EVALUATION OF ECOSYSTEM SERVICES IN RIPARIAN FORESTS USING BENEFIT TRANSFER METHOD

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Abstract
The aim of this paper is to evaluate ecosystem services in riparian forests of Latvia using benefit transfer method. The core of benefit-transfer method is to transfer economic costs from one economic situation to another by using pilot indicators, thus saving time and monetary resources of the research. This method also is applicable for tranfer of value of ecosystem services to research territories where such values have not been set. As to the evaluation of ecosystem services in riparian forests, data derived from these indicators are compared with the situation in riparian forest stands. Successful application of this method depends on the quality of existing research and their transferability. For example, the data on research of non-timber values can be used to set these values in riparian forests. Value of ecosystem services for 1 ha riparian forest stand in Latvia judging by 1) N and P removal (N - 8.14 euro ha^{-1} y^{-1}; P - 2.16 euro ha^{-1} y^{-1}), 2) Valuing carbon capture (478.6 euro ha^{-1} y^{-1}); 3) Valuing noise buffering (2.02 euro ha^{-1} y^{-1}); 4) Valuing air purification (NOx - 1332.5 euro ha^{-1} y^{-1}, NH3 - 216 euro ha^{-1} y^{-1}, particulate matter - 792 euro ha^{-1} y^{-1}); 5) Valuing pollination (timber - 15.25 euro ha^{-1} y^{-1}, non-timber - 4 euro ha^{-1} y^{-1}) total at 2850.67 euro ha^{-1} y^{-1}, which is significantly more than just the traditionally viewed timber value.
Key words: benefit transfer, forest value, riparian forests, ecosystem services.

Introduction

With the EU Biodiversity Strategy the member states were called to map and assess the state of ecosystems and their services in their national territory by 2014, with the assistance of the European Commission. Member states also must assess the economic value of ecosystem services and promote the integration of these values into accounting and reporting systems at EU and national level by 2020. Due to the large scale of interest in the evaluation of ecosystem services, several member states e.g. Belgium, Italy, UK etc. already have assessed values of most important ecosystem services. However, in Latvia ecosystem services have not been widely valuated yet. In this paper the evaluation of variable ecosystem services in riparian forests of Latvia has been done.

There are about 12 500 rivers and other types of water courses with the total length of about 37500 km in Latvia (Saklaurs *et al*., 2015). Today the use and management of riparian forests is a topical issue for various target groups – forest owners, policy makers and general public. As riparian forests are a transit zone between water and terrestrial ecosystems, they provide several ecosystem services and products. There are different methods for evaluation of ecosystem services and one of the methods is the usage of benefit transfer method.

Benefit transfer involves economic values that may be either positive or negative. In the latter sense, the terminology refers to a process of transferring economic costs from one economic situation to another. "Benefit transfer uses economic information captured at one place and time to make inferences about the economic value of environmental goods and services at another place and time (Wilson & Hoehn, 2006)''. Using this approach, economic estimates are either transferred as monetary value units (e.g., means or medians) or as value functions conditioned on explanatory variables that define the attributes of an ecological and economic choice setting. Value functions may be estimated using different approaches: 1) original value data (Loomis, 1992), 2) estimated using the meta-analysis of summary value functions (Woodward & Wui, 2001), 3) derived from a process of econometric calibration as in structural benefit transfer (Smith, Van Houtven, & Pattanayak, 2002).

"The benefit transfer approach has spread steadily in the last few decades as decision makers have sought timely and low cost ways to assign monetary values to goods and services that are not commonly traded in the marketplace. Conducting original valuation research is time consuming and expensive (Wilson & Hoehn, 2006)''.

Applicability of the benefit transfer method has been used in the research of riparian forests. These forests are very diverse judging by several aspects: 1) borderline of 2 different ecosystems (water and forest); 2) these territories are very inconsistent as the forest stand, the vegetation, soils, hydrological regime, relief, biodiversity, and other factors often differ even within the sub-compartment level; 3) the territory is important for the society as it is used for several activities, for example, tourism, gathering berries and mushrooms, swimming, walking, a source of inspiration; 4) within the territory there are natural resources that the society is willing to use for acquisition of economic goods.

The aim of this research is to evaluate ecosystem services in riparian forests of Latvia using benefit transfer method.

Materials and Methods

Ecosystem Services can be subdivided into economic benefits (provisioning services), regeneration services (supporting services), stabilizing services and conservation services (regulating services), life-fulfilling or cultural services (Millennium Ecosystem Assessment, 2003; Saklaurs & Krumins, 2015).

