removed in thinning or felling were done but simply tables were used. To estimate volume in single species stands at first it is necessary to assess height, age and site index of the stand. Next step is

to assess stocking index. To assess the stocking index (relation between volume estimated from stand measurement with volume from tables) some experience is needed therefore young foresters are doing it by guessing and then comparing with calculations while the experienced ones do it by estimating. Last step in the assessment process is to read volume from tables (Szymkiewicz 1986) according to appropriate site index and multiply by stocking index and after multiply by area, for calculations in the project it was not necessary to multiply by area because calculations were made for 1 ha stand. For the project also measurements of the trees were not done it was simply chosen I and II site indexes, than volume from tables was taken and multiply by stocking index. Stocking indexes were accepted after many consultations with practitioners and with Polish supervisor of the project Grzegorz Jednoralski. The stocking indexes before applying treatments taken in the project calculations are as follows:

- 1.1-pine and spruce age 20-30, early thinnings
- 0.9-pine and spruce three first late thinnings age 45-65
- 0.8-pine and spruce two last late thinnings age 75-85
- 0.7-pine and spruce at final felling age 100
- 0.8- spruce at final felling age 100

To estimate the volume which should be removed during the tending treatments the same procedure is used as the one applied in the process of estimating stand volume. Tending treatments according to forestry legislations are not possible in stands with stocking level 0.6 and less, removing of dead standing wood is allowed only. But those are extreme situations, and it is not reasonable to take them into consideration for the project assumptions.

After assessing volume of the stand in tending treatments and in final felling age it is important to take away bark because in Poland bark is not taken into account during volume evaluations. To subtract the bark during the evaluation process there are special tables for specific species. Bark thickness is given in percentage for height divisions. Bark table used for the project is presented below (table 5).

Table 5. Percentage of bark in pine and spruce

| Average height of the stand [m] | Percentage of bark volume according to stand volume with the bark | |
|---|---|---|
| | Pine | Spruce |
| 8 | 23.3 | 16.5 |
| 10 | 20.8 | 15.0 |
| 12 | 18.7 | 13.5 |
| 14 | 17.1 | 12.3 |
| 16 | 15.8 | 11.5 |
| 18 | 14.8 | 11.0 |
| 20 | 14.0 | 10.5 |
| 22 | 13.4 | 10.1 |
| 24 | 12.9 | 9.8 |
| 26 | 12.4 | 9.4 |
| 28 | 12.4 | 9.2 |
| 30 | 12.4 | 8.9 |
| 32 | 12.4 | 8.5 |
| 34 | 12.4 | 8.2 |

After taking out bark and multiplying by stocking index amount of volume removed in thinnings and fellings was estimated. It is important to notice that after consultations with Polish supervisor the amount of volume for spruce at the age of early thinnings was increased by 25% because volumes recommended by tables to be removed in early thinning stage for spruce are too low.

### 2.2.3 Cash flow analysis

Estimation of costs was the least complicated part of analysis. Early treatment costs like soil preparation, planting, repellents, mowing, early and late cleanings also land reclamation made in final felling age were given per hectare. Early and late thinnings as well as final fellings were given in PLN per cubic metre. Costs of treatments were then multiplied by the amount of $m^3$ harvested per hectare.

First incomes are coming with early thinning, before $30^{th}$ year of stand life. Incomes were calculated by multiplying price for wood by amount of wood (in $m^3$) harvested in every treatment. However prices were different for different wood assortments, there was less large diameter wood in early thinnings compared to late thinnings and both had a smaller amount when compared to final fellings. To evaluate income from every stand the amount of every assortment was calculated by its price and incomes were added together to give total income for a treatment. Assortments distribution for early and late thinnings as well as for final fellings were given from districts (Appendixes 1,2,3 ).

The silvicultural programme created in this project is typical for pine and spruce and it takes several factors into consideration: district actual management, prices for all treatments in the stand and given wood prices. With all this data it was possible to calculate all costs and incomes during the whole rotation which allowed creation of a cash flow analysis.

For every economical analysis choosing a proper interest rate is an important factor, in European forestry it is assumed that interest rate for forestry managing is between 2 and 4 % (Brukas et al. 2001). In Scandinavian countries a 3 % interest rate is accepted for forestry practice. In Poland the accepted interest rate for forestry is on 2-3 % level and in the project 3% interest rate was taken for calculations. Interest generally refers to earning rates on financial instruments like bank accounts, bonds, certificates of deposit or the rate used in discounting future values to arrive at present values (Klemperer, 1996).

In Poland and Lithuania the economical efficiency of forest districts is represented only using income and cost balance, no other indicators are used by Polish State Forestry. The essential element of investment activity is a precise determination of assessment criterions. Economists do not agree that simple income and cost balance is a good criterion for economical assessment, but there are other criterions common in economical investment profitability assessment which are as follows: Net Present Value (NPV ), Internal Rate of Return (IRR) and forest rent (FR).

NPV (Net Present Value)- it is the present value of revenues minus the present value of costs. (Klemperer, 1996).

$$\text{NPV} = \sum_{t=1}^{T} \frac{R_t - C_t}{(1+i)^t};$$

Fig. 5. NPV formula

Where:

R - Revenues in the subscripted years;

C - Costs in the subscripted years;

T - Rotation age;

t- Year on which revenues received or costs are done;

i – Interest rate

NPV is valuable source of information about costs and incomes layout in time, therefore it is useful in comparing values of alternative undertakings or the same undertaking but different variants.

Another economical indicator possible to calculate was IRR (internal rate of return). It is interest rate (discounted) by which NPV for certain investment equals zero. Investment can be accepted if IRR is higher than the lowest value of investment interest rate accepted by investor. In case of my project if IRR is higher than 3% investment can be profitable. Formula for IRR is presented below.

$$\sum_{t=1}^{T} \frac{R}{(1+i)^t} = \sum_{t=1}^{T} \frac{C}{(1+i)^t}$$

Fig. 6. IRR formula

where:

R - Revenues;

C - Costs;

T - Rotation age;

t- Year on which revenues received or costs are done;

i - Interest rate.

(Klemperer, 1996)

FR (Forest rent) it is all revenues minus all costs divided by rotation length, which leads to outcome corresponding to applying NPV using discount rate of zero (Brukas et al. 2001).

$$FR = \sum_{t=1}^{T} \frac{R_t - C_t}{T}$$

Fig. 7. Forest rent formula

Where :

R- Revenues at year t;

C- Costs at year t;

T- Rotation length;

t- Year on which revenues received or costs are done.

The forest rent approach includes timber prices and regeneration costs, which correspond to the Faustmann Model with a zero rate of interest. However, this still excludes an alternative investment option and assumes that a forest owner does not have a loan (or that a forest business has control over unlimited capital). Following forest rent may potentially lead to excess investments in forestry that cause large economic losses (Hyytiäinen & Tahvonen 2003).

### 2.2.4. Cash flow with administration costs

Cash flow analysis is based on data from one district, Starachowice, in the year 2006. Administration costs added to cash flow analysis consist of forest service costs, administration workers costs and money for supporting superior unit which is Regional Directorate of State Forests. All costs were given in total for the year 2006, to evaluate administration costs per 1 ha sum of all administration costs were divided by district area. Table 6 below is describing it well.

Table 6. Administration workers costs in Starachowice district.

| Year 2006 | | **Plan [€]** | **Done [€]** |
|---|---|---|---|
| **Costs altogether** | | **30,0248** | **313,120** |
| Administration and service workers salaries and benefits | | 153,506 | 196,568 |
| Administration and service workers salaries surcharges | | 20,536 | 8,023 |
| Amortization and capital assets maintaining | | 60,557 | 55,255 |
| Expenses for delegations and costs of transfer | | 286 | 250 |
| Maintain administrative transport | | 4,720 | 1,437 |
| Costs of industrial safety | | 954 | 1,501 |
| Costs of in-service training | | 2,857 | 2,661 |
| Taxes, donations and charge | | 6,857 | 11,525 |
| Office expenses | | 34,966 | 19,288 |
| Representative and promotion costs | | 4,286 | 3,741 |
| Other administrative costs | | 10,723 | 12,872 |
| **Material information:** | **Plan** | **Done** | |
| Number of employed administrative workers | 11.00 | 11.00 | |

To administration costs added for cash flow analysis also forest service workers costs where included. In specialist terminology forest service workers are not considered as administrative workers but forest service and its maintenance is the most expensive part of district costs (Table 7).

Table 7. Forest service workers costs in Starachowice district.

| **Year 2006** | **Plan [€]** | **Done [€]** |
|---|---|---|
| **Forest service workers costs altogether** | 765,142 | 841,427 |
| Salaries and benefits of forest service | 550,431 | 660,663 |
| Salaries surcharges | 62,905 | 14,172 |
| Expenses for delegations and costs of transfer | 4,000 | 3,755 |
| Costs of maintain of forest service workers cars | 69,581 | 58,207 |
| Costs of maintain forest service workers apartments | 42,639 | 57,238 |
| Costs of industrial safety | 4,071 | 6,196 |
| Costs of in-service training | 10,571 | 11,231 |
| Other forest service costs | 20,944 | 29,966 |

| **Material information:** | **Plan** | **Done** |
|---|---|---|
| Number of employed forest service workers | 33.00 | 31.00 |

In table 8 below total administration costs included in the project calculations are presented.

Table number 8. Starachowice district administration costs in total for year 2006.

| Administration costs in Starachowice district for year 2006 | | | | |
|---|---|---|---|---|
| District forest area [ha] | 14,449.63 | | | |
| | PLN | € | PLN / ha | € / ha |
| Costs of administrative workers | 2,944,955 | 841,416 | 204 | 58 |
| Costs of forest service workers | 1,095,920 | 313,120 | 76 | 22 |
| Superior unit support | 300,000 | 85,714 | 21 | 6 |
| Total | 4,340,876 | 1,240,250 | 300 | 86 |

To include administration costs into cash flow analysis 86 € /300 PLN per hectare was added to every year of rotation age.

### 2.2.5 Comparison of Lithuanian and Polish cash flows in 2006

Comparison was based on pine and spruce stands from the same II site index in both countries. Pine on Polish II site index in age 100 reach 24.1 m and in Lithuanian 24 m. Spruce in age 100 reach 29.3 m in Polish II site index and in Lithuanian 28.0 m. In comparison analysis much focus was put on IRR and NPV.

Data for the Lithuanian part of the project was collected from State Forests database and from a survey made among forest contractors. Detailed description of Lithuanian cash flow analysis methodology and results can be found in Gediminas Jasinevičius thesis report from 2008.

The Polish part of the comparison is based on the Starachowice district described already in the previous part of the project. The comparison results were converted from countries' currencies into Euro. Lithuania has a stable currency 1 Euro = 3.45 LT. Polish currency was converted into euro according to rate from Monday 25$^{th}$ of February 2008 and it was: 1 Euro equal 3.5 PLN. Polish currency is quite stable and for example rate for 01.01.2006 was 1Euro equal 3.8 PLN.

### 2.2.6. Comparison of Lithuanian and Polish cash flows in 2006 with administration costs.

Methodology of cash flow analysis with administration costs in Poland is explained in the previous paragraph. Comparing cash flow with administration costs is not an easy task. Administration costs are a very wide term and can be understood in many ways. In Appendix number 19 a table with Lithuanian State Forests costs for the year 2006 is given. In 'administration costs in Lithuania' the following costs were included: administration costs, personnel of forest districts costs and personnel of forest protection. All those costs gave 31 €/ha which was added to previously made cash flow analysis without administration costs. In Poland there was 86 €/ha of administration costs. Finally, proper comparison between two countries was made. The main problem in this part of project was to decide on the most compatible way of comparison. Every country has a different meaning of the term 'administration costs' and it was important to use the same for both countries. Additionally bookkeeping methods are different and often quite complicated like in Poland.

# 3. Results

## *3.1. Polish silvicultural regulations and reality*

Soil preparation and number of planted pine and spruce seedlings was the same as recommended by legislation. Pine repellents were used in the all districts in the first two years, when it is crucial to use them, and seedling tops are most susceptible for browsing. There are no strict regulations concerning repellents' use, it is done when needed.

In the silviculture programme applied, mowing is done three times in the first, second and third year, which is typical for the pine growing in the described districts, because plants are just one year old and cannot win the competition against weed. For spruce plants the case was slightly different, as they are two years old and quite big when they are planted, so just two mowings were done in the second and third year.

Early thinnings for pine were made as required in two intervals in all districts. Spruce early cleanings were made just once. Number of seedlings after early and late cleanings for pine should be around 5,000 trees/ha and spruce around 2,000 trees/ha. From those numbers we can simply calculate that around 50% of stems are removed in early and late cleanings. This is explaining the rationale behind those treatments and why they need to be done so often. In the silviculture programme designed for the purposes of this project early and late cleanings were made as presented in table 9 below.

Table number 9. Timing of treatments implemented in stands.

| District | Herby | | Namysłów | | Starachowice | |
|---|---|---|---|---|---|---|
| | Age in which treatment was implemented | | | | | |
| Species | Pine | Spruce | Pine | Spruce | Pine | Spruce |
| First Early Cleaning | 5 | 8 | 5 | 8 | 5 | 8 |
| Second Early Cleaning | 8 | - | 7 | - | 7 | -- |
| First Early Cleaning | 12 | 12* | 12 | 15 | 12 | 15 |
| Second Late Cleaning | 16* | 15;17* | 16 | - | 16 | - |

*made just in year 2006

From the table 9 it can be concluded that in Namysłów and Starachowice districts two early and two late cleanings for pine are done according to the regulations. For spruce it is not

necessary to make two intervals because the number of seedlings is almost two times lower than pine and it is possible to fulfil silviculture goals with one late cleaning. Considering cleanings project investigation based on three districts is describing that those treatments are done according to regulations. In Herby district the late cleanings were not done in two intervals in year 2001 but it is acceptable and two intervals were not recommended by management plans.

In Herby and Starachowice districts early thinnings are done according to recommendations, twice every ten years in pine and spruce stands. However Namysłów district has problems with labour workers and just 38% of early thinnings are planned to be done twice. Moreover only 8% of last 10 years plan was actually completed. The situation is slightly better with late thinnings, as 91% of them are made according to plan. In Herby district there is just one early thinning carried out for spruce and for pine but the reason is that in management plan for Namysłów district it is not recommended to make two early thinnings.

In all three districts late thinnings are done every ten years (once during a management plan). This is quite a profitable activity for contractors and so far there have not been any problems with fulfilling late thinnings requirements. Polish foresters believe that it is better to treat stands more often but with less intensity than vice versa.

Table 10. Amount of volume removed in stand treatments.

| | | | Herby district | | | Namysłów District | | | Starachowice District | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rotation Age | Height in 100 years | $m^3$ in ET | $m^3$ in LT | $m^3$ in FF | $m^3$ in ET | $m^3$ in LT | $m^3$ in FF | $m^3$ in ET | $m^3$ in LT | $m^3$ in FF |
| Pine I Site Index | 100 | 28m | - | - | - | - | - | - | 55 | 185 | 300 |
| Pine II Site Index | 100 | 24.1m | - | - | - | - | - | - | 36 | 168 | 250 |
| Pine I Site Index | 100 | 28.7m | 35 | 234 | 360 | 31 | 228 | 360 | - | - | - |
| Pine II Site Index | 100 | 25.3m | 18 | 187 | 312 | 17 | 185 | 311 | - | - | - |
| Spruce I Site Index | 100 | 33.3m | 43 | 427 | 540 | 35 | 456 | 537 | 43 | 450 | 538 |
| Spruce II Site Index | 100 | 29.3m | 35 | 363 | 446 | 25 | 354 | 445 | 35 | 347 | 489 |

Silvicultural programmes for single species stands are more complicated in Poland than in e.g. Scandinavian countries or Lithuania (Jasinevičius 2008). Thinning volumes for three investigated districts are presented in table number 10. Despite the importance of early treatments for a young stand frequent intervals of thinnings are the reality. The situation might change as there are still numerous people willing to work in forest. In the table 11 below applied silviculture programme is presented.

Table 11. Stand treatments implemented in Herby, Namysłów and Starachowice district.

| | Herby | | Namysłów | | Starachowice | |
|---|---|---|---|---|---|---|
| Age in which treatment was implemented | | | | | | |
| Treatment | Pine in age | Spruce in age | Pine in age | Spruce in age | Pine in age | Spruce in age |
| Planting | 0 | 0 | 0 | 0 | 0 | 0 |
| 1st mowing | 1 | 2 | 1 | 2 | 1 | 2 |
| 2nd mowing | 2 | 3 | 2 | 3 | 2 | 3 |
| 3rd mowing | 3 | - | 3 | - | 3 | - |
| 1st repellenting | 1 | - | 1 | - | 1 | - |
| 2nd repellenting | 2 | - | 2 | - | 2 | - |
| 1st early cleaning | 5 | 8 | 5 | 8 | 5 | 8 |
| 2nd early cleaning | 8 | - | 7 | - | 7 | - |
| 1st late cleaning | 12 | 15 | 12 | 15 | 12 | 15 |
| 2nd late cleaning | 16 | - | 16 | - | 16 | - |
| 1st early thinning | 28 | 29 | 28 | 26 | 21 | 22 |
| 2nd early thinning | - | - | - | - | 28 | 29 |
| 1st late thinning | 45 | 45 | 45 | 45 | 45 | 45 |
| 2nd late thinning | 55 | 55 | 55 | 55 | 55 | 55 |
| 3rd late thinning | 65 | 65 | 65 | 65 | 65 | 65 |
| 4th late thinning | 75 | 75 | 75 | 75 | 75 | 75 |
| 5th late thinning | 85 | 85 | 85 | 85 | 85 | 85 |
| Final Felling | 100 | 100 | 100 | 100 | 100 | 100 |

In general, forestry silvicultural legislations and recommendations are fulfilled in all three districts described in the project. Only Namysłów district is not able to fulfil its early thinnings plan in 100% due to lack of labourers. No significant difference was found between the rules and practice in the silviculture programme. Requirements are determined by 10 years management plans prepared for every district in Poland. It is a priority for every head of the forest district in Poland to fulfil the management plan made according to legislation, therefore there is no possibility in practice to avoid regulations considering silviculture regimes.

