Economy and Policy of Pre–Commercial Thinnings in Lithuanian Private Forestry

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ABSTRACT

This thesis investigates how well does pre-commercial thinnings (PCT) match silvicultural requirements in Lithuania as well as how adequately are the policy instruments steering the application of thinnings. Analysis is carried in three steps.

First, 15 selected sample stands were assessed in the central part of Lithuania. According to the regenerations projects, prevailing tree species in all stands should have been spruce that is commercially important target tree species in Lithuanian silviculture. Results revealed that in none of 15 stands pre-commercial thinnings were performed as required by legislation. Only two stands showed some marks of thinnings.

As the second step, economic assessment mostly concerned with calculations for potential economic result of PCTs in four selected model stands. Calculations were made employing methodology widely used in Scandinavian countries. The study compares cash flows, net present values and internal rates of return between treated and untreated stands. The results revealed that PCT's pays off already at the age of commercial thinnings, and significant economic gains (IRR > 4%) are achieved, when considering the period from PCTs until the end of forest rotation.

Lastly, relevant regulative, economic and informational (persuasion) policy instruments were evaluated. Forest legislation was reviewed to assess the regulatory framework. Pre-commercial thinnings have been specified as a mandatory forest management measure in *Regulations for forest fellings* already in 2010, but they still were ignored by private forest owners. Control of thinnings is very contradictory due to discrepancies between regulations in different acts. Analysis of economic policy instruments was mainly concentrated on European Unions' (EU) structural funds. Subsidies from EU funds could be easily reclaimable; however some of the requirements and procedural aspects of the application process are not well appreciated by private forest owners. This inhibits the use of such support system. The main issues are: prohibition to perform thinnings by owners themselves, relatively small percent of PCT expenses covered and too long and in some cases messy administrative process before support reaches applicant. Interviews with officers from Regional Environmental Protection Departments as well as private forest owners uniting associations confirmed that courses for private forest owners could be the most important informational policy tool for promotion of best practices. Analysis also revealed that owners are not well informed about such courses and participation is still weak. Possible reasons are further discussed.

Keywords: private forest owners, pre-commercial thinnings, policy instruments, internal rate of return, net present value.

SANTRAUKA

Šis darbas yra skirtas jaunuolynų ugdymo kirtimų kompleksiniam vertinimui privačiuose Lietuvos miškuose, apimant tiek ūkinį, tiek ir teisinio reguliavimo įvertinimą.

Siekiant tikslo – įvertinti miško ugdomuosius kirtimus privačiuose miškuose – darbo pradžioje buvo iškelti trys uždaviniai:

Pirma, atlikti privačiuose miškuose esančių, 15 – 20 metų amžiaus miško sklypų, būdingose eglynams augavietėse (*Myrtillo – oxalidosum*) inventorizaciją (natūraliai atžėlusių ir želdintų) ir įvertinti jaunuolynų ugdymo kirtimų reikalingumą šiuose sklypuose. Inventorizavus 15 sklypų buvo nustatyta, kad nei viename iš jų nebuvo pilnai vykdomi jaunuolynų ugdymo kirtimai, kaip to reikalauja teisiniai aktai, ir tik 2 sklypai buvo įvertinti kaip turintys ugdymo kirtimų požymių (gulintys stiebai, kelmai).

Antra, atlikti jaunuolynų ugdomųjų kirtimų ekonominį vertinimą. Kitaip tariant įvertinti kokią ekonominę naudą teikia, savalaikis jaunuolynų ugdomųjų kirtimų atlikimas. Skaičiavimai atlikti keturiems modeliniams, anksčiau inventorizuotiems, sklypams, pasitelkiant Skandinavijos šalyse paplitusią metodiką. Norint įvertinti miško teikiamą ekonominę naudą, nepakanka vien tik apskaičiuoti pajamų bei išlaidų skirtumą. Vertinant projekto generuojamus pinigų srautus, taikomi įvairūs vertinimo metodai. Šiame darbe vertinti du ekonominiai rodikliai: vidinė įplaukų norma, sutrumpintai **IRR** (*internal rate of return*) ir grynoji dabartinė vertė **NPV** (*net present value*). Atlikus ekonominę analizę paaiškėjo, kad pajamos, gaunamos įvairiose miško kirtimo stadijose, kuomet jaunuolynų ugdomieji kirtimai atliekami, viršija tas pajamas, kurios būtų gaunamos nevykdant ugdomųjų kirtimų. Išlaidos jaunuolynų ugdomiesiems kirtimams atsiperka jau retinimo kirtimų metu.

Trečia, įvertinti teisinius, ekonominius ir informacinius politikos instrumentus, kurie paskatintų miško savininkus atlikti ugdomuosius kirtimus. Analizė atskleidė, kad teisinis miško ugdomųjų kirtimų reguliavimas privačiuose miškuose yra nepakankamai apibrėžtas, todėl jaunuolynų ugdomųjų kirtimų priežiūra ir vertinimas tai atliekančių institucijų dažnai yra ignoruojami. Ekonominių skatinimo priemonių apžvalgoje daugiausiai dėmesio buvo kreipiama į Europos Sąjungos teikiamą paramą miško jaunuolyno ugdomiesiems kirtimams atlikti. Apklausiant privačius miško savininkus išaiškėjo, kad norint paskatinti pasinaudoti paramos priemonėmis, būtina padidinti finansavimo iš Europos Sąjungos fondų intensyvumą ir leisti savininkams patiems atlikti jaunuolynų ugdomuosius kirtimus savo sklypuose. Apklaustų privačių miško savininkų asociacijos atstovų ir Regioninių aplinkos apsaugos departamentų inspektorių

nuomone, Lietuvoje kol kas nėra kompleksinės privačių miškų savininkų konsultavimo sistemos, kuri padėtų savininkams suprasti ugdomųjų kirtimų reikšmę, tačiau kursai, kuriuose būtų aiškinama jaunuolynų ugdomųjų kirtimų nauda, būtų labai reikalingi ir naudingi.

Raktažodžiai: privačių miškų savininkai, jaunuolynų ugdomieji kirtimai, vidinė pelno norma, grynoji dabartinė vertė, Nacionalinė mokėjimo agentūra.

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1 INTRODUCTION

1.1 Project background

Today almost half of all forestland in Lithuania belongs to the State. However substantial share is in the hands of private forest owners. Owning 837.4 thous. ha private owners mostly see only environmental or aesthetical forest values. Some of them are using forest to produce fire wood or building materials, however only for their own needs. And that is understandable, because average forest holding is only 3.3 ha (LRAM, 2012). Only small part of owners think they can get economic benefits from their estates – owners who own relatively big, in Lithuanian case, more than 5 ha estates (Mizaraitė, 2001; Pivoriūnas, Lazdinis, 2004).

Pre-commercial thinnings (PCT) has been an important part of silvicultural practices in Lithuania as well as in other countries of the Baltic Sea region (Kuliešis et. al. 2012). That is the result of people's foresight, their cohesion with the forest and understanding that tended forest in the future could be worth more than savings in the bank. Unfortunately PCT's are not attaining sufficient attention from forest owners in Lithuania. Reasons for neglecting could be lack of monetary resources, knowledge, how to carry PCT's, or owners' age. Today typical forest owner in Lithuania is 56 years old female, living 100 km away from her estate (Mikalajūnas, 2009).

Investigation by Bitvinskaitė and Kazitėnas (2010) revealed that most private forest owners are trying to dispose their property as soon as they get warning from Regional Environmental Protection Department about insufficient management.

Late research showed that in only 20% of all private forests of Lithuania something is done according to Forest management plan (Kuliešis, 2010). Forest management plan is essential for every forest owner who is willing to have objective information on his estate and manage it rationally. Furthermore, Forest management plan is required by *Forest law* and preparation as well as affirmation of such management plan is strictly supervised by officers from Regional Environmental Protection Departments and State forest service. Considering that total forest coverage of the country is 33.3% (Statistics Lithuania, 2012) and nearly half of all forests belongs to private owners, the fact that only in one out of five estates any management is prevailing impel to doubt about the future economic value of private forests and the whole forestry in Lithuania. Forming forest purposefully, possibilities to reach required forest productivity, growing timber qualities, thickness properties and to avoid forest growth losses, while making extra timber, which can be lost due to self-thinning or mortality, are increasing substantially. However, when talking about pre-commercial thinnings, as one of the most important silvicultural practices leading to productive mature forest, forest owners in Lithuania

faces lack of information on what economic benefit does PCT's have in early forest ages as well later in maturity.

In this project investigations on economic outcomes are carried out only for spruce stands. Investigation object is only private forests of Lithuania.

1.2 Aim and analytical steps

This study aims to disclose possible pathways for improved policy and practice with regard to pre-commercial thinnings in private forests of Lithuania.

To meet the aim of the thesis the analysis was conducted in three stages:

1. Investigation of 15 – 20 years spruce stands on site in order to (*1*) assess the scale of pre-commercial thinnings in private forests and (*2*) to choose sample stands for further economic calculations (considering stand properties, such as tree species composition, age, tree number etc.);
2. Economic calculations to estimate payoff from application of pre-commercial thinnings in stands with different conditions;
3. Evaluation of currently applied policy tools to find out reasons for present situation with regard to pre-commercial thinnings in private forests and to reveal possible pathway for further improvement of policy tools.

Based on previous information the following hypothesis can be postulated: pre-commercial thinnings in private forests of Lithuania are insufficient regarding silvicultural requirements as well as long term profitability, and existing policy tools are not aimed at promoting pre-commercial thinnings among private forest owners.

2 PRIVATE FORESTRY AND THINNINGS IN LITHUANIA: AN OVERVIEW

2.1 Private forestry in Lithuania

2.1.1 Development of forest ownership

Latest data from Statistics Lithuania (2012) revealed that Lithuania's forest coverage increased from 33.2 % to 33.3 % since 2011 and today it counts to 2172.9 thous. ha.

In 1990, Lithuania has finally regained long awaited independence and at the same time land restitution process has been started by the officials. Unfortunately, this process is still in progress until now, therefore official numbers of land area that was officially returned to its initial owners, are still unknown. These numbers are increasing continuously. Private forest owners today own 837.4 thous. ha of forest, what is 38.6% of the total forest land area in Lithuania (LRAM, 2010).

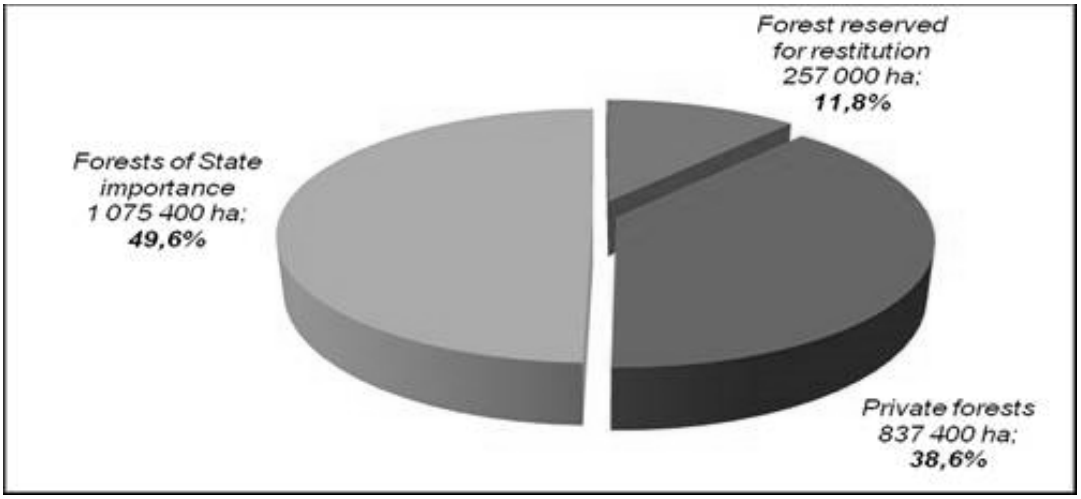

Figure 1. *Forest ownership categories in Lithuania (Source: VMT, 2011).*

After the restoration of independence, authorities decided that land must be returned to its former owners, and in 1992, in the name of Lithuanian Government all earlier not privatised forests, belonging to collective farms (*kolkhozy*) or military range were given to the State Forest Enterprises and National Parks (562.6 thous.ha) (ŽMŪM, 1997). In total, State Forest Fund accounted to 619 thous. ha of forest land at that time. In 1993, proportion between State owned and privately owned forests was 98.7% and 1% respectively. In the Figure 2 trend line between number of forest owners and forest land owned is represented.

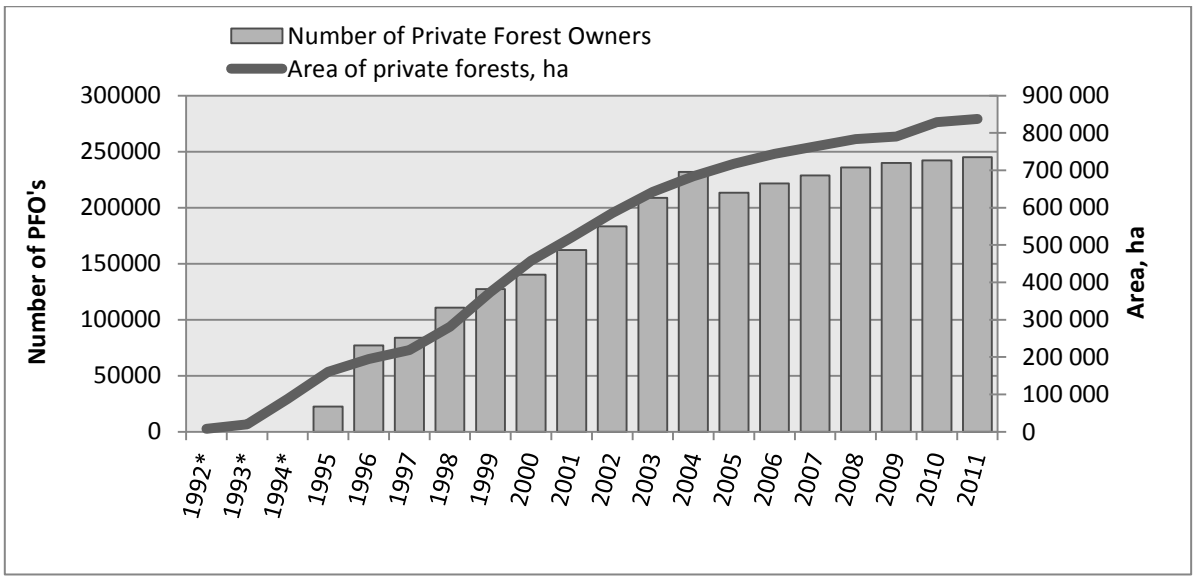

Figure 2. *Private Forest Ownership 1992-2011 (Source: VMT, 2011)*

** Number of Private Forest Owners is missing.*

Nevertheless land reform process is still unfinished. Today, the area of land set aside for restitution totals more than 200.000 ha. Government of Lithuania has set the new time schedule when restitution process should be finished. It should be done in the beginning of 2013, three years later than previously stated (www.balsas.lt). Practically there are no commercial activities performed in these areas.

2.1.2 Forest usage by ownership categories

Figure 3 represents fellings by ownership categories from 1993 to 2010. 1993 is considered as the beginning of private forest ownership in Lithuania. By looking at the red bars, which indicate fellings in state forests, the one peak in cuttings obtrude in 1995, when cuttings made 5.6 million m^3. After that, the cuttings were steadily decreasing and in 2005 they reached 3.6 million m^3. Though cuttings in private forests were steadily increasing until 2003, from 0.07 million m^3 in 1993, to 2.7 million m^3 in 2003. In 2006 they decreased to 2.5 million m^3.

