METHODS AND INDICATORS FOR EVALUATION OF FOREST ECOSYSTEM SERVICES IN RIPARIAN BUFFER STRIPS

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Abstract
In the research evaluation of the ecosystem services provided by riparian forests in Latvia has been studied. The aim of this research is to investigate the methods and indicators for assessing the value of ecosystem services of riparian forests and to establish the most appropriate methods of ecosystem service valuation in the case of Latvia. The study is based on analysis of scientific publications, special literature and reports of international organizations, studying results of previously performed qualitative and quantitative research methods in the field of ecosystem service evaluation. The results of this study revealed several methods that could be applied for evaluation of ecosystem services provided by riparian forests, taking into account that the set of available data may be limited and considering the costs and span of time that may be necessary to collect the missing data. The results also show that the majority of ecosystem service evaluation indicators can be applied if appropriate earlier studies have been performed and feasible data for similar territories or conditions are available. The knowledge of the methods and indicators for evaluation of ecosystem services is a crucial factor in the decision making process, when decisions on economic development or sustainable management of ecosystem services are made.
Key words: forest value, riparian forests, ecosystem services.

Introduction

Natural capital is one of four capital types that have been generally recognized by the economic theory (Gómez-Baggethun et al., 2010; Wittmer and Gundimenta, 2012). Evaluation of ecosystem services (natural capital) allows explaining its importance and the significance of its sustainable management (Soulard et al., 2012). As ecosystem services are a common resource that belongs to and is used by everyone by default, the incentive of a sustainable use of these services is very little (Chee, 2004). Value is given to ecosystem services from the human perspective, evaluating services that people perceive as important (various types of goods, services and intangible benefits) (MA, 2005; SEEA, 2012). If this value is not known, it can not be given a proper weight in the decision-making process, when decisions on economic development or sustainable management of ecosystem services are made (Mazza et al., 2013; Soulard et al., 2012).

The importance of ecosystem service evaluation has also been emphasized on the EU level, requiring all member states to set the economic value of their ecosystem services by 2020 (EC, 2013). To this day, however, the valuation of ecosystem services has not been implemented in Latvia.

Riparian forest buffer strips provide several ecosystem services and products, composing a large part of forest landscapes as a whole (Kuglerová et al., 2014; SEEA-Water, 2012; Soulard et al., 2012). Recent studies have confirmed that small multiform riparian forests also have a significant role in the functioning of ecosystems and biodiversity conservation.

Riparian forests are the transition zone between water and terrestrial ecosystems, which are important in biodiversity conservation. With an increasing extent of intense human activities in economically profitable lands the pressure on natural ecosystems has grown and they have been transformed in the course of time. A relatively compact river network with the average density of 0.6 km km^{-2} is characteristic to Latvia. Nearly all freshwater ecosystems and their adjacent areas are subjected to anthropogenic pressure and their functionality can be reduced or even lost due to pollution.

There is a variety of reasons for a continued reduction of environmental quality, including freshwater. A series of anthropogenic activities have increased river eutrophication (SEEA-Water, 2012), resulting in a negative impact on formerly abundant plant and animal species (Urtāns, 2008). Increased concentrations of phosphorus and nitrogen that originate from point sources in watercourses (SEEA-Water, 2012), diffuse nutrient runoff from the catchment area and other types of pollution and runoff have been identified as the main reasons of eutrophication (Russi et al., 2013). The degradation of river functions in relation to a reduction of extensive anthropogenic activities in riparian forests has been evaluated to a lesser extent (Urtāns, 2008). This urges to find ways to halt or control the biogenic pollution. One of the main solutions for vitalizing freshwater habitats in this case study is a sustainable management of riparian forest buffer strips (Kuglerová et al., 2014; SEEA-Water, 2012). A methodology that would allow assessing the impact of natural processes in riparian forest buffer strips is necessary to help decision makers express the benefit of the ecosystem services provided by riparian forests in a monetary value (De Groot et al., 2012). In order to estimate their value, it is important to assess the methods of ecosystem service valuation and the indicators that are included in them.