## *3.2. Cash flow analysis*

### 3.2.1 Stand treatments costs in 2001 and 2006

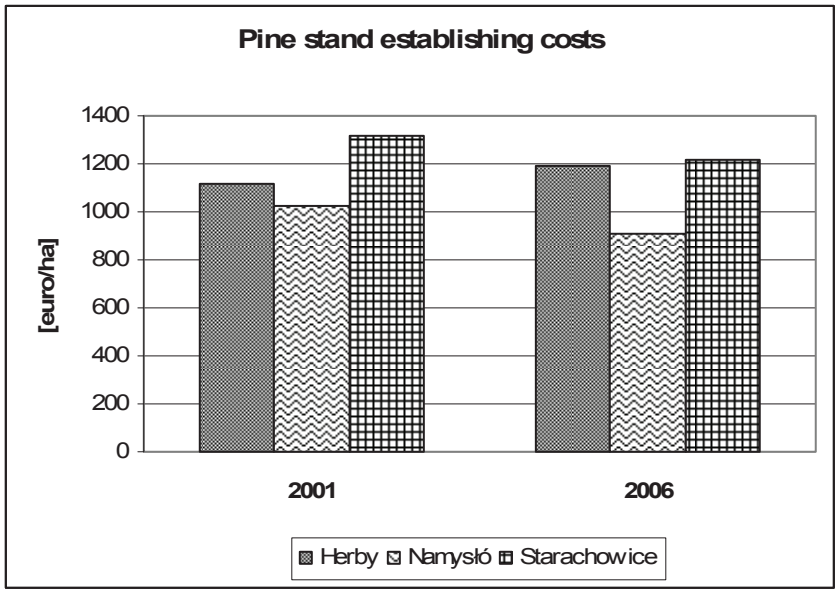


Fig. 8. Pine establishing costs in Poland.

In Namysłów and Starachowice districts pine establishing costs were higher in 2001 than in 2006 (Fig. 8). In Starachowice district establishing costs in 2001 were the highest among all districts partly because the number of planted seedlings per hectare was the highest, 13.000, in Herby and Namysłów 3,000 less. In 2006 number of seedlings in all districts was the same 9,000.

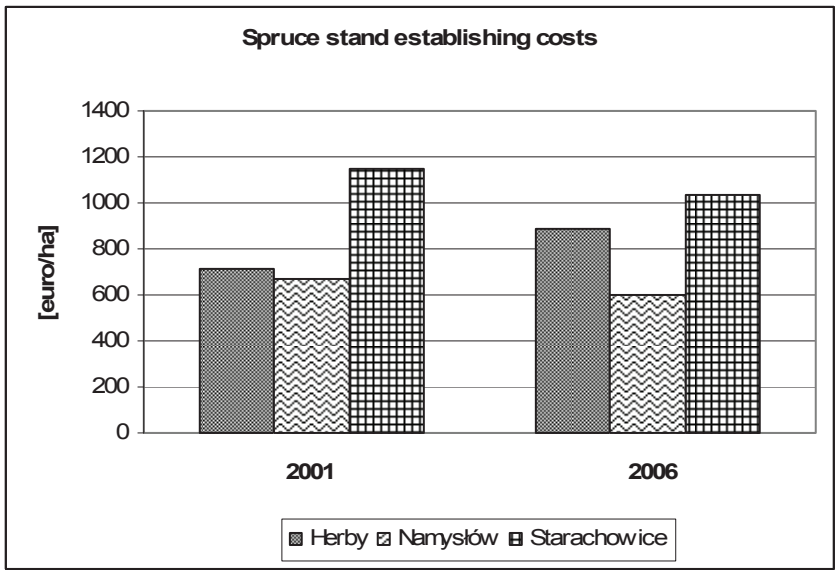


Fig. 9. Spruce establishing costs in Poland.

On figure 9 can be observed that the highest spruce stands establishing costs are in Starachowice district. It is probably because it is using more expensive two year old spruce seedlings with cut roots after one year. Namysłów district is using cheaper, one year old spruce seedlings and Herby two years but without cut roots after one year. Additionally Namysłów has much cheaper planting and soil preparation costs in year 2001 because it was using its own equipment.

Table 12. Polish stands establishing costs in year 2001 and 2006.

| Stand establishing costs [€/ha] | | | |
|---|---|---|---|
| Pine | | Spruce | |
| **2001** | **2006** | **2001** | **2006** |
| Herby | | | |
| 1116 | 1191 | 711 | 891 |
| Namysłów | | | |
| 1029 | 910 | 671 | 603 |
| Starachowice | | | |
| 1314 | 1218 | 1152 | 1033 |

In all districts spruce nominal establishing costs are lower than pine which is reflected in economical criterion because early costs have very significant influence on IRR and NPV (Table 12).

Table 13. Polish stand early treatments costs in year 2001 and 2006.

| | Costs [euro/ha] | | |
|---|---|---|---|
| | 2001 | 2006 | Change in % |
| Treatment | **HERBY** | | |
| Mowing | 83 | 149 | 80.0 |
| Early cleaning | 68 | 85 | 25.0 |
| Late cleaning | 84 | 93 | 11.0 |
| | **NAMYSŁÓW** | | |
| Mowing | 57 | 114 | 100.0 |
| Early cleaning | 71 | 80 | 13.0 |
| Late cleaning | 80 | 80 | 0 |
| | **STARACHOWICE** | | |
| Mowing | 43 | 73 | 70.0 |
| Early cleaning | 58 | 76 | 31.0 |
| Late cleaning | 63 | 84 | 33.0 |

It is clear that the price of most labour-intensive forestry works like mowing rose in all three districts in 2001-2006 (Table 13). There is a correlation between the increase in costs in 2001- 2006 and the labour-intensity of treatments. Namysłów district, situated close to the big city of Wrocław had the highest increase in mowing prices because it has been suffering from lack of labour workers and as the only one from the three investigated in the project used harvesters for thinnings and fellings. Namysłów district had similar level of costs already in 2001 as Starachowice district in 2006. Starachowice district is placed in southern-central Poland where there is a higher number of inhabitants and the distance to big cities with a population of 300,000 inhabitants or more is about 160 km. Additionally the region where Herby and Namysłów districts are located is closer to Germany and it is more wealthy than the region where Starachowice district is situated.

Table 14. Polish stands late treatments costs in year 2001 and 2006.

| | Costs [euro/ha] | | |
|---|---|---|---|
| | 2001 | 2006 | Change in % |
| Treatment | **HERBY** | | |
| Early thinnings | 10.6 | 13.0 | 22.0 |
| Late thinnings | 7.7 | 10.6 | 37.0 |
| Final fellings | 5.7 | 8.0 | 40.0 |
| | **NAMYSŁÓW** | | |
| Early thinnings | 13.4 | 16.3 | 21.0 |
| Late thinnings | 9.4 | 12.9 | 37.0 |
| Final fellings | 5.4 | 7.1 | 31.0 |
| | **STARACHOWICE** | | |
| Early thinnings | 10.9 | 12.9 | 18.0 |
| Late thinnings | 8.6 | 10.0 | 16.0 |
| Final fellings | 7.1 | 7.4 | 4.0 |

When comparing the thinnings' costs levels, a similar trend is visible as in the case of cleanings and mowings. Starachowice district has the lowest increase, Herby and Namysłów districts are under the jurisdiction of the same Regional Directorate and had almost the same increase in costs, much higher than in Starachowice. Again the highest costs are in Namysłów district. There are many reasons behind cost levels but main factor contributing to them are contractors demands. Obviously contractors cannot demand the same rates in the whole country, since the economy of regions differs (Table 14).

### 3.2.2 Wood prices

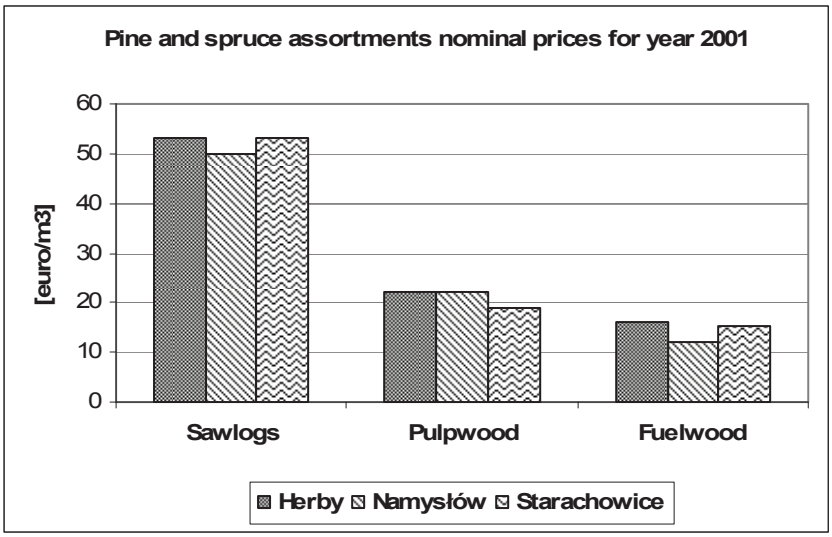


Fig. 10. Polish wood assortment prices in 2001.

Sawlogs and pulpwood prices do not differ significantly between districts. The differences in prices are not exciding 4 euro per cubic metre in 2001 as well as 2006 (Fig 10, Fig 11). However the difference in fuel wood prices in 2001 is rather substantial, as it is 25% between Herby and Namysłów district (Fig.10).

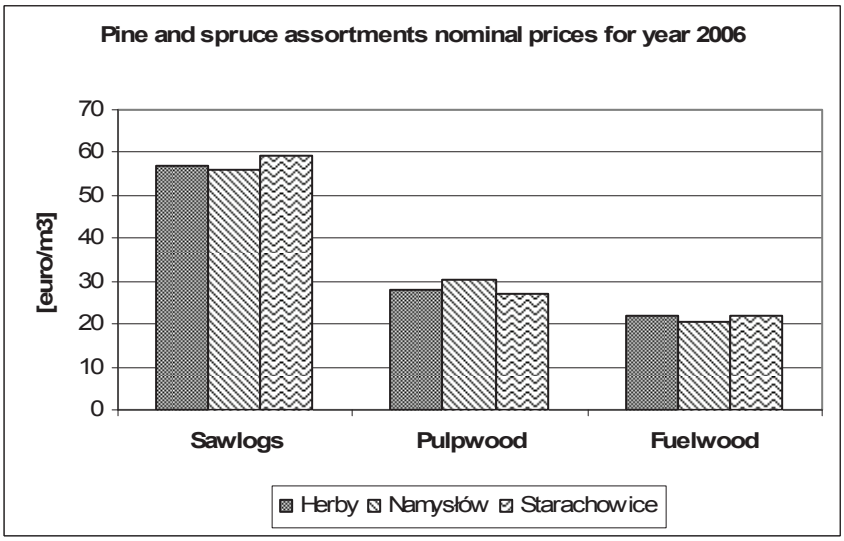


Fig. 11. Polish wood assortment prices in 2006.

Between 2001 and 2006 wood prices for every assortment in Poland increased. The most significant difference is in fuel wood prices 37% in Herby district up to 71% in Namysłów district. Sawlogs' price increase is much lower than fuel wood. The lowest dynamics in price changes is observed in Herby district as opposed to Namysłów district (Table 15).

Table 15. Polish nominal wood prices increase in period 2001-2006.

| | Price increase in period 2001-2006 [%] | | |
|---|---|---|---|
| Assortment | **Herby** | **Namysłów** | **Starachowice** |
| Sawlogs | 7.5 | 12 | 12 |
| Pulpwood | 27 | 39.5 | 42 |
| Fuel wood | 37 | 71 | 42 |

Treatment costs and wood prices in the years 2001- 2006 increase respectively, only mowing price increased by 70-100% which is exciding wood prices increase, but this treatment is done only two- three times during the whole rotation and its cost is not significant for stands cash flow.

### 3.2.3 Economic criterion

Cash flow analysis in detailed version is described in Appendixes from 4 to 14. For this project calculations 3% interest rate was taken for pine and spruce stands. Main results are in a table number 16 presented below.

Table 16. Polish stands economical indicators.

| | **Values of economical indicators** | | | | | |
|---|---|---|---|---|---|---|
| | 2001 | | | 2006 | | |
| Species and site index | NPV [€] | IRR [%] | FR [€] | NPV [€] | IRR [%] | FR [€] |
| | **HERBY DISTRICT** | | | | | |
| Pine I | 258 | 3.2 | 195 | 372 | 3.3 | 211 |
| Pine II | -93 | 2.9 | 161 | -127 | 2.9 | 171 |
| Spruce I | 2,029 | 4.8 | 325 | 2,117 | 4.6 | 351 |
| Spruce II | 1,533 | 4.5 | 268 | 1,586 | 4.3 | 290 |
| | **NAMYSŁÓW DISTRICT** | | | | | |
| Pine I | 183 | 3.2 | 206 | 195 | 3.2 | 197 |
| Pine II | -86 | 2.9 | 173 | -121 | 2.9 | 163 |
| Spruce I | 1,872 | 4.8 | 298 | 2,072 | 4.9 | 311 |
| Spruce II | 1,309 | 4.4 | 239 | 1,449 | 4.5 | 249 |
| | **STARACHOWICE DISTRICT** | | | | | |
| Pine I | -240 | 2.8 | 161 | -163 | 2.9 | 176 |
| Pine II | -478 | 2.6 | 132 | -461 | 2.6 | 145 |
| Spruce I | 1,475 | 4.1 | 296 | 1,892 | 4.5 | 304 |
| Spruce II | 1,010 | 3.8 | 252 | 1,391 | 4.2 | 256 |

Pine stands on II site index with light silvicultural programme is characterized by IRR 2.9% in both districts this programme was implemented and in both years. Pine stands on I site index obviously has higher internal rate of return and it is 3.3%. The lowest economical indicators are in Starachowice it is firstly due to different silviculture programmes implemented compared with two previous ones. In Starachowice strong silviculture programme is implemented therefore total volume is lower comparing with light silvicutural programme (Table 17) also there are in Starachowice the highest establishing costs.

Table 17. Total stand volumes according to site index.

| Site index | Average height in age 100 | Total volume [ m³] | | |
|---|---|---|---|---|
| | | Herby | Namysłów | Starachowice |
| Pine I | 28.7 m | 629 | 619 | - |
| Pine I | 28.0 m | - | - | 540 |
| Pine II | 25.3 m | 517 | 513 | - |
| Pine II | 24.1 m | - | - | 454 |
| Spruce I | 29.3 m | 1,010 | 1,028 | 1,031 |
| Spruce II | 33.3 m | 844 | 824 | 871 |

Hypothesis number one claimed that pine and spruce stands on I and II site indexes has higher profitability according to IRR, NPV and FR in 2006 than 2001. This hypothesis is fully proven by Starachowice district's IRR and NPV increase from 2001 to 2006 in every site index and species. Although Herby district is disproving this hypothesis only for pine I site index in this district present increase in IRR and NPV during years. Pine II site index decreased their IRR and NPV indicator in 2006 compared with 2001 and spruce I and II decreased IRR but NPV slightly increased. There are few reasons for the decrease in IRR. First is that of the three districts, Herby district had the lowest increase in wood prices and the highest increase in costs for all treatments. Another important reason for IRR's level is that in 2001 in pine and spruce stands only one interval of late cleaning was made as opposed to two in 2006. This change could have had significant influence on profitability according to IRR and NPV because it increased early stand age costs not income. FR increased during years in every calculated site, species and district except Namysłów pine II site index (Table 16).

Results of calculations in Namysłów district present that the IRR increase in years just in spruce stands however NPV increase in all stands excluding only pine II site index. Increase in IRR in Namysłów district is not high only 0.1% so profitability of stands according to this criterion is quite stable during years (Table 16).

In most of the stands first hypothesis is proven. IRR, NPV and FR indicators increased from 2001 to 2006. It could be also proven on the example of Herby district if the silvicultural programme will remain unchanged during years. It is important to emphasis that the increase in NPV was not very significant as increasing timber prices during the period were offset by increasing labour costs.

Forest rent in spruce stands is quite similar in all districts. In Starachowice IRR and NPV is significantly lower in 2001 and 2006 comparing with other two districts. The reason is not because of lower total yields as it is in pine stands but in much higher establishing costs in Starachowice district.

Hypothesis number II claiming that spruce and pine stands in the same year on the same site index but in different forest districts will have the same profitability according to IRR in pine stands is fully proven by Herby and Namysłów districts. The example of Starachowice district is rejecting this hypothesis because pine stands in this district are managed according to a strong silviculture programme with lower total volume than the ones in Herby and Namysłów districts. Pine on II site index in appropriate year in Herby and Namysłów districts have the same IRR equalling 2.9% but only 2.6% in Starachowice. Pine on I site index managed by light sliviculture programme resulted in IRR indicator equalling 3.2% in Herby district and 3.3% in 2006. In Starachowice district IRR for pine on I site index was 2.8% and 2.9% in 2006, significantly less due to lower total volume compared with the other two districts. Additionally another interesting trend became evident, namely IRR in pine stands managed by the same programme on the same site index but in different years and districts have the same level (Fig. 12).