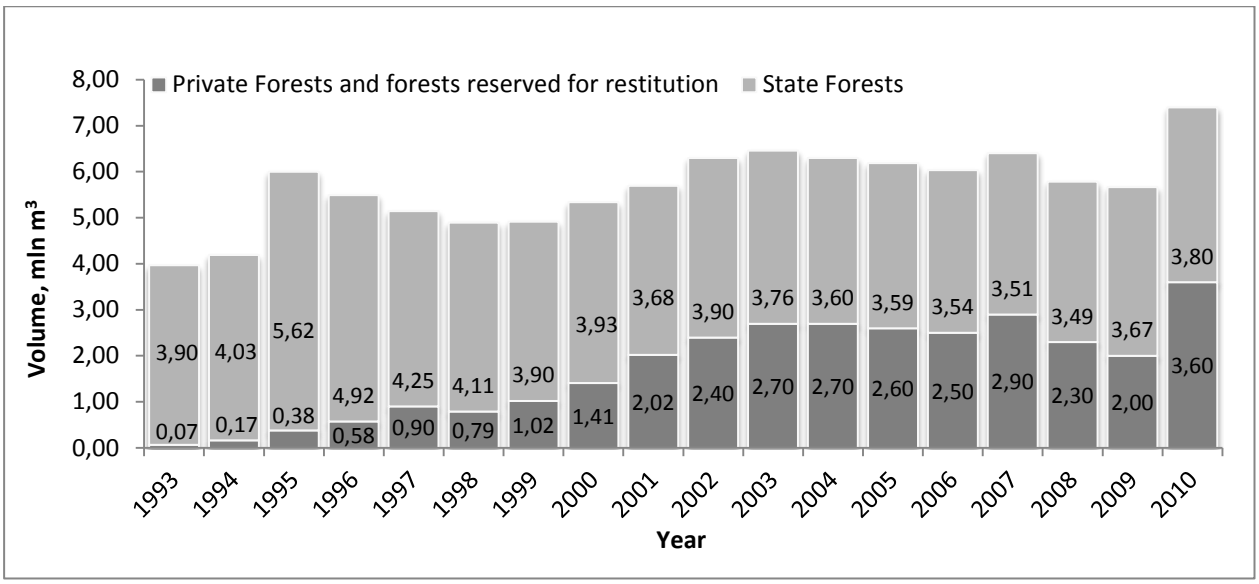

Figure 3. *Fellings by forest ownership categories, 1993 – 2010 (Source: VMT, 2001; VMT, 2009; VMT, 2011)*

Increase in forest fellings in 1995 has been caused by spruce (*Picea abies (L.) Karst.*) dieback and increased number in sanitary fellings (VMT, 2001). Increase in forest fellings in year 2000 could be caused by the fact that Lithuania and two other Baltic States have taken major steps in the transition from centralised to market economies (Pivoriūnas, Lazdinis, 2004) and wood consumption rates began to increase steadily.

In the past two years removals has decreased and remained stable. The round-wood export to neighbour countries due to reduced round-wood prices continued to slow down.

Increase in fellings in 2010 was mainly caused by increased number of intermediate feelings. Intermediate fellings volume increased by 16% up to 1.3 million m^3. This is the consequence of salvage and selective sanitary fellings followed after the storm that has damaged Lithuanian forests in August.

Table 1 represents amounts of fellings during different felling cycles and ownership categories.

Table 1. *Mean annual felled volume of living and dead tree stems by forest ownership, intermediate felling type and ownership during 1998 – 2011 (Source: Kuliešis et al. 2012)*

	Pre-commercial thinnings		Commercial thinnings		Salvage fellings		Other intermediate and other fellings		Area of all intermediate fellings		Final fellings	
	Area, 1000 ha	*Living/ dead trees m^3/ha*	*Area, 1000 ha*	*Living/ dead trees m^3/ha*	*Area, 1000 ha*	*Living/ dead trees m^3/ha*	*Area, 1000 ha*	*Living/ dead trees m^3/ha*	*1000 ha*	*± %*	*Area, 1000 ha*	*Volume, m^3/ha*
State forest	13.0	4/0	9.2	48/3	33.8	26/7	6.2	22/3	61.3	3.5	7.9	271
Private forests	1.0	2/0	6.0	65/7	29.6	30/9	17.0	34/3	52.0	3.9	6.5	281
Total	14.0	6/0	15.2	113/10	63.4	56/16	23.2	56/6	113.3	7.4	14.4	552

First thing to obtrude is the area of pre-commercial thinnings being performed. State forest officer managed to thin almost 20 times larger area than private owners. Moreover it should not be forgotten that State forest officers are also obliged to take care of forests that are set-aside for restitution, where they also managed to do PCT's in 400 hectares annually since 1998 to 2007 (VMT, 2010a).

More intensive thinnings, as could be expected, in private forest starts from 20 years, i.e. when commercial thinnings are possible (Fig 4.). In pine and partially in spruce stands volumes of cutted wood counts to 72 m^3/ha from private forests against 66 m^3/ha from State owned forests (Kuliešis et al. 2009). Once again could be concluded, that thinnings in privately owned forest are performed more actively only when merchantable timber is available.

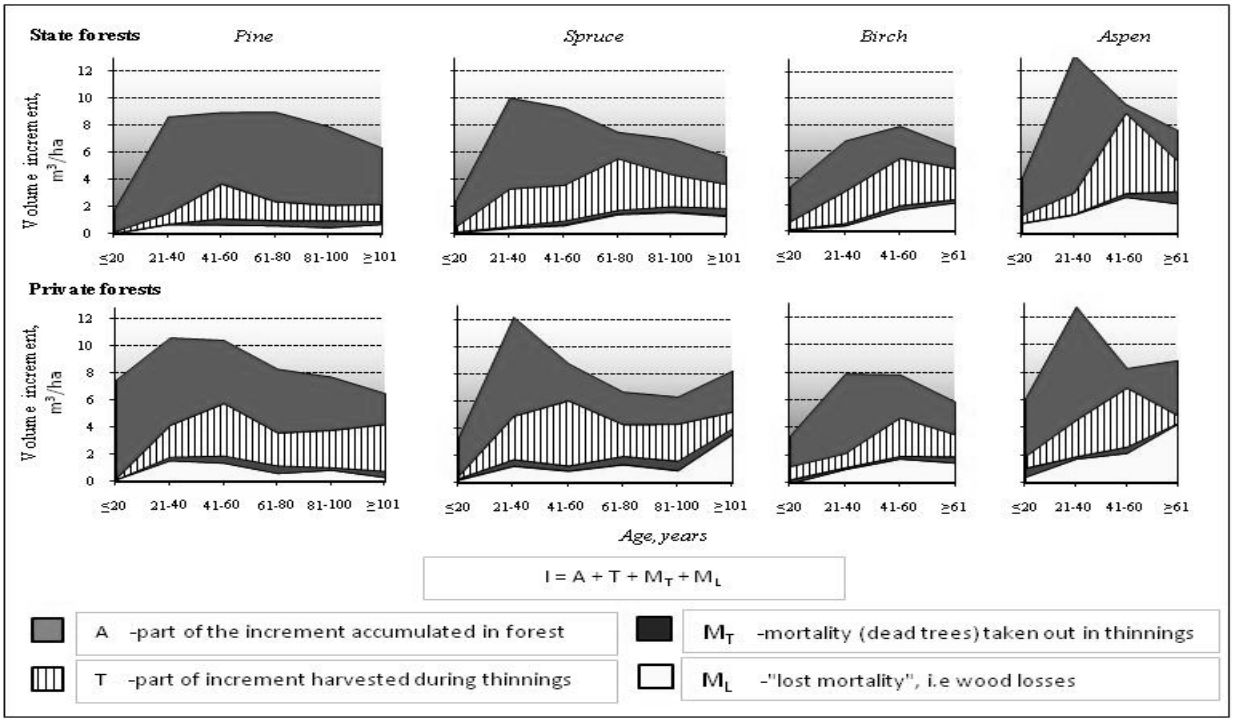

Figure 4. *The balance of gross volume increment during 1998-2007 in stands of III – IV*[1] *forest groups depending on age (Source: Kuliešis et al. 2009)*

Comparing difference between gross volume increment structure it could be noted that, increased natural self-thinning and related forest growing losses are the result of late as well as too low intensity pre-commercial and commercial thinnings. Growing losses in private forests are twice, or sometimes even larger, than in State forests (Fig. 5) (Kuliešis et al. 2009).

[1] Group I contain strict reserves. They occupy 1.2 % of all forests. Any silvicultural or other measures in forest of I group are not allowed. The main objective is to maintain natural growth, to maintain and increase biodiversity in forest;
Group II contain forests of special purpose. They are splitted into two subgroups: IIA - ecosystem protection forests occupy 9.3 % and IIB – recreational forests occupy 3.0 % of all forests. Ecosystem protection forests are used to preserve or to restore forest ecosystems or separate components of ecosystems. Recreational forest areas are used to preserve and to improve recreational forest environment. The final, restoring, not clear cuttings at the age of natural maturity, as well as thinning, tending and sanitary cuttings necessary to improve state, biodiversity, resistant of stand are allowed in forest of II group;
Group III contain protective forests: geological, geomorfological, hydrographical and cultural reserves, forests of field, soil, water, human living surroundings and infrastructure protection. Forests of III group occupy 15.2 % of all country forests. The main objective is to form productive forest stands, capable to perform various protection functions. Non – clear and small – area (up to 5 ha) clear-cut cuttings, forest tending and sanitary cuttings are allowed;
Group IV contain commercial forests, they occupy the main part of all forests – 71.3 %. The main objective is – to form productive forest stands and to supply continuously country industry and energy sector by wood following environment protection requirements. All type of cuttings are allowed. Clear cutting areas shall not exceed 8 ha.

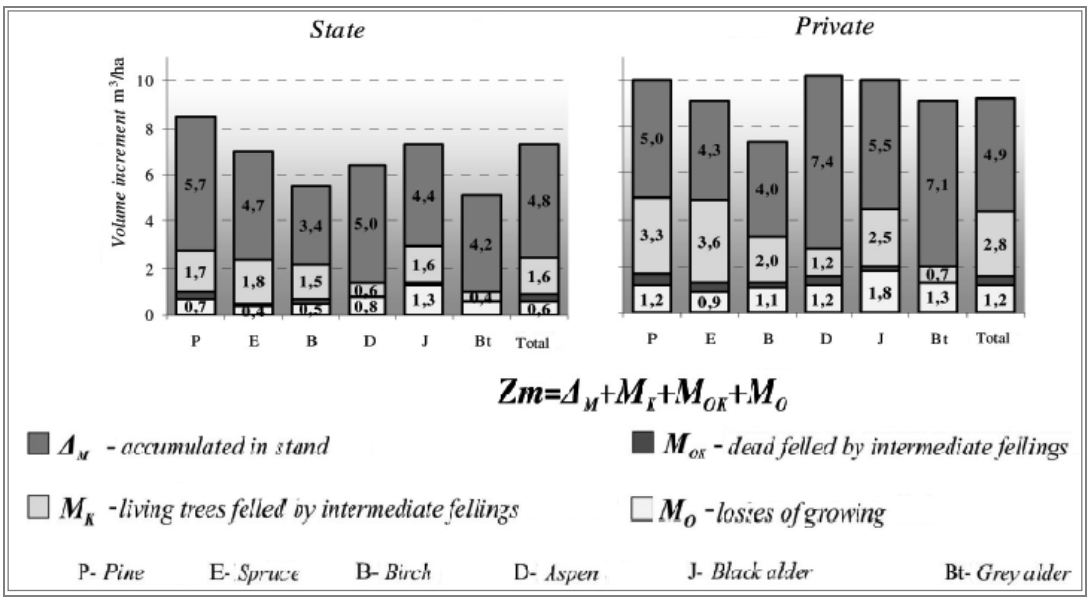

Figure 5. *The gross annual volume increment (Zm[2]) balance of stands at thinning age in III-IV forest groups of different ownership (Source: Kuliešis et al. 2009)*

2.2 Forest thinnings

2.2.1 Historical development of thinnings in Lithuania

There is no certain information when exact date of the beginning of thinnings in Lithuania could be named, but available sources allow us to presume that first thinnings were applied in the second half of the 19th century, when significantly increased demand for valuable timber and selective fellings were lawfully regulated (Juodvalkis and Kairiūkštis. 2008).

High impact on thinnings development had regulations published in 1897, allowing peasants in exchange of performed thinnings, in state owned forests, to take removable timber. According to these regulations, State owned coniferous and mixed forests not older than 30 years old were set for thinning for local inhabitants. Thinning performance in these areas was strictly supervised by State foresters. Even though, area of forests actually thinned was very low. During the period of 1909 – 1914 only 2500 ha were thinned with pre-commercials and 7200 ha were commercially thinned (Kairiūkštis, 2003).

After World War I, slightly greater attention to thinnings was paid. The pioneer for this movement was Prof. P. Matulionis. In 1920 he wrote first publication in Lithuanian language concerning thinnings, named “Forest nurture”. Clear goals for thinnings in different species forests were described in this edition and tentative hints, to use available trees number left after

[2] *Zm* – gross annual increment, Δ_M — volume accumulated instand, M_K — volume of removed living trees felled during intermediate fellings, M_{OK} — volume of removed dead trees felled during intermediate fellings, M_O — growth losses.

thinning instead of thinning intensity, as a main criterion for thinnings, provided (Juodvalkis and Kairiūkštis. 2008).

Regretfully at that time lack of qualified recommendations, new ideas and specialists interested in thinnings was perceptible.

Table 2. *Pre-commercial and commercial thinnings quantities in total thinning coverage in all State forests between 1960 – 2000* (*Source: Juodvalkis, 2011*)

Period	Total amount of thinnings			Thereof									
				Pre-commercial thinnings					Commercial thinnings				
	Area, 1000 ha	Felled volume, 1000 m^3	Thinning intensity, m^3/ha	Area, 1000 ha	Felled volume, 1000 m^3	Thinning intensity, m^3/ha	Percentage by area from total	Percentage by volume from total	Area, 1000 ha	Felled volume, 1000 m^3	Thinning intensity, m^3/ha	Percentage by area from total	Percentage by volume from total
1961-1970	49.9	543	10.8	22.4	137	6.1	45	25	27.5	406	30.6	55	75
1971-1980	49.8	603	12.1	22.9	76	3.3	46	13	26.9	527	39.5	44	87
1981-1990	29.8	389	13.1	17.1	33	1.9	57	9	12.7	356	63.8	43	91
1991-2000	23.8	494	20.8	12.6	19	1.5	53	4	11.2	475	42.4	47	96

Period between 1960 and 1980 could be named the revival for thinnings (Table 2). Nearly 50 thousand hectares of forest were thinned annually, and that was 3.5% of the total forest area belonging to the State. Annual volumes of timber from thinnings reached 500 – 600 thous. m^3, that is almost one fourth of all felled timber at that time (Juodvalkis, 2011).

Main reasons stipulating differences in thinning volumes between periods of 1961-1980 and 1981-2000 could be very active "thinnings for volume"[3] that were prevalent in 70's and 80's and subsequent reduction in area available for thinnings as well as disinclination to do thinnings by Forest Enterprises. At the end of eight decade, this type of thinnings was stopped by P. Matulionis himself. There are several reasons behind that. First of all the wording "poor quality tree" or "the worst tree" had many interpretations among foresters and not always meant removal of trees with the really poor qualities. During the second and later commercial thinning, trees with good qualities were removed instead of poor ones, and more young stands became un-thinned at all. Obviously overestimated foresters' faithfulness to pure forestry ideas lead that this type of thinnings disappeared reducing thinning quantities (Kairiūkštis, 2003).

