

2. Although the *WDR 2003* draft has adopted the vocabulary of "sources" and "sinks", it does not yet connect them by a throughput, much less recognize the entropic nature of the throughput and its economic consequences.
3. There is still no recognition in *WDR 2003* that throughput growth (or even GDP growth as currently measured) might conceivably generate illth faster than wealth, and thus be *uneconomic* growth. There is no concept of the optimal physical scale of the economy as subsystem relative to its containing ecosystem.
4. At a policy level there is still too much emphasis on "efficiency-first", as opposed to "frugality-first". Frugality first induces efficiency; efficiency first makes frugality less necessary.¹
5. There is no discussion of the problem of freeing the non-scarce from the market discipline – intellectual property rights in biotechnology are rather uncritically reaffirmed.
6. The *WDR 2003* should at least question whether global economic integration is an adequate institutional context for policies of enhancing net wealth creation and poverty alleviation. The role of rich countries in sustainable development should be addressed. Which action should rich countries take to help poor countries: (a) grow faster to provide bigger markets and more capital investment for poor countries, or (b) restrict their own growth in throughput to free up carrying capacity and ecological space for poor countries to use? Globalization opts for (a), and so apparently does *WDR 2003*, but without raising the question, much less making the case. But if throughput is the limiting factor should not the answer be (b)?

The reader will discover other areas both of agreement and disagreement, but the six points listed provide a basic context for viewing this paper as a comment on *WDR 2003 Draft*.

УДК 330.366

Томас ЖИЛИЧ – Варшавський університет

ЛІС ЯК СУСПІЛЬНЕ БЛАГО

Ліси виконують різноманітні функції, зокрема сировинну у промисловості, інші забезпечують нас суспільними благами (як наприклад, творення клімату, стабілізація водного режиму тощо). І якщо перші можуть бути приватизовані, то другі не є такими привабливими для підприємців, які впродовж десятків років чекають на повернення вкладених коштів. Позаяк ліси помірних широт відновлюються зі швидкістю 1-2% щороку, згідно з моделлю Кларка, сталі лісозаготівлі не можуть дати надходжень вищих, ніж швидкість природного відновлення. Тому, якщо приватний власник цікавиться комерційним лісівництвом, то це означає, що буде реалізовано одну з альтернатив: або він заготовлятиме ліс без дотримання вимог сталого ведення лісового господарства, або він розраховує на субсидіювання процесу продукування суспільних благ і послуг. Обидві альтернативи ставлять багато запитань до політики приватизації державних лісових підприємств Польщі. Зроблено огляд економіки лісового господарства та проаналізовано можливості реалізації цієї політики у Польщі.

Ключові слова: сталість, модель Кларка, модель Фаустмана, приватизація.

¹ Related to this is a focus on "patterns" of consumption rather than total volume of consumption. But it is the total volume that is limited by sustainability considerations, not the pattern. Let markets determine the pattern of consumption, but not the total volume (scale of throughput). Trying to control pattern (allocation) rather than volume (scale) is perverse from the perspectives both of the market and the environment.

While I am being cranky let me also complain about the *WDR*'s frequent use of the word "change" when what they mean is "improvement". Perhaps the same mindset that sees "growth" as always economic must also see "change" as always improvement.

Forest as a public good

Forests perform various functions, some of which lead to the provision of private goods (e.g. timber) and others provide public ones (e.g. climate control, stabilisation of the water cycle etc.). While the former can be privatised, the latter are not attractive for a private entrepreneur who expects a decent rate of return on investment. As temperate forest typically regenerate at the rate of 1 %-2 % per annum, the classic Clark model implies that sustainable harvests cannot lead to returns higher than this natural regeneration rate. Therefore, if a private agent reveals interest in commercial forestry, one of the following alternatives must hold. Either the agent plans an unsustainable harvest, or expects subsidies aimed at the provision of public services. Both alternatives make plans to privatise the Polish State Forest enterprise questionable. The paper offers an overview of the forestry economics and an analysis of policy options contemplated in Poland.

Keywords: sustainability, Clark model, Faustmann model, privatisation.

