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An economic aspect of conversion of Scots pine (*Pinus sylvestris* L.) stands in the Polish Lowland

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ABSTRACT: Pine stands at fertile sites need conversion into broadleaved or mixed forests. Yet, according to the age of stand, conversion may have different economic results. Therefore, in order to reduce costs of the process, the analysis on the basis of the potential income from wood sale has been done. The aim of the analysis has been to find an optimal date of conversion beginning. The date of conversion beginning has been fixed on the basis of the relation of the value of wood increment from the stands which need conversion to the value of average wood increment from stands conformable to the sites. By this means, three age intervals have been appointed.

Keywords: *Pinus sylvestris*; pine stands; oak stands; forest conversion; forest sites; Polish Lowland

In Europe, in the past, when forest management tried to meet the demands of industry, coniferous species were preferred due to their faster increment and therefore, Norway spruce in the mountains and Scots pine in the lowland were usually planted. At the present time, these tendencies have changed and tree site requirements are the most important considerations taken into account in the course of the forest regeneration process. However, due to the long lifetime of trees, there are still many coniferous stands which grow in sites unsuitable for them. In the case of the Polish Lowland, Scots pine is a dominant forest tree species. Many stands with this species growing on excessively fertile sites belong to the least stable forest formations. Therefore, there is an urgent need of their conversion into adapted to the site, broadleaved and mixed stands (Filius, Roosenschoon 1998; Wang 1998; Kazda, Pichler 1998; Hansen 2004; Loewenstein 2005).

Forest conversion consists in the replacement of the currently occurring tree species, unsuitable for the site, by other species indigenous to a given forest site. This type of conversion can be carried out at different stand ages but in the case of immature stands, their full production potentials can be wasted. On the other hand, stands well-adapted to a given site are usually more stable and allow obtaining higher numbers of valuable assortments. In addition, ecological considerations weigh in favour of earlier conversion because coniferous stands may exert a negative impact on forest sites causing their degradation. Moreover, the risk of wind damage is lower in broadleaved and mixed stands than in coniferous stands (Peterson 2000; Peltola et al. 2000; Gardiner et al. 2008).

The aim of this study was to determine optimal dates of conversion of Scots pine stands growing at unsuitable sites in conditions of the Polish Lowland. The analysis was performed taking into consideration exclusively economic premises disregarding ecological aspects completely. The assessment was carried out by comparing the income possible to obtain from the currently growing timber assortments with the potential income possible to obtain

Table 1. Areas taken up by pine stands at different site types under the administration of the Regional Directorate of the State Forests in Poznań

Forest site type	Mixed stand with more than 50% of pine (ha)	Single-species pine stands (ha)
Sites for coniferous forests	5,147	46,777
Sites for mixed forests with domination of coniferous species	18,632	36,436*
Sites for mixed forests with domination of broadleaved species	11,460*	8,348**
Sites for broadleaved forests	2,496**	1,234***
Total	37,735	92,795

***Conversion is urgent, **conversion is important, *conversion is needed

from the target stand (Ancukiewicz 1963; Klocek 1982, 1990; Stępień 1986; Klocek, Rutkowski 1986; Lorrain-Smith 1991). It is true that prices of timber assortments as well as mutual relations between them assumed for the calculations change in time and are different in different countries or even regions; nevertheless certain general trends remain unchanged.

The value of timber production based on prices of timber assortments is only one of several possible indicators for making a decision. A decision about the time of forest conversion could also be based on other economic indicators, e.g. financial efficiency, which is an indicator taking into account incomes and cost of processes.

MATERIAL AND METHODS

All the performed analyses were carried out on the basis of a computer database of the State Forests for the region of Wielkopolska (Western Poland) which provided information concerning 108,000 stands taking up the area of over 344,500 ha, of which the area of single-species pine stands was 92,800 ha and that of mixed stands in which pine was a dominant species – 37,700 ha (Table 1). The above data was obtained from the Regional Directorate of the State Forests in Poznań and derive from the Informatics System of the State Forests. In business practice these kinds of data describe in detail characteristics of individual stands and serve as the basis of forest management. Data about forests are updated every 10 years by carrying out direct measurements and descriptions in forests.

