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Forest ecosystem services – assessment methods

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Abstract

Forest ecosystems represent the most important values of natural assets. In economic valuation techniques, to estimate the value of forest ecosystem services, the attention is still focused mainly on their market values, i.e. the value of benefits measured in the economic calculation based, first of all, on the price of timber. The valuation of natural resources is currently supported by considerations of the global policy, in order to strengthen the argumentation justifying the need to incur expenditure related to the protection of biodiversity. There is increasing evidence that biodiversity contributes to forest ecosystem functioning and the provision of ecosystem services. Natural capital of forests can be consumed directly as food, wood and other raw materials or indirectly – by benefitting from purified water and air, safeguarded soils or protected climate. At the same time, forest ecosystems provide us with a range of intangible values – scientific, cultural, religious as well as encompass heritage to pass on to future generations. In the era of increasing pressure on the use of free public goods (natural resources), it is necessary to improve understanding of the role of forests in creating national natural capital, and in enhancing the quality of human life. All things considered, the so called non-market forest ecosystem services may have a much higher value than the profits from the production of timber and raw materials. Needless to say, non-market values of forest ecosystems are of great importance for the quality of human life, and the awareness of this should translate into social behavior in the use of natural resources. This paper reviews the methods to estimate the value of forest ecosystem services in view of recently acknowledged paradigm to move forward from economic production to sustainable human well-being.

Key words

forest functions, non-market forest values, economic valuation methods, biodiversity

Introduction

Economic valuation of ecosystem services has recently achieved considerable interest both in research and policy circles, and more than ever since the publication of the Millennium Ecosystem Assessment (MEA 2005), which drew attention to the value of biodiversity to ecosystem services, human well-being and sustainable development. One of the principles of the economic valuation of biodiversity and ecosystem services is to assign proper values in an attempt to facilitate making well-versed decisions on nature management. Yet, a number of people refuse to accept applying economic valuations and conventional cost-benefit analyses to biodiversity, and argue for relying on plural approaches to validate conservation (Norgaard 2009; Ninan and Inoue 2013).

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Economic valuation, however, does not disagree with other perspectives for better management of the environment. It simply seeks to put across that proper valuation of environmental goods and services will lead to better conservation outcomes.

Regardless of many reservations and difficulties in applying ecosystem valuation methods, they can play an essential role in communicating the value of nature and in designing environmental policy and tools. There exists a diverse mixture of techniques for monetary valuation of ecosystem services and the underlying natural capital stocks, nonetheless, the methodology or statistical standards for ecosystem accounting has not been so far agreed. In the recent decades, there has emerged the concept of "natural capital", which recognizes that environmental systems play a fundamental role in a country's economic effectiveness and social well-being, not only by providing resources and services, but also by absorbing emissions and wastes. If managed sustainably, natural capital is renewable but can be by far depleted or degraded if mismanaged. A range of elements of natural capital, such as biodiversity or uncontaminated air, soil and water are both delimited and vulnerable. The complexity of natural systems and irreversibility of environmental changes mean that replacing natural capital with other forms of capital is often impossible or carries significant risks. For example, the regulating ecosystem services, such as maintaining the quality of air and soil or flood control provided by forest ecosystems are somewhat imperceptible, and in consequence, as a rule taken for granted. However, if they are damaged, the resulting losses can be sizeable and not possible to restore (Constanza et al. 1997; MEA 2005; Tisdell 2007; TEEB 2010).

Of all the capital forms, natural capital should be perceived as fundamental, seeing that it provides the basic conditions for human existence by delivering essential resources. Natural capital sets the environmental limits for our socio-economic systems that call for continuous flows of material inputs and ecosystem services. Yet, even though a framework for experimental ecosystem accounting has been developed, for example – as part of the UN system (*System of Environmental-Economic Accounting* – SEEA), the TEEB (*The Economics of Ecosystems and Biodiversity*) initiative or else the simplified ecosystem capital accounts for Europe launched by the European Environment Agency (EEA), natural capital has not been so far included in nations' wealth accounting systems.

The instrument serving the international classification of ecosystem services was developed under the *Common International Classification of Ecosystem Services* (CICES). CICES takes the MEA (2005) classification of ecosystem services, yet, it modifies the approach to reflect current research. The three main ecosystem service categories under CICES are: provisioning services (e.g. biomass, water, fiber), regulating and maintenance services (e.g. soil formation and composition, pest and disease control, climate regulation) and cultural services (physical, intellectual, spiritual and symbolic interactions of humans with ecosystems and landscapes). In an attempt to reduce the risk of double-counting of benefits, the CICES system does not include services classified as supporting services, which are not consumed directly, i.e. the essential benefits attributable to the very existence of ecosystems, including: maintenance of temporal, spatial and structural continuity; the production of live biomass; contribution to soil formation and the biogeochemical cycles of carbon, oxygen, nitrogen, phosphorus, sulfur and water – all indispensable for ecosystems to provide goods of all kinds. The benefits as such belong to the group of the so called non-market goods, the values hardly ever included in financial (monetary) calculations (Haines-Young and Potschin 2017).

The development of methods and procedures for the valuation of non-market ecosystem services is, among others, a response to the need to strengthen fundamental principles for nature protection, in accordance with global environmental requirements stated in international agreements. In close cooperation with scientific community, the EU is responding to this challenge by developing more comprehensive environmental accounting systems, including approaches for measuring the condition of ecosystems (EEA 2010), which is supported by current efforts to develop new more inclusive indicators of social, economic and environment progress via the "Beyond GDP' initiative (http://ec.europa.eu/environment/beyond_gdp/index_en.html). The Beyond GDP initiative is about building indicators that are as clear and appealing as Gross Domestic Product (GDP) and all-encompassing environmental and social aspects of development for the reason that: *"We need indicators that promote truly sustainable development—develop-*

ment that improves the quality of human life while living within the carrying capacity of the supporting ecosystems" (Costanza et al. 2009).