1. Introduction

The forest and forestry can be analysed from various points of view and within various scientific disciplines. Economists typically see the forest as a renewable resource and calculate so-called optimum rotation period, i.e. the best time to cut the trees grown for commercial revenues. Since the 19th century, the classic Faustmann model has been analysed theoretically as well as empirically verified. In fact, several generations of foresters based their trade on the Faustmann model.

In this paper a question is raised whether private forestry can be run efficiently in temperate zone in the 21st century. For several decades forestry has been a part of the public sector in Poland, and its operations are considered quite successful. Nevertheless it used to be in private hands earlier, as it is even now in many market economies. Thus one may ask if both models can guarantee the efficiency of forestry operations. The problem is not only of theoretical significance, since plans to privatise the state forests in Poland pop up every couple of years after 1989. One of the versions of such a plan is to use the forests to satisfy claims of the Polish citizens who were expropriated during or after the World War II.

2. Clark model

In order to phrase the problem formally, we will refer to the well-known model of Clark [1976] of sustainable exploitation of a renewable resource. The model compares benefits from a sustainable harvest of the asset and its one-time (i.e. unsustainable) use.

In contrast to exhaustible ones, renewable resources can be used indefinitely. Thus it seemed to be natural to refer to the concept of *Maximum Sustainable Yield* (MSY). If the revenue from exploiting a renewable resource – such as forest, fishery or water cycle – was to be sustainable, only the natural increment G should be harvested. Otherwise the exploited stock x would change perhaps leading to a different increment in the next period. Yet this natural increment, i.e. the difference between the number of births and deaths (if one sticks to the Clark's fisheries model) or the difference between photosynthesis and decay (if one refers to the forestry example) may differ depending on how far the stock is from the carrying capacity of the environment. If the stock is small then the increment is small too (the number of deaths is low, but births are rare either). Likewise when the stock is close

to the carrying capacity of the environment K , its natural regeneration is small as well (the number of births is compensated by the number of deaths). Somewhere inside the interval $[0, K]$ one can expect to find the level of stock x_{MSY} , where the surplus of births over deaths is highest possible. If the stock is kept at this level, one can enjoy the MSY (see fig. 1).

This is a highly simplified model. In particular, it ignores the fact that keeping the stock and harvesting is costly which lowers the economic attractiveness of MSY. Nevertheless for many years the MSY concept was a key reference in economic analyses of renewable resources. It seemed that rational management of such resources leads to keeping them close to x_{MSY} . It was also deemed that by eliminating open access and privatising the stock one can guarantee reaching the MSY. As late as in the 1970 s, Clark demonstrated that, under certain circumstances, even a private owner can be better off by swapping the MSY for a one-time (unsustainable) exploitation of the entire stock.

Even though the Clark model was a simplified one, it drew attention to the fact that privatisation cannot solve the problem of managing renewable resources. Let us assume that a renewable resource – say, a stock of whales – has an owner who maximises the present value of benefits to be derived from the stock. First of all he or she may consider the MSY alternative. The corresponding stock level should be x_{MSY} . The annual increment that can be harvested without depleting the stock is then MSY . If p is the market price of the resource (a whale), the owner can sustain the annual revenue of $MSY p$ for ever. The present value of such an infinite flow discounted by a discount rate r is $MSY p/r$. Now this outcome can be confronted with the alternative of a one-time harvest and sale of the entire stock. Selling the stock x_{MSY} one earns $x_{MSY} p$. Hence it remains to check which of the alternatives is more attractive.