[3] In general "thinnings for volume" mean pre-commercial thinnings with the purpose of removal of poor quality trees while leaving only the most viable. The model was borrowed from German foresters, and was higly protected by former Minister of Forests Prof. P.Matulionis. (Source: *Kairiūkštis, L.. 2003. Lietuvos Miškų Metraštis)*

2.2.2 Thinning types and requirements

Fahlvik (2005) has presented, that pre-commercial thinning or cleaning can be defined as a tending, removal of trees without extraction of merchantable timber, except extraction of bio-fuel. Andersson and Savill (as cited in Fällman, 2005) has concluded that, the pre-commercial thinning is an economic investment, which is expected to raise profits from subsequent harvests, mainly by greater and faster diameter increase and increase of timber quality among the retained trees. Fahlvik (2005) in his study found that with pre-commercial thinning it is possible to reduce the costs of the first commercial thinning.

Several studies have found that the main aim of the pre-commercial thinnings is to favour preferable tree species to the site type and trees with desirable properties by removing trees of inferior quality and poor growth potential (as cited in: Fahlvik, 2005; Fällman, 2005).

Regulations for forest fellings of the Republic of Lithuania that came into force from 1st of March 2010, formulates thinning, or cleaning, main objectives as:

1. form main tree species composition; take care of its structure and density;
2. increase productivity;
3. increase timber quality and profitability;
4. increase forest resistance to wind throws, snow breaks and other calamities;
5. extract wood which would rotten due to natural thinning;
6. increase aesthetic and recreational forest values;
7. create optimal conditions for ecosystems, maintain and increase biodiversity in Ecological protection forests (IIa group).

Forest harvesting in Lithuania is divided into three groups (Table 3). Timing also differs among tree species.

Table 3. *Forest harvesting types and age (Source: LRS, 2010)*

Name of the thinning	Forest age, years	
	Coniferous and hard broadleaves	Soft broadleaves
Pre-commercial thinnings, cleanings	< 20	< 20
Commercial thinning	21–40	21–30
Final felling	41 >	31 >

Regulations for forest fellings (2010) have also set time of the year when harvesting is forbidden. According to this legislation pre-commercial thinnings are forbidden from 1st of April until 1st of June, and any activities concerning commercial and final fellings are not allowed from 1st of May until 1st of July.

Table 4 represents requirement that forest owner has to stick to when he does pre-commercial thinnings. It is also applicable for all other thinnings. These normative tables for different tree species are included in *Regulations for forest fellings*. First graph represents average height of viable spruce in meters, and the second – number of trees that should be left in spruce stand after thinning is done. Allowable inaccuracy is ± 20 %.

Table 4. *Recommended number of trees to leave after thinning at different average stand height (Source: LRS, 2010)*

Average tree height, m (Spruce)	Forest soil type (dtg) ox, m–ox, ox–h, ox–n (*Nc, Lc, Nd, Ld*) Number of trees, ha	Average tree height, m (Spruce)	Forest soil type (dtg) ox, m–ox, ox–h, ox–n (*Nc, Lc, Nd, Ld*) Number of trees, ha
5	2370	18	1280
6	2320	19	1180
7	2270	20	1080
8	2210	21	980
9	2140	22	890
10	2070	23	800
11	1980	24	720
12	1890	25	650
13	1800	26	590
14	1700	27	540
15	1590	28	490
16	1490	29	470
17	1380	30	450

Based on Table 4 necessity of pre-commercial thinnings in sample stands was estimated.

Thinning intensity in Lithuania is expressed as a percentage of tree number before thinning and target number of stems recommended being left after thinning. Thus, this type of evaluation is mostly useful for trial, in the juvenile stand age or in pre-commercial thinning phase, but is inaccurate when stand develops and reaches relevant parameters. Stand basal area could be more appropriate tool for evaluation of proper stand density (Pretzsch, 2009)

Reiteration of thinning depends on stand density, age, soil type and thinning intensity. General rule exists: reiteration must be infrequent as long as thinnings intensity is high. But it should not be forgotten that necessity to repeat thinnings mainly depends on how main tree species are choked by secondary tree species.

Based on necessity, thinnings are divided into three groups in Lithuania: (*i*) urgent, (*ii*) 1st rank, (*iii*) 2nd rank. Necessity of urgent thinning means that thinning must be performed in time of 1-2 years. 1st rank requires thinning to be performed during 5 years, 2nd rank – 10 years. However,

this doesn't mean that 1st or 2nd rank thinnings couldn't be performed earlier, but there is one common rule: it is not recommended to perform 1st and 2nd rank thinnings if there are still stands in need of urgent thinnings.

Pre-commercials urgent thinnings are applied when planted or naturally regenerated stands with main tree species are choked by secondary species, and when pure stands are too dense. 1st rank thinnings must be applied on mixed one layer spruce, ash and secondary species stands as well as on naturally regenerated young stands with sufficient viable spruce or ash understory. 2nd rank thinnings are applied on young stands of conifers and broadleaves when the density is normal but number of trees is some 15-20 % higher than should be according to regulations, and stands where basal area is low but there is expectancy of broadleaves to appear.

In general despite all mentioned presumptions it should not be forgotten that in essence thinnings are here to maintain forest biological and ecological values, improve its quality and production. To keep best ecological conditions, to control internecine relations between tree species and to grow straight, branchless trees remains the main goal for PCT, therefore thinning intensity, repetition and selection of trees, as well as other thinning qualities, must always be dependent on owners' goals.

2.2.3 Thinnings in Norway spruce stands

Spruce for this project was chosen for two reasons. First of all, comparing productivity of different tree species it was noted that spruce has highest productivity of all tree species and it is one of the most commercially important tree species in the Baltic Sea region. Broadleaves have only 60 – 90 % of spruce productivity, that means any mixture with broadleaves reduces spruce productivity, therefore broadleaves must be removed during thinnings. Secondly, spruce tangibly responds to thinnings by increasing growth in diameter and height due to reduced competition from surrounding trees (Juodvalkis, Kairiūkštis, 2009).

Spruce (*Picea abies (L.) Karst.*) is the third most dominant tree species in Lithuania (Fig. 6), by 2011 taking share of almost 21% of all forest land (VMT, 2011).

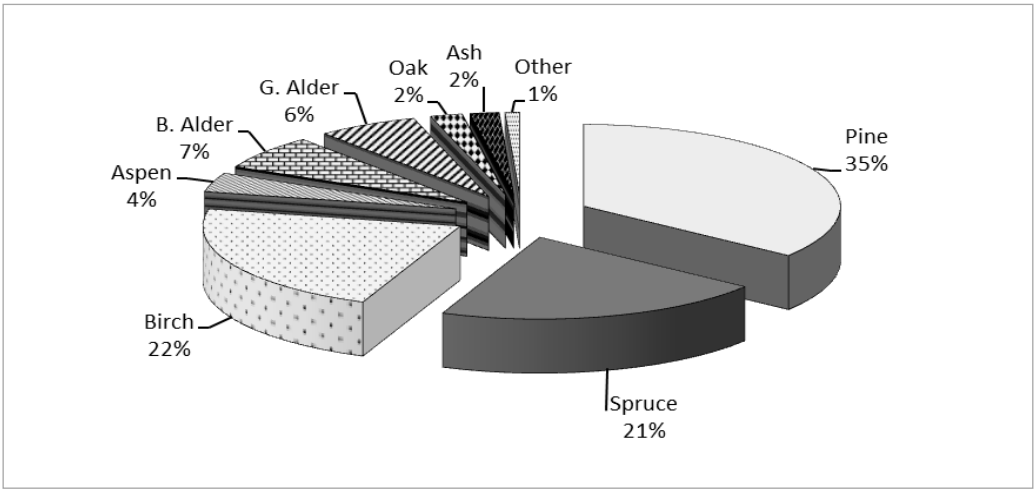

Figure 6. *Forest area by dominant tree species in Lithuania (Source VMT, 2011)*

Norway spruce habitat areal covers almost whole Scandinavia, central and northern - eastern parts of the Europe (Hanisch and Kilz, 1990) while Lithuania is in the southern part of this areal (Fig. 7). The biggest pure spruce habitats are in the western, central and northern parts of Lithuania. Spruce forests mixed with broadleaves are mostly located in central part. Average spruce stand age is 47 years, growing stock volume is 212 m^3/ha (VMT, 2011). Depending on forest group, final felling age starts from 71 years.

Spruce wood is still very demanded by pulp, construction and furniture industries in Lithuania and neighbouring countries.

Figure 7. *Natural habitat of Norway spruce (Picea abies (L.) Karst.) in Europe (Source: Hanisch, Kilz, 1990)*

Norway spruce usually can be met in quite fertile and humid soils like *Vaccinio-myrtillosum*, *Myrtillo – oxalidosum*, *Oxalidosum* (Fig. 8). In poor dry soils spruce share could be only up to 1 %. In wetlands spruce is also uncommon, but it often grows on the wet edges of it (Karazija, 1988; Kenstavičius and Brukas, 1984).

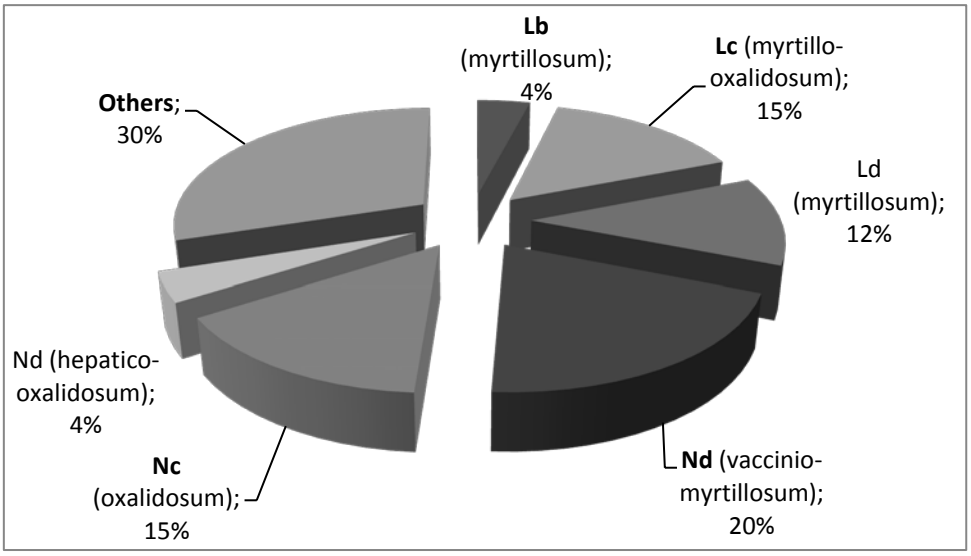

Figure 8. *Forest types mostly common for spruce stands in Lithuania (%) (Source: Vaičys et al. 2006)*

3 MATERIAL AND METHODS

This thesis is concerned with evaluation of pre-commercial thinnings in typical spruce stands in private forests of Lithuania. Methodology could be divided into three parts: inspection of the real situation; economic analysis of pre-commercial thinnings (including calculations on benefit from PCT) and analysis of relevant policy instruments.

3.1 Sample stands

Sample stands for this study were selected based on database provided by Lithuanian State Forest Cadastre (LSFC). This database is updated on a regular basis following the outcome of every next Stand-wise forest inventory, containing information on carried out silvicultural measures, ownership, administrative boundaries and other changes, on newly planted or naturally regenerated forests provided by forest enterprises and other institutions. A forest tract is considered to be a unit of LSFC registration, therefore LSFC is a database of forest tracts. The main LSFCs' purpose is to collect, compile, process, systematize, store, use, update and provide data on Lithuanian forests. It is also a component of state registers' system. LSFC database also contained information on: ownership, estate size, regeneration method, actual tree species composition and volume, unique cadastre ID etc.

Using description, what is called pre-commercial thinning or cleaning, and requirements, when they should be carried out, several decisions were taken before the investigation: first of all, to choose forest soil type typical to spruce stands (where spruce is dominant tree species), secondly include stands with age interval of 15 to 20 years. Selected stands should not be outlying more than 60 km away from Kaunas (central part of Lithuania) expecting to reduce travel expenses. Data was processed with ArcMap, fGIS, MS Access and Excel.

In total, using data from LSFC, 392 stands were found in the whole country, to be corresponding to earlier mentioned criteria. 50 of them were situated in central Lithuania region (predefined region in the beginning of the study). The target in the beginning of the investigation was to examine 10 naturally regenerated and 15 planted spruce stands, regretfully only 2 naturally regenerated and 13 planted spruce stands on *Myrtillo – oxalidosum* site type were examined. The target was not completed mainly because of extremely difficult identification of estates boundaries in situ, especially in naturally regenerated stands, and because such investigations are very time and finance consuming. To avoid biased results stands with unclear identification were held as uninspected. All stands belong to private physical persons of Lithuania. Stands were situated within 56 km from Kaunas. Stand size varied from 0.2 ha to 4.6 ha.

To locate sites in space ArcGIS system was used together with Google Earth and some help requested from the State Forest Service. More detailed guidelines and forest maps were received at the State Forest Enterprises and local Forest Districts.

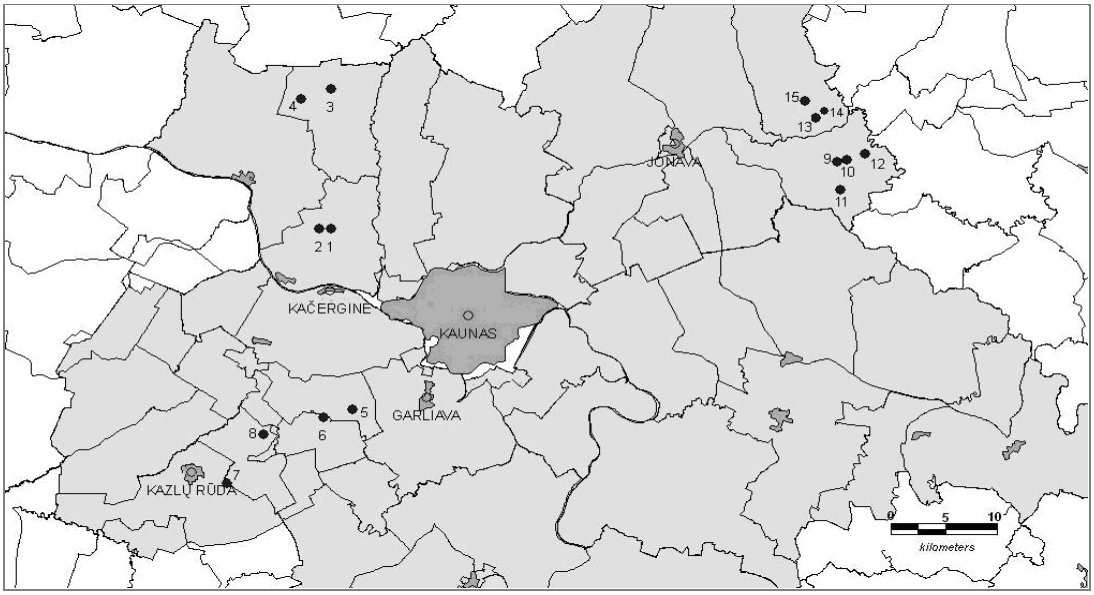

Figure 9. *Location of sample stands*

The aim of the field investigation was to check are or are not pre-commercial treatments done in private forests. Therefore 2 naturally regenerated and 13 planted spruce stands on *Myrtillo – oxalidosum* site type were examined in the central part of Lithuania (Fig. 9). Site type and dominant tree species were selected taking into account possible competition between spruce and broadleaves, necessity of pre-commercial thinnings, tree species productivity and soil productivity.

Calculations on research reliability were made. For this purpose statistical values of confidence interval and confidence level were used.

Using 10% confidence interval for determination of number of sample stands that must be inspected for research to be representative indicated that 77 sample stands must be visited and measured. However, this number of stands wasn't even available in the predefined region (central part of Lithuania). Nevertheless, selected region could be expanded by the author, but the results of visited stands (not only those that were inventoried, but also those that were rejected for unclear boundaries) allowed presuming rather similar situation in all required to visit stands. Considering practical reasons (monetary, time resources) this number of samples wasn't inspected. Total number of locally inspected stands is 15.