For valuation of ecosystem services in riparian forests of Latvia the benefit transfer method is used where simplified quantification functions and indicator values from different international research are used. The benefit transfer method is used to estimate economic values for ecosystem services by transferring available information from studies already completed in another location and/or context. Thus, the basic goal of benefit transfer is to estimate benefits for one context by adapting an estimate of benefits from another context.

Steps for application of the benefit transfer method:

Step 1: Identify existing studies or values that can be used for the transfer.

Step 2: Decide whether the existing values are transferable.

Step 3: Evaluate the quality of studies to be transferred. The better the quality of the initial study, the more accurate and useful the transferred value will be. This requires the professional judgment of the researcher.

Step 4: Adjust the existing values to better reflect the values for the site under consideration, using whatever information is available and relevant.

In the research information from literature is transferred into practical quantification functions for the most relevant services of riparian forest in Latvia for which sufficient information is available. These are:

1) CO^2 capture (contribution to climate regulation),
2) N and P sequestration in forest biomass (contribution to water quality and climate regulation),
3) Improvement of air quality by capturing pollutants as PM10,
4) Noise mitigation by providing a buffer function,
5) Pollination.

The quantification of the service “water retention” (flood control) depends on too many factors for a simple quantification function, so it was left out of the scope of this research project.

In the data summary of N and P balance sheets, 26 data sources form hemi boreal zone with major part of research from Latvia, Estonia and Sweden were used.

Following methods have been used to approximate the values of ecological services that were transferred to the riparian forests of Latvia:

Valuing N and P removal - Damage Cost Avoided, Replacement Cost, and Substitute Cost Methods

- Valuing carbon capture - Market Price Method
- Valuing noise buffering - Contingent Valuation Method
- Valuing air purification - Damage Cost Avoided, Replacement Cost, and Substitute Cost Methods
- Valuing pollination - Market Price Method

Economic benefits (provisioning services) are expressed using the market value of said goods. Benefits of riparian forest are evaluated and monetized as non-timber values, timber, etc. Provisioning services hardly provide any benefits in areas where biodiversity is the primary objective. (Liekens et. al 2009; Liekens et. al 2010). Taking into consideration the research territories, the provisioning services were seen as insignificant for the scope of this paper.

Life-fulfilling services (cultural services) are expressed through: willingness to pay (WTP) and willingness to accept (WTA). Both of them 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). Surveys are used in ecosystem service assessment, using the above mentioned methods – CV and CE. During a survey the public attitude towards 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 to the various obligations that would promote improvement of environmental condition and means to fund the necessary improvement measures must be clarified (Saklaurs, 2015).

Revealed preference methods use the relation between ecosystem services and one or a few market goods, grounding this method on information on 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 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).

Conservation services are evaluated using data sets that may be gathered as a part of the valuation and whose collection is not resource-demanding. During the field work, data on quality of the forest ecosystem are gathered, by describing the plant societies, forest stand and dead timber (Liepa *et al*., unpublished). On the other hand, the stabilizing services (water and air purification, etc.) and partly regeneration services (permanence of carbon sequestration) are hard to evaluate for riparian forests without conducting costly and time-consuming additional research. Thus, the benefit transfer method is used for objective evaluation.

Results and Discussion

Valuing N and P removal

The methodology to assess N and P capture in riparian forests is to compare human-made water treatment plant operating costs and the amount of nutrients fixed by forest ecosystem. By analyzing the forests capabilities of accumulation of N and P, balance sheet calculations were made. They were based on ideas of Ranger and Turpault (1999), Malmaeus and Karlsson (2010) that the input ± output nutrient budget is the simple algebraic balance between inputs and outputs of an ecosystem, based on a one year period.

By summarizing the N and P balance sheets with previously acquired data, the N and P removal in the territory of Latvia within forest ecosystems is 3.97 kg ha^{-1} yr^{-1} and 0.63 kg ha^{-1} yr^{-1}. The operating costs of man-made water treatment plants (intended for 10000 people) are 2.12 euro kg^{-1} for N and 3.44 euro/kg for P (Brambis & Laicāns, 2011). If we transfer these values to the forest of Latvia, we get that every year every 1 ha of forest land fixes N and P for 8.14 euro and 2.16 euro. If we scale it down to smaller settlements (500 inhabitants),the value of this ecosystem service increases considerably - 78.16 euro ha^{-1} for N and 6.01 euro ha^{-1} for P. Based on the rotation cycle of common birch – 71 years, the minimal value of N and P fixation is 577.94 euro for N and 153.36 euro for P. If we again scale it down to 500 people, the values are 5549.36 euro for N and 426.71 for P.