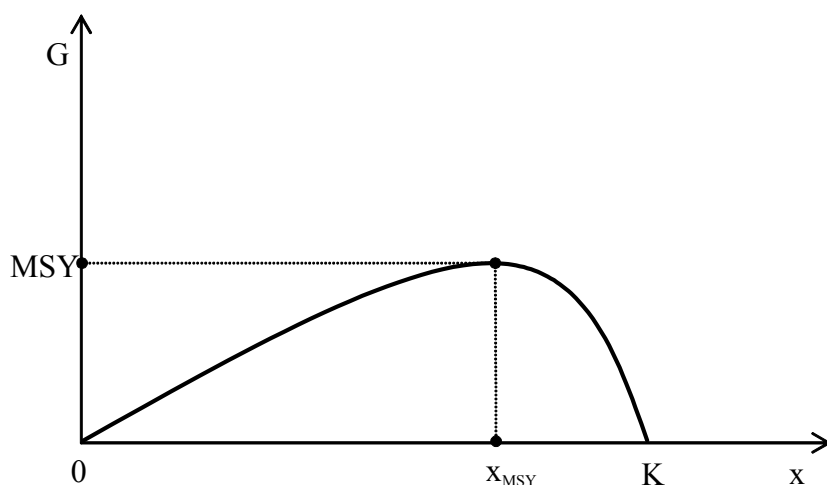


Fig. 1

The problem boils down to comparing $MSY p/r$ with $x_{MSY} p$. Equating the two expressions one gets $MSY p/r = x_{MSY} p$, which – once p is cancelled – can be simplified to $MSY/r = x_{MSY}$. But MSY is computed as $x_{MSY} g$, where g is the natural regeneration rate of the stock kept at its MSY level (i.e. at x_{MSY}). Hence we get the equation $x_{MSY} g/r = x_{MSY}$, which can be simplified to $g/r = 1$ when

x_{MSY} is cancelled. In other words, the owner is indifferent between the two alternatives if $g/r = 1$, i.e. $g=r$. If

$$g > r,$$

then MSY alternative is more attractive. On the contrary, if

$$g < r,$$

one-time harvest and sale of the entire stock is more attractive.

These conclusions can be interpreted in terms of annual revenues implied by the two alternatives. For the sustainable case this is $x_{MSY} g p$, while for the one-time harvest followed by sales and investing the capital elsewhere – $x_{MSY} r p$. Also in this approach it is easy to see that the attractiveness depends on the relationship between the discount rate r and natural regeneration rate of the stock g .

Economic analyses often assume the discount rate $r=4\%$ or more. At the same time, natural growth rate of whale populations is $g=3\%$ or less. Thus the extinction of several whale species in the 20th century cannot be explained by the open access. It turns out that even if the access was protected by private ownership of stocks, the one-time (unsustainable) harvest could have been more attractive commercially. The corollary from the Clark model is that effective management of renewable resources cannot confine to fixing property rights. If such resources are to be saved, they need to be protected otherwise. The recent critique of constant rate discounting [Weitzman 2001] does not apply to this case, since declining rates can be argued for long-term public investment projects, not for private ones.

Nevertheless the quoted version of the Clark model has a weak point its author was aware of. A one-time sale of the entire stock x_{MSY} instead of its annual increment $x_{MSY} g$ would result in lowering the price. Therefore the unsustainable alternative is in fact not nearly as attractive as implied by the model. Moreover, chasing the ever scarcer whales may turn out to be more costly which additionally acts against the unsustainable alternative.

Despite that, the main idea of the Clark model should not be rejected. Even though the fixed-price assumption for the sole owner case cannot be maintained, the model applies to the case where property rights are diffused and none of the owners controls the price. To see this one needs to slightly change the interpretation of model variables. This is particularly easy if the model applies to forestry where the stock is owned by thousands or even millions of private agents. Let us consider the decision problem faced by an individual owner. He or she has to decide whether to keep the resource at the MSY level x_{MSY} in order to earn $MSY = x_{MSY} g$ for ever (for instance, to take a good care of the forest and to harvest only its annual increment), or to go for the one-time yield in order to sell the entire stock x_{MSY} (for instance, to harvest all the timber at once thus depriving the area of the trees for many years). It is easy to see here that the same logic applies as in the original Clark model; as soon as the natural regeneration rate is lower than the discount rate, the MSY alternative loses its commercial attractiveness. It is more profitable to sell the entire stock and the revenue invest elsewhere.

The model is instructive as it demonstrates the key role of a discount rate in managing renewable resources. The lower the rate the more attractive is the sustainable use of the resource. And conversely, the higher the rate, the stronger incentives are for the unsustainable alternative.