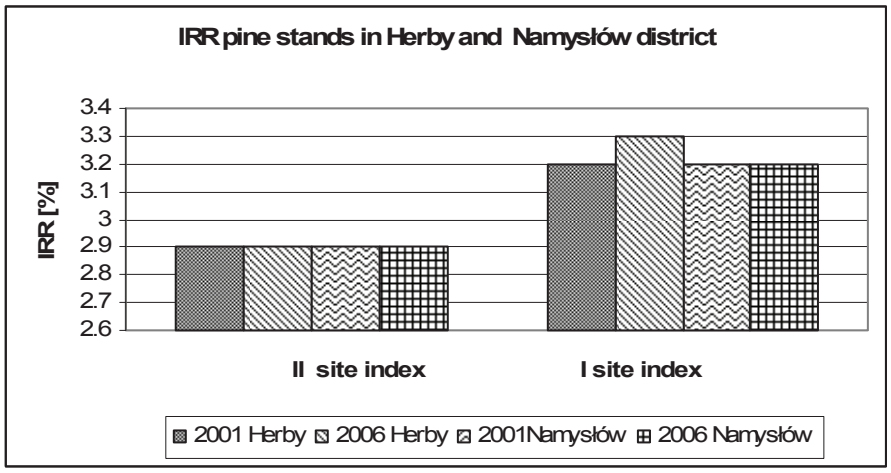


Fig. 12. IRR in pine stands in Herby and Namysłów district.

Second hypothesis cannot be fully proven according to spruce stands, however looking at figure 13 it is evident that the differences in IRR are not significant between districts. Only in Starachowice district we can observe a low IRR, but it was explained in previous paragraphs that in this district establishing costs are the highest in pine and spruce stands, which affects the IRR level. Roughly speaking we can claim that spruce stands among districts have a comparable IRR height (Fig. 13).

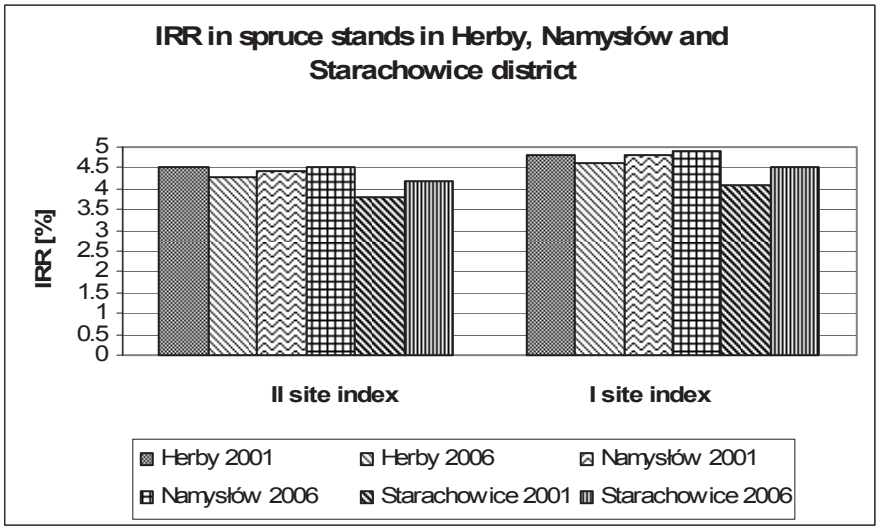


Fig. 13. IRR in spruce stands in Herby, Namysłów and Starachowice district.

In general, when comparing spruce and pine IRR and NPV we can claim that spruce stands are a more profitable investment in all districts than pine stands, the average IRR for spruce in three districts during the two investigated years was above 4% in I and II site index and pine is around 3% for I site index and 2.9% for II (Fig.14). Main reasons for that are much higher total yield in spruce stands and lower establishing costs for spruce.

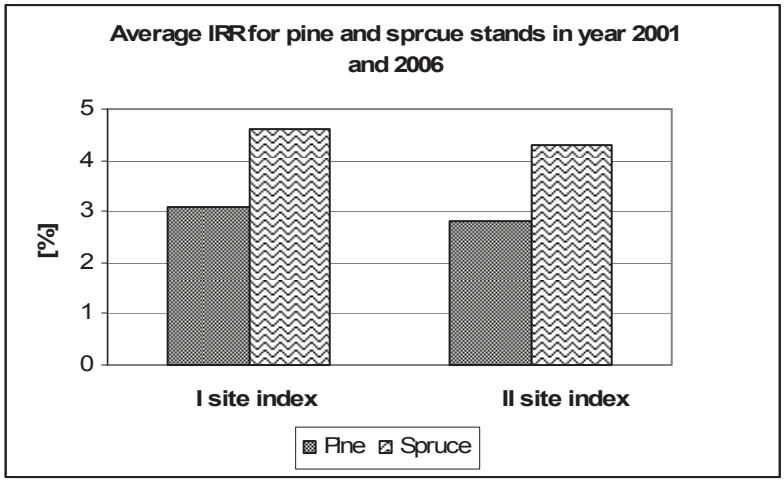


Fig. 14. Average IRR for Polish pine and spruce stands.

## 3.3 Cash flow analysis with administration costs

In table 18 below administration costs in total and per hectare are described.

Table 18. Administration costs in Starachowice district in year 2006 in total and per hectare.

| Administration costs in Starachowice district for year 2006 | | | | |
|---|---|---|---|---|
| District forest area [ha] | 14449.63 | | | |
| | PLN | € | PLN / ha | € / ha |
| Costs of administration workers | 2,944,955 | 841,416 | 204 | 58 |
| Costs of forest service workers | 1,095,920 | 313,120 | 76 | 22 |
| Superior unit support | 3,00,000 | 85,714 | 21 | 6 |
| Total | 4,340,876 | 1,240,250 | 300 | 86 |

Table 19 below is presenting costs and incomes during whole rotation (annual costs and incomes multiply by 100) and also incomes and costs balance is revealed in the table.

Table 19. Incomes and costs in Starachowice district per hectare for whole rotation.

| | Total incomes [€] | Total labourer costs [€] | Total administration costs [€] | Income and costs balance [€] |
|---|---|---|---|---|
| Pine I | 24,722 | 7,120 | 8,600 | 9,002 |
| Pine II | 20,784 | 6,325 | 8,600 | 5,859 |
| Spruce I | 41,123 | 10,704 | 8,600 | 21,819 |
| Spruce II | 34,812 | 9,194 | 8,600 | 17,018 |

The administration costs in pine I and II site index are exceeding labour costs. In spruce I and II site index labour costs slightly exceeding administration costs. In all stands income and costs balance is positive and it is correlated with total volumes it is increasing with increasing total yields.

Table 20. Pine and spruce economical indicators in Poland with and without administration costs.

| Pine stands economical indicators for year 2006 | | | | |
|---|---|---|---|---|
| Administration costs | | | | |
| | Yes | No | Yes | No |
| | Pine II | Pine II | Pine I | Pine I |
| NPV [€] | -3,272 | -460.9 | -2,957.43 | -163.3 |
| IRR [%] | 0.9 | 2.6 | 1.2 | 2.9 |
| FR [€] | 59 | 144.6 | 89 | 176.0 |
| | | | | |
| Spruce stands economical indicators for year 2006 | | | | |
| Administration costs | | | | |
| | Yes | No | Yes | No |
| | Spruce II | Spruce II | Spruce I | Spruce I |
| NPV [€] | -1,403.71 | 1,390.6 | -902 | 1,892.3 |
| IRR [%] | 2.1 | 4.2 | 2.5 | 4.5 |
| FR [€] | 170 | 256.3 | 218 | 304.3 |

Table 20 reveals economical indicators with and without administration costs.

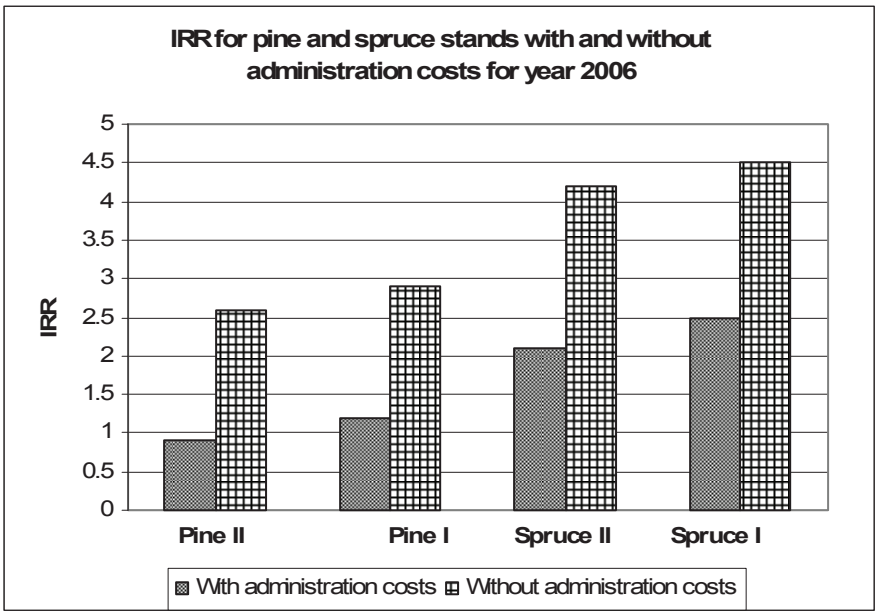


Fig. 15. IRR in Polish pine and spruce stands with administration costs.

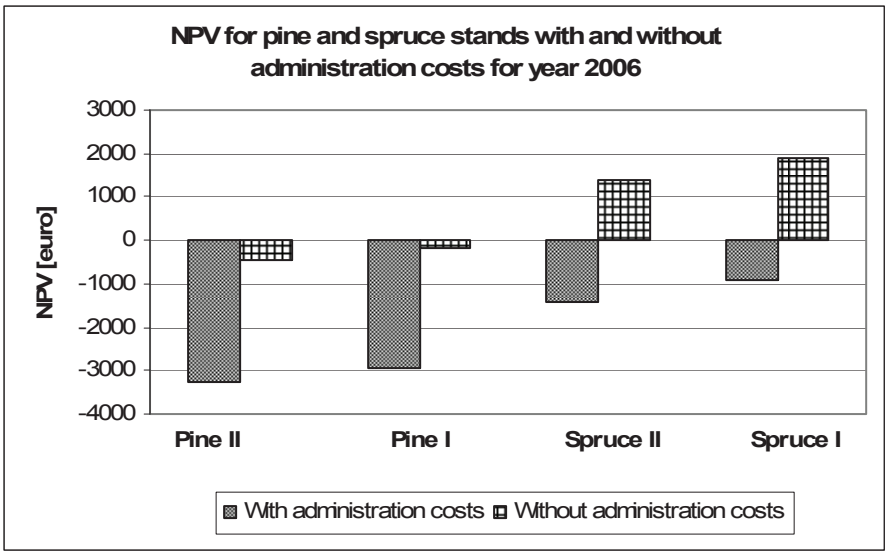

Fig. 16. NPV in Polish pine and spruce stands with administration costs.

Hypothesis number three claiming that administration costs will severely decrease profitability according to IRR in pine and spruce stands compared to stands indicators without administration costs is proven in spruce stands. In spruce stands I and II site index administration costs are decreasing NPV and IRR indicators twice as much when compared with indicators for calculations not including administration costs. In pine stands both IRR and NPV are decreased very severely by administration costs; for example in II site index after adding the administration costs the IRR decreased from 2.6% to 0.9% and NPV from 460.9 euro to 3,272 euro.

## *3.4 Lithuania and Poland cash flow comparison analysis*

Table 21. Comparison of cash flow analysis in Lithuanian and Polish pine II site index stand in year 2006.

| Thinnings and fellings comparison in pine stand II site index year 2006 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | LT | PL | LT | PL | LT | PL | LT | PL | LT | PL |
| Treatment | Age | Age | Intensity [m³] | Intensity [m³] | Income [€/ha] | Income [€/ha] | Cost [€/ha] | Cost [€/ha] | DCF [€/ha] | DCF [€/ha] |
| Planting and soil preparation | 0 | 0 | 4700 plants/ha | 9000 plants/ha | 0 | 0 | **522** | **1218** | -522 | -1218 |
| Protection | 1 | 1 | - | - | 0 | 0 | 100 | 206 | -97 | -201 |
| Protection | 2 | 2 | - | - | 0 | 0 | 100 | 206 | -94 | -194 |
| Protection | 3 | 3 | - | - | 0 | 0 | 100 | 110 | -92 | -101 |
| EC | - | 5 | - | - | - | 0 | - | 76 | - | -65 |
| EC | - | 7 | - | - | - | 0 | - | 76 | - | -61 |
| LC | - | 12 | - | - | - | 0 | - | 92 | - | -64 |
| LC | 15 | 16 | - | - | 0 | 0 | 152 | 82 | -98 | -51 |
| 1st ET | 25 | 21 | 26 | 16 | 437 | 433 | 306 | 207 | 62 | 121 |
| 2nd ET | - | 28 | - | 20 | - | 541 | - | 259 | - | 123 |
| 1st Lt | 45 | 45 | 58 | 30 | 1,521 | 1025 | 567 | 303 | 252 | 191 |
| 2nd Lt | 65 | 55 | 64 | 32 | 2,120 | 1094 | 633 | 323 | 218 | 152 |
| 3rd Lt | - | 65 | - | 34 | - | 1162 | - | 343 | - | 120 |
| 4th Lt | - | 75 | - | 36 | - | 1230 | - | 363 | - | 94 |
| 5th Lt | - | 85 | - | 36 | - | 1230 | - | 363 | - | 70 |
| FF | 105 | 100 | 305 | 250 | 12013 | 14069 | 2792 | 2096 | 414 | 623 |
| Total | - | - | **453** | **454** | **16091** | **20784** | **5272** | **6323** | 44 | -460 |

DCF- Discounted cash flow
LT- Lithuania
PL-Poland

Total yield of II site index pine stands where trees in 100 years reach 24 m are identical in Lithuania and Poland. Costs of establishing the stands are two times higher in Poland. It is a direct result of planting almost a twice the number of seedlings, 4,700 seedlings per ha in Lithuania and 9,000 seedlings per ha in Poland. Due to a different amount of treatments applied in both countries, their total costs during the whole rotation are 20 % lower than in Poland. In Lithuania just one PCT is performed, compared to as much as four in Poland. Polish pine stands are also treated by two early and five late thinnings every ten years and in Lithuania only one early and two late are performed. There is a significant difference in the number of treatments between those two countries but not a significant difference in total

costs. Early thinnings costs for 1 ha are just 2 euros (23%) more expensive in Lithuania but final felling costs are 2 euros (15%) more expensive in Lithuania. Late thinnings costs are identical in those two countries (Table 18).

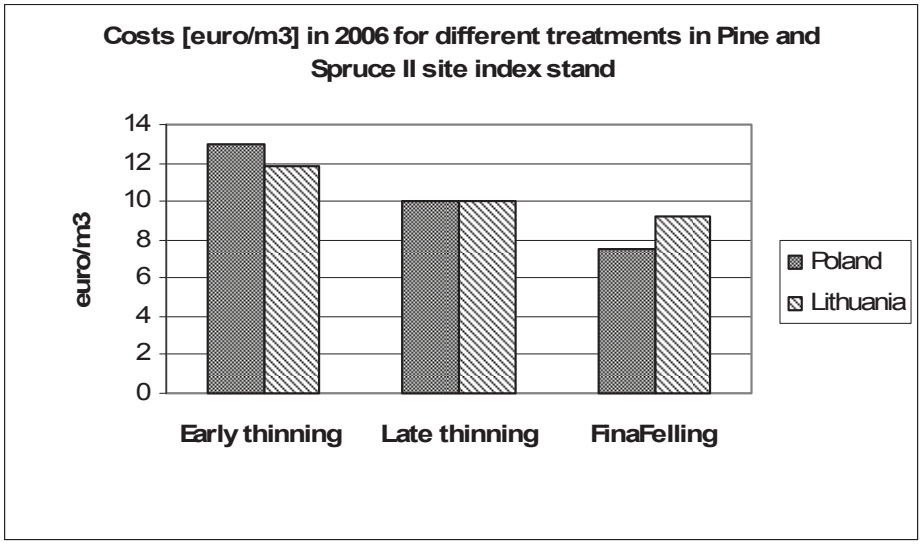


Fig. 17. Costs for treatments in Polish pine and spruce stands.

If the costs for treatments do not differ significantly between the two countries (Fig. 17) the difference in total costs must be correlated to the number of treatments and which is higher in Polish pine stands. Total incomes are about 23% higher in Poland than in Lithuania.

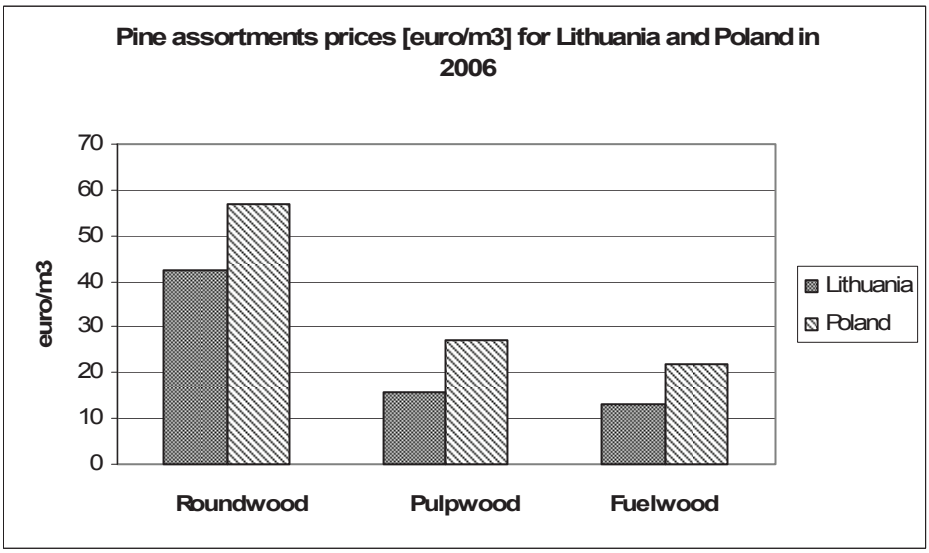


Fig. 18.Lithuanian and Polish pine wood assortment prices in year 2006.