Valuing carbon capture

An ETS – sometimes referred to as a cap-and-trade system – caps the total level of greenhouse gas emissions and allows those industries with low emissions to sell their extra allowances to larger emitters. By creating supply and demand for emissions allowances, an ETS establishes a market price for greenhouse gas emissions. The cap helps ensure that the required emission reductions will take place to keep the emitters (in aggregate) within their pre-allocated carbon budget (World Bank, 2016).

Abadie and Chamorro (2008) made summary statistics for CO2 emission allowances for 2006 – 2012 period of expiration. Results showed that in the period of 2006 – 2007 from 430 observations CO2 mean price was 11.15 +/-5.88 euro t^{-1} and in period of 2008 – 2012 from 1325 observations CO2 mean price was 18.63 +/-2.37.

Gorte (2009) proved that temperate forests, including the ones in Latvia, averages carbon stocks of 62 t C in biomass, 106 t C in soil, which put together is 168t ha^{-1} C. but Watson *et al*. (2000) discovered that average carbon stocks are 96 t C in biomass and 122 t C in soil, which constitutes 217 t ha^{-1} C in total. Watson *et al*. (2000) also proved that temperate forests average an uptake of 7.0 t of C ha^{-1} y^{-1}. As 1 t C = 3.67 t CO2, then temperate forests may accumulate 25.69 t of CO2 ha^{-1} y^{-1}. Regarding the fixed 25.69 t of CO2 ha^{-1} y^{-1} and the established price range of 18.63 +/- 2.37 euro t^{-1} CO2, the forest of Latvia fixes CO2 for the value of 478.6 +/- 60.8 euro y^{-1}.

Valuing noise buffering

Research (Dwyer *et al*., 1992) shows that trees and shrubs significantly reduce noise. Wide belts of tall dense trees combined with soft ground surfaces can reduce apparent loudness by 50% or more. Cook and Haverbeke (1974) says that density, height, length and width of tree belts are the most effective factors in reducing noise rather than leaf size and branching characteristics.

Cook and Haverbeke (1974) tell that width of vegetation belts is a significant noise reduction factor. Greater width resulted in more trees on the acoustic pathway, producing greater absorption and diffusion. Nasiri *et al.* (2015) have found that on average a 20 m wide forest stand can reduce the noise level by 10.5 dB, but 100 m wide stand gives reduction of 14.4 dB.

Berglund, Lindvall and Schwela (1999) uses cost-benefit analysis for the assessment of noise pollution. The objective is to identify control actions that achieve the greatest net economic benefit. To determine the costs of control action, the abatement measures used to reduce noise pollution must be known. This is usually the case for direct measures at the source and these measures can be monetarized. Costs of action should include all costs of investment, operation and maintenance. As riparian forests already have a pre-existent noise buffer with vegetation - trees and bushes, then there is no need for special noise reduction actions.

For an average value of forested land in Latvia at 1000 euro ha^{-1} (State land service of Latvia, 2013), excluding the timber value, if the property is purchased for housing purposes, then the noise reduction factor elevates the property value by 144 euro ha^{-1}, given that the forest stand is at least 100 m wide. Using as base the average rotational cycle of common birch (71 years) as the turnover time for the forest ecosystem and the width of forest stand at 100 m, authors of this paper got the result that riparian forests in Latvia generate 2.02 euro ha^{-1} y^{-1} in noise reduction value.

Valuing air purification

Quite often air pollution contributes to global warming and significant impact to forest and water ecosystems and their services. European forests absorb approximately 10% of Europe's annual greenhouse gas emissions, according to the latest State of Europe's Forests report (Michalak, 2011).

Trees exchange gases with the atmosphere and capture particulates that can be harmful to people. Emission of pollutants impacts the air quality, chemical makeup of precipitation, deposition of chemicals in soil and water, as well as acidification (SO2, NOx, NH3), eutrophication (NOx, NH3) and ground level ozone layer (NMGOS, NOx) (LEGMC, 2016).

The improvement of air quality is monetized through the marginal damage cost, the cost of the damage caused by one extra unit of pollution. Knowing the extent to which an improvement of air quality reduces the damage to the human health or economy, it is possible to obtain information that can be used to value the service. Particulate matter, nitric monoxide and ground-level ozone are three most recognized substances harmful to human health (EEA, 2015). Liekens *et al*. (2009) made a connection between the capture of particulate matter by vegetation and the concentrations in ambient air that are at the basis of negative health effects. European research on health effects of particulate matter has developed indicator values regarding the capturing of particulate matter. Health effects - chronic mortality, morbidity (including chronic bronchitis and diseases of the lower airways (CAFE, 2001).