3. Empirical evidence

One can go on to explain why in pre-capitalistic economies, where the capital circulated slowly, opportunities to invest profitably were few – and, as a result, the discount rate was low [Schumpeter 1912] – renewables were appreciated as a source of revenues. This situation changed in the 19th and 20th centuries with the change in the intensity of capital circulation and the resulting change in discount rates. Earning sustainable income from renewable resources became less attractive. Of course, environmental degradation and species extinction can be explained in many ways, for instance, by paying particular attention to increased population density over the last several generations, cultural changes, technological progress and other trends. Nevertheless the Clark model demonstrate the need to look at possible microeconomic mechanisms underlying the preference for unsustainable management of renewable resources.

Let us analyse further the relevance of the Clark model for the privatisation of the public forestry sector in Poland. A straightforward application of the MSY concept suggests that a tree should be cut when the average annual increment of timber volume (the most important commercial product of forestry) is maximum. Figure 2 illustrates how such a moment can be found if one knows the growth pattern of a tree. On a graph whose horizontal axis measures time and the vertical one corresponds to the volume of timber, the slope of a straight line crossing the origin can be interpreted as an average pace of cumulative growth. In figure 2 this slope is maximum if the tree is kept until it reaches the age of t_{MSY} . This is when the average annual increment is maximum and equals $MSY = V_{MSY}/t_{MSY}$. Therefore if one cuts the trees when they reach the age of t_{MSY} and immediately plants new ones in the cleared space, one will earn the MSY. For many European species such as spruce, pine and birch this age has been estimated at 40-70 years.

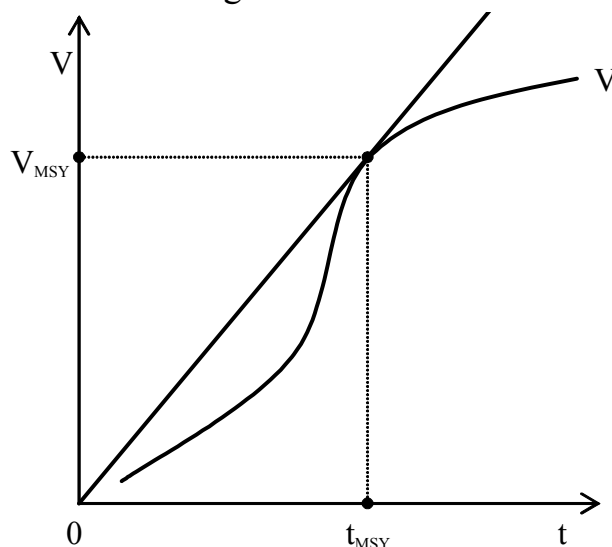


Fig. 2

This derivation, however, is not quite adequate from the point of view of economic theory, as it ignores several important considerations. First of all, it does not take into account the capital frozen in the forest. Planting a tree is costly and it does not translate into a revenue immediately. The profitability of the investment depends on the discount rate among other things. Also the maintenance of the forest is costly and – despite the foresters' efforts – it may fail to yield returns because of the risk of fires, pest infestation and other damages. All factors mentioned suggest that there may be incentives to cut the trees earlier, i.e. before the t_{MSY} moment.

4. Faustmann model and its extensions

A more accurate economic analysis should consider the forest an asset whose value may increase in time. If the forester is a price-taker and if the prices do not depend on the age of a tree, then the expected growth results from a physical increase in timber volume. Therefore the tree should be cut and sold in t_0 when its current rate of volume growth drops to the level of a discount rate r (see figure 3). If the owner of the forest cut the tree earlier, he or she would have lost a revenue more attractive than a return on an alternative investment (reflected in the discount rate). on the other hand, if the owner postponed the harvest until after t_0 , he or she would have earned less than from an alternative investment.

More formally, assuming that the value of a tree stand is proportional to the volume of timber V_t one can write $R_t = p V_t$, where p is the net price, i.e. net of costs of maintenance, transport etc. The cutting rule implied by this model is derived from the equation $d(p V_t)/dt: p V_t = r$, i.e. – after cancelling p both in the numerator and denominator –

$$dV_t/dt:V_t = r.$$

This is a different criterion than the one based on the MSY concept. The optimum cutting age t_0 (fig. 3) may differ from t_{MSY} .