The aim of this review is to address the methods that could be better in assessing the life quality than generally used GDP values, and in particular, the instruments which tackle the condition of ecosystems as the measure of the ecological well-being of the region/country. In this context, one of the relevant measures is the assessment of biodiversity status, combined with the economic valuation of non-market forest ecosystem services, based on public perception of goods provided by forests. The present paper reviews the methods to valuate non-market forest ecosystem services, in view of recently acknowledged paradigm of progress based on sustainable human well-being rather than on economic production.

Intrinsic values of forest ecosystems

Forests constitute a unique integral resource of natural capital, which not only organizes and brings together many functions, but has the ability to renew all of them, unless the human interference disturbs environmental conditions. The multiple functions fulfilled by forest ecosystems are the natural basis for generating numerous environmental goods. Apart from economic, market and institutional benefits, forests provide extremely important public ecosystem services: free of charge, all-available and non-market (Kostka 2008; Bartczak 2006; Bartczak at al. 2008; Płotkowski 2008; FOREST EUROPE 2014). Forest ecosystem services can be consumed as direct products: water, food, wood and other raw materials, or indirectly, as services related to water purification, climate regulation and air quality and a variety of generally intangible assets in the category of cultural services (recreational, scientific, cultural and religious – all the heritage passed on to next generations) (Costanza et al. 1997; Costanza et al. 2009; Żylicz 2010, 2013; Hølleland et al. 2017).

Forest functions make possible the provision of forest ecosystem services to people (direct and indirect contributions to human well-being). Each of the forest functions may add to the generation of one or many forest ecosystem services, and individual services may result from many interdependent functions of forest ecosystems. The infrastructural forest ecosystem services, such as: upholding biological productivity; shaping fauna and flora habitats; ensuring water purification and retention as well as soil preservation; maintaining the biogeochemical cycles, result from the durability of the forest ecosystem structure and the ongoing physical, chemical and biological processes. At the same time, forest ecosystems act as the multifaceted regulator and stabilizer of climate conditions – as they regulate the water balance (e.g. air humidity maintenance, groundwater supply), regulate temperatures (e.g. prevention of heat radiation), neutralize wind speed, and also – produce oxygen, as well as constitute carbon storage and absorb air pollution.

Being essential for the provision of a wide range of ecosystem goods and services that are important to human well-being, forest ecosystems support biodiversity. Forest biodiversity loss results in losses in forest productivity and sustainability, thus, in order to provide ecosystem services, forest management must take into account biodiversity – highly reliant upon the integrity, health and vitality of forests (Płotkowski 1996; FOREST EUROPE 2014; Maes et al. 2016). For safeguarding biodiversity, the most important forest ecosystem services are associated with habitat functions, including: sustainability of biotic production (capacity for self-renewal over time) and preservation of genetic resources. As biodiversity can be differently defined and measured in a range of manifold ways, the values of ecosystem services derived from biodiversity are hardly ever subject to conceptualization. Foresters focus mainly on tree stand diversity, which is a substitute measure for total biodiversity. According to subject literature, such attributes as the mixture of tree species in stands and the presence of dead wood are positively correlated with many other aspects of biodiversity, e.g. species diversity (Juutinen 2008; Van der Plas et al. 2018).

Economic valuation of forest ecosystem services is of principal importance for the design and implementation of effective sustainable forest management options and forest policies, at national, continental and global levels. The forest, as a source of many goods should be valued both in the dimension of its very existence as natural capital, as well as in terms of its contribution to socio-economic life. Recently, more and more important have become non-market values of forest ecosystems, whose products in the form of goods can be consumed by the society. Forestry non-market goods serve to satisfy social needs, and at the same time, are not regulated or valued by market mechanisms (De Groot et al. 2002). Consequently, the value of these goods/services corresponds to the assessment of benefits by consumers. Their willingness to pay for the forest natural values determine the price of ecosystem goods/services (Pearse 1990; Płotkowski 2008; Żylicz and Giergiczny 2013).

In this paper we focus on attempts to valuate forest ecosystem services resulting from forest functions, the effect of which are non-market services, such as preservation of biodiversity as well as the aesthetic, recreational and cultural values. Determining the value of the latter is especially important in the case of protected forest areas, which, in addition to biodiversity preservation, constitute the source of important benefits for humans, such as clean water and air, carbon storage, soil stabilization and mitigation of natural disasters.

Assessment of non-market forest ecosystem benefits

Conditional on the functions fulfilled by forest ecosystems, various procedures are used to assess ecosystem economic value. In contrast to the relatively straightforward valuation of ecosystem services, such as the production of raw materials or carbon storage capacity, the comprehensive assessment of numerous ecosystem services is extremely difficult, as it is e.g. in the case of the very existence of the ecosystem that embraces biodiversity along with genetic resources, as well as its cultural and recreational values (Getzner 2009, 2010; Maes et al. 2016).

The issue of economic valuation of non-market values of natural assets is still controversial, especially in the case of assessing the total value of ecosystem services. First of all, this refers to avoiding duplication in the valuation of forest ecosystems. According to some authors, the value of many services is already included in the value of the "final product", i.e. the total value of direct and indirect goods provided by forests (Holland et al. 1994; Pearce et al. 2006; TEEB 2010; EEA 2010). Then again, some authors believe that, especially in the case of managed forests, e.g. wood production should not be purely treated as an ecosystem service, as it is connected with expenditures, costs and economic gains of business entities and result from the consumption of forest management products and services. These goods are not just natural resources, as they are not derived simply from the functions of forest ecosystems, but constitute the sources of costs and profits that ought to be included in the accounts of economic entities, seeing that they contribute to the value of these entities (Klocek 2005; Klocek and Płotkowski 2007; Kostka 2008; Płotkowski 2008).