Table 22. Lithuanian and Polish wood assortment prices in year 2006.

| Pine | Prices in euro in 2006 | | |
|---|---|---|---|
| | Round wood | Pulpwood | Fuel wood |
| Lithuania | 42.3 | 15.9 | 13.0 |
| Poland | 57 | 27 | 22 |

Even if the share of round wood in thinnings is much higher in Lithuania than in Poland, the huge differences in prices of all assortments are covering the differences in assortments' distribution. Looking at final felling incomes in Lithuania and Poland, where the difference is about 2000 euro in favour of Poland when there are 50 cubic metres less volume harvested at this stage is explaining how significant the role of wood prices is for income level.

Table 23. Assortment share in different treatments in Lithuanian and Polish pine stands.

| Treatment | Percentage share of assortments in Pine for different treatments | | | | | |
|---|---|---|---|---|---|---|
| | Round wood | | Pulpwood | | Fuel wood | |
| | Lithuania | Poland | Lithuania | Poland | Lithuania | Poland |
| ET | 13% | 0% | 62% | 100% | 12% | 0% |
| Lt | 47% | 13% | 37% | 85% | 7% | 0% |
| Lt | 69% | 13% | 20% | 85% | 4% | 0% |
| FF | 91% | 85% | 5% | 12% | 2% | 3% |

Income and cost balance is describing the investment profitability in a simple way. The project calculations results show that pine II site index in Poland according to implemented silvicultural regimes and prices for the year 2006 is having lower IRR and NPV than Lithuanian pine stand on the same site productivity. The IRR in Polish pine stand is 2.6% and 3.1% in Lithuania, while NPV in Poland is -461 € and 44 € in Lithuania.

Those figures indicate that the wood prices are twice as high in Poland than in Lithuania and total yield has the same profitability according to IRR and NPV is lower in Poland. NPV is a valuable source of information about costs and incomes layout, and helps to compare different alternatives. NPV below zero does not have to be a proof that investment is not bringing profit, it only means that it will not allow the investment pay back the credit with a calculated interest rate. NPV is higher when costs are lower and are coming later and incomes are higher but coming earlier. Very high establishing costs, more expensive, frequent early stage protection treatments and cleanings have a huge impact on NPV low level in Poland as compared to Lithuania. Considering NPV as a criterion is a better investment alternative in

Lithuanian silviculture regimes than in Polish ones. Furthermore considering IRR is more desirable for Lithuanian pine scenarios than Polish ones.

Table 24. Lithuanian and Polish economical indicators in pine II site index.

| Pine II site index year 2006 | | |
|---|---|---|
| | Lithuania | Poland |
| IRR | 3.1 | 2.6 |
| FR | 103 | 145 |
| NPV | 44 | -461 |

From evaluated economical indicators forest rent is higher in Polish pine stands than in Lithuanian ones but this indicator cannot be considered separately when choosing better investment scenarios because it can cause high investment losses. Forest rent means only evaluating costs and income balance divided by rotation age.

Table 25. Comparison of Lithuanian and Polish cash flow analysis in spruce II site index stand in year 2006.

| Thinnings and fellings comparison in spruce stand II site index year 2006 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | LT | PL | LT | PL | LT | PL | LT | PL | LT | PL |
| Treatment | Age | Age | Intensity [m³] | Intensity [m³] | Income [€/ha] | Income [€/ha] | Cost [€/ha] | Cost [€/ha] | DCF [€/ha] | DCF [€/ha] |
| Planting and soil preparation | 0 | 0 | 3400 plants/ha | 4000 plants/ha | 0 | 0 | **570** | **1033** | -570 | -1033 |
| Protection | 1 | 2 | - | - | 0 | 0 | 73 | 73 | -71 | -69 |
| Protection | 2 | 3 | - | - | 0 | 0 | 73 | 73 | -69 | -67 |
| Protection | 3 | - | - | - | 0 | - | 73 | - | -67 | -209 |
| EC | 7 | 8 | - | | 0 | 0 | 164 | 76 | -133 | -60 |
| LC | 15 | 15 | - | | 0 | 0 | 164 | 92 | -105 | -59 |
| 1st ET | 25 | 22 | 46 | 15 | 734 | 440 | 546 | 194 | 90 | 128 |
| 2nd ET | - | 29 | - | 20 | - | 586 | - | 259 | - | 139 |
| 1st Lt | 45 | 45 | 82 | 60 | 2196 | 2367 | 832 | 605 | 361 | 466 |
| 2nd Lt | - | 55 | - | 66 | - | 2604 | - | 666 | - | 381 |
| 3rd Lt | - | 65 | - | 70 | - | 2762 | - | 706 | - | 301 |
| 4th Lt | - | 75 | - | 74 | - | 2920 | - | 747 | - | 237 |
| 5th Lt | - | 85 | - | 77 | - | 3038 | - | 777 | - | 183 |
| FF | 75 | 100 | 335 | 489 | 11667 | 20095 | 3147 | 3893 | 928 | 843 |
| Total | - | - | **463** | **871** | **14597** | **34812** | **5642** | **9194** | 364 | 1181 |

Two stands cash flows were compared, II site index stand where spruce in 100 years reach 29.3 m in Polish classification and 28m in Lithuanian. Total yield in Lithuanian stand is much lower than in Polish it is respectively 463 m³ and 871 $m^3$ .

Costs of establishing the stands are twice as high in Poland even though the amount of seedlings did not differ much like in pine stands. The reason for such a big variance in costs could be explained by seedling prices in Poland (spruce seedlings are two years old which results in high prices). Total costs for treatments during the whole rotation are almost two time higher in Polish spruce stands but the number of treatments is also doubled. In Lithuania no PCTs are done as opposed to two PCTs in Poland. Both stands are treated by early thinnings - two in Poland and one in Lithuania. Five late thinnings every ten years are implemented in Polish spruce stands and only one in Lithuania. Early thinnings costs for 1 ha are just 2 euros (23%) more expensive in Lithuania but final felling costs are 2 euros (15%) more expensive in Lithuania. Late thinnings costs are identical in the two countries. If the costs of treatments do not differ significantly between the two countries, the difference in total costs is in the number of treatments which is higher in Polish spruce stands. Moreover,

the price is calculated in euros per harvested $m^3$ and in Polish spruce stand total yield is 408$m^3$ higher, which makes the costs much higher.

Total incomes in Polish spruce stands are about 60% higher than in Lithuanian ones. It is possible because wood prices in 2006 were almost two times higher for every assortment in Poland than in Lithuania (look table 26).

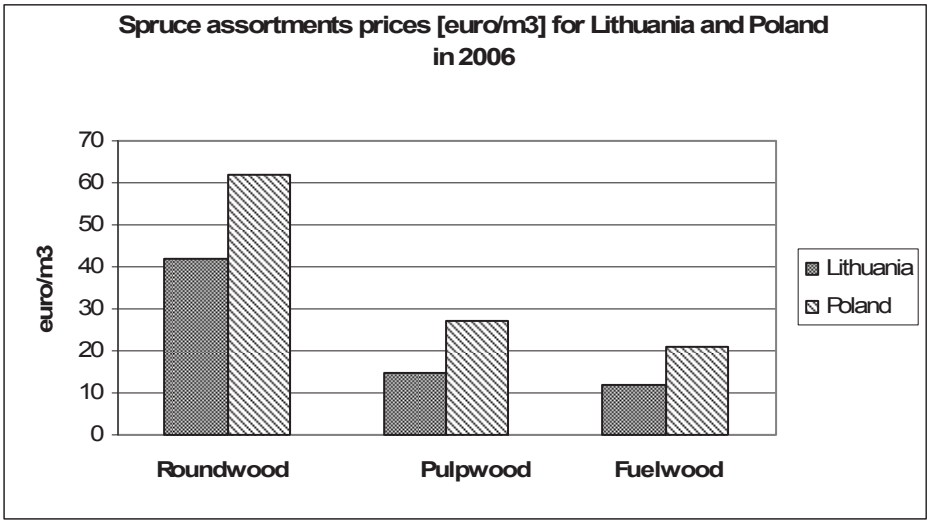


Fig 19.Lithuanian and Polish spruce assortments prices in year 2006.

Table 26. Lithuanian and Polish spruce wood prices in year 2006.

| Spruce | Prices in euro in 2006 | | |
|---|---|---|---|
| | Round wood | Pulpwood | Fuel wood |
| Lithuania | 42 | 15 | 12 |
| Poland | 62 | 27 | 21 |

In spruce stands the distribution of assortments is more similar than in pine. Only in the early thinning stage in Lithuanian stand there is two times more round wood than in Lithuania. Polish spruce stand described in comparison has a bigger share of pulpwood than a Lithuanian stand. All those differences are not of significant importance when considering differences in incomes because in a Polish stand the total yield is much higher and wood prices are twice as high.

Table 27. Assortment share in different treatments in Lithuanian and Polish spruce stands.

| Treatment | Percentage share of assortments in Spruce for different treatments | | | | | |
|---|---|---|---|---|---|---|
| | Round wood | | Pulpwood | | Fuel wood | |
| | Lithuania | Poland | Lithuania | Poland | Lithuania | Poland |
| ET | 13% | 6% | 63% | 94% | 13% | 0% |
| Lt | 50% | 45% | 55% | 85% | 7% | 0% |
| FF | 78% | 79% | 13% | 21% | 2% | 0% |

Wood prices are two times higher, total yield is 40 % higher in Polish spruce stands which is reflected in economic indicators. Differences in wood prices and in total yield have influence on IRR, NPV and FR. Those indicators are showing that spruce stands are a better investment in Poland than in Lithuania.

Table 28. Lithuanian and Polish economical indicators in spruce II site index.

| Spruce II site index year 2006 | | |
|---|---|---|
| | Lithuania | Poland |
| NPV | 364 | 4867 |
| IRR | 3.5 | 4.2 |
| FR | 199 | 897 |

Hypothesis number four claiming that Scots Pine and Norway spruce on II site index in Lithuania is having higher profitability according to IRR and NPV than Scots Pine and Norway spruce on II site index in Poland is disproved according to Spruce stands, but proven in pine stands' comparative analysis. It turned out that a typical rotation age for pine is 100 and for Lithuania 105 years and the total yield is the same when in spruce differences are much bigger, in Lithuania rotation age is 75 years and in Poland a typical rotation for spruce is 100 and total yields with 871m³ in Poland and 463m³ in Lithuania. Therefore the IRR and NPV indicators are higher in Polish spruce stands. Comparison analysis in pine and spruce second site index stands confirms that IRR for pine stands in Lithuania is higher than in Poland but mainly due to two times higher pine establishing costs and more early treatments implemented in Poland.

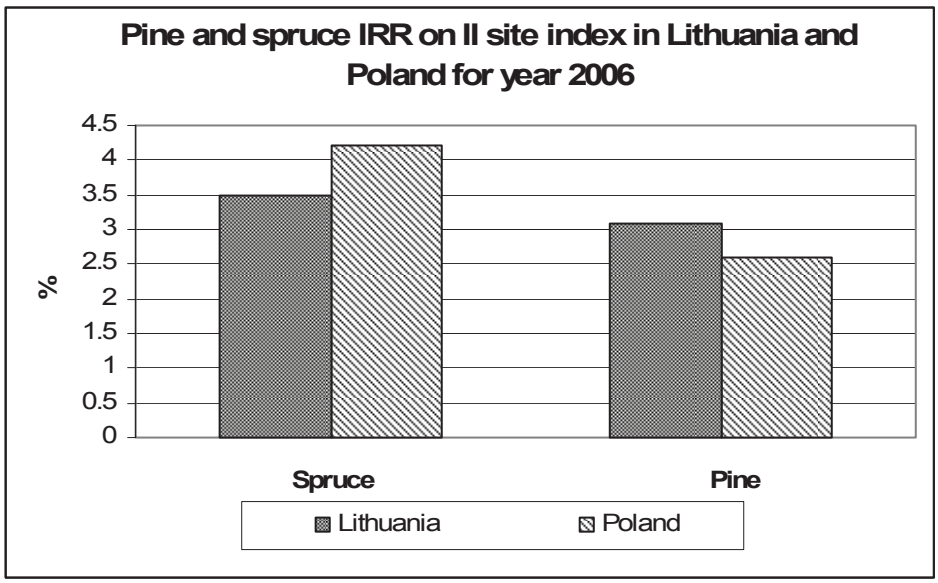


Fig. 20. IRR in pine and spruce stands in Lithuania and Poland.

IRR indicator for spruce is higher in Poland than in Lithuania, even with a lower rotation age in Lithuania which should have a positive influence on IRR level. However a much higher yield and wood prices in Poland are creating higher profitability according to IRR.

Table 29. Pine and spruce NPV in Lithuania and Poland.

| | Lithuania | Poland |
|---|---|---|
| Pine NPV | 44 € | - 461 € |
| Spruce NPV | 364 € | 4867 € |

The same trend in countries' comparison as in IRR is represented by NPV. It is lower in Polish pine stand but higher in spruce stand. It is important to point out that the difference in NPV level is significant - thirteen times higher in Polish spruce stand.

## *3.5. Comparison of Lithuanian and Polish cash flows with administration costs in year 2006.*

Administration costs in Lithuania account for 31 euro/ha and in Poland 86 euro / ha.

Table 30. Incomes and costs in pine and spruce stands on II site index in Lithuania and Poland.

| Species | Total incomes [€/ha] | | Total labourer costs [€/ha] | | Total administration costs [€/ha] | | Income and costs balance [€/ha] | |
|---|---|---|---|---|---|---|---|---|
| | LT | PL | LT | PL | LT | PL | LT | PL |
| Pine II | 16,092 | 20,784 | 5,272 | 6,325 | 3,286 | 8,600 | 7,534 | 5,859 |
| Spruce II | 14,597 | 34,812 | 5,642 | 9,194 | 2,356 | 8,600 | 6,599 | 17,018 |

The administration costs in pine and spruce on II site index in Poland are exceeding labour costs. In spruce I and II site index labour costs just slightly exceed administration costs. In Lithuania administration costs are two times lower in spruce and 160% lower in pine stand. In both countries the income and costs balance is positive in all stands. It is correlated with the total volumes and it is rising with increasing total yields. The highest is in the Polish spruce stand.

Table 31. Pine stands economical indicators in Lithuanian and Poland with and without administration costs.

| Pine stands economical indicators for year 2006 | | | | |
|---|---|---|---|---|
| | With administration costs | | Without administration costs | |
| | Lithuania | Poland | Lithuania | Poland |
| | Pine II | | | |
| NPV [€] | -974 | -3,272 | 44 | -460.9 |
| IRR [%] | 1.8 | 0.9 | 3.1 | 2.6 |
| FR [€] | 72 | 59 | 103 | 144.6 |

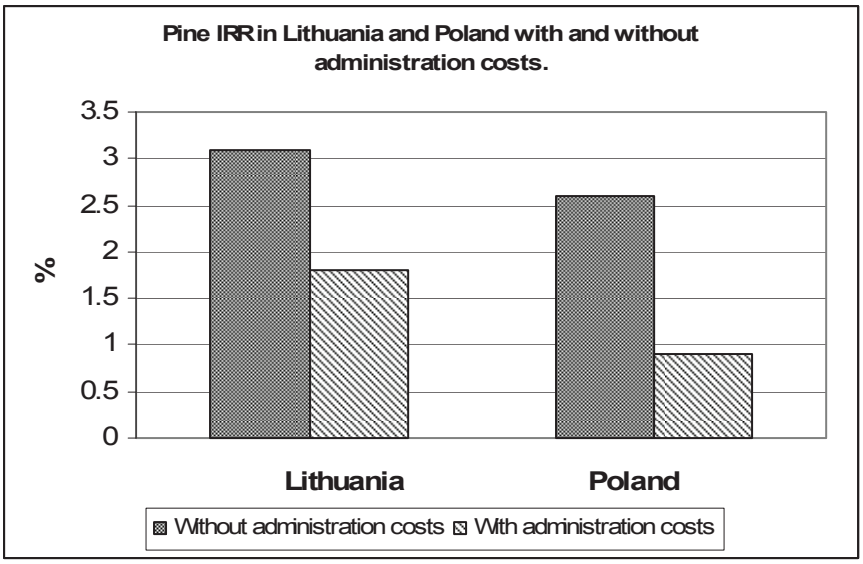

Fig. 21. Pine IRR in Lithuania and Poland.

Figure 21 revealed that administration costs are more severe decreasing profitability according to IRR in Poland than in Lithuania.