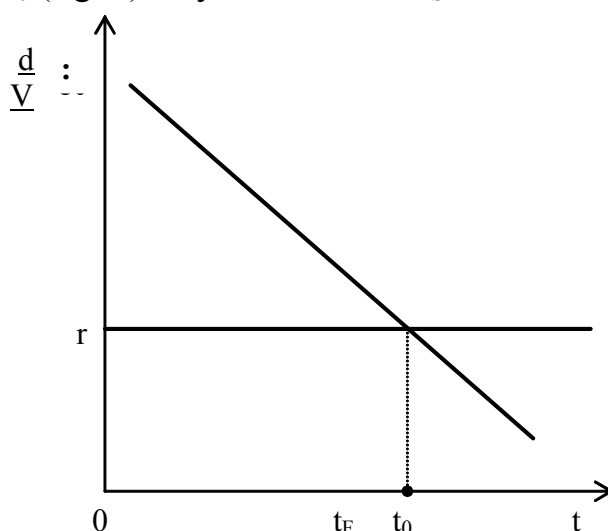


Fig. 3

Yet even t_0 is not a fully satisfactory solution to the problem of maximising economic surplus in forestry. It ignores the fact that even a cleared forest stand has some residual value. The land has a value because of a number of opportunities including planting a new forest. Taking this into account makes the optimum cutting

age somewhat lower than t_0 , because the expected growth rate in the asset value becomes less attractive. Namely, if the value of the cleared land is neglected then the alternative benefits are reflected in the discount rate only; otherwise the benefits from clearing the land include also additional opportunities which speeds up the optimum cutting moment. This concept of the optimum rotation period t_F (see fig. 3) was first introduced by Faustmann [1849] in the middle of the 19th century, and it has served as a reference for commercial forestry operations until now. According to the Faustmann model optimum rotation periods for species grown in Finland is between 50 and 90 years [Tahvonen and Kuuluvainen 2000]. Similar results – 45-60 years depending on the discount rate – can be derived for spruce in Poland [Kielar 2001].

It should be noted that these results contradict the hopes of environmentalists who prefer to see much longer rotation periods. Conservationists would welcome tree stands one hundred years old or even older, since an old forest performs unique ecological functions. Perhaps the volume of its timber does not grow fast enough, but old hollow trees together with well-developed undergrowth provide valuable habitats for many species. Moreover surveys confirm that people prefer visits to an old rather than a new forest. Yet the original Faustmann model does not include parameters that reflect such ecological and economic factors.

The problem can be solved by adding to the Faustmann model a value of "services" provided by an old forest. One can achieve this by making the timber price p variable with respect to the age of trees; it would grow with age – which can be characterised by the differential condition $dp_t/dt > 0$. By modifying our previous decision rule to the form

$$d(p_t V_t)/dt: p_t V_t = r$$

and calculating the derivative we get

$$p_t dV_t/dt: p_t V_t + V_t dp_t/dt: p_t V_t = r,$$

and after simplifications

$$dV_t/dt: V_t + dp_t/dt: p_t = r.$$

After moving the component $dp_t/dt: p_t$ to the right hand side of the equation we recover the original formula with a decreased right hand side:

$$dV_t/dt: V_t = r - dp_t/dt: p_t.$$

Thus taking into account specific benefits provided by an old forest has the same impact as lowering the discount rate, i.e. it extends the optimum rotation period beyond t_0 (or beyond the Faustmann rotation period which reflects the value of land).

Nevertheless the bare fact that one knows how to theoretically compute an optimum rotation period reflecting the value of an old forest does not solve the practical problem of postponing the moment of cutting a tree by a forest enterprise whose objective is to maximise profits. By postponing the harvest the enterprise supplies a public good in the form of environmental services of a mature forest – i.e. generates a positive externality – at the expense of its profit. This is a typical case of the market failure when an equilibrium is non-socially optimal. Economic theory studies such cases and suggests how private decisions can be changed in order to attain the optimum. A typical tool-box includes quantity constraints and tax incentives. A quantity constraint may take the form of a lower limit for the age of

harvested trees. On the other hand, governments may introduce tax incentives for late harvests – for instance, tax exemptions for timber harvested in old tree stands.