Non-market services are the fundamental natural benefits generated by forest ecosystems. In the process of classifying forest services, in order to attach monetary values, there may be useful the division proposed by Pearce and Turner (1990), who distinguished three levels of values, i.e. 1) individual benefits – commonly referred as private goods, 2) general benefits – valued in the form of social preferences and recognized as public goods, 3) structural values, in other words – the value of nature in itself, i.e. natural systems and processes that sustain life on Earth (Kostka 2008; Getzner 2009, 2010).

According to Płotkowski (2008), the non-market forest ecosystem services can be systematized on the basis of generally accepted economic criteria – as use values and non-use values (Fig. 1). Part of these benefits are public goods, available to users free of charge.

Non-market use values may be taken into account as equivalents of the preferences of people who have a share in the consumption/use of a good or service provided by forest ecosystem. The concept illustrated in Fig. 1 refers to use values as the benefits of contact with nature (e.g. camping, animal-watching, trekking, cross-country skiing, trips to national parks/nature reserves, mushroom picking, etc.). The activities such as camping, hunting, fishing constitute the direct use of natural resources and obtaining consumer values, whereas e.g. observation of nature, bird watching or admiring views are included in the category of non-consumer values, as the actions of consumers of this type do not significantly affect the state of nature resources.

As part of the presented conceptual approach to assessing the value of forest ecosystems, non-use values are arbitrarily divided into the values defined as existential – resulting from the very existence of natural systems (forest ecosystems), including the so called substitute value, which results from the fact of assigning values to rare species or scenic landscapes, whose exist-

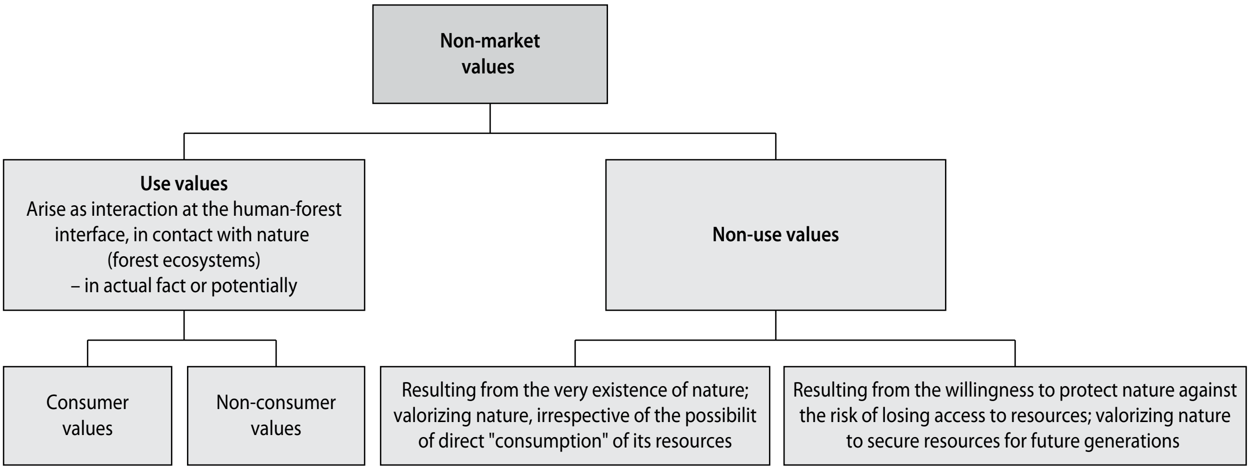

Figure 1. Allocation of non-market values (adopted from Płotkowski 2008)

ence we know only indirectly, through various media, without the possibility of personal contact with such objects. The value of the nature option corresponds to the maximum amount that consumers are willing to pay for the opportunity to access recreation/tourism resources or services in the future. Option valuation is used to valorize nature benefits such as "tourist and recreational value of forests". The value of "hereditary transmission" is determined by the consumer's readiness to pay for the possibility of conveying to the next generations unique and irreplaceable natural assets in the unaltered state. Additionally, the valuation of non-use values is related to individual attribution of values and disclosure of preferences, i.e. it depends on individual, often incomparable ways of perceiving and understanding reality, related to individual emotions, ways of reaction and systems of views (Klocek and Płotkowski 2007; Płotkowski 2008).

Surveys carried out by Żylicz and Giergiczny (2013) aimed at estimating forest ecosystem non-market benefits, with a special focus on examining those, who are particularly esteemed by forest visitors. The value of forest recreational goods, estimated at a national level, amounted to 363 PLN /ha/year. According to the authors, this outcome can be increased by about 10%, which corresponds to the value of berries and mushrooms collected by visitors for their own needs. In the study by Żylicz and Giergiczny (2013), there were distinguished forest attributes such as: forest type (coniferous, deciduous or mixed), species diversity, age diversity, undergrowth height and density, tree distribution, shape and type of forest edges, occurrence of dead wood, intensity of management and residue left behind after forestry works, as well as tourist infrastructure. This study showed that the recreational value of forests depended evidently on forest attributes such as: species composition and the age of trees, and also – which was not obvious at the beginning – from the presence (moderate) of dead wood. In general, research shows that forest biodiversity is vitally important for increasing the value of ecosystem services in the consumer judgment (Czajkowski et al. 2009; Eckehard et al. 2017). According to the study carried out in Finland, on 32 forests with old pine stands, the value of benefits resulting from maintaining biodiversity, was 251 EUR/ha. Meanwhile, the value of benefits obtained from timber production of the stands examined was on average just about 106 EUR/ha (Juutinen 2008).