The aim of this research is to analyze methods and indicators for assessing the value of ecosystem services of riparian forests and to establish the most appropriate methods of ecosystem service valuation in the case of Latvia.

To achieve the aim, the following objectives were defined:

- To characterize the functions, services and goods which are provided by riparian forest ecosystems;
- To investigate indicators of riparian forest ecosystem service valuation;
- To analyze common, internationally recognized methods of ecosystem service valuation;
- To describe methods that can be applicable in assessing ecosystem services of riparian forests in Latvia.

Materials and Methods

To meet the objectives of this study, the following written materials were used: scientific publications, scientific and specialized literature, reports of international organizations, online materials, publications in press. Articles and reports that focus on the case of Latvia and cases in northern Europe were a priority, when selecting information for analysis. Data and information from the above mentioned materials was analyzed, synthesized and grouped, and, by applying logical and abstract constructive methods, the conclusions of this study were drawn. Characteristics of the methods for valuation of ecosystem services and the corresponding indicators were studied in scientific literature and periodicals of Latvian and foreign authors. This research is based on the author`s theoretical and practical knowledge and a series of studies that are performed in relation to the doctoral thesis.

Results and Discussion

The assessment of riparian forests and the ecosystem services that are provided by them has been performed in several studies. A great part of research that has been performed in Latvia is indirect in relation to riparian forests (e.g. research on forest stands, vegetation, water quality, protected species and habitats). Research has also been performed in watercourses that run through forest stands, studying the dynamics of eutrophication and sedimentation.

However, there is a significant lack of knowledge in the fields related to ecosystem services that are provided by riparian forests. Several studies have used various cost approaches, such as replacement costs, costs for an environmental damage and market prices that are assimilated to the assessment of ecosystem services. In ecosystem service studies the main focus has been on the identification of ecosystem services as values of cultural history (Estonia-Latvia, 2011). It should be noted that the majority of research is not directly aimed at assessing the ecosystem services of riparian forest stands, but forest stands altogether. It is a gain, as the existing methods and the gathered data can be used in further research that is related to forest stands of particular areas. It should be emphasized that ecosystem services, which are related to diversity and habitats, should be set as priority topics for future research (EC, 2013; MA, 2005).

There is still a number of blank fields in research on the services of landscape, aesthetics, cultural heritage and recreation. Complete knowledge on economic benefits, such as food, medicinal products and wood of riparian forests is also missing. It is important to gain information on the impact of forest stands on a wider scale, e.g. on water quality in catchment area and the Baltic Sea, the impact on eutrophication and sedimentation in watercourses as well as fish resources.

It should be recognized that research is frequently adapted to specific situations and separate localities but is not aligned to general quantitative conclusions on the forest environment on river banks. This, however, is extremely important for it to be used interlinked to the aims of existing policies. It should also be noted that the existing quantitative data of a broad scope does not always represent the real situation in life – outdated information should be stressed, as it highlights the necessity for large-scale research, which would clarify the true situation in riparian forests and their ability to provide ecosystem services.

The main threats that have been addressed by scholars in their previous research, and are indirectly related to riparian forests, are processes of eutrophication and sedimentation that take place in watercourses (SEEA-Water, 2012; Urtāns, 2008). The attention is also put on the catchment areas that are directly related to the Baltic Sea, have an impact on its condition and regeneration of fish resources and, unfortunately, contribute to eutrophication of the Baltic Sea (BalticSTERN, 2013).

1. Integrated assessment and valuation of ecosystem functions, goods and services

The field of ecological economics has witnessed a spectacular rise of concern with the valuation of ecosystem functions, goods and services (De Groot et al., 2002).

A principal scheme has been developed to identify the areas of ecosystem services, goods and services within the decision-making process. Ecosystem functions and ecological values are directly influenced by the structure of a specific ecosystem and the processes that take place within. Ecological, social an economical values form a total economic value that, in case of their total identification, could be used in the decision-making process to set the development strategies of territories.