The problem would have disappeared if the externality generated by forest enterprises could have been privatised, that is if the foresters could have sold services provided by an old forest as they sell timber. To some extent this is possible and there are forests (both public and private) that try to earn money from selling tourist or scientific services. However, by its very nature, forest ecosystems are public goods and "free riding" behaviour – i.e. using the good without paying for it – can never be eliminated completely. A spontaneous market correction is rather unlikely and hence a conscious public policy is indispensable.

Based on the analyses above, one can be surprised by requests voiced by Polish environmental non-government organisations to introduce a moratorium on cutting old trees in a number of ecologically valuable areas (e.g. in the Białowieża Primeval Forest). Are such requests irrational, or can they be economically justified?

One can further modify the Faustmann model in order to assess the moratorium on cutting old trees. To this end one has to assume that benefits from keeping old forest stands are larger than the market value of timber. A harvest lets maximise revenues from timber sales net of planting and maintenance costs, but it deprives the economy of even larger benefits from other functions of the old forest. The problem is that these other benefits are typically external from the point of view of a forest enterprise and they do not contribute to the bottom line of the enterprise. Consequently a correction of the market mechanism is needed.

What remains to be explained is to answer the question why the foresters let achieve certain tree stands the age that is considered too mature on the grounds of Faustmann model. Why were not these trees harvested earlier? Making harvest decisions in a forest enterprise is actually much more complicated than the classical Faustmann model asserts. In particular, one should take into account that timber produced from the finest old trees may get higher prices and such benefits are not external, but they can be enjoyed by foresters. Thus without any intervention, market itself can spontaneously determine a rotation period longer than implied by a simple model. However, after reaching certain age, tree stands start to generate external benefits that disappear after the harvest. Hence foresters face a paradox. Trying to maximise commercial profits they extend the rotation period up the point when environmentalists begin to see external benefits and request that the trees are saved from harvesting thus depriving them of the planned profits from timber sales.

If the foresters were to strictly maximise their private benefits, they should cut the trees just before these become of interest to conservationists. There is some evidence that precisely such incidents happen: a tree is cut just when it was supposed to receive a protective status. Nevertheless forest enterprises in Poland and elsewhere are managed by engineers and natural scientists who do not always confine themselves to efficiency criteria but instead they pay attention to externalities as well.

5. Further empirical evidence

The argument above leads to the conclusion that applying optimum rotation periods at best guarantees reaching the maximum sustainable yield corresponding to the average rate of timber growth g which in Poland is close to 2 % (if one com-

compares the volume of timber, i.e. 1,500 million m^3 and its annual increase, i.e. 30 million m^3 ; actual harvest is lower [Ochrona 2004]). Taking into account the cost of capital can imply a deviation from t_{MSY} and consequently from the growth rate g . Therefore an actual rate of return on investment in forestry can be as low as 1.5 % or even worse. It is obvious that any commercial owner of the forest will deem such a rate of return as unattractive. The Clark model predicts that a resource managed under such circumstances is likely to be the subject of a one-time (unsustainable) extraction. In other words, keeping the resource at the maximum sustainable yield level turns out to be less profitable than boosting immediate profits at the expense of sustainability.

If a commercial agent reveals interest in privatising a public forest, he or she cannot see such an investment as a profitable one – unless an unsustainable use is planned. A similar type of analysis is sometimes carried out in order to check the credibility of a public-private partnership. It happens that a commercial agent planning to enter into a public-private partnership claims that the investment will be funded mainly from private funds. Estimating expected revenues and confronting these with a normally accepted rate of return (10 %-20 % or even more) allows to determine if the agent is credible. Finding that an officially expected rate of return on private capital is much lower than a usual one implies that the public partner is engaged in an investment project where its actual contribution will be higher than declared officially.

The case analysed in this paper very much resembles such a situation. A private investor declares interest in a state forest affirming that the forest will be sustainably managed. Unfortunately the credibility of this assertion is questionable if one checks the expected rate of return. Nobody can consider anything yielding 1.5 % per annum an attractive investment. One may thus reasonably suspect that privatisation of public forests would have caused a significant decay of the natural capital.