The second type of information used in this study concerns data on the assortment structure of stands and their value assessed on this basis. This information was obtained from the Regional Directorate of the State Forests in Poznań and refers to 11,500 stands at different ages. The data was determined in two ways. In younger stands, the assortment structure was estimated on the basis of indices obtained in similar stands during tending fellings. In older stands, their assortment structure was determined individually for each stand. The combination of the above-mentioned two types of information

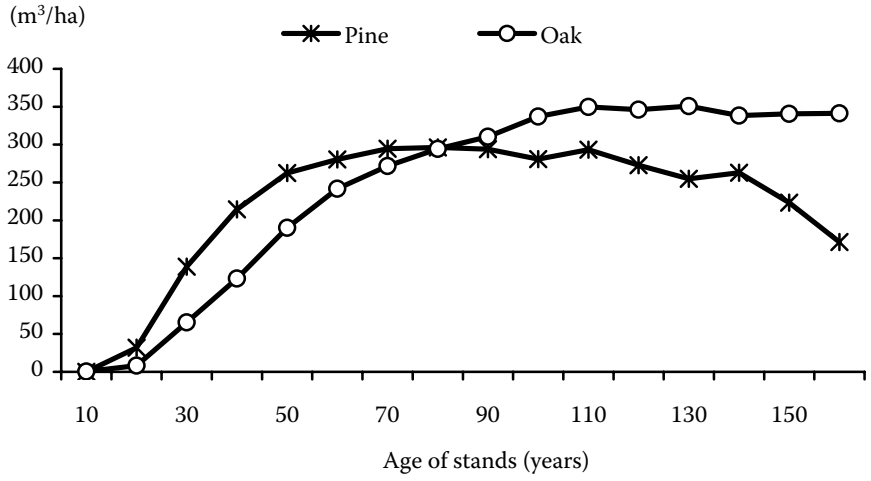

Fig. 1. Mean volume of pine and oak stands at 10-year age intervals

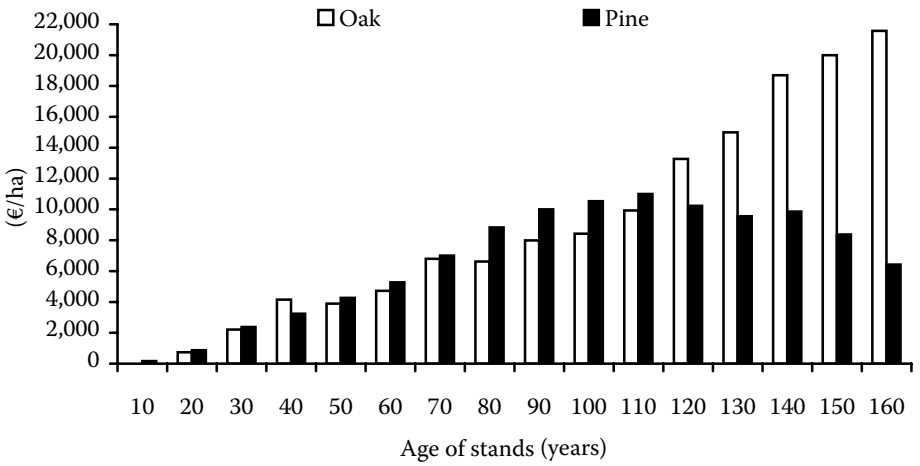

Fig. 2. Mean timber values of pine and oak stands at 10-year age intervals

made it possible to analyze value changes in stands of different species composition occurring at different site. Information concerning pine stands requiring conversion but growing at excessively fertile sites suitable for broadleaved forests was particularly important. The data concerning the assortment structure of stands was collected for several years but the prices of assortments refer to the year 2004.