Table 32. Spruce stands economical indicators in year 2006.

| Spruce stands economical indicators for year 2006 | | | | |
|---|---|---|---|---|
| | With administration costs | | Without administration costs | |
| | Lithuania | Poland | Lithuania | Poland |
| | Spruce II | | | |
| NPV [€] | -588 | -1,403.71 | 364 | 1,390.6 |
| IRR [%] | 2.3 | 2.1 | 3.5 | 4.2 |
| FR [€] | 88 | 170 | 119 | 256.3 |

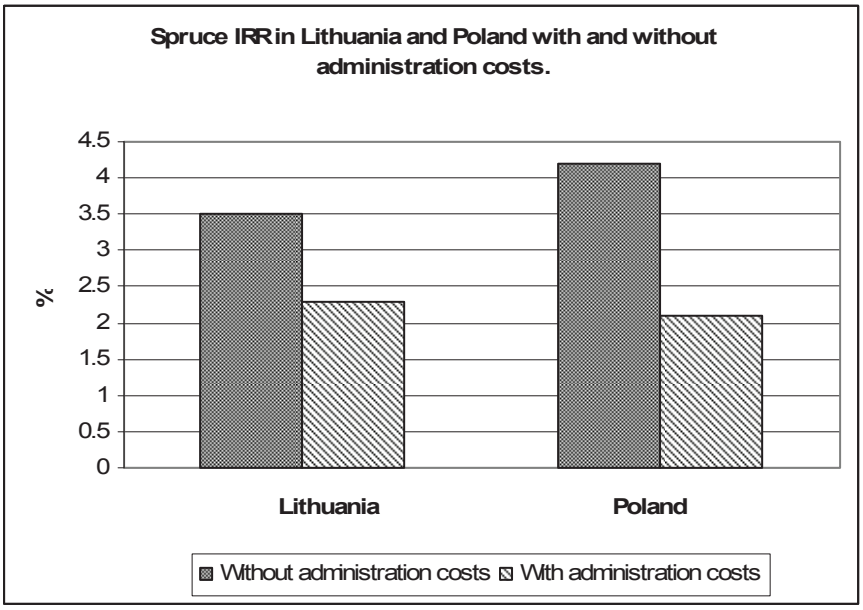


Fig.22. Spruce IRR in Lithuania and Poland with administration costs.

Hypothesis number five, claiming that according to IRR administration costs in 2006 in pine and spruce stands will decrease profitability more severely in Poland than in Lithuania is proved for both pine and spruce stands (table 31, 32 and figure 21, 22, 23).

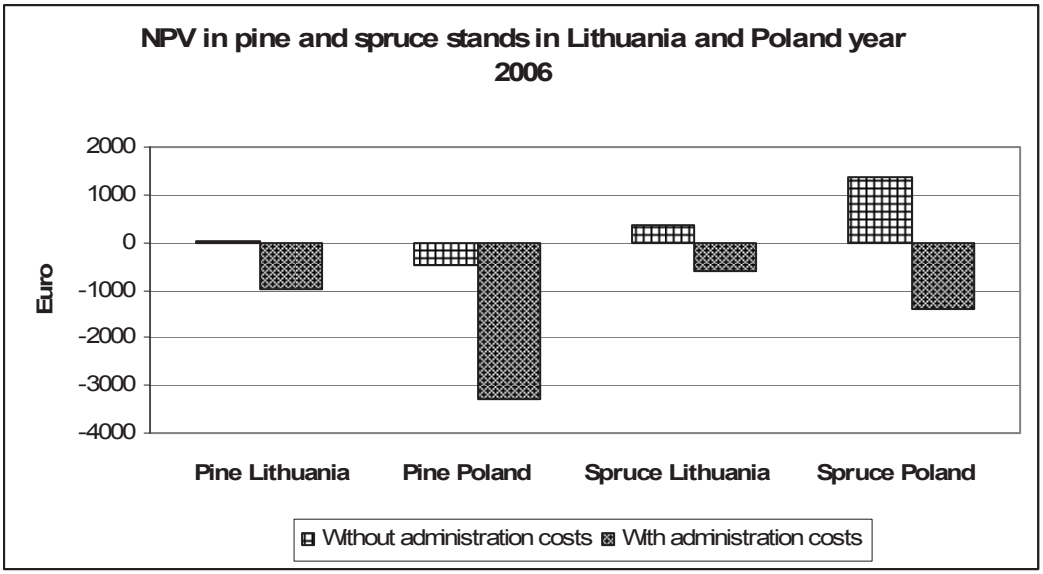


Fig.23. NPV in pine and spruce stands in Lithuania and Poland in year 2006.

The same hypothesis is disproved when applying the NPV criterion. It is clearly visible on the figures and tables above that the administration costs are lowering the NPV level more rapidly in Lithuania than in Poland. The biggest disproportion between NPV with and without administration costs is noticed in Lithuanian pine stand. NPV is lowered by administration costs as much as 22 times and seven times in Poland. Different situation is observed in spruce stands. In both countries NPV is about two times lower after adding administration costs.

# 4. Discussion

## *4.1. Polish silviculture regulations and reality*

Main aim of the project was to formulate and compare cash flow analysis for the Scots Pine (Pinus sylvestris) stand on II site index where pine in 100 years is reaching 24.1 m height and Norway Spruce (Picea abies) stand on II site index where tree reach 29.3 m in 100 years in Poland and 28 m in Lithuania. The aim was achieved and the results will be discussed in this chapter.

In first words of this part of project it is important to emphasise that the silvicultural programme presented in the thesis is a kind of a model for pine and spruce monocultures. It is only a model because in reality in Polish forestry there are almost no typical monocultures like in e.g. Sweden or Finland. Polish geographical location does not allow that. There are always some additional species, for example alders (Populus tremula) birches (Betula pendula) etc. Moreover, it would be hard to implement it because not every stand in Poland has the same tending needs as the ones described in the project. However, the silvicultural programme presented in the project is a typical layout of how the pine and spruce stands are lead in Poland. Results of the project based on three Polish districts prove that silvicultural regimes legally bonded by law are fulfilled. However some problems like lack of labour workers are discovered. Namysłów district placed close to a big city, Wrocław, is not able to make early thinnings twice because of lack of workers. Labour work is becoming less and less attractive when compared to work in services. Number of people employed directly in the forestry sector is constantly decreasing and their average age is increasing. There is a threat of a labour generation gap (Nowacka et al., 2006). The majority of operators complain about insufficient wages. Additionally, nowadays the forestry practice with an increasing share of complex felling from 11,7% in year 2001 up to 19,2% in year 2006 is favouring cutting by chain saw not harvesters. The level of wood harvesting mechanization is in Poland rather low. Chain saws are commonly used and 99% of total wood removed in Poland is harvested with this tool, the rest is done by harvesters. But there are some activities like early and late cleanings which need to be done by chain saw because stands in time of those treatments are too small to be cut by a harvester.

Fulfilling silvicultural regimes, paying high salaries and increasing social security costs can lead to either an increase in the number of foreign workers, which are willing to work for

lower salaries or developing certain changes in silvicultural programme, which is currently quite demanding and complicated.

## 4.2. Polish coniferous stands' profitability

For project calculations, the money rate is not changed during rotation. In other economic calculations such a concept has no existence but in forestry it is not easy to include money rate and adjust it for 100 years. The biggest doubts in forestry calculations are calculating according to interest rate which is the same for every stand (every investment). From an economic point of view it is a mistake to accept a constant interest rate. Additionally stand structure (capital structure), species and age structure have a big influence on the forestry interest rate. Every stand should have each own interest rate, created taking factors such as management, nature, technical, organizational and economic conditions into consideration. Project analysis could also be done in a more precise way (sensitivity analysis) by using different interest rates, but it would require an enormous amount of work, impossible to complete within a single thesis report.

IRR without administration costs oscillates between 2.6-3.3 % in pine stands in the three investigated project districts and it depends greatly on harvested volumes. When examining Polish wood prices - which are on very high level despite very low labour costs - the results of calculations seem very low. Main reason is that in the contemporary Polish forestry practice there are no economical considerations in the management programmes. The Forestry Act is making it almost impossible for forestry districts to increase harvesting volumes leading to increasing incomes. Also management plans are very strict about the number of required cleanings, early and late thinnings and quite costly. Low mechanization level is also not increasing profitability. The idea of multifunctional forestry strongly implemented in Poland is of a big influence on the forest economy and finance. The economic analysis analyses of main commercial species at stand level allows expecting that Polish State Forests can be managed profitably. However forestry goals aims at putting production on the least important position after social and protection needs. By implementing such a law Poland is representing a minority in Europe. In this situation it is hard to talk about forestry in Poland as an income source because it is not the forestry's aim to fulfil all of the above-mentioned principles. Therefore a certain question needs to be asked: who should fulfil the aims mentioned in the law? We all know that harvested wood is the forestry's main income source, therefore, outside of production functions should it be included in the price of wood? Those issues are making economic calculations very difficult. There is no price for protection and

social functions of forests, which are given to the society to use for free, despite creating a need of carrying out additional treatments and thus leading to losses in forestry production. Proven hypothesis number two, that different districts have the same profitability according to IRR in the same years and the same site indexes is describing how centralized the Polish State Forests management is. Very similar wood prices, and management programmes are creating the same profitability in different districts, only labour costs very in different regions. There are no predictions for a wood price increase in Poland which will cause a need for decreasing costs. However Polish State Forests did some improvements from 2001. First of all, the number of planted seedlings decreased from the required 10,000-16,000 pine seedlings per hectare to 8,000- 10,000. The number of required spruce seedlings planted per hectare were reduced after 2002 from 4,000-6,000 to 3,000-5,000. This is of course not a significant reform but a step towards a more profitable forest management. The decrease in the number of seedlings planted per hectare has a big influence on the NPV level because a higher number of seedlings increases establishing costs, which affects NPV as first incomes will come after around 30 years. Hypothesis number one, claiming that according to IRR, NPV and FR pine and spruce stands on I and II site indexes have higher profitability in 2006 than 2001 could not be fully proven. Only in Starachowice district an increase in every site index and in both species was observed, but in this district the silvicultural programme remained unchanged. The Second improvement after decreasing number of seedlings is that the majority of work in state forests has been privatized. The problem is that private forest enterprises are usually very sparse (up to 5 persons) with a small potential (Nowacka et al., 2006). About 43 forwarders and 16 harvesters are currently in the hands of private entrepreneurs in Poland but some of these machines belong formally to the State Forests units. The usage of those machines by private operators is increasing the State Forests costs but forestry contractors do not have the sufficient funds to buy such expensive equipment. However this systematic taking over of forest work execution by private contractors even with some influence from the State Forests' budget has brought definite economical profits (Kocel, 2000). Harvesters are mainly working in the northern part of Poland. In Radom Regional Directorate of State Forests where Starachowice district is situated, there are not any forwarders or harvesters. In Katowice Regional Directorate of State Forests in which Namysłów and Herby district are situated, there are 3 forwarders and 2 harvesters. In the last one hundred years, forestry was characterized by a low ratio of return of invested capital employed in forest economy, which was mainly due to a constant and significant rise in forest production costs coinciding with

insignificant increase in timber prices. On this basis, a hypothesis about economic scarcity of forest resources has been drawn (Klocek, 2005).

Herby district has 53 full time workers, Namysłów 54 and Starachowice 43. It gives 3 workers per 1000 ha in Herby and Starachowice districts and 3.3 in Namysłów. Just around 5% of them are labourers. For administration costs calculations only Starachowice district was taken into consideration. However, the number of workers per 1000 ha is the same in all three districts. Total administration costs in Starachowice in pine and spruce stands are slightly exceeding the level of forestry activities costs. Administration costs in pine stands decreased IRR from 2.6 % to 0.9% and NPV from -460.0 euro to -3.272 euro. After adding administration costs spruce stands' IRR decreased twice to 2.1 % on II site index. Hypothesis number three claiming that administration costs will doubly decrease profitability according to IRR in spruce stands was proven on the example of spruce. In his article from 2004 Professor Żylicz from Warsaw University stated that the Polish stand rate of return cannot be higher than 1.5% and that commercially minded forest owners will not find it attractive. This project results' are proving the trend described by the aforementioned article. However, State Forests administration costs are on very high level, and perhaps private owners will achieve a higher rate of return if they decrease the administration costs, but to prove that more research is required. In the project there are no results considering the year 2001 with administration costs included in cash flow calculations, but there are many facts convincing that since 2001 the administration costs were decreased. In the beginning of 90ties there were 103,000 employees working in State Forests and in 1997 37,000. In 2001 State Forests employed 32,000 people and owned 50,000 flats. In 2001 for the first time in the post-war period the income was negative (Dawidziuk, 2002). After this experience State Forests changed the administration policy. In 2002 there were 439 forestry districts. In 2006 the number went down to 428. The area of forest nurseries decreased from 3264,000 to 2920,000 hectares. Total number of employed workers also dropped from 29,996 in 2002 to 25,860 in 2006. The number of labourers decreased from 6,697 in 2002 to 3,973 in 2006 (GUS 2007). Those activities lowered expenses for administrative activity costs from 41% in 2001 to 33.7% in 2006. There are no doubts that a high number of administration workers is decreasing profitability of forestry practice. Still, this number is very high and has negative influence on State Forests profitability. Another important feature of Polish forestry is that organizational units are sparse which also results in low profitability. State Forests policy is aiming to accomplish a self-financing forestry management, continuity and stability of forest use and creating forest districts consisting of uneven aged stands on a big area. Moreover, rational

management requires that growing stock volume should be high enough to provide big volume increase. These conditions are fulfilled on the national level and also investigated in project districts. In Polish conditions the districts which are not self financing units are supported by the Forest Fund. The Forest Fund, which has so far saved 371,5 million zł (data until 1.01.2006) and it increased its savings from 2005 by 6,8 million zł, is an insurance for state forestry and a necessary help for unprofitable districts which have too low harvesting levels to be self-financing. It is trying to avoid forcing districts to increase cutting levels just for supporting own existence. All those facts are showing that the Polish forestry strategy has not turned into an economy but a national wealth and multifunctional forestry. Very strict rules about considering amount of harvesting volume contained in accordance to enacted forestry Act from 1991 with amendments from 1997 are resulting in accomplishing sustainable forestry management.

## *4.3 Profitability comparison between Poland and Lithuania.*

Polish pine stand with the same total volume has lower profitability than Lithuanian stands according to IRR and NPV. Reasons are in higher establishing costs and more frequent costly cleanings. The situation cannot be changed without changing legally binding rules, for example the number of seedlings planted. If nowadays there are 9, 000 pine seedlings planted per hectare in Poland and 4,700 in Lithuania, it is obvious that early treatments need to be more frequent in Poland and after the late cleaning time 50% of stems need to be removed. Costs of forest activities in 2006 are similar in both countries but wood prices were much higher in Poland. That is why carrying out frequent and more costly early treatments while having high wood prices is making the production of forest profitable in Poland. Spruce stands in 2006 in Poland have 60% higher total incomes than Lithuanian spruce stands. It is a result of much higher productivity and higher wood prices in every assortment. The described differences are creating a much better economic situation according to IRR, NPV and FR in Polish spruce stands in comparison with Lithuania. Hypothesis number four claiming that Scots pine and Norway spruce on II site index in Lithuania is having higher profitability according to IRR and NPV than Scots pine and Norway spruce on II site index in Poland is disproved according to spruce stands but proved in pine stands comparative analysis. Before finishing project calculations it was expected that shorter rotation ages in Lithuania will create a better economical situation in comparison with Poland. Additionally it was not expected that wood prices in 2006 will differ much between countries. It also turned out that a typical rotation age for pine is 100 years in Poland and 105 in Lithuania, and a total yield is the same when in spruce differences are bigger, in Lithuania rotation age is 75 years and in Poland typical rotation for spruce is 100 and Polish spruce stands total yield is two times higher than Lithuanian respectively 871m³ and 463m³. One explanation of this big difference lies in rotation ages – 75 years in Lithuania and 100 years in Poland. Slight influence on yield dissimilarity could have had a difference on the average height of the stands. However it is not so obvious why there is such a big variation between those two stands. Lithuanian results could be underestimated or Polish overestimated. One explanation could be higher productivity of Polish spruce stands for the reason that according to the tables spruce stand on II site index in age 75 will have around 600 $m^3$ total volume and in Lithuania it is 463$m^3$. Finally, a reason for a much lower total yield in Lithuanian stand could be a higher mortality rate caused by more seldom thinning operations. Therefore yields in spruce stands relevant to rotations are much higher in Poland than in Lithuania.

Moreover despite of the differences in wood prices and total yields, in Lithuania, NPV is lower probably due to less thinnings resulting in income spread in time, which has the highest influence on NPV during rotation.

High wood prices in Poland are also expressed in forest rent which is much higher in Polish pine and spruce stands than in Lithuanian ones. It is quite interesting that neighbouring countries like Lithuania and Poland have such a big difference in wood prices in 2006. For example the price of 1 $m^3$ of spruce fuel wood in Poland was 21 euro and in Lithuania only 12. There are a big differences in every assortment. The increase of coniferous wood prices in Lithuania came in the 2006 – 2007 period and it was enormous. To compare, saw log prices increased by 38% in Lithuania and in Poland 8%, pulpwood by 225% in Lithuania and in Poland by 10%, firewood by 43% in Lithuania when in Poland by ca. 7% (Jasinevičius, 2008). It can be said that a comparison of cash flow analysis between Lithuania and Poland will present much different results in 2007 than in 2006.

In general, similar trends in forestry markets in Lithuania and Poland are observed. Wood prices are going up and labour costs as well. Significant changes in wood prices increased profitability of forestry practice in Lithuania as well as Poland. Wood production costs vary depending on the region Poland and Lithuania; treatments are substantially more expensive around big cities.

The high number of people employed in the forestry sector in Lithuania can be linked to traditions and salaries. During the last ten years salaries increased by 270% - from 210 € in 1996 to 560 € in 2006, in the period when inflation rate was not significant (Jasinevičius 2008). In Poland, an average State Forests salary in 2006 was much higher than in Lithuania and it was 1156 €. Administrative costs in Lithuania correspond to 11% ; and it means around 31 Euro per hectare every year. In Poland administration costs in 2006 corresponds to 33.7% and ca. 80 euro per hectare. These costs depend directly on the number of employees, which is very high in Lithuania and in Poland, especially when compared to Scandinavian countries for example. However, 2.5 times higher administration costs per hectare in Poland than in Lithuania have a big influence on NPV level and differences between the two countries (Table 32). Hypothesis number five claiming that administration costs in 2006 in pine and spruce stand will decrease profitability more severely according to IRR and NPV in Poland than in Lithuania could be fully proved.