Methods used in valuation of non-market forest ecosystem services

Non-market benefits have no price and are not traded on the market. Most of these are infrastructural (intrinsic) values of forest ecosystems and public goods that result from broadly understood contribution of forests to shaping quality of human life and the environment. The valuation of ecosystem services of this kind is based on the methods enabling determination of forest ecosystem value for potential consumers and reconciling monetary values with them. These may be valuations derived from the so called preferences stated or revealed by surveyed consumers, followed by the determination of the value of a given good based on an analysis of data from related markets. The valuation methods are the subject of numerous discussions in subject literature (Giergiczny 2009; Turner 2010; Hölzinger and Dench 2011; Poskrobko 2012; Czajkowski 2013; Żylicz 2010, 2013; Marx-Bielska and Zielińska 2014; FOREST EUROPE 2014; Zawilińska 2015). The most commonly described/used valuation methods include: contingent valuation, choice experiment, travel cost, hedonic pricing, benefit transfer, as well as the cost-based methods (damage cost avoided, replacement cost, and substitute cost methods).

The *Contingent valuation* (CV) and the *Choice experiment* (CE) are the stated preference methods most frequently used in valuation of non-market forest ecosystem services. They consist in the measurement of values that people attribute to forest services/goods that are not traded on the market. For the needs of these methods, interview/survey schemes are developed, the purpose of which is to determine preferences with regard to the stated willingness to pay (WTP) for improving the quality of the availability of natural assets or else with reference to the minimum amount of money that someone is willing to accept to abandon a good or put up with adverse changes in the natural environment (willingness to accept – WTA). The stated preference methods enable establishing WTP, based on the choice of scenarios, taking into account the various attributes of a given natural asset, e.g. forest features related to recreation, leisure and tourism, such as e.g.: species composition and age of tree stands, forms of forest protection or the availability of tourist infrastructure. The choice of the scenario is dictated by the degree of attractiveness/usefulness of specific forest attributes stated by individual survey respondents. The surveys/interviews including the WTA approach are aimed at e.g. answering the question of how individual respondents assess changes that could theoretically occur and worsen the state of natural/environmental assets. Opinion polls are carried out on the assumption that the respondents are aware of the benefits of natural goods, know well their value and current status, and have information about potential quantitative and qualitative changes in the environment. The CV and CE methods based on stated preferences are considered less reliable than the methods that make use of data on market prices and focus on revealed consumer preferences, where economic values are evaluated on the basis of research on markets. Among revealed preference methods, the most commonly used are: the travel cost method and the hedonic pricing method.

The *Travel Cost Method* (TCM) is applied to the valuation of components of the natural environment (forests, national parks, nature reserves), whose “consumption” is associated with the necessity of incurring expenses determined by market prices. For example, a visit to a national park embracing forest areas is associated with expenses for commuting (travel), the cost of which implicitly attests to the quality of tourist/recreational value of the destination. The turnout of stays and the amount of travel expenditures are, therefore, an indirect indicator of the attractiveness of the forest/national park that constitutes its value to the consumer. This method of valuation allows estimating values related to the quality of the environment and tourist attractions (admiring the views, trekking, recreation, etc.) (Ward and Beal 2000).

The *Hedonic Pricing Method* (HPM) uses valuation of e.g. a property, depending on its location in the natural environment. The basic premise for using the HPM is the fact that the prices of market goods depend on the existence of non-market (natural) goods, such as proximity to the forest, clean air, uncontaminated water or low noise. As components of the natural environment highly influence real estate prices, it is possible to ultimately estimate the value of services provided by forest ecosystems on the basis of property prices. A new variant of the HPM is the so called “happiness approach” (Turner 2010), in other words: evaluation of “human happiness “ or “life satisfaction”, for which experimental measures were worked out in 2001–2010. In terms of a declared part of income, the method enables valuation of natural assets that affect an individual sense of happiness (Welsch and Kuhling 2008). A survey respondents subjectively evaluate the feeling of life satisfaction, using different measures and scales, e.g. from 1 (dissatisfaction) to 10 (satisfaction). Different measures of life satisfaction are interrelated and can be treated together as a coherent logical structure. “Happiness” is inherently associated with a combination of individual and demographic characteristics, as well as socio-economic factors. By confronting the characteristics that make up happiness with data on the natural environment, one can estimate the value of ecosystem services in a different way than using the WTP or e.g. the cost-based method (Turner 2010; Welsch 2010).

In the context of this review, there also deserves attention the *Benefit Transfer* (BT) method. This technique consists in extrapolating the results of tests carried out elsewhere than the area of interest, assuming that all conditions in the examined and compared areas are commensurate or largely equal. Carrying out valuations using the BT method requires the use of databases containing the results of previously conducted valuations, e.g. the results obtained in studies carried out with the use of the CV or CE methods. The BT method has found the most common application in the case of valuation of ecosystem services in terms of benefits for human health. In the valuation of non-market forest ecosystem services, this method has been used to determine the costs of quantitative or qualitative changes in a given forest ecosystem (e.g. aesthetic, recreational, biodiversity richness) (Johnston and Wainger 2015).

The cost-based methods take into account damage cost avoided, replacement cost, substitute cost and involve estimating how much it would cost to restore/replace a given natural asset if it was destroyed. It is assumed that if people bear costs to avoid damage caused by loss of ecosystem services, the value of a given service will be at least equal to the cost incurred in order to regenerate or replace it. The cost-based methods have been largely used in valuation of wetland ecosystem services through the assessment of costs of restoration/restitution of damaged wetland ecosystems (De Groot et al. 2002).