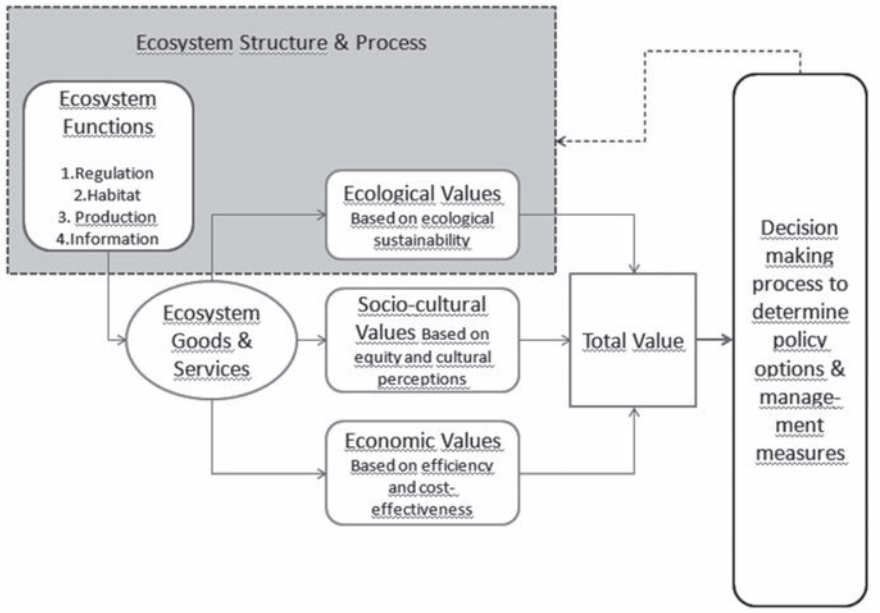

Figure 1. Framework for integrated assessment and valuation of ecosystem functions, goods and services. (Adapted from De Groot et al., 2002).

Ecosystem functions.

All ecosystem functions are divided into four larger groups that allow to assess the ecosystem value to human society. Goods and services that result from services of **regulation** (natural bio-geochemical cycles and biospheric processes) and **habitat** (providing diversity and evolution) create the necessary prerequisites for services of **production** (creation of living biomass) and **information** (mental and recreational value). The direct and indirect benefits that result from the above mentioned ecosystem functions are crucial for human well-being and are, therefore, highly valuable (Groot et al., 2002).

Ecosystem goods and services.

Within the context of a sustainable development, riparian forests hold a special importance. In addition, they also provide ecosystem services and benefits to the social sphere, nature protection and economy. The above mentioned services are divided into several groups (Chee, 2004; Daily, 1999).

Ecosystem services (or the goods that arise as a result of these services) can be expressed as values that can be used to set a total economic value. A system of values and indicators is used in assessment. Values are mostly expressed by qualitative features that can be valued, classified and analysed. Setting of values is mostly based on indicator marks – these indicators reflect the condition of an object as well as the changes that are taking place. Indicators are means for setting value. The measurement of an indicator is quantitative, while in separate cases it is possible to identify descriptive or qualitative indicators (Table 1).

In order to assess the value of ecosystem services, the values to be assessed can be applied, such as: land cover, forest productivity, flora and fauna richness, local and introduced tree species, game mammals and birds, successional stages, ecotones, deadwood, forest productivity, forest stand age, forest stand structure, habitats, forest habitat conservation and protection, forest stand continuity, fragmentation, natural and anthropogenic elements of forest lands, forest renewal.