At the beginning, mean volumes of pine stands requiring conversion at the age of 1–160 years as well as mean volumes of oak stands of the same age range were calculated. Next, mean timber assortment values were calculated in €/ha for the two above-mentioned groups of stands (i.e. requiring conversion and appropriate for the site). In the next step, mean levels of stand value changes were determined

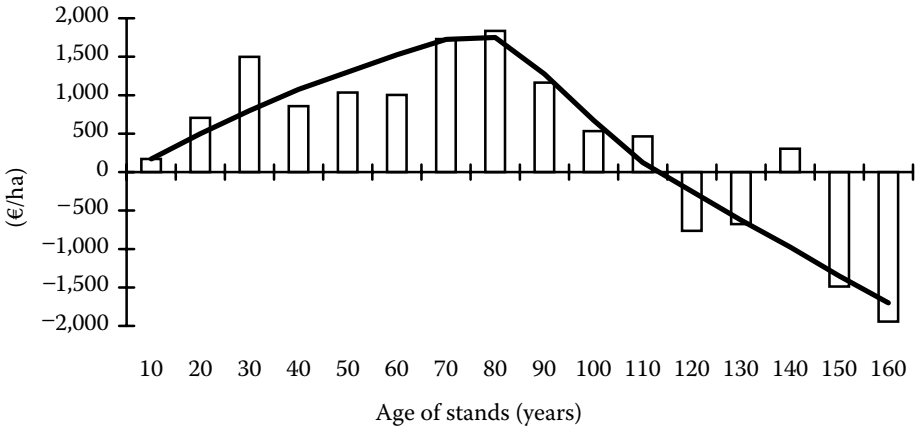

Fig. 3. Changes in mean timber values of pine stands at consecutive 10-year age intervals

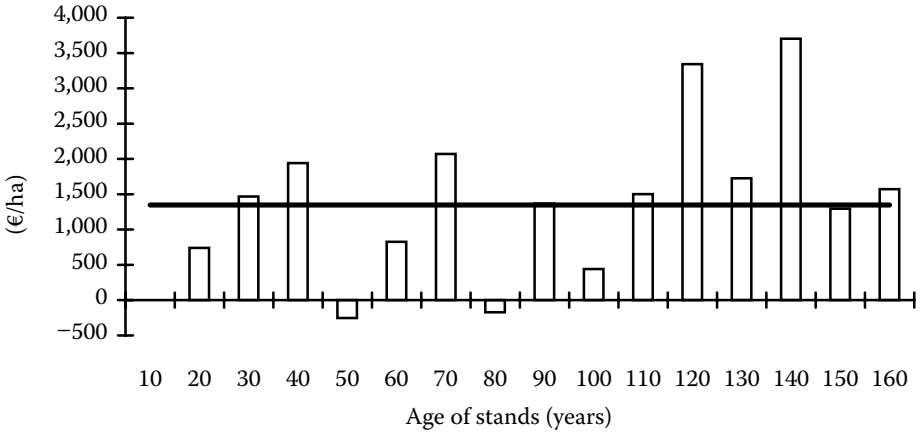

Fig. 4. Changes in mean timber values of oak stands at consecutive 10-year age intervals

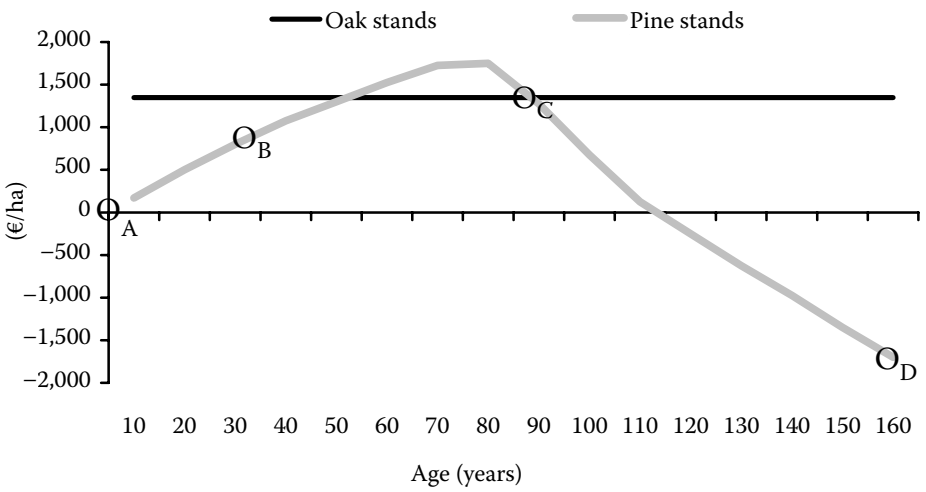

Fig. 5. Relation between mean timber values of pine stands and mean timber values of oak stands at consecutive 10-year age intervals

between the consecutive 10-year age intervals. These values were presented in the form of a diagram. A trend line was determined for pine stands, while for oak stands the authors marked the horizontal line which is a mean value. These two lines juxtaposed in one diagram illustrate mutual relationships between pine stands growing at unsuitable sites and oak stands corresponding to target stands.