Critical evaluation of the possibility of pricing non-market forest ecosystem services in the light of literature analysis is presented in Table 1.

Table 1. Analysis of the possibilities of valuations of forest ecosystem services (adapted from FOREST EUROPE 2014)

Method group	Valuation method	Forest good or service valued	Benefits of method	Limitations of method
1	2	3	4	5
Stated preference	*Contingent Valuation* (CV)	All goods and services, including: – recreation/tourism, – health and well-being benefits – landscape aesthetics – inspiration for culture and design – cultural/spiritual – scientific – historical legacy – biodiversity protection – maintaining the pools of genetic resources – soil protection – climate stabilization – air quality regulation – flood prevention	Allows to: – capture the total economic value (use and no-use values) – make the most of flexibility – valuate non-market goods (with no markets) – assess individual forest characteristics (by means of WTP)	– not a rapid assessment – based on not observed behavior – credibility – correctness – potential bias in response – expensive and time-consuming
	Choice Experiment (CE)	All goods and services, and especially: – naturalness of ecological processes – rare species – forest characteristics, especially valued by visitors (e.g. recreational)	Allows to: – capture use and no-use values – infer flexibly – obtain statistically sound data – obtain additional information on respondent preferences	– not a rapid assessment – based on not observed behavior – credibility – correctness – potential bias in response – expensive and time-consuming – requires intellectual effort in respondent

1	2	3	4	5
Revealed preference	*Travel Cost* (TCM)	All ecosystem services that contribute to recreational activities, such as: – tourism, – sport activities – improvement of mental health/ well-being – landscape aesthetics – culture inspiration – cultural heritage	– based on observed behaviors – allows for including tangible costs (travel expenses)	– not a rapid assessment – applies only in the valuation of use values – the question arises, what a fraction of the cost should be assigned to consecutively visited places when there are more destinations in one trip
	Hedonic Pricing (HPM)	Ecosystem services such as: – climate regulation – clean air – uncontaminated waterlow – noise control – aesthetic and landscape values – proximity to natural areas – soil protection	– based on market data and current choices	– not a rapid assessment – the need to have a large database – complicated statistical procedures – not always reliable data related to property
	Cost-based methods considering equally applicable: – damage costs avoided – replacement costs – substitution costs	Ecosystem services such as: – soil protection – water protection – climate regulation	– opportunity of using robustly available market data	– possible overestimation of actual values
Other	*Benefit Transfer* (BT)	Ecosystem services such as: – health improvement – water quality – recreation – aesthetic/scenic landscape, – biodiversity, – socio-cultural aspects	– potential application in situations where conducting empirical research in situ is not possible	– depends on the accurateness of the original valuation – requires extensive databases – generalization can cause valuation errors

The methods summarized above show a wide range of applications and possibilities of valuation of non-market value of forest ecosystem services. However, all these have not been so far in widespread use, especially they are lacking in the economic analyses of forest benefits. Furthermore, goods delivered to society on account of non-productive forest functions have not been reflected in the economic calculation concerning forests (Płotkowski 2008; FOREST EUROPE 2014).

There should be noted that the methods referred to in the present paper and their application to the valuation of ecosystem services have been criticized. Criticism of the Contingent Valuation (CV) and the Choice Experiment (CE) focuses on two issues: reliability and validity of conducted survey/research (Ahlheim 1998; MacMillan et al. 2006).

The reliability o of the survey results is about the extent to which the answers obtained vary among the respondents (e.g. as regards willingness to pay for a particular ecosystem service provided) and may be encumbered by different errors. The reliability refers to the stability and repeatability of the results obtained. These aspects are influenced by: the actual random error (important in statistics), the method of respondent selection and the structure of the questionnaire. The reliability of the results requires that in repeated surveys any value (e.g. that of willingness to pay) should change according to the changes in the real value of a given good, and that it would remain unchanged if the real value of the good remains unchanged (Bateman and Langford 1997; Venkatachalam 2004; Wróblewska 2014).

The validity is influenced by three characteristics of the survey questionnaire: content, criteria and construction. The category "content" includes aspects, such as properly formulated/asked questions and the amount declared by the respondent to pay in the context of the supposedly existing market for ecosystem services referred to in a survey. Due to the fact that such market does not exist in the reality, it is not possible to formally determine even the potential market price of a given good. Thus, the evaluation of the content of the questionnaire is carried out by the researcher – unavoidably subjectively. The category "criterion" (truthfulness of the results) is connected with the verification/comparison of the obtained results, e.g. the willingness to accept (WTA) criterion should be comparable with the "factual/real" value of the ecosystem service for which the survey was conducted. An evident disadvantage of the stated preference methods is that, in most cases, the "real" value is not known, therefore simulated markets are used in the comparisons. The "construction" category refers to scenarios and convergence with the values obtained using other techniques. However, comparing the results obtained using the CV and CE methods with the results obtained by means other methods can be considerably difficult (Venkatachalam 2004; Smith et al. 2005).

An important aspect, and often a problem indeed, is the selection of the respondents surveyed/questioned in support of the preparation of the forest ecosystem service valuation. There exists a correlation between the possibility/willingness to pay for a given natural good and basic variables, such as: age, gender, income level and education of the population surveyed. It is generally accepted that the need to benefit from non-market forest ecosystem services grows with public awareness/knowledge on the natural environment and an increase in society prosperity. Clarification is necessary as regards the problem how to minimize the effects of possible demographic differences in the group of respondents. From the statistical point of view, this is related to ensuring that the respondents are carefully selected, so that the results are not biased due to differentiation of the basic variables listed above, and consequently, the results obtained are sufficiently representative/characteristic for a given population. Meanwhile, in various studies carried out with survey methods, the values declared by respondents are often added up in order to obtain the average e.g. WTP value, representative e.g. for a given region or social group (Marks-Bielska and Zielińska 2014).