6. Conclusions and policy implications

Two questions need to be addressed. First, why is it that in some countries privately owned forests are not degraded. Second, what institutional conditions are to be satisfied if the State Forest enterprise in Poland could be privatised without compromising sustainability constraints.

The first question has to refer to a historical argument. In circumstances when the pace of economic growth was low (implying a low discount rate, $r=1\%$, or less), profits from forestry (based on the natural regeneration rate $g=1.5\%$ or more – depending on the fertility of the soil and other edaphic factors) were attractive for commercial agents. Logging technology was not very advanced and population density was low. Consequently there were neither economic incentives nor technological opportunities for excessive tree cutting (apart from well known exceptions). The situation changed in modern times. In many places forestry operations have collapsed. In countries where they have not despite private ownership, their sustainable operations were forced by constraints established by governments in due time. Often the constraints are supported by public subsidies whose existence is a *sine qua non* condition to keep sustainability. Thus private property of the forest is a relic of the time when the relationship between the natural regeneration

rate and the discount rate were different. Its continuation requires an active participation of the government typically supported by public subsidies.

Based on that an answer to the second question – about the privatisation of state forests – can be positive. One just has to clarify how much it will cost and what precautions it will require. The starting point is to admit that revenues from timber sales do not give attractive returns to assets invested. This situation can be tolerated by a public entity, while a private entrepreneur would have to boost the revenues dramatically. According to Clark model, the most straightforward way to do so is to switch from sustainable yields to on-time extraction. If one wishes to avoid this alternative, additional revenue sources should be identified. Privatisation of some external benefits accompanying timber production provides an opportunity. For instance, a forest owner can charge for picking berries and mushrooms or for recreational services delivered by sufficiently old forests stands. Nevertheless not all external benefits can be privatised (internalised) in this way. Some externalities – such as provision of habitats and stabilising global cycles – are public goods and they cannot be sold and bought in the market. Such goods should be effectively financed only from public sources. If a private owner is to provide its optimum supply, he or she has to be subsidised.

In conclusion, privatisation of the State Forest enterprise in Poland is theoretically possible, but its desirability is questionable. If a list of constraints binding prospective private forest owners was to be compiled, it would become clear that sizable subsidies are called for. If the State Forest enterprise operated at a slack, then one could expect that its privatisation will enhance its profits. At the same time, putting the sector under the commercial pressure will increase the risk of reduced supply of the public good e.g. through establishing shorter rotation periods – something one can avoid only by spending more on control, monitoring and law enforcement. As a result, improved efficiency may turn out to be illusory. If, on the contrary, the State Forest enterprise operates efficiently, then its privatisation cannot be justified from the social welfare point of view if a flow of subsidies required by prospective private owners is taken into account.

References

1. **Clark, W. Collin** 1976, *Mathematical Bioeconomics: The Optimal Management of Renewable Resources*, Wiley, New York.
2. **Faustmann, M.** 1849, "Berechnung des Wehrtes, welchen Waldboden sowie nach nicht haubare Holzbestände fuer die Waldwirtschaft besitzen", *Allgemeine Forst und Jagd Zeitung* no. 25, P. 441. [quoted after Clark 1976, pp. 257-263].
3. **Kielar, Rafal** 2001, *Uogólnienie i analiza podstawowych modeli optymalizacji wieku rebnosci drzewostanu, opartych na modelu Faustmanna*, M.A. thesis at the Warsaw University Department of Economics [Generalisation and analysis of Faustmann-based models of optimum rotation periods].
4. **Ochrona Srodowiska** 2004, *Statistical yearbook*, Central Statistical Office, Warsaw [Environmental protection 2004].
5. **Schumpeter, A. Joseph** 1912, *Theorie der wirtschaftlichen Entwicklung*, Wien.
6. **Tahvonen, Olli and Jari Kuuluvainen** 2000, "The economics of natural resource utilization", in: H. Folmer and L. Gabel (eds.), *Principles of Environmental and Resource Economics. A Guide for Students and Decision-Makers*, Second Edition, Edward Elgar, Aldershot, pp. 665-699.
7. **Weitzman, L. Martin** 2001, "Gamma discounting", *American Economic Review*, vol. 91, pp. 260-271.