Further calculations on confidence interval for all 392 stands with two particular cases were made after the inspection of stands:

Case 1: presumed that all 15 investigated stands are not thinned, under probability of 0.95 resulted confidence interval between 94% and 99%, what means that if all 392 stands were inspected we could expect that from 368 to 388 stands still were not treated with PCT;
Case 2: presumed that 2 out of 15 investigated stands had some marks of PCT (as presented in Table 7), resulted confidence interval between 70% and 99%, thus from 274 to 388 stands are not thinned. Conclusion could be drawn that applying one of the cases under probability of 0.95 would result confidence interval from 70% to 99%. In other words: under probability of 0.95 we can be sure that if the research was carried in all 392 stands still would be found from 274 to 388 stands that are not thinned.

3.2 Data collection

Evaluation of pre-commercial thinnings was divided into two categories in the beginning of this investigation: Cleaning and PCT. In the first category, *cleaning*, pre-commercial thinning was counted, if there were any marks that may indicate treatment (old lying stems and stumps, visible stand structure and tree species composition, spatial shoots of some broadleaves species). Missing trees and visible stumps not always mean performance of PCT though trees could be cut for fire-wood or other needs, therefore counting the early treatment (*cleaning*) is more based on the estimations. In the second category, PCT, the treatment was included, if there were any certain signs for classical pre-commercial thinning (stumps, lying stems, formed stand structure etc.).

Stand density was measured to determine the necessity of pre-commercial thinnings in certain stand. All vital tree species were counted, total number of trees estimated and competing understory was described in 50 m^2 (circle with the radius of 3.98 m) sample plots (Fig. 10). The centres of the sample plots were chosen based on the 24 annex of the Standwise Forest Inventory (SFI) instructions approved by the Order of the Director of the State Forest Service under Ministry of Environment, according to which, centres of the sample plots could be defined by choosing most representative place of the stand (*visual inventory method with measuring elements*) (VMT, 2010b). Number of sample plots depending on area of the stand is also defined in the SFI instructions, but seeking higher representativeness and because number of sample plots defined is rather tool low to reveal the real situation, more than recommended sample plots were measured. Number of sample plots actually measured (based on area size) is presented in Table 5.

Table 5. *Number of sample plots in different size area*

Area of the stand	Number of sample plots
0 – 0,5 ha	1
0,5 – 1 ha	2
1 – 3 ha	3
> 3 ha	4

Diameter at breast height (Dbh, cm) and tree height (m) of average sample tree for all tree species were measured (Fig. 10).

Figure 10. *Visualization of measurements held in sample plot.*

3.3 Policy analysis

Policy tools form one of the key parts in forest policy process (Lazdinis, et al. 2003). Forest policy tools or mix of tools have not been widely addressed in forest policy studies (Merlo, Paveri, 1997). However it was indicated that the general set of tools or instruments in forest sector is not exclusive and whatever the problems are, the tools or instruments for implementation of the policies addressing them are rather similar with other sectors (Le Master et al, 2002).

The approach for policy analysis in this thesis is based on typical phases in policy process (Fig. 11), described by Merlo and Paveri (1997). First three phases (analysis of problems, setting of

goals and objectives, definition of course of actions) of the policy process are known as policy formation. Policy tools are considered to be an essential phase of the policy process to determine course of actions. Last remaining phases of the policy analysis are concerned with the assessment, estimation, or appraisal of policy, including its content, implementation, and effects.

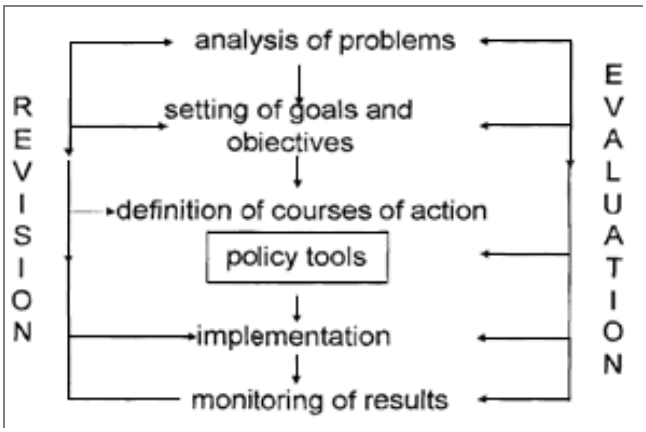

Figure 11. *The policy process (Source: Merlo, Paveri, 1997)*

The set of the policy tools and mechanisms investigated in this thesis is presented in Figure 12. Institutions, including administrations and services, are constituted as a key concept in policy formation and implementation. At the same time poor institutions and interaction between institutions and various policy tools are often the reason for policy failure.

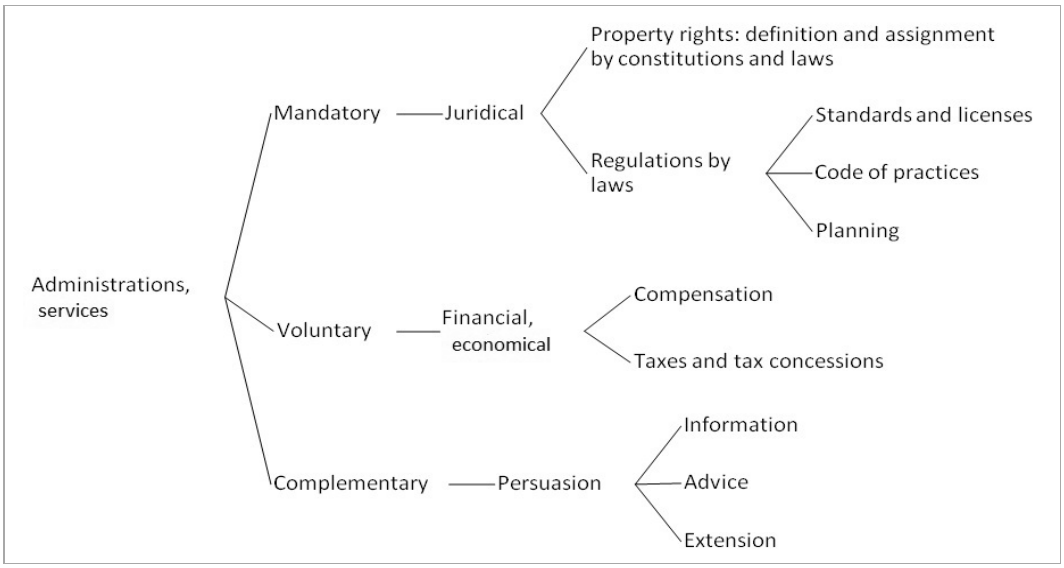

Figure 12. *Forest policy tools applicable at local/national/international levels (Source: Merlo, Paveri. 1997)*

Policy tools here are divided into three categories: juridical, financial or economic, and persuasion. Juridical tools are considered as mandatory tools including constitutions and laws as legally binding instruments, while financial or economic tools are considered as voluntary tools,

including compensation (subsidies), taxes and tax concessions. Compensations are based on the idea to convince people to implement certain measures in exchange of various economic advantages. Taxes and tax concessions are respectively aimed to prevent undesirable land use or to maintain traditional products. However clear boundaries between mandatory and voluntary tools are difficult to define and better when they are integrated and used together.

Information, education, advice and extension services were considered as complementary tools helping to implement mandatory and voluntary policies.

Analysis of juridical tools included review of four main documents describing forest policy and its implementation for private forest owners in Lithuania: *Forest law of the Republic of Lithuania (LRS 2012), Regulations for forest felling (LRS 2010) Regulations for tending and usage of private forests (LRS 2004) and Regulations for drafting forest management plan (LRAM 2006).* Using expert judgement method, 2 officers from Private Forests Division (Forest Department under Ministry of Environment) were interviewed, being responsible for preparation of appropriate regulations. During discussion main question considered: definition of pre-commercial thinnings in earlier mentioned documents and approaches to their implementation.

For voluntary tools, expert interviews were used together involving: (*i*) 2 officers from Forest Department, who were responsible for formulation of legal regulations in the beginning of European Union's programme when this was launched in Lithuania; (*ii*) 6 officers from National paying agency's regional district and representative from the head office; and (*iii*) 4 private forest owners were interviewed. The main goal from this research was to understand, how financial support system is working and to what degree is it used among forest owners.

For persuasion tools, educative system for private forest owners was investigated, to see how it is working in reality and to analyse what are the strengths, possibilities or weaknesses of it. A helpful source was research made by Stanislovaitis (2009), who investigated Lithuanian private forests control system. Interesting facts were also revealed from the discussion with the person, who was responsible for earlier organized courses for private forest owners.

3.4 Economic analysis

Economic analysis was conducted with intension to calculate what economic benefit private forest owners obtain or what losses they incur while doing pre-commercial thinnings. It is important to estimate what PCTs cost for owners and when do they pay off. Furthermore, Internal Rate of Return (IRR) and Net Present Value (NPV) of different management operations during rotation period were calculated.

Four earlier inspected stands were chosen for simulations (Table 8). To estimate the economic effect of pre-commercial thinnings two programs were used.

The first program is "Röjningsanalys" [4] (Skogforsk, 2013). This is a simulation program designed for private forest owners of Sweden. It is based on existing growth and yield functions (Näslund, 1986; Söderberg, 1986; Fahlvik & Nyström, 2006) and available data about cost for forest operations as well as price for forest products. This internet-based calculator with simple input data as geographical conditions as well as information about the stand (structure, height, site index, number of trees) is able to simulate forest growth up to first commercial thinning. It is capable to show effect of pre-commercial thinnings in monetary terms, when these thinnings are performed and when not. Furthermore, expenses for thinnings can also be calculated. However cost calculation is reflects Swedish conditions and was not used in this thesis, therefore they were replaced by calculations based on Lithuanian data.

The second modelling program is "ProdMod" created by PM Ekö from Swedish University of Agricultural Sciences (SLU) (Ekö, 1985). It was used to simulate forest growth from commercial thinning age up to final felling. This model is able to simulate forest growth to final felling age or even for the next rotations. Required data is basal area, stem number, site index and age of certain tree species. Two commercial thinnings were modelled as it is required by regulations for forest fellings. Thinning intensity was chosen considering recommended number of trees that should be left after thinning at different average tree height, expressed in Table 4.

Cost for PCT and prices for pulpwood and timber in Lithuania were used and the program "Röjningsanalys" with ProdMod" were modified after discussions with PM Ekö (PM Ekö personal communication, 2011).

Wood prices for merchantable timber available from commercial thinnings and final fellings were calculated based on average prices supplied by Directorate General of State Forests of Lithuania for the last five years. Pricelist is differentiated by prices for saw-logs. Prices for pulp-wood and fire-wood were also included. To estimate prices for certain diameter logs, interpolation method between log diameter and timber value was used (Fig. 13).

[4]Pre-commercial thinning analysis (eng.).
Available from: http://www.skogforsk.se/sv/KunskapDirekt/Alla-Verktyg/Rakna-pa-din-rojning/

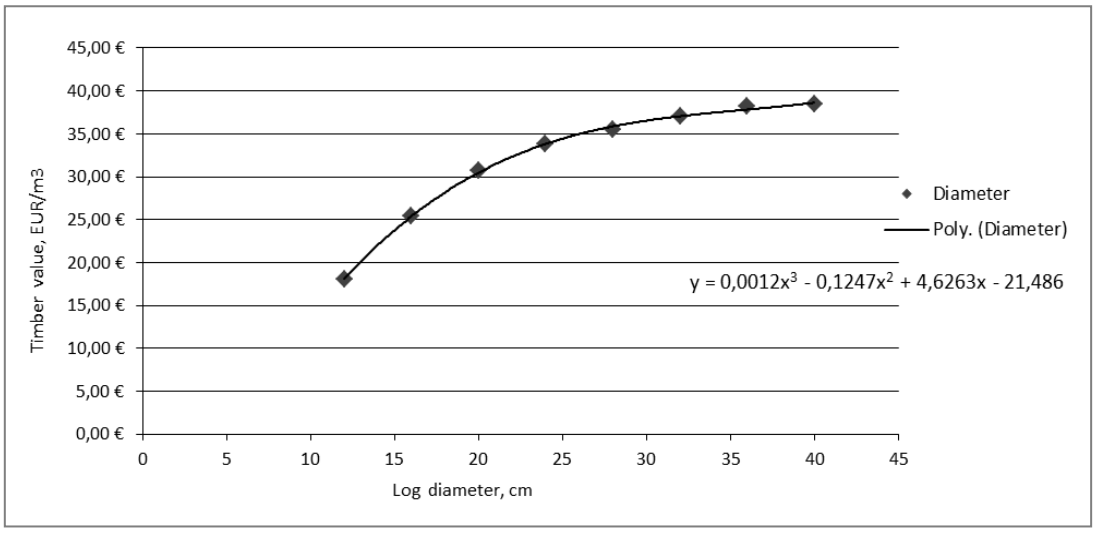

Figure 13. *Price curve for Norway spruce*

Calculating revenues from thinnings and final fellings, costs for forest management operations were also included. The estimates were received form Directorate General of State Forests of Lithuania and from contractors (Table 6).

Table 6. *Costs of forest management operations*

Felling type	EUR/m3
CT + Forwarding	*13.7*
CT	8.5
CT Forwarding	5.2
Final felling + Forwarding	*8.6*
Final felling	4.3
Forwarding	4.3

To evaluate management efficiency it is not enough to calculate income and cost balance. Several economic criteria could be used to estimate how forest can be managed more efficiently. Properly used criteria can help to design forest management programme, to choose right tree species, predict cash flow, evaluate forest price before buying or selling it etc. According to Klemperer (1996) two most adequate economic criteria are the Net Present Value (NPV) and Internal Rate of Return (IRR).

NPV (net present value) - is the present value of revenues minus the present value of costs (Klemperer, 1996).

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

where:

R – Revenues in the subscripted years;
C – Costs in the subscripted years;
T – Rotation age;
t – Year in which revenues are received or costs are incurred;
i – Interest rate.

In this study interest rate of 2 % was chosen considering recommendations made by Brukas et al. (2001). Net present value was calculated for all 4 stands with and without PCT and later compared (Fig 16).

IRR (internal rate of return) tells what interest rate of return the firm or individual can expect from successive additions to investment in growing stock (Duerr, W. 1993). In more specific terms, the IRR of an investment is the discount rate at which the present value of revenues minus the present value of costs equals 0, or where NPV=0 (Klemperer, 1996).

$$\sum_{t=1}^{T} \frac{R_t}{(1+IRR)^t} - \sum_{t=1}^{T} \frac{C_t}{(1+IRR)^t} = 0\ ; \qquad (2)$$

where:

R – Revenues;
C – Costs;
T – Rotation age;
t – Year in which revenues are received or costs are incurred;
i – Interest rate.

In this thesis Internal rate of return until first commercial thinnings was calculated employing the following formula:

$$IRR = \sqrt[n]{TR \div C} - 1; \qquad (3)$$

where:

n – number of years between PCT and first commercial thinning (1CT);
TR – total revenue from 1CT in the case of PCT treatment (difference between net revenue from 1CT with PCT treatment and net revenue from 1CT without PCT treatment);
C - cost of PCT.

IRR for the whole rotation period was calculated. Differences between net revenues from case with PCT and without occur during all later thinnings and final fellings due to substantial income for greater diameter logs and reduced expenses for felling operations. The rotation period

counted to 71 years as it is required according to minimal forest felling age for IV (commercial forests) group (LRS, 2010b).

All calculations were made for the same stands (Table 8) with and without pre-commercial thinnings and later compared.