Respondents may also be influenced by the interviewers and the way the questions are asked (e.g. is enough attention paid to the respondents' answers or are the answers suggested). Maguire (2009) investigated the effect of the method of surveying on the results obtained by conducting the same questionnaire by telephone, e-mail and in face-to-face contact. The respondents gave different answers in the indirect contact when compared to those given in the presence of the interviewer. Additionally, the interpretation of the survey results can also be a source of numerous discrepancies, e.g. resulting from the way respondents answer questions (omitted questions, inappropriate answers or inconsistent with real beliefs of the respondent) (Meyerhoff and Liebe 2006).

There are several issues involved in the practical application of the *Hedonic Pricing Method* HPM, based on indirect valuations coming from an additional market (e.g. real estate). It is unlikely to find identical properties for which price differences are due to only one reason (e.g. presence/absence of a natural asset). Therefore, in searching for a link between property prices and various natural attributes that determine ecosystem services, there must be analyzed the records of numerous different transactions. These analyzes require building a large database and using advanced data processing/interpretation techniques. Moreover, the assumption that property buyers are in possession of exceptional information about the real estate market and are fully aware of ecosystem service effects on the prices of their possessions, often leads to a situation that a clear cut identification of implicit prices is not possible, as the total property price does not fully reflect the values of specific natural assets (Pearce et al. 2006).

The *Travel Cost Method* (TCM) has a limited scope of application, because the data obtained refers only to specific sites of recreation, not a larger whole (e.g. a national park). The TCM estimates the total economic value of ecosystem services, including biodiversity and other services, therefore does not allow for the monetary quantification of individual ecosystem services of a given area. Another important issue related to the application of the TCM is that only use values are estimated while non-use values are not covered. In the case of successively visited places during one trip, there is no certainty on which fraction of the costs should be assigned to visiting a particular site. The concept of the method is based on the assumption that consumers make rational decisions, and the benefits from the visit are greater than the costs associated with arriving at the place, thus the value assigned to a given site should not be lower than the cost of travel. It should also be borne in mind that the results obtained by the TCM depend on theoretical assumptions as to the distribution of many attributes characterizing the population of visitors, and can be biased by significant discrepancies. When confronting the results obtained using the TCM method with the results obtained using the stated preference methods, the travel cost method usually provides "inflated" estimates (Ward and Beal 2000; Płotkowski 2008; FOREST EUROPE 2014).

In view of the above, all of the proposed methods of non-market ecosystem service valuation are encumbered by issues related to data availability, reliability, and accuracy, as well as they are labor and time consuming, hence – expensive. When valuating the environmental benefits of forest ecosystems, it would be necessary to elaborate valuation procedures based on aggregated indicators of relevant forest ecosystem functions. For the effective conservation of forest natural assets, and first of all of biodiversity, the valuation of ecosystem goods/services provided by valuable/protected areas is of great importance. This is particularly important in view of the implementation of the European Strategy for Biodiversity conservation until 2020 (Maes et al. 2016).

Conclusion

Ecosystem services are coupled with the concept of natural capital, which in itself is very difficult to assess, and as a rule economically underestimated. Methodological difficulties arise for the reason that ecosystem services are hardly ever traded in the markets, thus do not "disclose" their monetary value in the way material goods and services do. Economic valuation of services provided by ecosystems has been challenging, seeing that over the last decades economists have experimented with various methods to estimate the monetary value of non-market ecosystem services.

Forest ecosystems endow with a number of non-market services, derived from a large number of forest functions, that are either neglected or not captured by established markets. Difficulties in economic valuation of forest ecosystem services result from both the multitude of forest functions and the multiple criteria for qualifying relevant benefits. Sound scientific evidence exists that maintenance of forest biodiversity is vital for safeguarding forest functions generating a range of goods and services. Many of these comprise non-market goods, albeit very important for the society. These include the deliverance of means for the protection of environmental components and human health (e.g. flood defense, pollution absorption, medicines) or pleasure (recreation, biodiversity, scenic landscapes).

In view of sustainable forest management the urgent need has long been recognized to economically valuate all forest services equally. Improving ecosystem valuation methods presents an opportunity for partnership and interdisciplinary dialogue between foresters, ecologists and economists, as well as research and policy communities. Development of methodology for estimating the monetary value of forest ecosystem services is a step towards their incorporation in national accounts, hence – in Gross Domestic Product (GDP). To all intents and purposes, appropriate economic valuation of total forest ecosystem goods and services will help to emphasize their indispensable value in the income statements of forest-based enterprises.

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References

Ahlheim, M. 1998. Contingent valuation and the budget constraint. *Ecological Economics*, 27 (2), 25–211.

Bartczak, A. 2006. Wartość funkcji rekreacyjnej lasów w Polsce. *Ekonomia i Środowisko*, 2 (30), 23–41.

Bartczak, A., Lindhjem, H., Navrud, S., Zandersen, M., Żylicz, T. 2008. Valuing forest recreation on the national level in a transition economy. The Case of Poland. MPRA Paper No. 11483. http://mpra.ub.uni-muenchen.de/11483/

Bateman, I.J., Langford, I.H. 1997. Non-users' Willingness to pay for a national park: an application and critique of contingent valuation method. *Regional Studies*, 31, 6, http://dx.doi.org/10.1080/00343409750131703

Constanza, R. et al. 1997. The value of the world's ecosystem services and natural capital. *Nature*, 387. http://dx.doi.org/10.1038/387253a0

Costanza, R., Hart, M., Posner, S., Talberth, J. 2009. Beyond GDP: The need for new measures of progress. The Pardee Papers 4. Boston University Creative Services. Trustees of Boston University.