Riparian forests are fully related to values of their functions, they perform processes that fully influence their values. Regardless of the importance of function values and their application they can be greatly influenced by unified factors that are evaluated jointly – e.g. natural disturbances (fire, wind, snow, water, biological disturbances), factors that limit the natural disturbances, anthropogenic factors (forest cuts, disturbances, forest sinantropisation and eutrophication, grazing). Accordingly, indicators are used for their evaluation: a) the number of forest fires – (pcs.), areas damaged by windfall – (ha), areas damaged by snowbreaks – (ha), forest areas that have been invaded by meadow grasses , ruderal plants, alien trees – (ha), length of riverbank with signs of eutrophication – (km), grazing in forest – (ha).

2. Valuing ecosystem functions, goods and services

A number of valuation methods exist that allow to aggregate different values that are included in the total economic value (TEV). As a great part of ecosystem services is of a non-market nature, the valuation can not be direct, while majority of valuation methods are applicable to specific use-values, creating a challenge

Table 1

The system of values and indicators for ecosystem services that are provided by riparian forests (Modified from Chee, 2004; Daily, 1999; Hattam et al., 2015)

Services	Values	Indicators and measurememt units (examples)
Economic benefits	Food: terrestrial animal and plant products, forage, food, spices	Extracted food and forage, including berries, mushrooms, game ($t*ha^{-2}$)
	Medicinal products	Extracted amount ($kg*ha^{-2}$)
	Materials (natural fibre, timber)	Extracted amount of timber (m^3*ha^{-2}), extracted amount of natural fibre ($t*km^{-2}$)
	Energy (biomass fuels, low-sediment water for hydropower)	Extracted amount of timber (m^3*ha^{-2}) Amount of purified water (m^3*ha^{-2})
	Industrial products (waxes, oils, fragrances, dyes, precursors to synthetic products)	Amount of extracted products ($kg*km^{-2}$)
	Genetic resources	Specially protected nature territories (ha), habitat types (pcs.), habitat area (ha), deadwood (m^3*ha^{-2}), species composition (pcs.), species diversity index s
Regeneration services	Circulation of substances in nature (detoxification, decomposition of waste, renewal of soil fertility, purification of air and water)	Permanence of carbon sequestration (annual carbon turnover, t), Increase of forest stand stock (m^3*ha^{-2})
	Dispersal of seeds necessary for revegetation and pollination of crops	Species composition (pcs.)
Stabilizing services	Partial stabilization of climate, moderation of weather extremes (e.g., temperature and wind)	Areas damaged by windfalls (ha)
	Regulation of the hydrological cycle (reduction of flooding and drought)	Assessment of water level alterations (cm)
	Maintenance of coasts and waterways	Number of trees in a waterway ($pcs.*km^{-2}$), Extent of errosion (m^3 or number of indentified locations)
	Compensation and substitution of one species for another when environments vary	Species composition (pcs.), deadwood (m^3), species diversity index s
	Control of the majority of potential pest species	Area of forest stands invaded by pests (m^3)
Life-fulfilling services	Provision of cultural, intellectual and spiritual inspiration	Public assessment (quality)
	Provision of aesthetic beauty	Public assessment (quality)
Conservation services	Maintenance of ecological components and systems needed for the future	Specially protected nature territories (ha), habitat types (pcs.), habitat area (ha), deadwood (m^3*ha^{-2}), species composition (pcs.), species diversity index s
	Supply of goods and services awaiting discovery	Number of introduced goods and services (pcs.)

for setting the non-use values. There are, however, few methods for assessing the non-use values (Turner et al., 2010; Wittmer and Gundimeda, 2012).

Methods to assess ecosystem services and goods – each with their benefits and drawbacks – can be divided into three groups:

Pricing approaches – a widely used method that usually allows to assess a part of the benefits provided by ecosystem services. Nevertheless, it is applicable to gain an estimate of the monetary value that may be difficult to assess otherwise. Methods where market prices are used are usually based on turnover, while methods where the direct costs are used, are based on clean-up costs (including costs that should be covered in case of an environmental damage, necessity to replace ecosystem services with man-made systems or provide precautions in providing ecosystem services) (Turner et al., 2010).