4 RESULTS

4.1 Current status of pre-commercial thinnings

Area of private forests in Lithuania was increasing steadily since 1998 to 2011, in average by 44.2 thousand hectares annually, but area of pre-commercial thinnings was rather small. According to the data provided by the State Forest Service there are only in average 1000 hectares where PCT was performed in private forests annually, which is just only 2.3 % from the total area that requires PCT considering age structure of private stands (VMT, 2008; VMT, 2011). In private forests there are 42 659 ha. of forests in the 2nd (11-20 years) age class in which according to Regulations for forest fellings PCTs' must be performed. For instance, State forest area increased by nearly 16 thousand hectares, and pre-commercial thinnings were executed in 13 000 hectares annually, and that is 16 % of the area in age class 2 (80 814 ha.).

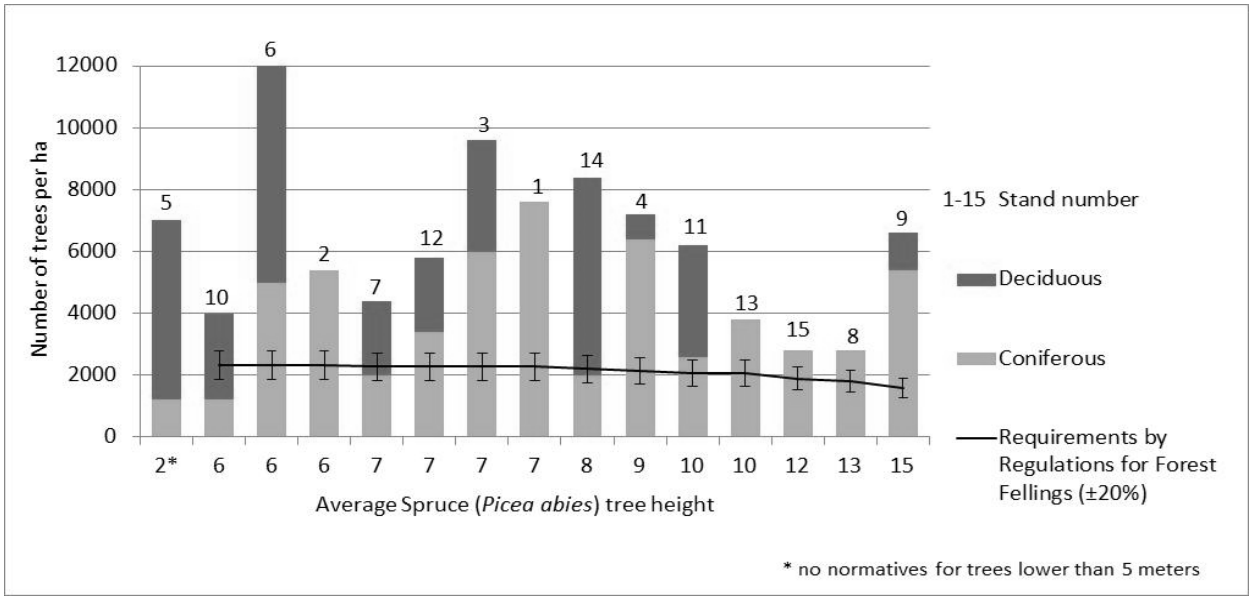

Figure 14. *Comparison between sampled stands and mandatory requirements for number of trees per ha.*

As could be seen from Figure 14, field inventory revealed that most of the stands are too dense. This shows management being insufficient or not done at all. Only stands number 8 and 15 are close to requirements and they are not in need of urgent thinnings.

Stand number 5 is naturally regenerated. Obviously that regeneration is not sufficient because only few spruce trees, less than two meters height, were found of very poor quality and very suppressed by soft broadleaves. A measure called "*Help to natural regeneration*" (LRS, 2008) where artificial planting is combined with natural regeneration could be still applied there, if the intention was to have a productive spruce forest.

Table 7. *Description of sampled stands*

Stand	Area, ha*	Origin*	Layer	%	Species	Age, a*	H, m	D, cm	N/ha	Cleaning	PCT	Notes
1	0.3	P								1	0	Urgent Th. intensity 64%
			1	100	Spruce	14	7	6	7600			
							Total of first layer		7600			
	Area, ha	Origin*	Layer	%	Species	Age, a*	H, m	D, cm	N/ha	Cleaning	PCT	Notes
2	1.0	P								1	0,5	Urgent Th. intensity 48%
			1	100	Spruce	14	6	6	5400			
							Total of first layer		5400			
	Area, ha	Origin*	Layer	%	Species	Age, a*	H, m	D, cm	N/ha	Cleaning	PCT	Notes
3	0.3	P								0	0	Urgent Th. intensity 72%
			1	63	Spruce	14	7	6	6000			
			1	35	G.Alder		16	9	3400			
			1	2	Birch		18	12	200			
							Total of first layer		9600			
	Area, ha	Origin*	Layer	%	Species	Age, a*	H, m	D, cm	N/ha	Cleaning	PCT	Notes
4	2.9	P								0	0	Urgent Th. intensity 64%
			1	90	Spruce	13	9	9	6400			
			1	10	G.Alder	13	12	9	800			
							Total of first layer		7200			
	Area, ha	Origin*	Layer	%	Species	Age, a*	H, m	D, cm	N/ha	Cleaning	PCT	Notes
5	0.5	S								0	0	*No normatives for trees lower than 5 meters*
			1	15	Spruce	15	2	2	1200			
			1	8	Oak	15	2	2	600			
			1	77	Birch	15	1,5	1	5200			
			A		G. Willow		1,5	1	6800			
							Total of first layer		8000			
	Area, ha	Origin*	Layer	%	Species	Age, a*	H, m	D, cm	N/ha	Cleaning	PCT	Notes
6	4.6	P								0	0	Urgent Th. intensity 77%
			1	42	Spruce	10	6	6	5000			
			1	33	Birch	10	7	5	4000			
			1	25	Aspen	10	7	6	3000			
			A		G.Willow		4	3	5200			
							Total of first layer		12 000			
	Area, ha	Origin*	Layer	%	Species	Age, a*	H, m	D, cm	N/ha	Cleaning	PCT	Notes
7	0.4	P								0	0	Urgent Th. intensity 38%
			1	46	Spruce	13	7	6	2000			
			1	54	B.Alder	20	30	11	2400			
							Total of first layer		4400			
	Area, ha	Origin*	Layer	%	Species	Age, a*	H, m	D, cm	N/ha	Cleaning	PCT	Notes
8	0.2	P								1	1	2nd rank Th. intensity 23%
			1	100	Spruce	15	13	8	2800			
							Total of first layer		2800			
	Area, ha	Origin*	Layer	%	Species	Age, a*	H, m	D, cm	N/ha	Cleaning	PCT	Notes
9	0.4	P								0	0	Urgent Th. intensity 71%
			1	82	Spruce	15	15	10	5400			
			1	18	Birch		25	13	1200			
							Total of first layer		6600			
	Area, ha	Origin*	Layer	%	Species	Age, a*	H, m	D, cm	N/ha	Cleaning	PCT	Notes
10	0.5	P								0	0	Urgent Th. intensity 30%
			1	30	Spruce	15	6	6	1200			
			1	65	B. Alder	10	18	14	2600			
			1	5	G.Alder	10	26	16	200			
							Total of first layer		4000			
	Area, ha	Origin*	Layer	%	Species	Age, a*	H, m	D, cm	N/ha	Cleaning	PCT	Notes
11	0.7	S								0	0	Urgent

Stand	Area, ha*	Origin*	Layer	%	Species	Age, a*	H, m	D, cm	N/ha	Cleaning	PCT	Notes
			1	42	Spruce	10	10	7	2600			Th. intensity 60%
			1	13	Oak	10	7	4	800			
			1	45	Birch	5	23	7	2800			
							Total of first layer		6200			
	Area, ha	Origin*	Layer	%	Species	Age, a*	H, m	D, cm	N/ha	Cleaning	PCT	Notes
12	1.0	P								0	0	Urgent Th. intensity 53%
			1	59	Spruce	11	7	5	3400			
			1	41	G.Alder		25	10	2400			
							Total of first layer		5800			
	Area, ha	Origin*	Layer	%	Species	Age, a*	H, m	D, cm	N/ha	Cleaning	PCT	Notes
13	0.2	P								0	0	2nd rank Th. intensity 35%
			1	100	Spruce	15	10	9	3800			
							Total of first layer		3800			
	Area, ha	Origin*	Layer	%	Species	Age, a*	H, m	D, cm	N/ha	Cleaning	PCT	Notes
14	0.3	P								0	0	Urgent Th. intensity 68%
			1	24	Spruce	11	8	8	2000			
			1	57	Aspen	7	12	4	4800			
			1	14	Birch	7	14	7	1200			
			1	5	Oak		4	2	400			
							Total of first layer		8400			
	Area, ha	Origin*	Layer	%	Species	Age, a*	H, m	D, cm	N/ha	Cleaning	PCT	Notes
15	0.8	P								0	0	2nd rank Th. intensity 19%
			1	100	Spruce	10	12	10	2800			
							Total of first layer		2800			

Layer: *1 – first layer*

A – bushes, understory

Cleaning: *1 – some marks which might indicate for PCT in early age (stumps, lying stems)*

PCT: *1 – some marks which indicates to typical PCT (stumps, lying stems, stand structure)*

0.5 – PCT done partly

Table 7 presents inventory data for all 15 stands. Observe that stand number 2 (Table 7) was marked 0.5 in the column PCT, instead of being marked 1 as it was determined in the beginning of the research. Such marking was introduced for the stands having classical pre-commercial thinning model. Reason for marking this stand with 0.5 is that not the entire stand was judged as thinned with classical model, only some separate places showed earlier formed structure, broadleaves were removed as it is required. Thinnings still need to be applied there.

In the column named *"Notes"* (Table 7) estimations on how necessary thinnings are in each stand and how intensive they should be are presented. Following recommendations made by Juodvalkis and Karazija (2009) presumed that 12 of 15 stands require urgent thinnings, as it was described in section 2.2.2 (*Thinning types and requirements*). Three stands could be thinned in next 10 years as they were assessed as 2nd rank. However, stands number 8 and 13 are already 20 years old and according to *Regulations for forest fellings* thinnings that would be performed in the following years will be categorized as commercial thinnings (Table 3).

Thinning intensity shows the share of trees that must be removed. Thinning intensity was calculated to maximum allowable tree number, left after thinnings (Table 4). It varies from 19% to 77% for different stands. It could be also named that, according to Lithuanian regulations, the intensity varies from average (up to 25%) to very intense, for those with required intensity higher than 35%.

It should be noted that, here thinning intensity was calculated not paying attention to possible storm and other damages, also it is not recommended to perform such high intensity thinning in one cycle, each stand is different and required thinning regime must be set out individually, considering stand conditions and owners objectives.

4.2 Economic calculations

For estimation of the economic effect four stands with different shares of spruce were chosen. The spruce share varies from 42 percent to 100 percent (Table 8).

Table 8. *Sample stands chosen for economic calculations*

Nr.	Stand nr.	Area, ha	Layer	%	Species	Age	H, m	D, cm	N/ha
1	2	1.0							
			1	100	Spruce	19	6	6	5400
2	4	2.9							
			1	90	Spruce	18	9	9	6400
			1	10	G.Alder	18	12	9	800
3	7	0.4							
			1	46	Spruce	18	7	6	2000
			1	54	B.Alder	25	18	13	2400
4	6	4.6							
			1	42	Spruce	20	6	6	5000
			1	33	Birch	20	7	5	4000
			1	25	Aspen	20	7	6	3000
			A		G.Willow		4	3	5200

By looking at the Table 9 and Table 10 it easy to distinguish the differences that are caused by PCT. Average height is twice bigger in the stands where pre-commercial thinnings were performed. Diameter in retained trees is also bigger in stands with PCT.

Table 9. *Example of "Röjningsanalys" programme for the stand number 1. Case with PCT*

Röjningsanalys - PCT programme		
First thinning		
Age	19	year
Thinning grade	25%	%
Average height	13.7	m
Basal area	24.2	m^2/ha
Removed volume	47	m^3/ha
Stems	1800	per ha
Average D	13	cm
Composition		
Spruce	100%	%
Broadleaves	0%	%
Volume	184	m^3

Table 10. *Example of "Röjningsanalys" programme for the stand number 1. Case without PCT*

Röjningsanalys - PCT programme		
No PCT		
Age		year
Thinning grade	-	%
Average height	6	m
Basal area	39.6	m2/ha
Removed volume	-	m3/ha
Stems	5260	per ha
Average D	10	cm
Composition		
Spruce	100%	%
Broadleaves	0%	%
Volume	316	m^3

In Tables 11 and 12 examples of simulations with "ProdMod" for sample stand *1* are presented. Table 11 represents simulations with stands where PCTs were carried and Table 12 where PCTs were ignored. Stand is 100% spruce stand. Number of trees counted in 1 ha of this stand before the thinning is 5400.

Table 11. *Example of "ProdMod" programme for stand number 1. Case with PCT*

ProdMod - CT programme								
Second thinning			**Third thinning**			**Final felling**		
Age	41	year	Age	56	year	Age	71	year
Thinning grade, ba*	25%	%	Thinning grade, ba	25%	%	Height spruce	25.0	m
Thinning grade, st*	40%	%	Thinning grade, st	35%	%	Basal area	32.3	m^2/ha
Before thinning			**Before thinning**			Volume spruce	330	m^3/ha
Height spruce	17.8	m	Height spruce	21.9	m	Stems	615	per ha
Basal area	28.8	m^2/ha	Basal area	32.5	m^2/ha	Diameter spruce	26	cm
Volume spruce	221.0	m^3/ha	Volume spruce	301.0	m^3/ha	Mean ann. growth	6.3	m^3/ha/a
Stems	1765	per ha	Stems	1000	per ha			
Diameter spruce	14.4	cm	Diameter spruce	20.4	cm	Natural mortality	36.0	m^3/ha
After thinning			**After thinning**					
Height spruce	17.8	m	Height spruce	21.9	m			
Basal area	21.6	m^2/ha	Basal area	24.4	m^2/ha			
Volume spruce	169.0	m^3/ha	Volume spruce	226.0	m^3/ha			
Stems	1059	per ha	Stems	650	per ha			
Diameter spruce	16.1	cm	Diameter spruce	21.9	cm			
Volume removed	53.8	m^3/ha	Volume removed	75.3	m^3/ha			

**ba – thinning grade of basal area; *st – thinning grade of stem number*

As could be seen comparing Tables 11 and 12, second thinning in the case without PCT in the first place (Table 12) is more intense. This is natural condition, because due to higher number of available trees, while avoiding PCT, we require more intense following thinnings in order to reach desired properties.

Considering PCT effect through all rotation period it could be said that with pre-commercial thinnings we get bigger diameter trees as well as better quality logs. Ignoring PCT we get more cubic meters of low quality and value timber which is most suitable for pulp wood.

Table 12. *Example of "ProdMod" programme for stand number 1. Case without PCT*

ProdMod - CT programme								
Second thinning			**Third thinning**			**Final felling**		
Age	41	year	Age	56	year	Age	71	year
Thinning grade, ba*	35%	%	Thinning grade, ba	25%	%	Height spruce	25.0	m
Thinning grade, st*	55%	%	Thinning grade, st	35%	%	Basal area	37.2	m^2/ha
Before thinning			**Before thinning**			Volume spruce	349	m^3/ha
Height spruce	17.8	m	Height spruce	21.9	m	Stems	1335	per ha
Basal area	43.5	m^2/ha	Basal area	39.1	m^2/ha	Diameter spruce	19	cm
Volume spruce	315.0	m^3/ha	Volume spruce	335.0	m^3/ha	Mean ann. growth	7.4	m^3/ha/a
Stems	5148	per ha	Stems	2180	per ha			
Diameter spruce	10.4	cm	Diameter spruce	15.1	cm	Natural mortality	44.0	m^3/ha
After thinning			**After thinning**					
Height spruce	17.8	m	Height spruce	21.9	m			
Basal area	28.3	m^2/ha	Basal area	29.3	m^2/ha			
Volume spruce	209.0	m^3/ha	Volume spruce	251.0	m^3/ha			
Stems	2317	per ha	Stems	1417	per ha			
Diameter spruce	12.5	cm	Diameter spruce	16.2	cm			
Volume removed	105.4	m^3/ha	Volume removed	83.8	m^3/ha			

**ba – thinning grade of basal area; *st – thinning grade of stem number*

More detailed simulation results on all 4 selected stands are presented in Annex I.