Liekens *et al*. (2009) has calculated the value for emissions of PM10 for fireplaces (including households) at 36 euro kg^{-1}.Value of capturing fine dust = 0.84 x 36 euro kg^{-1}= € 30 kg^{-1} captured dust. Value of capturing particulate matter: 0.5 x 36 euro kg^{-1} = 18 euro kg^{-1} captured dust.

For the valuation of the capture of NOx and also NH3 authors of this paper rely on the estimation of external costs for the emission of 1 kg of NOx. Adjusted for inflation it is 6.5 euro kg^{-1}. On the basis of weighting factors from the literature (aerosol formation factor), we can estimate the environmental damage costs. (De Leeuw, 2002; Van Steertegem, 2009). Because there is greater uncertainty about the NH3 contribution to the effects on human health that can only be included in a sensitivity analysis.

Witteveen, van der Jagt and Tänzer (2006) estimates for capturing and/or effects on concentrations of NO2, ozone and NH3 are 205 kg ha^{-1} of NOx and 45 kg ha^{-1} of NH3 y^{-1} in a forest. Witteveen *et al*. (2006) estimates the capturing of particulate matter at 50 kg ha^{-1} without underbrush and 100 kg ha^{-1} with underbrush y^{-1}. In turn, Oosterbaan (2006) estimates 36 kg ha^{-1} without underbrush and 44 kg ha^{-1} with underbrush y^{-1}. Only in a few cases the riparian forest is without underbrush so the lowest estimated value was considered (44 kg ha^{-1} y^{-1}).

Europe's sustained ground-level O3 concentrations damage forests and plants by reducing their growth rates. O3-induced growth reductions also result in an economic loss for forest owners. Karlsson (2005) has calculated that prevailing mean ozone exposure has the potential to reduce forest growth by 2.2% and the economic return of forest production by 2.6%.

Latvian forest statistics (VMD, 2016) states that the average volume of timber in a forest stand is 181.14 m^3 ha^{-1}. According to LLC (2011), the average value of forest stand in Latvia is 1387 euro ha^{-1} (with an interest rate of 4.25%). Accordingly, 1 ha of forest stand in Latvia loses 36.06 euro of its value y^{-1}due to O3-induced growth reductions.

Valuing pollination

There are very large gaps in the knowledge base on the economic value of pollination services especially in forestry (Hanley, Ellis, & Breeze, 2013).The pollination provides two-fold benefits for ecosystems of riparian forests: 1) natural pollination of vegetation; 2) natural genetic variation of pollinators. Most of the existing studies that evaluate the economic importance of pollination services focus on agriculture and the honey bee (Nabhan & Buchmann, 1997). Pollination and pollinator importance in the riparian forests is high due to the fact that many plant species can propagate only with insect interaction. And in case the pollinators disappeared, the entire ecosystem would collapse. (Kearns, Inouye, & Waser, 1998). Thus the pollination also has *Noneconomic Considerations.* For example pollinator-dependent plant communities help to bind the soil, reducing erosion that fouls creeks and impacts habitat for a wealth of aquatic life from salmon to mussels (ESA, 2016). Forested areas provide both forage and protection from excessive sun or wind for the main part of pollinators. Forest trees, especially deciduous forest trees, are excellent for shading beehives. Riparian buffer strips follow the contours of the stream or other watercourse they are protecting, and their multi-layered format (zone 1 - trees along the water, zone 2 - shrubs behind and upslope from the trees, zone 3 - native grasses behind and upslope from the shrubs) offers many opportunities for siting hives and/or providing bee forage. Riparian buffer strips will help ensure the health and survival of these "busy" workers (Hill, 1998).

Currently established approaches for pollination service value calculations are:

1) Proportion of total value attributed to insect pollination = annual production value x insect dependence factor (Losey & Vaughan, 2006; Liekens *et al*., 2009; Hanley, Ellis, & Breeze, 2013)

2) Direct managed pollination value = hive rental cost (Burgett, Rucker, & Thurman, 2004)

3) Replacement value = (annual production value attributed to insect pollination) - (annual production value using pollinator replacement) (Allsopp, De Lange, & Veldtman, 2008)

The information available on direct effect of pollination in riparian forest of Latvia is limited. Subsequently in this case the "Proportion of total value attributed to insect pollination" method was used, supplementing it with annual production value and insect dependence factor. Liekens *et al*., (2009) created a formula for determination of wild insect pollination value based on plant reliance of insect pollination (A) and plant dependence on pollination by insects (B) coefficients (from 0 to 1).