Czajkowski, M., Buszko-Briggs, M., Hanley, N. 2009. Valuing changes in forest biodiversity. *Ecological Economics*, 68 (12), 2910–2917.

Czajkowski, M. 2013. Metody wyboru warunkowego i wyceny warunkowej. www.polforex.wne.uw.edu.pl [07.09.2013].

De Groot, R.S., Wilson, M.A., Boumans, R.M.J. 2002. A typology for the classification, description and valuation of ecosystem functions, goods and services. *Ecological Economics*, 41, 393–408.

Eckehard, G., Brockerhof, L., Castagneyrol, B., Forrester, D.I., Gardiner, B., González-Olabarria, J.R. Lyver, P., Meurisse, N., Oxbrough, A., Taki, H., Thompson, I.D. Van der Plas, F., Jactel, H. 2017. Forest biodiversity, ecosystem functioning and the provision of ecosystem services. *Biodiversity and Conservation*, 26 (13), 3005–3035.

EEA. 2010. Scaling up ecosystem benefits: A contribution to the Economics of Ecosystems and Biodiversity (TEEB) study Ecosystems goods and services. EEA Report No 4/2010. https://www.eea.europa.eu

FOREST EUROPE. 2014. Expert Group and Workshop on pan-European approach to valuation of forest ecosystem services. Final report. Group of Experts (2012–2014) & Belgrade Workshop (Republic of Serbia), 24–25 September 2014. https://foresteurope.org/publications/

Getzner, M. 2009. Economic and cultural values related to protected areas. Part A: Valuation of Ecosystem Services in Tatra (PL) and Slovensky Raj (SK), National Parks, Final report, WWF-DCP, Vienna.

Getzner, M. 2010. Ecosystem services, financing, and the regional economy: A case study from Tatra National Park, Poland. *Biodiversity*, 11, 1/2, 55–61. DOI: 10.1080/14888386.2010.9712648

Giergiczny, M. 2009. Rekreacyjna wartość Białowieskiego Parku Narodowego. *Ekonomia i Środowisko*, 2 (36), 116–128.

Haines-Young, R., Potschin, M.B. 2017. Common International Classification of Ecosystem Services (CICES) V5.1 and Guidance on the Application of the Revised Structure. Available from: www.cices.eu

Holland, D.N., Lilieholm, R.J., Roberts, D.W. 1994. Economic trade-offs of managing forests for timber production and vegetative diversity. *Canadian Journal of Forest Research*, 24 (6), 1260–1265.

Hölzinger, O., Dench, D. 2011. The Economic Evaluation of Gwen Finch Wetland Reserve. Case Study for the Worcestershire Wildlife Trust, Worcester, November 2011.

Hølleland, H., Skrede, J., Holmgaard, S.B. 2017. Cultural heritage and ecosystem services: A literature review. *Conservation and Management of Archaeological Sites*, 19 (3), 210–237. DOI: 10.1080/13505033.2017.1342069

Johnston, R.J., Wainger, L.A. 2015. Benefit transfer for ecosystem service valuation: An introduction to theory and methods. In: The economics of non-market goods and resources. A guide for researchers and practitioners (eds.: J. Rolfe, R.J. Johnston, R.S. Rosenberger, R. Brouwer), 237–273. https://link.springer.com/chapter/10.1007/978-94-017-9930-0_12

Juutinen, A. 2008. Old-growth boreal forests: Worth protecting for biodiversity? *Journal of Forestry Economics*, 14 (4), 242–267.

Klocek, A., Płotkowski, L. 1997. Las i jego funkcje jako dobro publiczne. In: Kongres leśników polskich. Materiały i dokumenty, t. II, cz. 2 (ed.: T. Borecki). Agencja Reklamowo-Wydawnicza A. Grzegorczyk, Warszawa.

Klocek, A. 2005. Wielofunkcyjność gospodarki leśnej – dylematy ekonomiczne. *Sylwan*, 6, 3–16.

Klocek, A., Płotkowski, L. 2007. Wyzwania przyszłości polskiego leśnictwa. In: Wyzwania przyszłości polskiego leśnictwa. Polskie Towarzystwo Leśne, Kraków, Poland.

Kostka, M.S. 2008. Las jako kategoria ekonomii. *Ekonomia i Środowisko,* 1 (33), 25–38.

MacMillan, D.C., Hanley, N.D., Lienhoop, N. 2006. Contingent valuation: environmental polling or preference engine? *Ecological Economics*, 60 (1), 299–307.

Maes, J., Liquete, C., Teller, A., Erhard, M., Paracchini, M.L., Barredo, J.I., Grizzetti, B., Somma, F.A., Petersen, J.E., Meiner, A., Royo, G.E., Zal, N., Kristensen, P., Bastrup-Birk, A., Biala, K., Piroddi, Ch., Egoh, B., Degeorges, P., Fiorin, C., Santos-Martín, F., Naruševičius, V., Verboven, J., Pereira, J.M., Bengtsson, J., Gocheva, K., Marta-Pedroso, C., Snäll, T., Estreguil, C., San-Miguel-Ayanz, J., Pérez-Soba, M., Grêt-Regameyn, A., Lillebøo, A.I., Abdul Malak, D., Condé, S., Moenr, J., Czúczs, B., Drakou, E.G., Zulian, G., Lavalle, C. 2016. An indicator framework for assessing ecosystem services in support of the EU Biodiversity Strategy to 2020. *Ecosystem Services*, 17, 14–23.