Revealed preference methods use the relation between ecosystem services and one or several market goods, grounding this method on information of the behaviour of individuals and businesses in market where ecosystem services can be indirectly purchased (Turner et al., 2010). The most important estimation methods are: production function method (assumes that conservation of good environmental quality is an investment in the future production of goods and services), travel cost method (studies the amount of financial and time-consuming travel costs that arise in order to use ecosystem services for recreation), *hedonic price method* (assessing the prices that people pay for goods that are related to ecosystem services, analysing information on prices in the housing market) and *defensive expenditure method* (focuses on data on human behaviour).

Stated preference method is used when a weak relation exists between ecosystem services and market goods that are insufficient to perform a monetary assessment. This method is especially useful when an impact on non-market values that are related to important non-use values must be evaluated and revealed preference methods can not be used (Turner et al., 2010). Willingness to pay (WTP) and willingness to accept (WTA) are used to create a hypothetical market situation to assess people's willingness to pay for non-use value provision, using the contingent valuation - CV (social surveys that include hypothetical scenarios with descriptions of alternatives such as WTP to improve an existing situation in order to enjoy wider benefits from ecosystem services) and *choice experiments* - CE (Turner et al., 2010).

Indirect market valuation methods, such as *avoided cost* (when ecosystem services allow costs that would have been incurred in absence of these services to be avoided) and factor income method (when the ecosystem services enhance income) also exist, but are not studied in detail in this research.

Ecological functions and services can overlap, leading to the possibility of economic 'double counting'. To avoid double counting and enhance data comparability has been addressed in different papers (Fisher et al., 2008).

3. Methods for ecosystem service valuation of the riparian forests in the case of Latvia

While analysing evaluation methods and indicators of ecosystem service valuation, prerequisites that are important for the specific situation of Latvia (which, above all, would allow cost-effective collection of data that is of high demand but currently lacking), were identified. They are as follow: 1) existing and available data that can be used in valuation or 2) data sets that can be gathered as a part of the valuation and whose collection is not resource-demanding. Considering the above mentioned prerequisites, to assess the ecosystem services that are provided by riparian forests, the following approaches are recommendable for Latvia:

First approach: Forest surveying is performed, which determines the characteristic elements of the forest stand, the amount and condition of the dead wood, species diversity nearby the stream in a 10-30 m zone and 60-80 m zone by setting sample plots with size of 20 x 20 m (400 m^2). The sample plot size (20 x 20 m) is typical in forest-related research, as it describes the tree stand, as well as bush and herbaceous stand. It is the most representative sample plot size, which is often used in research, as it is small enough to describe the typical condition of the forest and keep within a single forest type and, simultaneously, large enough to create a full impression of the forest.

Transects are placed accordingly, perpendicularly to the stream bank and reached further into the forest interior. Transects that are located nearby the stream describe the interaction between the forest and river, also describing the impact of disturbances (that are created by flooding, for example), while transects that are placed further away from streams, describe the typical forest situation. For every stream three transects are established with the distance between transects of 1 km (Liepa et al., 2015). The gained data was then analyzed by the substitute-cost method, which allows assessing the monetary value of the "substitute" resource. To set the value for the dead wood, the market price for firewood is applied, while the market price of industrial wood is applied to living trees. Therefore, the forest stand information, which is further transformed into monetary assessment, is used, providing a theoretical monetary value of the forest stand. This method is also used to assess the total monetary value of biodiversity. Its main principle is to set the total costs for a situation when damage would be done to the biodiversity of a certain area that should be replaced, or it was necessary to provide precautions to provide these ecosystem services in the future (ten Brink et al., 2012). In order to gain results, data and measurements from field work are used, allowing forest stands with their specific vegetation and dead wood to be assessed in monetary terms.