# 5. Conclusions

A long production period and uniqueness of forestry holding is making forestry calculations difficult to perform and investments profitability is very low. Economical efficiency is highly dependable on volumes harvested (spruce stands more profitable than pine) and forest production. There are no economic considerations in Polish management programme and it has a very big influence on production profitability (more required treatments less profitable). Project results showed that spruce stands with much higher total volume and slightly lower establishing costs are more profitable than pine stands according to IRR, NPV and FR. Countries comparison analysis also revealed a huge difference in wood prices for every assortment in year 2006, they were as much as two times higher in Poland. Calculations made on Polish pine and spruce stands with administration costs on most common second site index are presenting that they are not profitable according to IRR and NPV. However forest rent stayed positive. Considering State Forests as an enterprise which has no loans in the banks, the positive forest rent in investigated stands is showing that Lithuanian and Polish forestry practice is bringing profit. Contemporary market with low labour costs and high wood prices is creating favourable situation for both countries' forestry profitability. However, fluctuating prices are creating uncertainties in long term forestry projects. Project results also show that modern State Forests practice required by law is not economically attractive for private owners. The economic analysis of main commercial species at stand level allows expecting that Polish State Forests can be managed profitably however forests and forest management cannot be submitted to maximization of incomes and solutions transferred from private managing. Results of the project are leading to conclusions that most likely administration costs have to be decreased in future as they are taking to significant share in total costs of forestry activities. Only those entrepreneurs who are willing to freeze their capital for long time in bringing low interest rate investment can invest money in forest. Wood production is also a burden for non-productive services which results in higher costs. Lithuanian and Polish forestry may have to introduce different models for forestry management like lowering personal costs, mechanization, increasing salaries depending on work results, reduction of working places, decentralization of organizational structure and managing, lowering the administration workers' number and increasing the use of private companies.

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Starachowice district

http://www.radom.lasy.gov.pl/starachowice/

Herby district

http://bip.lp.gov.pl/pl/bip/dg/rdlp_katowice/nadl_herby

Namysłów district

http://bip.lp.gov.pl/pl/bip/dg/rdlp_katowice/nadl_namyslow

Currency converter

http://www.oanda.com/convert/classic

# 7.Appendixes

## Appendix 1

### Data from Herby district

**Calculations of incomes from 1ha of stand -pine-100 years, spruce-100 years (Herby)**

| Detailed list | Measurement unit | 2001 | | 2006 | |
|---|---|---|---|---|---|
| | | pine | spruce | pine | spruce |
| Price for deep-hole planting | PLN/1,000items | 173.51 | 173.51 | 187.31 | 187.31 |
| Number of plants | items/ha | 10,000 | 5,000 | 9,000 | 4,000 |
| Plants price (spruce-2/0, pine-2/0) | PLN/1,000items | 140 | 170 | 72 | 134.24 |
| Plants price (spruce-2/0, pine-2/0) | PLN / ha | 1,400 | 850 | 648 | 536.96 |
| Cost for deep-hole planting | PLN / ha | 1735.10 | 867.55 | 1685.79 | 749.24 |
| Soil preparation by forest plough | PLN / ha | 769.79 | 769.79 | 1833.67 | 1833.67 |
| Soil cultivation,mowing x 3 | PLN / ha | 875.49 | 875.49 | 1046.67 | 1046.67 |
| Cost of early cleaning - 1 treatment | PLN / ha | 238.34 | 238.34 | 297.03 | 297.03 |
| Cost of early cleaning - second treatment | PLN / ha | 238.34 | 238.34 | 297.03 | 297.03 |
| Cost of late cleaning - first treatment | PLN / ha | 293.38 | 293.38 | 324.59 | 324.59 |
| Cost of late cleaning - second treatment | PLN / ha | - | - | 250.94 | 250.94- |
| Pine repellenting x2 | PLN / ha | 171 | - | 373 | - |
| Total early stage management costs | PLN / ha | 5483.1 | 3894.55 | 6459.69 | 5039.1 |

| Harvesting costs: | | | | | |
|---|---|---|---|---|---|
| Pine, Spruce-I and II stand quality. Land reclamation | PLN / ha | 631.51 | 631.51 | 1110.79 | 1110.79 |
| Average price for coniferous wood | PLN /m³ | 150.30 | | 150.14 | |
| efficiency of cuttings: | | pine | | spruce | |
| Early thinning - age 20-40 years (II stand quality) | $m^3$/ ha | 19 | | 20 | |
| Early thinning - age 20-40 years (I stand quality) | $m^3$/ ha | 37 | | 43 | |
| Late thinning-age (90-40years Pine,90-40years Spruce) II stand quality | $m^3$/ ha | 236 | | 433 | |
| Late thinning-age(90-40years Pine,90-40years Spruce)I stand quality | $m^3$/ ha | 290 | | 556 | |
| Final cuttings products (stocking | $m^3$/ ha | 444 | | 606 | |

| | | | |
|---|---|---|---|
| index-1.0)- II stand quality | | | |
| Final cuttings products (stocking index-1.0)- I stand quality | $m^3$/ ha | 514 | 734 |
| Sum of final cutting products I stand quality | $m^3$/ha | 841 | 1,333 |
| Sum of final cutting products II stand quality | $m^3$/ha | 699 | 1,059 |
| Price of services in harvesting: | | altogether 2001 | altogether 2006 |
| Harvesting and extraction- Early Thinning | PLN / $m^3$ | 37.35 | 46.24 |
| Harvesting and extraction- Late Thinning | PLN / $m^3$ | 26.64 | 36.96 |
| Harvesting and extraction- Final Felling | PLN / $m^3$ | 20.46 | 28.10 |

| Treatment | Pine and spruce wood assortments in percentage share 2001 | | | | |
|---|---|---|---|---|---|
| | W | S1 | S2 | S3 | S4 |
| ET | 0 | 27 | 19 | 52 | 2 |
| Lt | 14 | 59 | 13 | 13 | 1 |
| FF | 80 | 2 | 14 | 0 | 4 |
| | Price in PLN for coniferous wood assortments in percentage share year 2001 | | | | |
| Pine and spruce | 191.29 | 108.6 | 77.37 | 71.84 | 56.02 |
| Treatment | Pine and spruce wood assortments in percentage share 2006 | | | | |
| | W | S1 | S2 | S3 | S4 |
| ET | 0.0 | 10 | 75 | 10 | 5 |
| LT | 22 | 36 | 38 | 1 | 3 |
| FF | 80 | 2 | 14 | 0 | 4 |
| | Price in PLN for coniferous assortments in year 2006 | | | | |
| Pine and spruce | 197.92 | 163.34 | 99.03 | 109.88 | 75.33 |

# Appendix 2

**Data from Namysłów district**

**Calculations of incomes from 1ha of stand -pine-100 years, spruce-100 years**

| Detailed list | Measurement unit | 2001 | | 2006 | |
|---|---|---|---|---|---|
| | | pine | spruce | pine | spruce |
| Price for deep-hole planting | PLN/1000 items | 210 | 210 | 180 | 180 |
| Number of plants | items/ha | 10,000 | 5,000 | 9,000 | 5,000 |
| Plants price (Spruce-1/0, Pine-1/0) | PLN/1000items | 100 | 160 | 96 | 102 |
| Plants price (Spruce-1/1, Pine-1/0) | PLN/ ha | 1,000 | 800 | 864 | 510 |
| Cost for deep-hole planting | PLN/ ha | 2,100 | 1,050 | 1,620 | 900 |
| Soil preparation by forest plough | PLN/ ha | 500 | 500 | 700 | 700 |
| Soil cultivation,mowing x 3 | PLN/ ha | 800 | 800 | 1,200 | 1,200 |
| Cost of early cleaning - 1 treatment | PLN/ ha | 250 | 250 | 280 | 280 |
| Cost of early cleaning - second treatment | PLN/ ha | 250 | 250 | 280 | 280 |
| Cost of late cleaning - first treatment | PLN/ ha | 310 | 310 | 300 | 300 |
| Cost of late cleaning - second treatment | PLN/ ha | 280 | 280 | 280 | 280 |
| Pine repellenting(x2) | PLN/ ha | 280 | - | 280 | - |
| Total early stage management costs | PLN/ha | 5,770 | 4,240 | 5,804 | 4,450 |

| | | | | | |
|---|---|---|---|---|---|
| Final harvesting costs: | | | | | |
| Pine, Spruce-I stand quality. Land reclamation | PLN/ ha | 420 | 560 | 1,280 | 1,430 |
| Harvesting costs: | | | | | |
| Pine, Spruce-II stand quality. Land reclamation | PLN/ ha | 350 | 470 | 1,070 | 1,190 |
| Price for coniferous wood | PLN/ $m^3$ | 118 | | 166 | |

| efficiency of cuttings: | | pine | spruce |
|---|---|---|---|
| Early thinning - age 20-40 years (II stand quality) | $m^3$/ ha | 19 | 20 |
| Early thinning - age 20-40 years (I stand quality) | $m^3$/ ha | 37 | 43 |
| Late thinning-age(90-40years pine,90-40years spruce) II stand quality | $m^3$/ ha | 236 | 433 |

| | | | |
|---|---|---|---|
| Late thinning-age(90-40years pine,90-40years spruce)I stand quality | $m^3$/ ha | 290 | 556 |
| Final cuttings products (stocking index-1.0)- II stand quality | $m^3$/ ha | 444 | 606 |
| Final cuttings products (stocking index-1.0)- I stand quality | $m^3$/ ha | 514 | 734 |
| Sum of final cutting products I stand quality | $m^3$/ha | 841 | 1,333 |
| Sum of final cutting products II stand quality | $m^3$/ha | 699 | 1,059 |
| | | | |
| Price of services in harvesting: | | altogether 2001 | altogether 2006 |
| Harvesting and extraction-Early Thinning | PLN / $m^3$ | 47 | 57 |
| Harvesting and extraction-Late Thinning | PLN / $m^3$ | 33 | 45 |
| Harvesting and extraction-Final Felling | PLN / $m^3$ | 19 | 25 |

| Treatment | Wood assortments in percentage share year 2006 | | | | | | |
|---|---|---|---|---|---|---|---|
| | WB | WC | WD | S1 | S2 | S3 | S4 |
| pine Lt | 1 | 17 | 2 | 4 | 73 | 1 | 2 |
| pine ET | 0 | 1 | 0 | 2 | 89 | 6 | 2 |
| spruce Lt | 0 | 17 | 25 | 0 | 48 | 1 | 9 |
| spruce ET | 0 | 2 | 1 | 0 | 81 | 7 | 9 |
| pine FF | 24 | 51 | 3 | 0 | 18 | 0 | 4 |
| spruce FF | 6 | 39 | 19 | 0 | 33 | 0 | 3 |
| Species | Prices in PLN for wood assortmens, year 2006 | | | | | | |
| pine | 236 | 196 | 146 | 140 | 104 | 56 | 75 |
| spruce | 242 | 199 | 153 | 157 | 110 | 82 | 70 |
| | | | | | | | |
| Treatments | Wood assortments in percentage share, year 2001 | | | | | | |
| | WB | WC | WD | S1 | S2 | S3 | S4 |
| pine Lt | 1 | 24 | 0 | 27 | 43 | 2 | 3 |
| pine ET | 0 | 3 | 0 | 5 | 65 | 25 | 2 |
| spruce Lt | 1 | 40 | 4 | 5 | 18 | 9 | 23 |
| spruce ET | 0 | 13 | 1 | 2 | 45 | 17 | 22 |
| pine FF | 28 | 61 | 0 | 0 | 7 | 0 | 4 |
| spruce FF | 9 | 63 | 4 | 1 | 5 | 4 | 14 |
| Price in PLN for wood assortments, year 2001 | | | | | | | |
| pine | 253 | 175 | 101 | 108 | 78 | 54 | 47 |
| spruce | 244 | 178 | 101 | 112 | 77 | 61 | 40 |

# Appendix 3

**Data from Starachowice district**

**Calculations of incomes from 1ha of stand pine-100 years, spruce-100 years**

| | | 2001 | | 2006 | |
|---|---|---|---|---|---|
| Detailed list | Unit of measurement | pine | spruce | pine | spruce |
| | | | | | |
| Price for deep-hole planting | PLN/1000 items | 131.00 | 167.00 | 217.35 | 217.35 |
| Number of plants | items/ha | 13,000 | 5,000 | 9,000 | 4,000 |
| Plants price (spruce-1/1, pine-1/0) | PLN/1000items | 150.00 | 450.00 | 151.00 | 450.00 |
| Plants price (spruce-1/1, pine-1/0) | PLN/ha | 1950.00 | 2250.00 | 1359.00 | 1800.00 |
| Cost for deep-hole planting | PLN/ha | 1703.0 | 835.00 | 1956.15 | 869.40 |
| Soil preparation by forest plough | PLN/ha | 946.98 | 946.98 | 946.98 | 946.98 |
| Soil cultivation,mowing x 3 | PLN/ha | 681.00 | 454.00 | 1156.86 | 771.24 |
| Cost of early cleaning - 1 treatment | PLN/ha | 202.00 | 202.00 | 264.60 | 264.60 |
| Cost of early cleaning - second treatment | PLN/ha | 202.00 | 202.00 | 264.60 | 264.60 |
| Cost of late cleaning - first treatment | PLN/ha | 222.00 | 222.00 | 321.30 | 321.30 |
| Cost of late cleaning - second treatment | PLN/ha | 222.00 | 222.00 | 288.23 | 288.23 |
| Pine repellenting(x2) | PLN/ha | 184.00 | 0.00 | 674.00 | 0.00 |
| Total early stage management costs | PLN/ha | 6312.98 | 5333.98 | 7231.72 | 5526.35 |

| Harvesting costs: | | | | | |
|---|---|---|---|---|---|
| Pine, spruce-I and II stand quality. Land reclamation | PLN/ha | 735.19 | 735.19 | 758.42 | 758.42 |
| Price for coniferous wood | PLN/m3 | 150.69 | | 170.06 | |

| efiiciency of cuttings volume without bark: | | So | Św |
|---|---|---|---|
| Early thinning - age 20-40 years (II stand quality) | $m^3$/ha | 32.84 | 32 |
| Early thinning - age 20-40 years (I stand quality) | $m^3$/ha | 49.80 | 39.2 |
| Late thinning-age(90-40years pine,90-40years spruce)II s.q. | $m^3$/ha | 195.47 | 385.37 |
| Late thinning-age(90-40years pine,90-40years spruce)I s.q. | $m^3$/ha | 215.50 | 500.0 |
| Final cuttings products (stocking index-1,0)- II stand quality | $m^3$/ha | 311.82 | 551.46 |
| Final cuttings products (stocking index-1,0)- I stand quality | $m^3$/ha | 375.80 | 673.08 |
| Sum of final cutting products I stand quality | $m^3$/ha | 641.10 | 1211.05 |
| Sum of final cutting products II stand | $m^3$/ha | 538.13 | 953.0 |

| quality | | | |
|---|---|---|---|
| Price of services in harvesting: | | Altogether 2001 | Altogether 2006 |
| Harvesting and extraction- Early Thinning | PLN/m³ | 37.73 | 45.24 |
| Harvesting and extraction- Late Thinning | PLN/m³ | 30.27 | 35.31 |
| Harvesting and extraction- Final Felling | PLN/m³ | 24.54 | 26.31 |

| Treatment | Wood assortments in percentage share, year 2001 and 2006 | | | | | | |
|---|---|---|---|---|---|---|---|
| % | WB | WC | WD | S1 | S2 | S3 | S4 |
| pine Lt | 1 | 12 | 0 | 36 | 51 | 0 | 0 |
| pine ET | 0 | 0 | 0 | 5 | 95 | 0 | 0 |
| spruce Lt | 0 | 25 | 20 | 0 | 55 | 0 | 0 |
| spruce ET | 0 | 6 | 0 | 0 | 94 | 0 | 0 |
| pine FF | 26 | 58 | 1 | 0 | 12 | 0 | 3 |
| spruce FF | 0 | 60 | 19 | 0 | 21 | 0 | 0 |
| Price in PLN for wood assortments, year 2001 | | | | | | | |
| Species | | | | | | | |
| pine | 246 | 196 | 140 | 99 | 68 | 94 | 57 |
| spruce | 205 | 199 | 129 | 102 | 63 | 0 | 52 |
| | | | | | | | |
| Price in PLN for wood assortments, year 2006 | | | | | | | |
| | | | | | | | |
| Pine | 247 | 203 | 151 | 126 | 93 | 99 | 78 |
| Spruce | 274 | 206 | 169 | 143 | 96 | 111 | 75 |

## Appendix 4

### Cash flow in spruce stand II site quality in Herby district

| Spruce II site quality Herby | | 2001 | | | | 2006 | | |
|---|---|---|---|---|---|---|---|---|
| | Intensity [m3] | Year | Income [€] | Cost [€] | DCF [€] | Income [€] | Cost [€] | DCF [€] |
| planting and soil preparation | | 0 | 0 | 711 | -711 | 0 | 891 | -891 |
| mowing | | 2 | 0 | 83 | -79 | 0 | 149 | -141 |
| mowing | | 3 | 0 | 83 | -76 | 0 | 149 | -137 |
| EC | | 8 | 0 | 68 | -54 | 0 | 85 | -67 |
| LC | | 12 | 0 | - | 0 | 0 | 93 | -65 |
| LC | | 15*17 | 0 | 84 | -54 | 0 | 72 | -43 |
| ET | 35 | 29 | 825 | 374 | 192 | 1,054 | 462 | 251 |
| Lt | 63 | 45 | 1,995 | 480 | 401 | 2,580 | 665 | 506 |
| Lt | 69 | 55 | 2,185 | 525 | 327 | 2,826 | 729 | 413 |
| Lt | 73 | 65 | 2,311 | 556 | 257 | 2,990 | 771 | 325 |
| Lt | 77 | 75 | 2,438 | 586 | 202 | 3,153 | 813 | 255 |
| Lt | 81 | 85 | 2,565 | 617 | 158 | 3,317 | 845 | 200 |
| FF, land reclamation | 446 | 100 | 21,443 | 2,787 | 971 | 22,743 | 3,898 | 981 |

| 2001 | | 2006 | |
|---|---|---|---|
| IRR | 4.5% | IRR | 4.3% |
| FR | 268 € | FR | 290 € |
| NPV(r=3%) | 1,533 € | NPV (r=3 %) | 1,586 € |