In the Figure 15 difference in revenues in each forest management operation during the whole rotation is represented. This probably is not so surprising that PCT pays off already in the first commercial thinning in all stands irrespective of spruce share in it. This could disclaim all doubts from forest owners concerning PCT's profitability. The future value of timely thinned forest is increasing further with the stand age.

Value for the logs in the final felling age in the stands where pre-commercial thinnings were performed is higher from 1300 EUR to almost 2000 EUR per hectare than those without PCT. Of course, this result might have some deviations, considering unexpected costs for management operations or lower timber prices, but nevertheless it might provide a tangible incentive for owners owning to do pre-commercial thinnings.

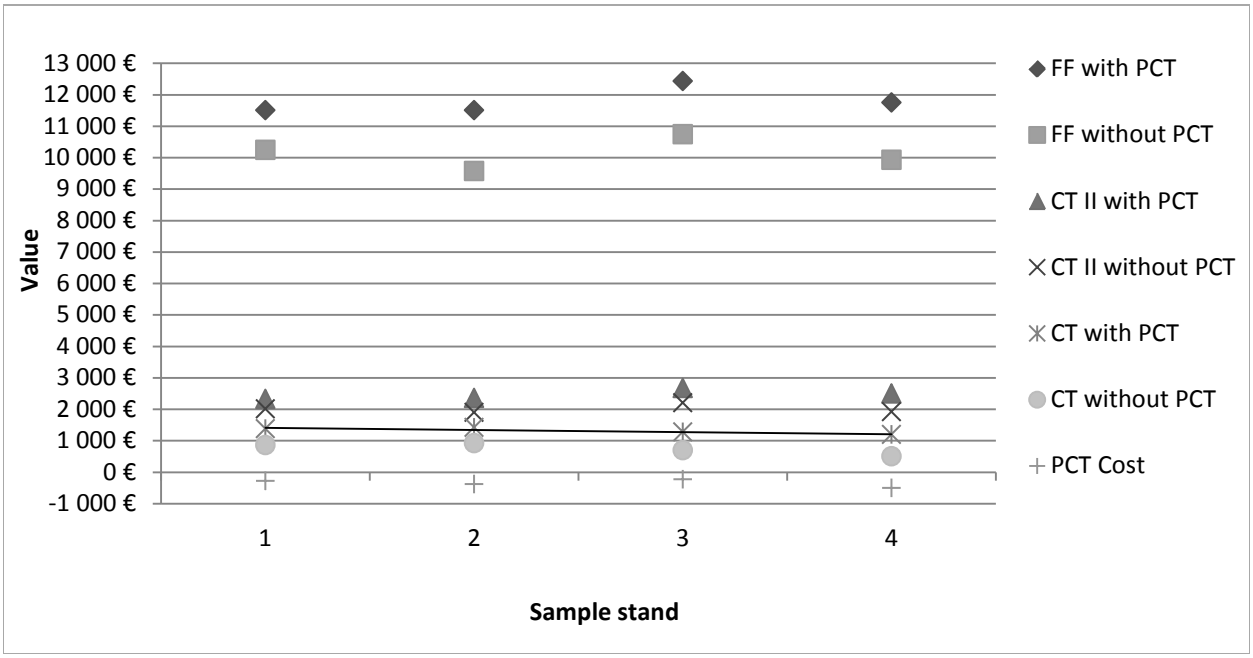

Figure 15. *Difference in revenues between forest management operations with and without PCT*

Considering internal rate of return, in this particular case it is relatively high already until first commercial thinning and in some cases even higher than interest rate applied for savings in the bank. That shows high projects' recoupment. IRR for the whole rotation is from 4.8 % to 6.7 %.

Net present value with interest rate of 2% in case with pure spruce stand resulted circa 700 EUR higher than project without PCT. Stands with lower spruce share resulted from almost 900 EUR to 1100 EUR higher NPV than those without PCT management.

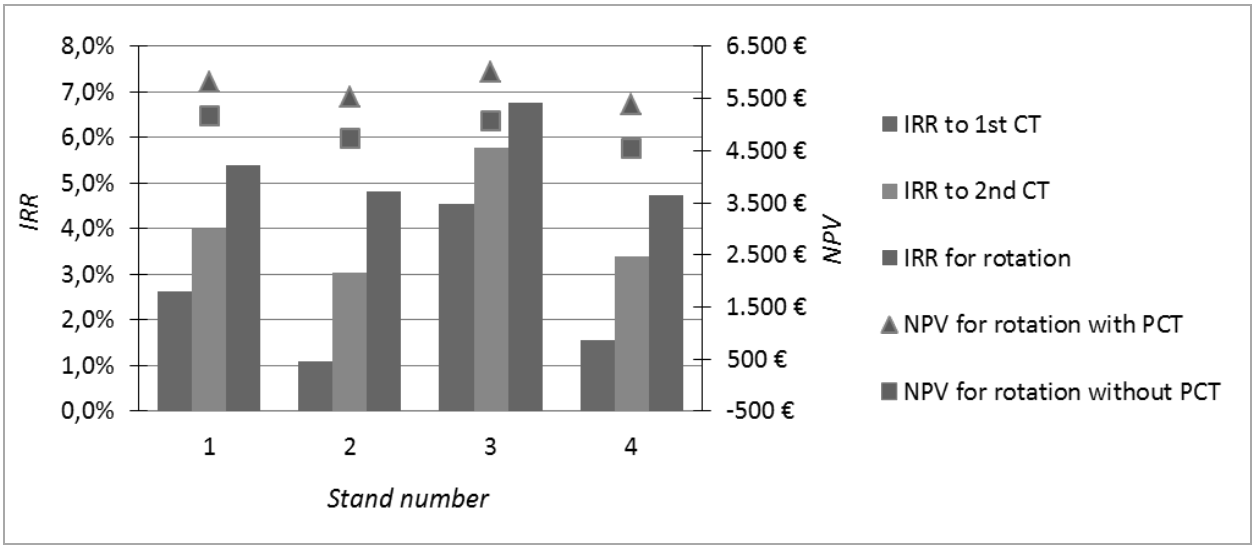

Figure 16.*Comparison between IRR for different periods and NPV for the whole rotation with and without PCT*

In the Tables 13 and 14 results from calculations are presented. Summing up the values it could be seen that forest management with pre-commercial thinning gives better economic results than without PCT.

Table 13. *Economic outcomes (EUR) from stands with PCT management*

MANAGEMENT WITH PCT													
No	Stand	Density	Year of PCT	Year of 1st thinning	Year of 2nd thinning	Year of final felling	PCT Cost	1CT Income	2CT Income	Final felling income	Cost/Income balance PCT to FF	NPV PCT to FF	EUR /Year
1	2	5400	19	41	56	71	289,9	1369,8	2320,5	11498,5	14899,0	5817,6	209,8
2	4	7200	18	42	57	72	387,3	1418,2	2353,8	11498,5	14883,3	5528,5	206,7
3	7	4400	18	38	58	73	237,8	1273,1	2663,7	12426,0	16125,0	6006,7	220,9
4	6	12000	20	40	60	75	509,5	1191,6	2496,3	11747,9	14926,3	5376,2	199,0

In the Table 14 economic outcomes from stands when PCT were not carried out are presented, though prices for PCT management operations are not included.

All thinnings were carried at the same time as in case with PCT and all rates are adequate.

Table 14. *Economic outcomes (EUR) from stands without PCT management*

MANAGEMENT WITHOUT PCT												
No	Stand	Density	Year of 1st thinning	Year of 2nd thinning	Year of final felling	PCT Cost	1CT Income	2CT Income	Final felling income	Cost/Income balance PCT to FF	NPV PCT to FF	EUR /Year
1	2	5400	41	56	71	-	857,3	2004,4	10236,6	13098,3	5173,4	184,5
2	4	7200	42	57	72	-	915,9	1894,9	9569,2	12380,0	4729,2	171,9
3	7	4400	38	58	73	-	693,0	2196,2	10734,9	13624,1	5073,3	186,6
4	6	12000	40	60	75	-	495,4	1910,3	9922,0	12327,7	4537,3	164,4

It must be noted that all prices were calculated for Lithuania's conditions in National currency Litas, and later converted to Euros. 1 Litas is equal to 0.289 Euro.

4.3 Policy tools

4.2.1 Juridical tools

Attitude that PCT's are mandatory, whether it is state owned or private forest has never been included in *Regulations for forest fellings* and appeared only in 2010. Pre-commercial thinnings were described as voluntary tool for long time in *Regulations for forest felling* (RFF), which regulates all felling types in all ownership forests in Lithuania. But the new version of RFF that came into force from 1st of March (2010) clearly defines PCT's as mandatory tool for all forest owners. It is also worth mentioning that State owned forests has always been more or less thinned with PCT's because all of them have forest management plans that must to stick to, otherwise irresponsible Forest District could be warned by officials from the State Forest Service. So seems this amendment has been adopted with the intention to private owners, in which forests pre-commercial thinnings are forgotten or insufficient.

However, no other official document as *Forest law*, *Regulations for tending and usage of private forests* (RTUPF) or *Regulations for drafting forest management plan* mentions PCT as mandatory tool for private owners, what could be seen as legislative weakness, indicating that many acts issued by the authorities are not harmonized between each other. If considering who is typical private forest owner in Lithuania (56 years old women) it would be rational for him/her to expect finding all the requirements in the *Forest law* or other very important, describing all mandatory forest management operations for private owners, document – *Regulations for tending and usage of private forests*. Regretfully PCT's still are not described in this document today. Though, officers at the Forest Department argue that it is impossible to put all the requirements into the *Forest law*, therefore as the link, avoiding possibly intentional noncompliance with additional regulations, 16th article was included referring to all other

normatives and regulations adopted by Ministry of Environment (MoE) (LRS, 2010a). However, to follow up for all the legislations issued by MoE could require certain skills and is very time consuming not only for private forest owners (taking into account their entity) but even also for public officers working in that system, therefore expectations that newly listed acts will reach the addressee and will be executed on time might be way too optimistic.

Besides, information on how PCT's will be regulated and what sanctions are waiting for disobeying the law are still missing.

4.2.2 Supervision of pre-commercial thinnings

Regional Environmental Protection Departments (EPD) since January 1st 2012, by the especially urgent order of the Parliament of Lithuania, were subordinated to State Forest Service (SFS) under Ministry of Environment. This was done in order to centre execution of all the functions, concerning supervision of *Forest law*, under one institution. There are 8 regional departments scattered in major regions of Lithuania (Fig. 17). For evaluation of policy implementing institutions expert judgement method was used, officers from six regional EPD's were interviewed.

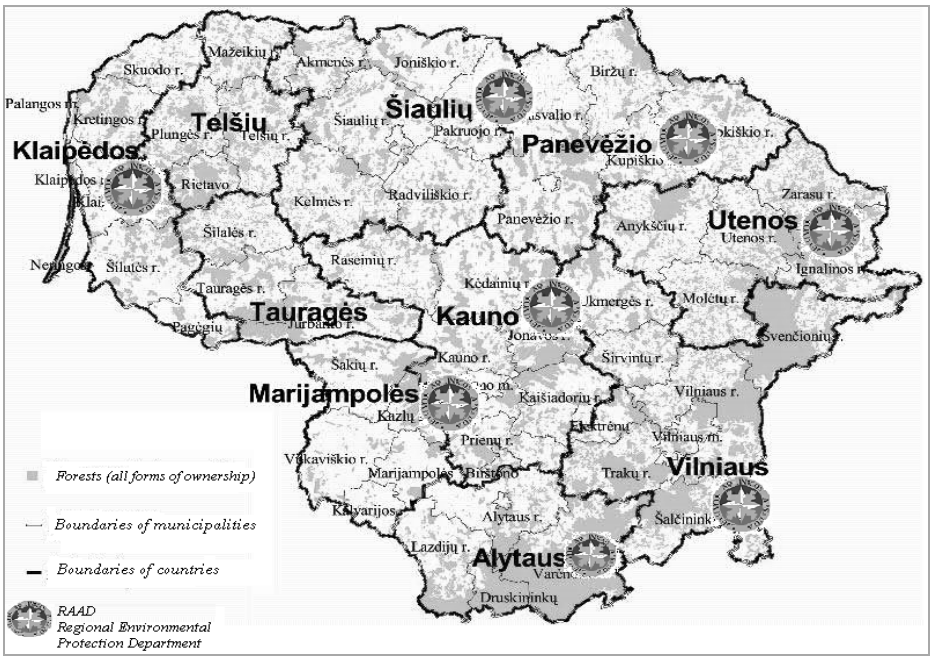

Figure 17. *Distribution of Regional Environmental Protection Departments*

The EPD's controlling institution since 1st of January 2012 is Forest Control Department under State Forest Service.

All Environmental Protection Departments are responsible for carrying environmental protection and environmental monitoring at State level.

The main tasks concerning forestry part are to control how *Forest law* is implemented and periodically inspect all ownership categories forests condition, usage, regeneration and protection. They also withdraw forest felling licenses, consult private forest owners.

Departments, according to their rulebook, should also be responsible for inspection of pre-commercially thinned stands in private forests. Nevertheless it is different in the reality. Main problem that was named by officers working at the departments is too high workload for performing job at least at satisfactory level. Usually there are two, in bigger regions three, officers working at the department that are responsible for forestry issues. Each officer is accountable for over 10.000 ha of forests in the region. Inspection of pre-commercially thinned stands is not considered as urgent, furthermore there are no clear indications how many exactly stands should be inspected. It was surprising to hear that EPD's controlling institution (SFS), which is inspecting EPD officers on how they are performing inspections, not always are inspecting stands with required PCT (according to Forest management plan) that should be inspected by EPD officers. Mostly attention is paid to forest regeneration.

Evaluation of the performance of thinning on site is done using normatives or mostly – by quite rough measurements and later comparing results with requirements. As officers explained, there are two levels of warnings that owner can get for not doing PCT. Firstly – oral warning. That is the most common method which usually works. Secondly – written warning. Officers claim they are trying to avoid of using this type of warning, because it is bureaucratic and very time consuming, and also it could evoke owners' discontent if they feel themselves to be pushed. Overall many interviewed officers noticed that clearer sanctions for not doing PCT, explained directly to forest owners or written in some legislative act, would be very helpful not only for officers but also for owner as they can evaluate the risk for disobeying the law. But it should not be forgotten that in such country as Lithuania, where private owners are claiming that they are too much controlled by different laws and regulations, new legislation should be more liberate and flexible (EPD officer, 2011), so there is a need for a balanced solution, ensuring the achievement of the necessary thresholds without exaggerated detail of regulation.

Fines for disobeying PCT performance as well as for all other environmental protection offences should be assigned according to *Code of administrative violations of the Republic of Lithuania*. Information on imposition is missing and this could indicate that EPD officers are not minded

against private owners and not necessarily want to fine them, the main objective is to ensure good condition of all forests (EPD officer, 2011).

Drawing the conclusion from this chapter becomes obvious that today the main concern is for adoption or amendment of relevant legislation, however the clear mechanism how the implementation of these regulations should be supervised, who could be responsible for this is rather forgotten, and remains unclear both for the owners and for the State officers.

4.2.3 Economic tools

According to *Forest law* (2010), Government of the Republic of Lithuania can supply subsidies or credits on favourable conditions for private owners. However, in most cases they are supplied only on very excludable conditions, for instance when transferring private forest to forest that meets social needs or establishing new protected areas. Despite that support for pre-commercial thinnings has not been provided by the Government, support from European Union funds emerged in 2007.