Maguire, J. 2009. Does mode matter? A comparison of telephone, mail and in-person treatments in contingent valuation survey. *Journal of Environmental Management*, 90, 3528–3539.

Mandziuk, A., Janeczko, K. 2009. Turystyczne i rekreacyjne funkcje lasu w aspekcie marketingowym. *Studia i Materiały Centrum Edukacji Przyrodniczo-Leśnej*, 11, 4 (23), 65–66.

Marks-Bielska, R., Zielińska, A. 2014. Ocena wybranych metod szacowania pozaprodukcyjnych funkcji lasów. *Ekonomia i Środowisko*, 1, 34–45.

MEA. 2005. Millenium Ecosystem Assessment. http://www.millenniumassessment.org/ documents /document.356.aspx.pdf

Meyerhoff, J., Liebe, V. 2006. Protest beliefs in contingent valuation: explaining their motivation. *Ecological Economics*, 57 (4), 583–594.

Ninan, K.N., Inoue, M. 2013. Valuing forest ecosystem services: What we know and what we don't. *Ecological Economics*, 93, 137–149.

Ninan, K.N., Kontoleon, A. 2016. Valuing forest ecosystem services and disservices – Case study of a protected area in India. *Ecosystem Services*, 20, 1–14.

Norgaard, R.B. 2009. Ecosystem services: From eye-opening metaphor to complexity blinder. *Ecological Economics*, 69, 1219–1227. doi:10.1016/j.ecolecon.2009.11.009

Pearce, D.W., Turner, R.K. 1990. Economics of Natural Resources and the Environment. JHU Press.

Pearce, D.W., Atkinson, G., Mourato, S. 2006. Cost-benefit analysis and the environment. Recent developments. OECD, Paris.

Pearse, P.H. 1990. Introduction to Forestry Economics. University of British Columbia Press, Vancouver.

Płotkowski, L. 1996. Ekonomiczne aspekty ochrony różnorodności biologicznej lasu. In: Ochrona i zrównoważone użytkowanie lasów w Polsce. Fundacja IUCN, Warszawa, Poland.

Płotkowski, L. 2008. Ekonomiczne aspekty oceny funkcji lasu, czyli gospodarka leśna w koncepcji zrównoważonego rozwoju. *Studia i Materiały Centrum Edukacji Przyrodniczo-Leśnej*, 10, 3, (19), 252–272.

Poskrobko, B. 2012. Metodyczne aspekty ekonomii zrównoważonego rozwoju. *Ekonomia i Środowisko*, 3 (43), 10–27.

Smith, R.I., Dick, J.McP., Scott, E.M. 2011. The role of statistics in the analysis of ecosystem services. *Evironmetrics*, 22 (5), 608–617. DOI:10.1002/env.1107

TEEB. 2010. The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature. http://ec.europa.eu/environment/nature/biodiversity/economics/

Tisdell, C.A. 2007. Knowledge and the valuation of public goods and experiential commodities: information provision and acquisition. *Global Business and Economics Review*, 9 (2/3), 170–182.

Turner, K. 2010. A pluralistic approach to ecosystem services Evaluation. CSERGE Working Paper EDM No 10–07 CSERGE, School of Environmental Sciences, UEA, Norwich, https://www.econstor.eu/obitstream/10419/48825/1/626009499.pdfhttps://www.econstor.eu/obitstream/10419/48825/1/626009499.pdf

Ward, F.A., Beal, D. 2000. Valuing nature with travel cost models. A manual. New Horizons in Environmental Economics series, Edward Elgar, Cheltenham.

Venkatachalam, L. 2004. The contingent valuation method. A review. *Environmental Impact Assessment Review*, 24 (1), 89–124.

Wróblewska, A. 2014. Wartościowanie dóbr środowiskowych w świetle badań ankietowych według metody wyceny warunkowej. *Woda-Środowisko--Obszary Wiejskie*, 14, 2 (46), 155–171.

Welsh, H., Kuhling, J. 2008. Using happiness data for environmental valuation: issues and applications, *Journal of Economic Surveys*, 23, 385–406.

Welsh, H. 2009. Implications of happiness research for environmental economics. *Ecological Economics*, 68, 2735–2742.

Van der Plas, F. et al. 2017. Continental mapping of forest ecosystem functions reveals a high but unrealised potential for forest multifunctionality. *Ecology Letters*, 21 (1), 1–150. http://onlinelibrary.wiley.com/doi/10.1111/ele.2018.21.issue-1/issuetoc

Zawilińska, B. 2015. Ekonomiczna wartość obszarów chronionych. Zarys problematyki i metodyka badań. *Zeszyty Naukowe Uniwersytetu Ekonomicznego w Krakowie*, 12 (936), 113–129.

Żylicz, T. 2010. Wycena usług ekosystemów. Przegląd wyników badań światowych. *Ekonomia i Środowisko*, 1 (37), 31–45.

Żylicz, T. Giergiczny, M. 2013, Wycena pozaprodukcyjnych funkcji lasu. Raport końcowy. Uniwersytet Warszawski Wydział Nauk Ekonomicznych, Warszawa, Poland.

Żylicz, T. 2013. Wycena usług ekosystemów leśnych. Panel Ekspertów: Wartość. Lasy jako czynnik rozwoju cywilizacji: współczesna i przyszła wartość lasów. Instytut Badawczy Leśnictwa, Sękocin Stary.

http://ec.europa.eu/environment/beyond_gdp/index_en.html