Second approach: Surveys are used in ecosystem service assessment, using the above mentioned methods – CV and CE. During a survey the public attitude on environment (i.e. riparian forests) is established. To deal with issues that are related to riparian forests and evaluate the associated risks, the public attitude on the various obligations that would promote improvement of environmental condition and means to fund the necessary improvement measures must be clarified. Telephone interviews as well as face-to-face interviews can be used in such a survey. When performing a survey, its objective should first be explained to the interviewee, followed by clarification of the main connections of respondents to the specific area as well as their attitude to the processes that occur there. The questions of the survey must be mainly aimed at the potential issues of riparian forests and solutions to these issues, including potential costs that could occur to handle environmental problems and the amount of costs that each household is ready to bear in exchange for specific ecosystem services. Each questionnaire should be designed accurately and include background information and existing problems of riparian forests and their effects on ecosystem services. Background information (age, sex, income) is requested to

provide comparability to the Latvian population and possible corrections that may be necessary later. The questionnaire should include different development scenarios and their costs per household, as it would facilitate in-depth understanding of the issue and provide better and more focused answers. It is extremely important to provide cost distributions for different development scenarios.

By using the methodology for gathering vegetation data that has been described under the first approach, basic information is gained that allows to model the use of CV and CE methods, thereby offering potential development scenarios and possible future alternatives in riparian forests. A question on a potential implementation of a payment system should also be included. The CV method is used in this research, determining the costs that the society is ready to pay in order to reduce the negative processes in riparian forests. During the research both – the use (forest resources) and non-use values (aesthetics) of riparian forests - should also be viewed. Studies that are based on CV method are mostly applicable to valuation situations where coherent hypothetical alternatives of environmental change are valued. CE method, however, provides good results when the values of individual attributes are assessed. When constructing the questionnaire, a number of potential impacts for a specific future scenario can be described, defining the quality and costs of each of these.

To establish the value of recreation services of riparian forests, the applicability of travel cost method was analyzed. This method is based on surveys that focus on recreation activities that are appealing to interviewees (hikes, orienteering, bird watching etc.), travel time, distance, duration and costs that occur to reach these activities as well as the number of travels to the specific location in a set period of time. This allows creating a demand curve of a specific location, which is defined by the travel costs. The method is based on evaluation of a specific place that is used for recreation, e.g. nature trail, bird watching tower etc. If this method was used, the analysis would not return results on the whole territory – all riparian forests, but specific places instead. Accordingly, to determine the recreation services provided by riparian forests and the value of the quality of this specific place, the above mentioned CV and CE methods should be used. It should be noted that the question on the place of residence of respondents and whether they own a riparian forest should be definitely included in the background information of the survey, so that proper respondent groups could be divided in data analysis.

Third approach: Riparian forests are a fundamental solution in reduction of river pollution. Research shows that biologically diverse and productive riparian forest stands can retain and accumulate pollutants and nutrients (SEEA-Water, 2012; Soulard et al., 2012). Riparian forests can stabilize or reduce nutrient runoff. This ecosystem service of riparian forests can be assessed using the pricing approach method of replacement costs, as forest stands provide a clean-up service. The value of this clean-up service can be assessed by comparing the costs of expensive and energy intensive man–made water treatment plants to the water treatment services that are provided by riparian forests.

Fourth approach: The benefit-transfer method, which is based on existing research, can be used to assess ecosystem services of riparian forests. It allows using piloted indicators - the data derived from these indicators can be compared to the situation in riparian forest stands. Successful application of this method depends on the quality of existing research and their applicability. For example, the data on research of non-timber values can be used to set these values in riparian forests (Account Latvia, 2010).

Conclusions

1. When assessing ecosystem services it is suggested to use methods and indicators that simultaneously define ecological, social and economic factors, thereby assessing the total economic value of ecosystem services and their components.
2. It is possible to assess the ecosystem services of riparian forests in Latvia, using the methodology that has been described in this research, taking into account the fact that up-to-date scientific research on riparian forests is very little or absent altogether.
3. Methods and indicators must be used according to the available data and data whose collection is limited in time and costs.
4. Consequent research will address the issue of specific data availability in Latvia; however preliminary signals show that lack of relevant field data could threaten the performance of a fluent research.

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