Support from European Union (EU) fund is administrated by National paying agency (NPA). The NPA is an independent institution of the executive branch of the Republic of Lithuania; a budgetary institution, acting in the field of administration of the Ministry of Agriculture.

4.2.4 National Paying Agency

The National Paying Agency under the Ministry of Agriculture was established by the resolution of the Government of the Republic of Lithuania in the end of 1999 for the purpose of administration of the support, provided for agricultural and rural development by the Republic of Lithuania and the European Union (NMA, 2012)

Support for pre-commercial thinnings is included in the "Rural Development Programme for Lithuania 2007 – 2013" measure "Improvement of economic value of forest" *activity 1*, aimed at "Restructuring (reconstruction) of forest stands of low economic value and thinning of young stands". This measure was designed to reinforce the physical economic potential and promote innovation in the forestry within the framework of implementing the goal and objectives of the first axis of the 2007-2013 Rural Development Programme. The support will be granted for forests owned by private owners and their associations or municipalities and their associations. The measure is first of all aimed at (*i*) increasing the economic value of forests through reconstructing forest stands of low economic value and (*ii*) young stands thinning (pre-commercial thinning) by forming stands that are more productive and valuable from the

economic viewpoint (NMA, 2010). The maximum financial support per one PCT project could be up to 50.000 EUR. Total funding assigned for the period of 2007 – 2013 is 14 707 600 EUR.

Types of available investments under *activity 1* are the following:

a) Young stands thinning (pre-commercial thinning) under the Rules of Forest Thinning;
b) Restructuring (reconstruction) of forest stands of low economic value under the Rules of Forest Regeneration and Afforestation. Support cannot be granted for the activities related to regeneration after final felling;
c) Arrangement of forest management plan and other documents related with implementation of this activity;
d) Publicity arrangements of the project.

Eligibility criteria and requirements for support are also set out for this activity:

a) The forest area benefiting from the investment shall be owned by the applicant under ownership right;
b) For the forest holding in which the investment will be done the applicant shall submit the forest management plan;
c) The applicant shall submit project for reconstruction of stand of low economic value, including a detailed description of reconstruction process, estimated costs of project implementation and a validation of such costs.
d) The applicant shall invest into own forest holding with area of not less than 1 ha.

Several programme evaluation criteria, for each of the measures, were set before the start of the programme by the Ministry of Agriculture. Intention of at least 65 successive applicants and at least 800 ha thinned young stands has been set before the start of the *activity 1*, "Restructuring (reconstruction) of forest stands of low economic value and thinning of young stands" under the measure named "Improvement of economic value of forest". However, hardly this aim can be succeeded by 2013 watching such aloofness from forest owners and having in mind that only 52% from the target applications number have been succeeded so far (data for 2007 – 2013.01.01) while 0 applications for support have been collected in 2012. Area that was actually thinned with pre-commercials is only 231 ha (data for 2007 – 2012.01.01), what is only 29% of the target number (800 ha). Currently succeeded results are presented in Table 15.

Table 15. *Number of applications collected and payments made through 2007-2012 (Source: NMA. 2012)*

Axis. *Improving Competitiveness of the Agricultural and Forestry Sectors*				
Measure. *Improvement of Economic Value of Forests*				
Activity (1). *Restructuring (reconstruction) of Forest Stands of Low Economic Value and Thinning of Young Stands*				
Evaluation criteria	***Measure unit***	***2007 - 2013 target***	***2007 - 2011 succeeded****	***Share from target, %***
Number of applications	unit	65**	34**	52 %**
Amount of support	1000	512.3 LTL 148.4 EUR	472.0 LTL 136.7 EUR	92%
Area thinned with pre-commercials	ha	800	231	29%

***** *data for 2007 – 2011 presented on 2012.01.01*
*** *data presented for 2007 – 2012, that was presented on 2013.01.01 by NPA*

During the overall evaluation of this measure, different demand between the two activities has been noted by programme administrators. An annual report state that *activity 1* is new, which has not been supported in earlier stages of this programme, and the passiveness of the applicants could be kept as usual practice also supported by the long-time programme observations. Indeed, it is rational to expect that the *activity 2*, providing support for the purchase of new forest harvesting, round wood logging and bio-energy machinery would be more appreciated by private forest owners. Therefore, it was decided to redistribute product and result indexing. As the result, number of possibly supported forest holdings and forest land area under *activity 1* decreased on the account of *activity 2* (Mizaras et al., 2012).

Despite all the benefits that National Paying Agency (NPA) can supply to forest owners there are some negative aspects that usually stop forest owners in Lithuania from using support. Some of the requirements look unnecessary or even incomprehensible.

Requirement to hire companies to do pre-commercials instead of doing it by owner itself raises most of discussions. Interviewed private owners argue that it is cheaper to hire contractor to do PCT's for own means other than messing with NPA. Contractors are always amenable and ready to offer the best price for the owners, of course some other terms and conditions are applied. However the requirement that owner can't to do PCT was set by European Commission which states that it is impossible adequately to estimate price of own work. Forest Department is preparing suggestions to apply average or even highest price for work hour available in Lithuania. Changes might encourage owners to show interest to forest management and later perform all management operations at their forests with high quality.

The second issue, relates to the compensation rates. Interviewed owners complained that today available 50% compensation rate is too low. Requirements to do thinnings only by legal entities, which are able to prove dealing with the owner by issued invoice, force owners to look for not quite legal ways to have thinnings done in their estates. Thinnings for companies who are performing them are profitable (excluding taxes and other expenses) only when their price doubles the compensation owner is able to get. It means that owner can agree with company to pay for performed work from his own means (what is almost equal to the share owner must to pay anyway, according to support agreement with NPA, though he loses all the paper work!) as well as company agrees not to record this deal in any account-book in such a way avoiding taxes. On the other hand when identical statement was removed from requirements for support for afforestation of former agricultural land it resulted in massive number of applicants. Furthermore as it is explained it takes almost a year before you get money to your account so according owners' opinion it is not worth of waiting for so long because asked support amount for average forest holding could be some 2000 EUR. Preparation of documents for support application is also time consuming. Moreover you must be ready to show all applied operations in your forest to NPA officers at any time. Typically inspections are unscheduled and oblige owners to go to their estate at unpredictable time. Note, that average forest owner is 56 years old women living 100 kilometres away from her estate. VAT tax should be also paid by applicant.

Currently experts from Forest Department under Ministry of Environment are working on proposals to European Commission how compensation rates could be increased to private owners, to encourage them actively use the support.

4.2.5 Support administration

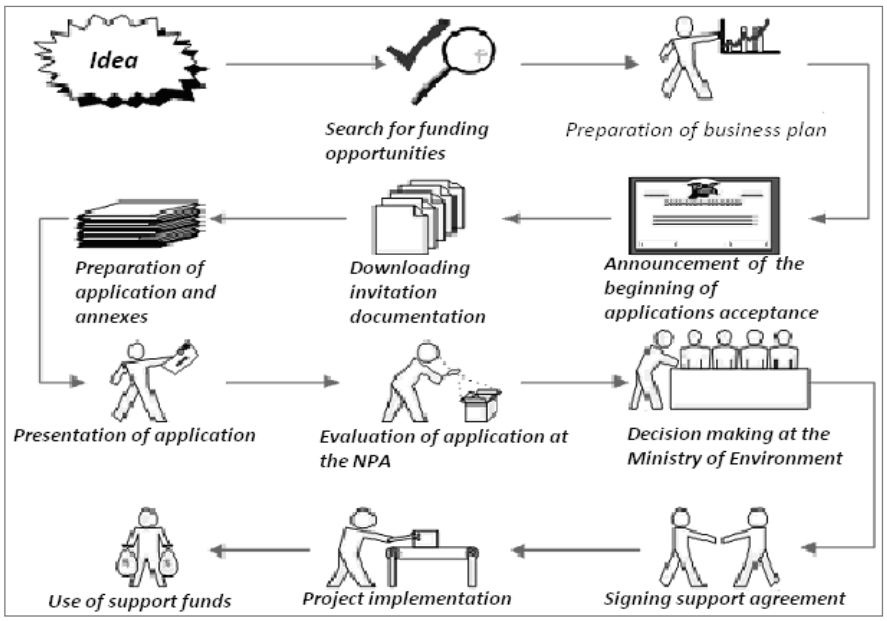

Figure 18. *Support administration scheme (Source: NMA, 2011)*

In the Figure 18 step-by-step support administration process is represented. Some of the requirements are not obligatory for forest owners pursuing support for PCT activity.

Business plan is not necessary when applying for support for pre-commercial thinnings.

Applications for PCT support are accepted at given deadline once per year.

The whole application form consists of 13 pages and can be easily filled by hand or computer. No special knowledge is necessary. Filled application must be presented by owner itself or through authorised person. Mailed, faxed forms are not accepted. Forest owners complained that additional presentation of missing documents, that somehow might be forgotten to provide when filling form for the first time (for instance cadastral information, proof of ownership right etc.) is very time consuming and inconvenient due to long distances to NPAs' regional departments and compulsory personal participation.

According to National Paying Agency in the time of three month after presentation of application forest owner should be approved as support recipient. Owners argue the whole procedure until you get money into your account takes about one year. That is also one of the key points why support is ignored.

Support is transferred to applicant's account after invoices for the completed purchases are presented to the agency.

4.2.6 Persuasion

State Forest Enterprises, up to 2002, provided advice concerning legal aspects of forest management and silviculture to private forest owners in Lithuania. Since spring 2002, these activities were responsibility of Regional forestry control divisions at the State environmental protection inspection (Lazdinis et al, 2003). In January 2012 responsibility to provide consultations to private forest owners was assigned to SFS. However as new data concerning evaluation of advice given to private forest owners under SFS is still not available, in this research such evaluation is done on the basis of advice provided by Regional forestry control divisions under State environmental protection inspection (up to 2012). 75% owners indicated these advices as being high quality and gave pass mark: average. Though, some mismatches still exist. Inspectors when asked, what advices, on their opinion, private owners need most of all, named: forestry, legal aspects and technological guidance. However, private owners preferred to get more information on legal aspects than on forestry. Information on commercial issues (felling contractors, timber prices) was also named as important (Stanislovaitis, 2009).

Private Forest Owners Association of Lithuania sometimes organizes free training courses to its members, but mostly participation in such courses is charged.

The program "Vocational training and information actions" comes under National Paying Agency with objective to increase the competitiveness of agriculture and forestry sector by strengthening human capacities and implementing advanced technologies and innovations as well as to educate and increase the level of knowledge, to improve professional competence and develop entrepreneurial skills of persons engaged in agriculture and forestry sectors (NMA, 2010). Thirty courses, each 5 days long, were held in different regions of Lithuania in 2010. One day was dedicated to explain all forest felling requirements and to answer owners' questions indoors and other half a day was spent outdoors showing specific examples. Major trend perceived after courses that many private forest owners do not understand the necessity of PCTs and requirement how they should be performed. Another problem could be named – location. Many forest owners complained about inconvenient location where courses are held. Usually they were held in State Forest Enterprises or in the Centres of Counties that is too far from their home locations (Šepetienė, 2011).

In 2011 the decision by Ministry of Environment was made to organise individual consultations for private forest owners at their own estates, hoping to help them better to understand all forest management subtleties. 500 consultations in not less than 10 municipalities will be held by 15 consultants of Forest Owners Association of Lithuania who won the open contest organized by

the ministry. This could be the most effective way of consultation, though quite costly for the Government. The programme will be financed from the State budget and will be free of charge for private owners (Kupstaitis, 2011). Details on when and how it will be organized and what issues analysed still unclear.

An impression could come that persuasion is working very actively in Lithuania, but there is another side of it. Earlier described courses held by NPA revealed relatively low attendance from private forest owners. There could be two reasons: first of all owners are not interested in such courses, or – owners are not informed about the presence of courses.

If considering number of owners attended free courses out of the total forest owners it would be only 0.3%. Investigation held by Stanislovaitis (2009) where questionnaire was sent to private forest owners presented results that 87% of all owners are in need of consultations. Then this very low attendance is hard to explain, especially when courses are free of charge.

Another problem could be envisaged here. Private forest owners are not well informed about presence of such courses. During personal communication with EPD officers and private forest owners impression emerged that nor State forest and EPD officers are interested in agitating owners to participate in courses neither owners are familiar with the existence of such courses. At this point various associations uniting private forest owners could play an important role by informing them about running courses in their area. However, only 2% of owners belong to any associations and more than 50% are not intended to join any association at all (Stanislovaitis, 2009). There are two large association in Lithuania but they typically consolidate owners owning relatively big estates (bigger than average), small private owners don’t see benefit of being members of such associations. In general there is no common organization in Lithuania that would be responsible for agitation and information of private owners.

5 DISCUSSION

Volume of thinnings is very dependent on demand and availability to sell timber in all countries and Lithuania is not an exception. Here, even during interwar period demand for small diameter timber was quite high (Kairiūkštis, 2003). However while forming normative acts and recommendations for thinnings the greatest attention has always been paid to biological tree growth properties such as tree height, diameter and "stress effect" etc. leaving the economy apart. Therefore this investigation was held, to estimate economic effect of thinnings in Lithuania supplemented by analysis of currently applied policy instruments to promote the use of PCT's.

There are many problems concerning current situation in Lithuanian forestry, but I would name three as the most important:

1. Lack of information of economic benefit that pre-commercial thinnings can bring to the owner.

This problem couldn't be named as just persuasion issue. The whole point is that there is the lack of interest to solve the problem already in the germ of it. The weak motivation from university, which should be the perfect solution provider, encourages students to choose more silvicultural research, but it should not be forgotten that not only silvicultural practices, but also economical approach to pre-commercial thinnings in our conditions could substantially improve forests.

2. Lack of information on available support measures.

Here I see a problem with NPA. Nevertheless it is not paying adequate attention to conveyance of support provided to forestry, but it also managed to redistribute product and result indexing meaning nothing than reduced support for private forest owners under PCT measure. I am almost sure that current situation would change if the support share would increase substantially, as it was with support for afforestation, where increased support infused many private forest owners.

3. Lack of information on practical use of pre-commercial thinnings.

Very favourable conditions for amending existing situation emerged in 2012, when SFS became controlling institution for EPD. The main office of SFS is situated in Kaunas and unlike EPD officers, who are usually pursuing their daily routines outside the office, would be able provide

extension and advice services for private forest owners, especially when SFS have all the sophistication and required arrangements to do so. Another topic could be existence of strong private owners association, uniting together small private forest owners. As it was mentioned in the text (Chapter 3.5), today they are mostly uniting large forest owners, and small ones doesn't see benefit of being members of such alliance. However, cooperation of many small private owners could bring none less benefit, especially from PCTs. Being a part of such alliance could emerge of selling wood, from PCTs under more favourable conditions, than selling it individually. It is not a secret that wood processors not always deal with small owners because of too small amounts of timber they can provide, but it is also inefficient economically, considering transportation costs. And that could be also one of the reasons why PCTs are disregarded by owners themselves, because there is not many opportunities to sell timber alone and to make profit. Furthermore, cooperation could enable forest owners to participate in others support mechanisms, for instance – obtaining relevant machinery, required for thinnings. On the other hand, first of all people must be motivated to do so either by the good practice from other countries or by any type of subsidies.

And finally it must be noted that juridical, legally binding instruments together with economic financial tools and persuasion are far from being separated and should be jointly devised and applied in order to achieve an effective and efficient forest policy. The adoption of a carefully designed policy tools mix can help evolutionary approaches, able to change the policy emphasis according to the needs of the real world, whilst avoiding "drastic" solutions or people inertia.