* year 2001

## Appendix 5

**Cash flow in spruce stand I site quality in Herby district**

| Spruce I site quality Herby | | 2001 | | | | 2006 | | |
|---|---|---|---|---|---|---|---|---|
| | Intensity [m3] | Year | Income [€] | Cost [€] | DCF [€] | Income [€] | Cost [€] | DCF [€] |
| planting and soil preparation | | 0 | 0 | 711 | -711 | 0 | 891 | -891 |
| mowing | | 2 | 0 | 83 | -79 | 0 | 149 | -141 |
| mowing | | 3 | 0 | 83 | -76 | 0 | 149 | -137 |
| EC | | 8 | 0 | 68 | -54 | 0 | 85 | -67 |
| LC | | 12 | - | - | - | 0 | 93 | -65 |
| LC | | 15*17 | 0 | 84 | -54 | 0 | 72 | -43 |
| ET | 43 | 29 | 1,014 | 374 | 272 | 1294 | 568 | 308 |
| Lt | 70 | 45 | 2,216 | 533 | 445 | 2867 | 739 | 563 |
| Lt | 77 | 55 | 2,438 | 586 | 364 | 3153 | 813 | 460 |
| Lt | 86 | 65 | 2,723 | 655 | 303 | 3522 | 908 | 383 |
| Lt | 93 | 75 | 2,944 | 708 | 244 | 3809 | 982 | 308 |
| Lt | 101 | 85 | 3,198 | 769 | 197 | 4136 | 1,067 | 249 |
| FF, land reclamation | 540 | 100 | 25,963 | 3337 | 1,177 | 27537 | 4,653 | 1191 |

| 2001 | | 2006 | |
|---|---|---|---|
| IRR | 4.8 % | IRR | 4.6 % |
| FR | 325 € | FR | 351 € |
| NPV (r= 3%) | 2,029 € | NPV (r=3%) | 2,117 € |

## Appendix 6

**Cash flow in spruce stand II site quality in Namysłów district**

| Spruce II site quality Namysłów | | 2001 | | | | 2006 | | |
|---|---|---|---|---|---|---|---|---|
| | Intensity [m3] | Year | Income [€] | Cost [€] | DCF [€] | Income [€] | Cost [€] | DCF [€] |
| planting and soil preparation | | 0 | | 671 | -671 | 0 | 603 | -603 |
| mowing | | 2 | | 57 | -54 | 0 | 114 | -114 |
| mowing | | 3 | | 57 | -52 | 0 | 114 | -114 |
| EC | | 8 | | 71 | -56 | 0 | 80 | -80 |
| LC | | 15 | | 80 | -51 | 0 | 80 | -80 |
| ET | 25 | 26 | 573 | 336 | 110 | 762 | 407 | 355 |
| Lt | 60 | 45 | 1,917 | 566 | 357 | 2,263 | 771 | 1,491 |
| Lt | 65 | 55 | 2,077 | 613 | 288 | 2,451 | 836 | 1,616 |
| Lt | 71 | 65 | 2,269 | 669 | 234 | 2,678 | 913 | 1,765 |
| Lt | 78 | 75 | 2,492 | 735 | 191 | 2,942 | 1,003 | 1,939 |
| Lt | 80 | 85 | 2,556 | 754 | 146 | 3,017 | 1,029 | 1,989 |
| FF, land reclamation | 445 | 100 | 19,218 | 2,550 | 867 | 20,292 | 3,544 | 16,748 |

| 2001 | | 2006 | |
|---|---|---|---|
| IRR | 4.42,% | IRR | 4.51,% |
| FR | 239 € | FR | 249 € |
| NPV(r=3%) | 1,309 € | NPV(r=3%) | 1,449 € |

# Appendix 7

**Cash flow in spruce stand I site quality in Namysłów district**

| Spruce I site quality Namysłów | | 2001 | | | | 2006 | | |
|---|---|---|---|---|---|---|---|---|
| | Intensity [m3] | Year | Income [€] | Cost [€] | DCF [€] | Income [€] | Cost [€] | DCF [€] |
| planting and soil preparation | | 0 | | 671 | -671 | 0 | 603 | -603 |
| mowing | | 2 | | 57 | -54 | 0 | 114 | -108 |
| mowing | | 3 | | 57 | -52 | 0 | 114 | -105 |
| EC | | 8 | | 71 | -56 | 0 | 80 | -63 |
| LC | | 15 | | 80 | -51 | 0 | 80 | -51 |
| ET | 35 | 26 | 802 | 470 | 154 | 1,067 | 570 | 230 |
| Lt | 76 | 45 | 2,428 | 717 | 453 | 2,866 | 977 | 499 |
| Lt | 82 | 55 | 2,620 | 773 | 363 | 3,093 | 1,054 | 401 |
| Lt | 92 | 65 | 2,939 | 867 | 303 | 3,470 | 1,183 | 335 |
| Lt | 98 | 75 | 3,131 | 924 | 241 | 3,696 | 1,260 | 265 |
| Lt | 108 | 85 | 3,451 | 1,018 | 197 | 4,073 | 1,389 | 218 |
| FF, land reclamation | 537 | 100 | 23,191 | 3,075 | 1,047 | 24,487 | 4,244 | 1,053 |

| 2001 | | 2006 | |
|---|---|---|---|
| IRR | 4.76% | IRR | 4.89 % |
| FR | 298 € | FR | 311 € |
| NPV(r=3%) | 1,872 € | NPV(r=3%) | 2,072 € |

## Appendix 8

**Cash flow in spruce stand II site quality in Starachowice district**

| Spruce II site quality Starachowice | | 2001 | | | | 2006 | | |
|---|---|---|---|---|---|---|---|---|
| | Intensity [m3] | Year | Income [€] | Cost [€] | DCF [€] | Income [€] | Cost [€] | DCF [€] |
| planting and soil preparation | | 0 | 0 | 1,152 | -1,152 | 0 | 1,033 | -1,033 |
| mowing | | 2 | 0 | 43 | -41 | 0 | 73 | -69 |
| mowing | | 3 | 0 | 43 | -39 | 0 | 73 | -67 |
| EC | | 8 | 0 | 58 | -46 | 0 | 76 | -60 |
| LC | | 15 | 0 | 63 | -41 | 0 | 92 | -59 |
| ET | | 22 | 305 | 162 | 75 | 440 | 194 | 128 |
| ET | 15 | 29 | 407 | 216 | 81 | 586 | 259 | 139 |
| Lt | 20 | 45 | 1,889 | 519 | 362 | 2,367 | 605 | 466 |
| Lt | 60 | 55 | 2,078 | 571 | 297 | 2,604 | 666 | 381 |
| Lt | 66 | 65 | 2,204 | 605 | 234 | 2,762 | 706 | 301 |
| Lt | 70 | 75 | 2,330 | 640 | 184 | 2,920 | 747 | 237 |
| Lt | 74 | 85 | 2,424 | 666 | 143 | 3,038 | 777 | 183 |
| FF, land reclamation | 77 | 100 | 21,955 | 3,639 | 953 | 20,095 | 3,893 | 843 |

| 2001 | | 2006 | |
|---|---|---|---|
| IRR | 3.8 % | IRR | 4.2 % |
| FR | 252 € | FR | 256 € |
| NPV (r=3%) | 1,010 € | NPV(r=3%) | 1,391 € |

## Appendix 9

**Cash flow in spruce stand I site quality in Starachowice district**

| Spruce I site quality Starachowice | | 2001 | | | | 2006 | | |
|---|---|---|---|---|---|---|---|---|
| | Intensity [m3] | Year | Income [€] | Cost [€] | DCF [€] | Income [€] | Cost [€] | DCF [€] |
| planting and soil preparation | | 0 | 0 | 1152 | -1152 | 0 | 1033 | -1,033 |
| mowing | | 2 | 0 | 43 | -41 | 0 | 73 | -69 |
| mowing | | 3 | 0 | 43 | -39 | 0 | 73 | -67 |
| EC | | 8 | 0 | 58 | -45 | 0 | 76 | -60 |
| LC | | 15 | 0 | 63 | -41 | 0 | 92 | -59 |
| ET | | 22 | 569 | 216 | 100 | 586 | 259 | 171 |
| ET | 20 | 29 | 844 | 248 | 151 | 674 | 297 | 160 |
| Lt | 23 | 45 | 2,645 | 519 | 362 | 2,367 | 605 | 466 |
| Lt | 60 | 55 | 3,526 | 692 | 359 | 3,157 | 807 | 462 |
| Lt | 80 | 65 | 3,967 | 778 | 301 | 3,551 | 908 | 387 |
| Lt | 90 | 75 | 4,408 | 865 | 249 | 3,946 | 1,009 | 320 |
| Lt | 100 | 85 | 5,290 | 1,038 | 222 | 4,735 | 1,211 | 286 |
| FF, land reclamation | 120 | 100 | 33,816 | 3,982 | 1,050 | 22,107 | 4,261 | 929 |

| 2001 | | 2006 | |
|---|---|---|---|
| IRR | 4.1 % | IRR | 4.5 % |
| FR | 296 € | FR | 304 € |
| NPV (r=3%) | 1,475 € | NPV (r=3%) | 1,391 € |

## Appendix 10

**Cash flow in pine stand II site quality in Herby district**

| Pine II site quality Herby | | 2001 | | | | 2006 | | |
|---|---|---|---|---|---|---|---|---|
| | Intensity [m3] | Year | Income [€] | Cost [€] | DCF [€] | Income [€] | Cost [€] | DCF [€] |
| planting and soil preparation | | 0 | 0 | 1116 | -1116 | 0 | 1,191 | -1191 |
| mowing, repellents | | 1 | 0 | 108 | -105 | 0 | 153 | -149 |
| mowing, repellents | | 2 | 0 | 108 | -102 | 0 | 153 | -144 |
| mowing | | 3 | 0 | 83 | -76 | 0 | 100 | -91 |
| EC | | 5 | 0 | 68 | -59 | 0 | 85 | -73 |
| EC | | 8 | 0 | 68 | -54 | 0 | 85 | -67 |
| LC | | 12 | 0 | 84 | -59 | 0 | 93 | -65 |
| LC | | 16 | 0 | - | - | 0 | 72 | -45 |
| ET | 18 | 28 | 424 | 192 | 101 | 542 | 238 | 133 |
| Lt | 34 | 45 | 1076 | 259 | 216 | 1392 | 359 | 273 |
| Lt | 36 | 55 | 1140 | 274 | 170 | 1474 | 380 | 215 |
| Lt | 37 | 65 | 1171 | 282 | 130 | 1515 | 391 | 165 |
| Lt | 39 | 75 | 1235 | 297 | 102 | 1597 | 412 | 129 |
| Lt | 41 | 85 | 1298 | 312 | 80 | 1679 | 433 | 101 |
| FF, land reclamation | 312 | 100 | 15001 | 2004 | 676 | | 2,822 | 681 |

| 2001 | | 2006 | |
|---|---|---|---|
| IRR | 2.9 % | IRR | 2.9 % |
| FR | 161 € | FR | 171 € |
| NPV (r=3%) | -93 € | NPV (r=3%) | -127 € |

## Appendix 11

**Cash flow in pine stand I site quality in Herby district**

| Pine I site quality Herby | | 2001 | | | | 2006 | | |
|---|---|---|---|---|---|---|---|---|
| | Intensity [m3] | Year | Income [€] | Cost [€] | DCF [€] | Income [€] | Cost [€] | DCF [€] |
| planting and soil preparation | | 0 | | 1,116 | -1116 | 0 | 1,191 | -1191 |
| mowing, repellents | | 1 | | 108 | -105 | 0 | 153 | -149 |
| mowing, repellents | | 2 | | 108 | -102 | 0 | 153 | -144 |
| mowing | | 3 | | 83 | -76 | 0 | 100 | -91 |
| EC | | 5 | | 68 | -59 | 0 | 85 | -73 |
| EC | | 8 | | 68 | -54 | 0 | 85 | -67 |
| LC | | 12 | | 84 | -59 | 0 | 93 | -65 |
| LC | | 16 | | - | - | 0 | 72 | -45 |
| ET | 35 | 28 | 814 | 373 | 192 | 1216 | 462 | 329 |
| Lt | 38 | 45 | 1203 | 289 | 242 | 1556 | 401 | 305 |
| Lt | 44 | 55 | 1393 | 335 | 208 | 1802 | 465 | 263 |
| Lt | 47 | 65 | 1488 | 358 | 165 | 1925 | 496 | 209 |
| Lt | 50 | 75 | 1583 | 381 | 131 | 2048 | 528 | 166 |
| Lt | 55 | 85 | 1741 | 419 | 107 | 2252 | 581 | 136 |
| FF, land reclamation | 360 | 100 | 17308 | 2,285 | 782 | 18358 | 3,208 | 788 |

| 2001 | | 2006 | |
|---|---|---|---|
| IRR | 3.3 % | IRR | 3.3 % |
| FR | 195 € | FR | 211 € |
| NPV (r=3%) | 258 € | NPV (r=3%) | 372 € |

## Appendix 12

**Cash flow in pine stand II site quality in Namysłów district**

| Pine II site quality Namysłów | | 2001 | | | | 2006 | | |
|---|---|---|---|---|---|---|---|---|
| | Intensity [m3] | Year | Income [€] | Cost [€] | DCF [€] | Income [€] | Cost [€] | DCF [€] |
| planting and soil preparation | | | 0 | 1,029 | -1116 | 0 | 910 | -910 |
| mowing, repellents | | 1 | 0 | 116 | -105 | 0 | 154 | -150 |
| mowing, repellents | | 2 | 0 | 116 | -102 | 0 | 154 | -145 |
| mowing | | 3 | 0 | 76 | -76 | 0 | 114 | -105 |
| EC | | 5 | 0 | 71 | -59 | 0 | 80 | -69 |
| EC | | 7 | 0 | 71 | -54 | 0 | 80 | -65 |
| LC | | 12 | 0 | 89 | -59 | 0 | 86 | -60 |
| LC | | 16 | 0 | 80 | 101 | 0 | 80 | -50 |
| ET | 17 | 28 | 424 | 228 | 216 | 496 | 277 | 96 |
| Lt | 32 | 45 | 1,076 | 302 | 170 | 1,117 | 411 | 187 |
| Lt | 35 | 55 | 1,140 | 330 | 130 | 1,222 | 450 | 152 |
| Lt | 37 | 65 | 1,171 | 349 | 102 | 1,292 | 476 | 119 |
| Lt | 39 | 75 | 1,235 | 368 | 80 | 1,361 | 501 | 94 |
| Lt | 42 | 85 | 1,298 | 396 | 676 | 1,466 | 540 | 75 |
| FF, land reclamation | 311 | 100 | 15,001 | 1,788 | -1116 | 16,234 | 2,587 | 710 |

| 2001 | | 2006 | |
|---|---|---|---|
| IRR | 2.9 % | IRR | 2.9 % |
| FR | 161 € | FR | 163 € |
| NPV (r=3%) | -93 € | NPV (r=3%) | -121 € |

## Appendix 13

**Cash flow in pine stand I site quality in Namysłów district**

| Pine I site quality Namysłów | | 2001 | | | | 2006 | | |
|---|---|---|---|---|---|---|---|---|
| | Intensity [m3] | Year | Income [PLN] | Cost [PLN] | DCF [PLN] | Income [PLN] | Cost [PLN] | DCF [PLN] |
| planting and soil preparation | | 0 | 0 | 3600 | -3600 | | 3184 | -3184 |
| mowing, repellents | | 1 | 0 | 407 | -395 | | 540 | -524 |
| mowing, repellents | | 2 | 0 | 407 | -384 | | 540 | -509 |
| mowing | | 3 | 0 | 266 | -243 | | 400 | -366 |
| EC | | 5 | 0 | 250 | -216 | | 280 | -242 |
| EC | | 7 | 0 | 250 | -203 | | 280 | -228 |
| LC | | 12 | 0 | 310 | -217 | | 300 | -210 |
| LC | | 16 | 0 | 280 | -174 | | 280 | -174 |
| ET | 31 | 28 | 2,349 | 1,457 | 390 | 3,168 | 1,767 | 612 |
| Lt | 35 | 45 | 3,840 | 1,155 | 710 | 4,276 | 1,575 | 714 |
| Lt | 39 | 55 | 4,279 | 1,287 | 589 | 4,765 | 1,755 | 592 |
| Lt | 46 | 65 | 5,047 | 1,518 | 517 | 5,620 | 2,070 | 520 |
| Lt | 51 | 75 | 5,596 | 1,683 | 426 | 6,231 | 2,295 | 429 |
| Lt | 57 | 85 | 6,254 | 1,881 | 355 | 6,964 | 2,565 | 357 |
| FF, land reclamation | 360 | 100 | 66,575 | 7,260 | 3,086 | 65,772 | 10,128 | 2,895 |

| 2001 | | 2006 | |
|---|---|---|---|
| IRR | 3.15 % | IRR | 3.16 % |
| FR | 719 € | FR | 688 € |
| NPV (r=3%) | 640 € | NPV (r=3%) | 682 € |