RESULTS

The comparison of the mean volume of pine stands requiring conversion with oak stands revealed the existence of a considerable differences between them (Fig. 1). Younger pine stands growing at fertile sites reach higher volumes than their corresponding oak stands. However, these relationships become reversed with age. Some pine stands more than 80 years old degrade and their mean volumes increase no longer, while in the case of oak stands, their volume keeps increasing until they are 160 years old.

A similar picture is obtained when we compare the values of pine stands requiring conversion with their oak counterparts of the same age (Fig. 2). Fig. 3 shows changes in the pine stand values between the consecutive 10-year intervals. It is quite evident that the trend line shows a growing tendency only to the age of approximately 80 years and then falls rapidly. Fig. 4 shows the same diagram for the oak and the horizontal line in this diagram shows the mean increment of the stand value for the entire 160-year period. This line represents the reference level to which the current value increment of stands requiring conversion is compared. Using the horizontal line instead of the trend line for the oak is useful in comparing their value of production with pine, which has a completely different rotation period. Fig. 5 collates trend lines of pine and oak stand value increments. Mutual relations between these lines made it possible to distinguish three time intervals in the life of the stand during which different approaches will be more economical (Table 2). In the first period (interval A–B), the conversion should be carried out as quickly as possible. In the middle period (interval B–C), quick conversion is unprofitable and for economic reasons it would be better to wait until the end of the period. In the last period (interval C–D), the conversion should also be carried out as fast as possible.

The necessity of quick conversion in the last period is obvious because its postponement means financial losses. However for younger stands (interval A–C) the sum of the expected value increments of stands

Table 2. Age intervals and optimal dates of conversion of pine stands (Fig. 5)

Age interval	Optimal date of conversion
Between points A and B – younger stands	as soon as possible
Between points B and C – middle age stands	at the end of the period – at point C
Between points C and D – older stands	as soon as possible

to the point C (90 years of age) was calculated. And in the period A–B the sum of the expected value increments of stands was larger for oak but in the period B–C it was larger for pine.

CONCLUSIONS

The analyses carried out on the basis of data concerning forests administered by the Regional Directorate of the State Forests in Poznań allowed drawing the following conclusions:

- With the passage of time, changes in the mean volume of Scots pine stands growing at unsuitable sites and oak stands growing at appropriate sites follow different pathways.
- The increment rate of the mean value of pine stands from unsuitable sites is initially greater than that of oak stands but these relationships get reversed at older age.
- The mean value of pine stands from unsuitable sites increases only to the age of 80 years and later on this value decreases significantly.
- For economic reasons, the conversion of pine stands growing at unsuitable sites in conditions of the Polish Lowland should be conducted either at a very young age or should be carried out in mature stands.

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Ekonomický aspekt přeměny porostů borovice lesní (*Pinus sylvestris* L.) v Polské nížině

ABSTRAKT: Borové porosty na úrodných stanovištích mají být přeměněny na listnaté nebo smíšené lesy, ale podle věku porostu může mít tato přeměna různé ekonomické výsledky. Za účelem snížení nákladů na tento proces byla provedena analýza na základě potenciálních příjmů z prodeje dřeva. Cílem analýzy bylo najít optimální čas pro zahá-

jení přeměny. Ten byl určen podle vztahu hodnoty přírůstu dřeva z porostů, jež potřebují přeměnu, a hodnoty průměrného přírůstu dřeva z porostů odpovídajících stanovištím. Tímto způsobem byly určeny tři věkové intervaly.

Klíčová slova: *Pinus sylvestris*; borové porosty; dubové porosty; přeměna lesa; lesní stanoviště; Polská nížina

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