6 CONCLUSIONS

Summing up investigation the following conclusions could be drawn[5]:

1. In none of 15 inspected stands pre-commercial thinnings were performed. Only three stands were marked as having any signs of thinning (Table 7). Lying stems and stumps indicated previous intervention, regretfully that not always means purposely and timely formed stand structure, by removing thriving soft-broadleaves, usually it is the sign of extracted fire-wood.

2. Estimated economic benefit already from commercial thinnings, as well as for the whole forest rotation, when pre-commercial thinnings are performed timely and purposely could enforce owners to change their opinion on their necessity.

3. Evaluation of policy tools leave impression that pre-commercial thinnings are not judged as important factor by controlling bodies. Indifferent attitude from officers allow owners to disobey the law and to leave forest to grow naturally until commercial thinnings.

4. Financial support could encourage thousands of small forest owners to do PCT, because it raises big interest among them. But firstly changes in regulations for support holders must be made. The methodology how to evaluate owners work in monetary terms should be established and owners should be allowed to do PCT by themselves instead of hiring contractors. Increased share of European funds support per project could also be a solution to attract owners to use these measures.

5. The weakness from persuasion tools could be named as absence of strong organization which would be responsible for provision of relevant information and educational services to private forest owners. Currently existing institutions as Environmental protection departments, State forest service or State forest enterprises are not working as information centres for private forest owners, they are more concerned on forest policy implementation and control.

[5] ***Note:*** *this investigation was held in 2010, defended at the University of Aleksandras Stulginskis (former Lithuanian University of Agriculture) in the beginning of 2011 and changes in legislation system that took place after 2011.01.01 were disregarded. However some important changes has been involved in 2011.01.17 in Regulations for Tending and Usage of Private Forests, particularly requirement to perform thinnings in private forests subject to the provisions noted in Regulations for Forest Regeneration and Planting as well as Regulations for Forest Fellings. Additional investigation held by thesis author subject to the late changes in the legislation revealed no changes in the real situation comparing to the results presented in this study.*

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ANNEXES

Annex 1. *Simulation results for stand number 1.*

Röjningsanalys - PCT programme			ProdMod - CT programme								
First thinning			**Second thinning**			**Third thinning**			**Final felling**		
Age	19	year	Age	41	year	Age	56	year	Age	71	year
Thinning grade	25%	%	Thinning grade, ba*	25%	%	Thinning grade, ba	25%	%	Height spruce	25,0	m
Average height	6	m	Thinning grade, st*	40%	%	Thinning grade, st	35%	%	Basal area	32,3	m2/ha
Basal area	24.2	m2/ha	**Before thinning**			**Before thinning**			Volume spruce	330	m3/ha
Removed volume	47	m3/ha	Height spruce	17,8	m	Height spruce	21,9	m	Stems	615	per ha
Stems	1800	per ha	Basal area	28,8	m2/ha	Basal area	32,5	m2/ha	Diameter spruce	26	cm
Average D	13	cm	Volume spruce	221,0	m3/ha	Volume spruce	301,0	m3/ha	Mean annual growth	6,3	m3/ha/a
Composition			Stems	1765	per ha	Stems	1000	per ha			
Spruce	100%	%	Diameter spruce	14,4	cm	Diameter spruce	20,4	cm	Natural mortality	36,0	m3/ha
Broadleaves	0%	%	**After thinning**			**After thinning**					
Volume	184	m3	Height spruce	17,8	m	Height spruce	21,9	m			
			Basal area	21,6	m2/ha	Basal area	24,4	m2/ha			
			Volume spruce	169,0	m3/ha	Volume spruce	226,0	m3/ha			
			Stems	1059	per ha	Stems	650	per ha			
			Diameter spruce	16,1	cm	Diameter spruce	21,9	cm			
			Volume removed	53,8	m3/ha	Volume removed	75,3	m3/ha			

Röjningsanalys - PCT programme			ProdMod - CT programme								
No PCT			**Second thinning**			**Third thinning**			**Final felling**		
Age		year	Age	41	year	Age	56	year	Age	71	year
Thinning grade	-	%	Thinning grade, ba*	35%	%	Thinning grade, ba	25%	%	Height spruce	25,0	m
Average height	6	m	Thinning grade, st*	55%	%	Thinning grade, st	35%	%	Basal area	37,2	m2/ha
Basal area	39,6	m2/ha	**Before thinning**			**Before thinning**			Volume spruce	349	m3/ha
Removed volume	-	m3/ha	Height spruce	17,8	m	Height spruce	21,9	m	Stems	1335	per ha
Stems	5260	per ha	Basal area	43,5	m2/ha	Basal area	39,1	m2/ha	Diameter spruce	19	cm
Average D	10	cm	Volume spruce	315,0	m3/ha	Volume spruce	335,0	m3/ha	Mean annual growth	7,4	m3/ha/a
Composition			Stems	5148	per ha	Stems	2180	per ha			
Spruce	100%	%	Diameter spruce	10,4	cm	Diameter spruce	15,1	cm	Natural mortality	44,0	m3/ha
Broadleaves	0%	%	**After thinning**			**After thinning**					
Volume	316	m3	Height spruce	17,8	m	Height spruce	21,9	m			
			Basal area	28,3	m2/ha	Basal area	29,3	m2/ha			
			Volume spruce	209,0	m3/ha	Volume spruce	251,0	m3/ha			
			Stems	2317	per ha	Stems	1417	per ha			
			Diameter spruce	12,5	cm	Diameter spruce	16,2	cm			
			Volume removed	105,4	m3/ha	Volume removed	83,8	m3/ha			

Annex 2. *Simulation results for stand number 2*.

Röjningsanalys - PCT programme		
First thinning		
Age		year
Thinning grade	25%	%
Average height	9	m
Basal area	24.5	m^2/ha
Removed volume	48	m^3/ha
Stems	1751	per ha
Average D	13	cm
Composition		
Spruce	100%	%
Broadleaves	0%	%
Volume	190	m^3

ProdMod - CT programme		
Second thinning		
Age	42	year
Thinning grade, ba*	25%	%
Thinning grade, st*	40%	
Before thinning		
Height spruce	18.1	m
Basal area	29.1	m^2/ha
Volume spruce	231.0	m^3/ha
Stems	1717	per ha
Diameter spruce	14.7	cm
After thinning		
Height spruce	18.1	m
Basal area	21.8	m^2/ha
Volume spruce	175.0	m^3/ha
Stems	1030	per ha
Diameter spruce	16.4	cm
Volume removed	55.7	m^3/ha

Third thinning		
Age	57	year
Thinning grade, ba	25%	%
Thinning grade, st	35%	
Before thinning		
Height spruce	22.1	m
Basal area	32.6	m^2/ha
Volume spruce	303.0	m^3/ha
Stems	973	per ha
Diameter spruce	20.6	cm
After thinning		
Height spruce	22.1	m
Basal area	24.4	m^2/ha
Volume spruce	227.0	m^3/ha
Stems	633	per ha
Diameter spruce	222	cm
Volume removed	75.9	m^3/ha

Final felling		
Age	72	year
Height spruce	25.1	m
Basal area	32.2	m^2/ha
Volume spruce	330	m^3/ha
Stems	598	per ha
Diameter spruce	26	cm
Mean annual growth	6.2	m^3/ha/a
Natural mortality	37.0	m^3/ha

Röjningsanalys - PCT programme		
No PCT		
Age		year
Thinning grade	-	%
Average height	9	m
Basal area	43.3	m^2/ha
Removed volume	-	m^3/ha
Stems	6570	per ha
Average D	9	cm
Composition		
Spruce	95%	%
Broadleaves	5%	%
Volume	346	m^3

ProdMod - CT programme		
Second thinning		
Age	42	year
Thinning grade,	35%	%
Thinning grade, st*	55%	
Before thinning		
Height spruce	18.1	m
Basal area	47	m^2/ha
Volume spruce	336.0	m^3/ha
Stems	6425	per ha
Diameter spruce	9.6	cm
After thinning		
Height spruce	18.1	m
Basal area	30.5	m^2/ha
Volume spruce	223.0	m^3/ha
Stems	2891	per ha
Diameter spruce	11.6	cm
Volume removed	112.6	m^3/ha

Third thinning		
Age	57	year
Thinning grade, ba	25%	%
Thinning grade, st	35%	
Before thinning		
Height spruce	22.1	m
Basal area	41.3	m^2/ha
Volume spruce	347.0	m^3/ha
Stems	2717	per ha
Diameter spruce	13.9	cm
After thinning		
Height spruce	22.1	m
Basal area	30.9	m^2/ha
Volume spruce	260.0	m^3/ha
Stems	1766	per ha
Diameter spruce	14.9	cm
Volume removed	86.8	m^3/ha

Final felling		
Age	72	year
Height spruce	25.1	m
Basal area	39	m^2/ha
Volume spruce	357	m^3/ha
Stems	1662	per ha
Diameter spruce	17	cm
Mean annual growth	7.6	m^3/ha/a
Natural mortality	47.0	m^3/ha

Annex 3. *Simulation results for stand number 3.*

Röjningsanalys - PCT programme			ProdMod - CT programme								
First thinning			**Second thinning**			**Third thinning**			**Final felling**		
Age	18	year	Age	38	year	Age	58	year	Age	73	year
Thinning grade	25%	%	Thinning grade,	25%	%	Thinning grade, ba	25%	%	Height spruce	25.3	m
Average height	7	m	Thinning grade,	40%	%	Thinning grade, st	35%	%	Basal area	33.7	m^2/ha
Basal area	22.1	m^2/ha	**Before thinning**			**Before thinning**			Volume spruce	352	m^3/ha
Removed volume	40	m^3/ha	Height spruce	16.9	m	Height spruce	22.4	m	Stems	572	per ha
Stems	1708	per ha	Basal area	27	m^2/ha	Basal area	34.8	m^2/ha	Diameter spruce	27	cm
Average D	13	cm	Volume spruce	207.0	m^3/ha	Volume spruce	332.0	m^3/ha	Mean annual growth	6.5	m^3/ha/a
Composition			Stems	1676	per ha	Stems	931	per ha			
Spruce	95%	%	Diameter spruce	14.3	cm	Diameter spruce	21.8	cm	Natural mortality	43.0	m^3/ha
Broadleaves	5%	%	**After thinning**			**After thinning**					
Volume	160	m^3	Height spruce	16.9	m	Height spruce	22.4	m			
			Basal area	20.2	m^2/ha	Basal area	26.1	m^2/ha			
			Volume spruce	157.0	m^3/ha	Volume spruce	249.0	m^3/ha			
			Stems	1005	per ha	Stems	605	per ha			
			Diameter spruce	16	cm	Diameter spruce	23.4	cm			
			Volume	50	m^3/ha	Volume removed	83	m^3/ha			

Röjningsanalys - PCT programme			ProdMod - CT programme								
No PCT			**Second thinning**			**Third thinning**			**Final felling**		
Age		year	Age	38	year	Age	58	year	Age	73	year
Thinning grade	-	%	Thinning grade, ba*	35%	%	Thinning grade, ba	25%	%	Height spruce	25.3	m
Average height	7	m	Thinning grade, st*	55%	%	Thinning grade, st	35%	%	Basal area	35.4	m^2/ha
Basal area	31.6	m^2/ha	**Before thinning**			**Before thinning**			Volume spruce	342	m^3/ha
Removed volume	-	m^3/ha	Height spruce	16.9	m	Height spruce	22.4	m	Stems	1039	per ha
Stems	4160	per ha	Basal area	36	m^2/ha	Basal area	37.4	m^2/ha	Diameter spruce	21	cm
Average D	10	cm	Volume spruce	254.0	m^3/ha	Volume spruce	331.0	m^3/ha	Mean annual growth	6.9	m^3/ha/a
Composition			Stems	4077	per ha	Stems	1695	per ha			
Spruce	80%	%	Diameter spruce	10.6	cm	Diameter spruce	16.8	cm	Natural mortality	46.0	m^3/ha
Broadleaves	20%	%	**After thinning**			**After thinning**					
Volume	221	m^3	Height spruce	16.9	m	Height spruce	22.4	m			
			Basal area	23.4	m^2/ha	Basal area	28	m^2/ha			
			Volume spruce	169.0	m^3/ha	Volume spruce	2480	m^3/ha			
			Stems	1834	per ha	Stems	1101	per ha			
			Diameter spruce	12.7	cm	Diameter spruce	18	cm			
			Volume removed	85.2	m^3/ha	Volume removed	82.8	m^3/ha			

Annex 4. *Simulation results for stand number 4.*

Röjningsanalys - PCT programme			ProdMod - CT programme								
First thinning			**Second thinning**			**Third thinning**			**Final felling**		
Age	20	year	Age	40	year	Age	60	year	Age	75	year
Thinning grade	25%	%	Thinning grade, ba*	25%	%	Thinning grade, ba	25%	%	Height spruce	25.6	m
Average height	6	m	Thinning grade, st*	40%	%	Thinning grade, st	35%	%	Basal area	32	m^2/ha
Basal area	21	m^2/ha	**Before thinning**			**Before thinning**			Volume spruce	332	m^3/ha
Removed volume	39	m^3/ha	Height spruce	17.5	m	Height spruce	22.8	m	Stems	549	per ha
Stems	1638	per ha	Basal area	25.5	m^2/ha	Basal area	32.9	m^2/ha	Diameter spruce	27.2	cm
Average D	13	cm	Volume spruce	194	m^3/ha	Volume spruce	313.0	m^3/ha	Mean annual growth	6.0	m^3/ha/a
Composition			Stems	1607	per ha	Stems	894	per ha			
Spruce	92%	%	Diameter spruce	14.2	cm	Diameter spruce	21.6	cm	Natural mortality	40.0	m^3/ha
Broadleaves	8%	%	**After thinning**			**After thinning**					
Volume	153	m^3	Height spruce	17.5	m	Height spruce	22.8	m			
			Basal area	19.1	m^2/ha	Basal area	24.7	m^2/ha			
			Volume spruce	147.0	m^3/ha	Volume spruce	234.0	m^3/ha			
			Stems	964	per ha	Stems	581	per ha			
			Diameter spruce	15.9	cm	Diameter spruce	23.2	cm			
			Volume removed	46.8	m^3/ha	Volume removed	78.2	m^3/ha			

Röjningsanalys - PCT programme			ProdMod - CT programme								
No PCT			**Second thinning**			**Third thinning**			**Final felling**		
Age	20	year	Age	40	year	Age	60	year	Age	75	year
Thinning grade	-	%	Thinning grade, ba*	25%	%	Thinning grade, ba	25%	%	Height spruce	25.6	m
Average height	6	m	Thinning grade, st*	40%	%	Thinning grade, st	35%	%	Basal area	48.5	m^2/ha
Basal area	44.6	m^2/ha	**Before thinning**			**Before thinning**			Volume spruce	430	m^3/ha
Removed volume	-	m^3/ha	Height spruce	17.5	m	Height spruce	22.8	m	Stems	2909	per ha
Stems	8920	per ha	Basal area	49.1	m^2/ha	Basal area	52.7	m^2/ha	Diameter spruce	14.6	cm
Average D	8	cm	Volume spruce	336.0	m^3/ha	Volume spruce	433.0	m^3/ha	Mean annual growth	8.3	m^3/ha/a
Composition			Stems	8721	per ha	Stems	4784	per ha			
Spruce	60%	%	Diameter spruce	8.5	cm	Diameter spruce	11.8	cm	Natural mortality	68.0	m^3/ha
Broadleaves	40%	%	**After thinning**			**After thinning**					
Volume	326	m^3	Height spruce	17.5	m	Height spruce	22.8	m			
			Basal area	36.8	m^2/ha	Basal area	39.5	m^2/ha			
			Volume spruce	255.0	m^3/ha	Volume spruce	324.0	m^3/ha			
			Stems	5232	per ha	Stems	3109	per ha			
			Diameter spruce	9.5	cm	Diameter spruce	12.7	cm			
			Volume removed	80.9	m^3/ha	Volume removed	108.3	m^3/ha			