## Appendix 14

**Cash flow in pine stand II site quality in Starachowice district**

| Pine II site quality Starachowice | | | 2001 | | | 2006 | | |
|---|---|---|---|---|---|---|---|---|
| | Intensity [m3] | Year | Income [€] | Cost [€] | DCF [€] | Income [€] | Cost [€] | DCF [€] |
| planting and soil preparation | | 0 | | 1,314 | -1,314 | | 1,218 | -1,218 |
| mowing, repellents | | 1 | | 91 | -89 | | 207 | -201 |
| mowing, repellents | | 2 | | 91 | -86 | | 207 | -195 |
| mowing | | 3 | | 65 | -59 | | 110 | -101 |
| EC | | 5 | | 58 | -50 | | 76 | -65 |
| EC | | 7 | | 58 | -47 | | 76 | -61 |
| LC | | 12 | | 63 | -45 | | 92 | -64 |
| LC | | 16 | | 63 | -39 | | 82 | -51 |
| ET | 16 | 21 | 318 | 173 | 78 | 433 | 207 | 121 |
| ET | 20 | 28 | 397 | 216 | 79 | 541 | 259 | 123 |
| Lt | 30 | 45 | 825 | 259 | 150 | 1,025 | 303 | 191 |
| Lt | 32 | 55 | 881 | 277 | 119 | 1,094 | 323 | 152 |
| Lt | 34 | 65 | 935 | 294 | 94 | 1,162 | 343 | 120 |
| Lt | 36 | 75 | 991 | 311 | 74 | 1,230 | 363 | 95 |
| Lt | 36 | 85 | 991 | 311 | 55 | 1,230 | 363 | 70 |
| FF, land reclamation | 250 | 100 | 13,494 | 1,963 | 600 | 14,069 | 2,096 | 623 |

| 2001 | | 2006 | |
|---|---|---|---|
| IRR | 2.6 % | IRR | 2.6 % |
| FR | 132 € | FR | -461 € |
| NPV (r=3%) | -478 € | NPV (r=3%) | 145 € |

## Appendix 15

**Cash flow in pine stand I site quality in Starachowice district**

| Pine I site quality Starachowice | | | 2001 | | | 2006 | | |
|---|---|---|---|---|---|---|---|---|
| | Intensity [m3] | Year | Income [€] | Cost [€] | DCF [€] | Income [€] | Cost [€] | DCF [€] |
| planting and soil preparation | | 0 | | 1,314 | -1,314 | | 1,218 | -1,218 |
| mowing, repellents | | 1 | | 91 | -89 | | 207 | -201 |
| mowing, repellents | | 2 | | 91 | -86 | | 207 | -195 |
| mowing | | 3 | | 65 | -59 | | 110 | -101 |
| EC | | 5 | | 58 | -50 | | 76 | -65 |
| EC | | 7 | | 58 | -47 | | 76 | -61 |
| LC | | 12 | | 63 | -45 | | 92 | -64 |
| LC | | 16 | | 63 | -39 | | 82 | -51 |
| ET | 23 | 21 | 457 | 248 | 112 | 622 | 297 | 175 |
| ET | 32 | 28 | 631 | 343 | 126 | 859 | 411 | 196 |
| Lt | 30 | 45 | 825 | 259 | 150 | 1,025 | 303 | 191 |
| Lt | 33 | 55 | 908 | 285 | 123 | 1,128 | 333 | 156 |
| Lt | 36 | 65 | 991 | 311 | 99 | 1,230 | 363 | 127 |
| Lt | 42 | 75 | 1,156 | 363 | 86 | 1,435 | 424 | 110 |
| Lt | 44 | 85 | 1,211 | 381 | 67 | 1,504 | 444 | 86 |
| FF, land reclamation | 301 | 100 | 16,227 | 2,318 | 724 | 16,919 | 2,477 | 751 |

| 2001 | | 2006 | |
|---|---|---|---|
| IRR | 2.8 % | IRR | 2.9 % |
| FR | 161 € | FR | 176 € |
| NPV (r=3%) | -240 € | NPV (r=3%) | -163 € |

## Appendix 16

### Polish administration costs data

| Year 2006 | | Plan [€] | Done [€] |
|---|---|---|---|
| **Costs altogether** | | **30,0248** | **313,120** |
| Administration and service workers salaries and benefits | | 153,506 | 196,568 |
| Administration and service workers salaries surcharges | | 20,536 | 8,023 |
| Amortization and capital assets maintaining | | 60,557 | 55,255 |
| Expenses for delegations and costs of transfer | | 286 | 250 |
| Maintain administrative transport | | 4,720 | 1,437 |
| Costs of industrial safety | | 954 | 1,501 |
| Costs of in-service training | | 2,857 | 2,661 |
| Taxes, donations and charges | | 6,857 | 11,525 |
| Office expenses | | 34,966 | 19,288 |
| Representative and promotion costs | | 4,286 | 3,741 |
| Other administrative costs | | 10,723 | 12,872 |
| **Material informations:** | **Plan** | **Done** | |
| Number of employed administrative workers | 11.00 | 11.00 | |
| **Forest service workers costs altogether** | | 765,142 | 841,427 |
| Salaries and benefits of forest service workers | | 550,431 | 660,663 |
| Salaries surcharges | | 62,905 | 14,172 |
| Expenses for delegations and costs of transfer | | 4,000 | 3,755 |
| Costs of maintain of forest service workers cars | | 69,581 | 58,207 |
| Costs of maintain forest service workers apartments | | 42,639 | 57,238 |
| Costs of industrial safety | | 4,071 | 6,196 |
| Costs of in-service training | | 10,571 | 11,231 |
| Other forest service costs | | 20,944 | 29,966 |

| **Material informations:** | **Plan** | **Done** |
|---|---|---|
| Number of employed forest service workers | 33.00 | 31.00 |

## Appendix 17

**Cash flow in pine stand I and II site quality in Starachowice district in year 2006 with administration costs**

| Pine Starachowice with administration costs | | | | 2006 I site index | | | 2006 II site index | | |
|---|---|---|---|---|---|---|---|---|---|
| | Intensity [m3] | | Year | Income [€] | Cost [€] | DCF [€] | Income [€] | Cost [€] | DCF [€] |
| | I site | II | | | | | | | |
| planting and soil preparation | | | 0 | 0 | 1303 | -1303 | 0 | 1,303 | -1,303 |
| mowing, repellents | | | 1 | 0 | 292 | -284 | 0 | 292 | -284 |
| mowing, repellents | | | 2 | 0 | 292 | -275 | 0 | 292 | -275 |
| mowing | | | 3 | 0 | 196 | -179 | 0 | 196 | -179 |
| EC | | | 5 | 0 | 161 | -139 | 0 | 161 | -139 |
| EC | | | 7 | 0 | 161 | -131 | 0 | 161 | -131 |
| LC | | | 12 | 0 | 178 | -125 | 0 | 178 | -125 |
| LC | | | 16 | 0 | 168 | -105 | 0 | 168 | -105 |
| ET | 23 | 16 | 21 | 622 | 383 | 128 | 433 | 293 | 75 |
| ET | 32 | 20 | 28 | 859 | 496 | 159 | 541 | 344 | 86 |
| Lt | 30 | 30 | 45 | 1,025 | 388 | 168 | 1,025 | 388 | 168 |
| Lt | 33 | 32 | 55 | 1,128 | 419 | 140 | 1,094 | 409 | 135 |
| Lt | 36 | 34 | 65 | 1,230 | 449 | 114 | 1,162 | 429 | 107 |
| Lt | 42 | 36 | 75 | 1,435 | 509 | 101 | 1,230 | 449 | 63 |
| Lt | 44 | 36 | 85 | 1,504 | 530 | 79 | 1,230 | 449 | 63 |
| FF, land reclamation | 301 | 250 | 100 | 16,919 | 2562 | 747 | 14,069 | 2,182 | 619 |

| 2006 I site index | | 2006 II site index | |
|---|---|---|---|
| IRR | 1.2 % | IRR | 0.9 % |
| FR | 89 € | FR | 206 € |
| NPV (r=3%) | -2,957 € | NPV (r=3%) | -11,452 € |

## Appendix 18

**Cash flow in spruce stand I and II site quality in Starachowice district in year 2006 with administration costs**

| Spruce in Starachowice district with administration costs | | | | 2006 I site index | | | 2006 II site index | | |
|---|---|---|---|---|---|---|---|---|---|
| | Intensity [m3] | | | Income | Cost | DCF | Income | Cost | DCF |
| | I | II | Year | [€] | [€] | [€] | [€] | [€] | [€] |
| planting and soil preparation | | | 0 | 0 | 1,119 | -1,119 | 0 | 1119 | -1,119 |
| mowing | | | 2 | 0 | 159 | -150 | 0 | 159 | -150 |
| mowing | | | 3 | 0 | 159 | -146 | 0 | 159 | -146 |
| EC | | | 8 | 0 | 161 | -127 | 0 | 161 | -127 |
| LC | | | 15 | 0 | 178 | -114 | 0 | 178 | -114 |
| ET | 20 | 15 | 22 | 586 | 344 | 126 | 440 | 280 | 84 |
| ET | 23 | 20 | 29 | 674 | 383 | 124 | 586 | 344 | 103 |
| Lt | 60 | 60 | 45 | 2,367 | 691 | 443 | 2,367 | 691 | 443 |
| Lt | 80 | 66 | 55 | 3,157 | 893 | 445 | 2,604 | 752 | 365 |
| Lt | 90 | 70 | 65 | 3,551 | 994 | 374 | 2,762 | 792 | 288 |
| Lt | 100 | 74 | 75 | 3,946 | 1,095 | 311 | 2,920 | 832 | 227 |
| Lt | 120 | 77 | 85 | 4,735 | 1,296 | 279 | 3,038 | 863 | 176 |
| FF, land reclamation | 538 | 489 | 100 | 22,107 | 4,347 | 924 | 20,095 | 3,978 | 839 |

| 2006 I site index | | 2006 II site index | |
|---|---|---|---|
| IRR | 2.5 % | IRR | 2.1 % |
| FR | 218 € | FR | 170 € |
| NPV (r=3%) | -902 € | NPV (r=3%) | -1,404 € |

# Appendix 19

## Lithuanian State Forests administration costs

| State forest enterpise | Administration LTL/ha | Personnel of forest districts LTL/ha | Personnel of forest protection LTL/ha | Forest sanitary protection LTL/ha | Forest fire protection LTL/ha | Recreational objects building LTL/ha | Transportation LTL/ha |
|---|---|---|---|---|---|---|---|
| Alytaus | 39.6 | 63.9 | 13.7 | 1.2 | 1.0 | 2.5 | 616.8 |
| Anykščių | 39.0 | 73.4 | 15.3 | 0.7 | 11.3 | 4.4 | 274.9 |
| Biržų | 33.5 | 58.6 | 9.8 | 0.7 | 1.4 | 2.7 | 560.0 |
| Druskininkų | 20.1 | 39.9 | 7.2 | 0.9 | 5.4 | 5.3 | 77.9 |
| Dubravos | 51.9 | 75.8 | 23.1 | 2.3 | 2.8 | 4.2 | 487.2 |
| Ignalinos | 30.5 | 49.6 | 10.2 | 0.5 | 5.5 | 4.0 | 613.6 |
| Jonavos | 31.7 | 51.4 | 12.2 | 1.3 | 6.1 | 3.9 | 183.8 |
| Joniki | 29.2 | 62.5 | 12.4 | 0.5 | 0.4 | 2.7 | 857.7 |
| Jurbarko | 30.6 | 64.5 | 14.1 | 1.6 | 5.1 | 1.4 | 252.2 |
| Kaišiadorių | 42.5 | 53.6 | 12.6 | 2.2 | 7.4 | 7.4 | 528.7 |
| Kauno | 45.7 | 70.3 | 12.9 | 1.4 | 4.2 | 1.8 | 484.1 |
| Kazlų Rūdos | 39.0 | 64.5 | 10.9 | 1.7 | 5.3 | 5.8 | 334.6 |
| Kėdainių | 36.1 | 70.2 | 12.5 | 1.4 | 1.6 | 4.2 | 412.7 |
| Kretingos | 23.8 | 56.7 | 5.7 | 1.3 | 1.6 | 1.1 | 1023.1 |
| Kupiškio | 37.1 | 57.0 | 12.2 | 0.5 | 1.9 | 1.2 | 451.4 |
| Kuršėnų | 41.7 | 78.0 | 11.0 | 0.8 | 1.6 | 1.4 | 0.0 |
| Marijampolės | 30.0 | 50.8 | 9.2 | 1.8 | 1.5 | 1.5 | 514.3 |
| Mažeikių | 27.9 | 61.2 | 6.1 | 1.2 | 2.5 | 0.8 | 908.5 |
| Nemenčinės | 22.6 | 57.0 | 6.8 | 0.9 | 9.4 | 4.5 | 848.4 |
| Pakruojo | 37.7 | 71.2 | 12.3 | 0.9 | 3.6 | 0.9 | 136.7 |
| Panevėžio | 30.1 | 82.4 | 12.9 | 0.6 | 2.8 | 3.5 | 669.7 |
| Prienų | 36.4 | 64.4 | 10.3 | 2.5 | 5.4 | 6.0 | 701.9 |
| Radviliškio | 31.5 | 43.7 | 8.6 | 1.0 | 0.9 | 1.1 | 286.7 |
| Raseinių | 39.1 | 73.6 | 13.4 | 1.4 | 0.2 | 3.0 | 530.8 |
| Rietavo | 37.6 | 57.4 | 9.7 | 1.1 | 2.3 | 2.8 | 521.1 |
| Rokiškio | 30.3 | 73.0 | 9.8 | 2.3 | 0.7 | 3.1 | 361.6 |
| Šakių | 31.9 | 72.0 | 10.0 | 1.3 | 5.6 | 2.6 | 81.4 |
| Šalčininkų | 28.5 | 52.8 | 10.5 | 1.9 | 8.4 | 1.0 | 502.2 |
| Šiaulių | 42.5 | 59.3 | 9.0 | 0.5 | 5.6 | 4.1 | 1061.7 |
| Šilutės | 30.3 | 52.9 | 10.9 | 1.2 | 1.5 | 5.1 | 788.4 |
| Švenčionėlių | 20.1 | 51.1 | 7.0 | 0.8 | 6.5 | 2.4 | 760.5 |
| Tauragės | 21.3 | 55.1 | 8.9 | 0.9 | 2.7 | 1.8 | 957.5 |
| Tellu | 33.4 | 60.2 | 11.9 | 1.8 | 2.8 | 4.7 | 1604.5 |
| Tytuvėnų | 39.4 | 67.7 | 11.1 | 0.3 | 4.5 | 2.7 | 549.1 |
| Trakų | 37.2 | 80.9 | 11.2 | 1.6 | 10.3 | 4.1 | 1183.0 |
| Ukmergės | 29.5 | 107.2 | 10.3 | 1.0 | 3.4 | 3.7 | 1580.2 |
| Utenos | 43.6 | 77.3 | 13.2 | 1.4 | 4.4 | 1.5 | 131.5 |
| Valkininkų | 36.6 | 71.1 | 10.5 | 2.6 | 7.7 | 3.4 | 987.0 |
| Varėnos | 20.4 | 39.5 | 6.6 | 0.6 | 6.6 | 1.6 | 223.4 |
| Veisiejų | 38.4 | 69.9 | 13.0 | 2.0 | 7.1 | 2.8 | 439.1 |
| Vilniaus | 33.4 | 70.1 | 9.1 | 1.7 | 7.3 | 7.0 | 1412.7 |
| Zarasų | 42.7 | 65.9 | 13.7 | 2.3 | 13.0 | 5.4 | 202.7 |

| State forest enterpise | Administration LTL/ha | Personnel of forest districts LTL/ha | Personnel of forest protection LTL/ha | Forest sanitary protection LTL/ha | Forest fire protection LTL/ha | Recreational objects building LTL/ha | Transportation LTL/ha |
|---|---|---|---|---|---|---|---|
| **Total** | **32.5** | **63.4** | **10.5** | **1.3** | **4.5** | **3.2** | **25103.3** |

## Appendix 20

**Cash flow in pine stand on II site quality in Lithuania in year 2006 with administration costs.**

| Lithuanian pine stand cash flow with administration costs in year 2006 | | | | | |
|---|---|---|---|---|---|
| | Intensity [%] | Year | Income [€] | Cost [€] | DCF [€] |
| planting and soil preparation | | 0 | | 553 | -553,0 |
| repellents | | 1 | | 131 | -127,2 |
| repellents | | 2 | | 131 | -123,5 |
| repellents | | 3 | | 131 | -119,9 |
| PCT | | 15 | | 183 | -117,5 |
| Lt | 25 | 25 | 436 | 337 | 47,3 |
| Lt | 25 | 45 | 1,521 | 598 | 244,1 |
| Lt | 20 | 65 | 2,121 | 664 | 213,3 |
| FF, land reclamation | 100 | 105 | 12,014 | 2,823 | 412,5 |

| Pine 2006 II site index | |
|---|---|
| IRR | 1.8 % |
| FR | 72 |
| NPV (r=3%) | -974 |

## Appendix 21

**Cash flow in spruce stand on II site quality in Lithuania in year 2006 with administration costs.**

| Lithuanian spruce stand cash flow with administration costs in year 2006 | | | | | |
|---|---|---|---|---|---|
| | Intensity [%] | Year | Income [€] | Cost [€] | DCF [€] |
| planting and soil preparation | | 0 | | 601 | -601 |
| repellents | | 1 | | 104 | -101 |
| repellents | | 2 | | 104 | -98 |
| repellents | | 3 | | 104 | -95 |
| PCT | | 7 | | 195 | -159 |
| PCT | 25 | 15 | | 195 | -125 |
| Lt | 30 | 25 | 734 | 577 | 75 |
| Lt | 25 | 45 | 2,196 | 863 | 352 |
| FF, land reclamation | 100 | 75 | 11,667 | 3,178 | 925 |

| Spruce 2006 II site index | |
|---|---|
| IRR | 2.3 % |
| FR | 88 |
| NPV (r=3%) | -588 |