Wild insect pollination value: D = C x A x (1-B), where

C = turnover (yield x sales value) (euro $year^{-1}$)

D = proportion of sales per plant that can be attributed to wild pollinators (euro $year^{-1}$).

For main economically important tree species, which are found in riparian forests of Latvia, birch (*Betula pendula*), Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*), European aspen (*Populus tremula*), black alder (*Alnus glutinosa*) and grey alder (*Alnus incana*) the pollination mostly happens through abiotic factors, mainly wind, more seldom water. Thus insect dependence factor is 0. Some species as small-leaved lime (Tilia cordata) and Norway maple (Acer platonoides) are pollinated by insects. Still as the small-leaved lime in forest biotopes mostly propagate through stump offshoots, the insect contribution is marginal. The flowers of Norway Maple are cross-pollinated primarily by bees, including honeybees, bumblebees, and Andrenid bees. From economically important tree species Norway maple and small-leaved lime together with less important species constitute 0.11% of total area (VMD, 2016), so insect dependence factor is set at 0.011.

Bilberry (*Vaccinium myrtillus*), lingonberry (*Vaccinium vitis-idaea*) and cranberry (*Oxycoccus palustris*), are economically important plant species that are found mainly in pine forest plant societies. Here the main pollinators are bees – Hymenoptera, Anthophila and many other types of insects (Rodríguez & Kouki, 2015). Thus we can conclude that insect dependence factor is 1.0 for dwarf shrubs. With an average value of forest stand in Latvia at 1387 euro (with interest rate of 4.25%) (LLC, 2011), pollination value for forest stand is 15.27 euro ha^{-1} y^{-1} using dependence factor of 0.011%. The commercial plants in Latvia are valued at 4 euro ha^{-1} $y^{-1}$and applying the dependence factor of 1, the pollination value is also 4 euro ha^{-1}.

Summary of values of ecosystem services for riparian forests in Latvia

The quantification functions and the indicators for valuation of ecosystem services for riparian forests in Latvia can be used on every decision scale, because the

Table 1

Summary of values of ecosystem services for riparian forests in Latvia

	Volume per ha	**Value per volume**	**Total value, euro ha^{-1} y^{-1}**
Nutrient removal	*kg ha^{-1} y^{-1}*	*Euro kg^{-1}*	
N	3.97	2.12	8.14
P	0.63	3.44	2.16
Carbon capture	*t ha^{-1} y^{-1}*	*Euro t^{-1}*	
CO2	25.69	18.63	478.6
Noise buffering	-	-	2.02
Air purification	*kg ha^{-1} y^{-1}*	*euro kg^{-1}*	
NOx	205	6.5	1332.5
NH3	45	4.8	216
Particulate matter	44	18	792
Pollination			
Timber	-	-	15.25
Non-timber	-	-	4
		Total	**2850.67**

growth in a regulating service is relatively linear with the size of the area or the number of areas. The study presented in this paper definitely is not exhaustive. Further research will deliver new information on ecosystem services and specific ecosystems.

In Table 1 the summary of values of ecosystem services for riparian forests in Latvia is given.

This study reveals that in the riparian forests of Latvia timber itself is not a major benefit if we look at these forests from ecosystem service prospective. Riparian forests play an important role for such ecosystem services as air purification, carbon capture, pollination, etc. In near future forest management practices in Latvia should be revisited because forests provide multiple benefits for human welfare.

In this paper the presented quantification and valuation functions are built on the present knowledge and data availability. Described list of ecosystem services is not complete, because it was not possible to derive quantification functions for all the ecosystem services. They will be improved in the future when new scientific insights emerge and better data become available especially for use of riparian forests.

Conclusions

1. Benefit transfer method is applicable for tranfering of value of ecosystem services to riparian forests in territories where such values have not been set and there is limited time and monetary resources. Additional research is needed to estimate the correctional values for riparian forests as these are very dynamic and diverse ecosysems.
2. The value of ecosystem services for riparian forests in Latvia for 1 ha forest stand consisting of 1) N and P removal; 2) carbon capture; 3) noise buffering; 4) air purification; 5) pollination totals at 2850.67 euro y^{-1}, which is significantly more than just the traditionally viewed timber value.
3. With the benefit transfer method the largest value of ecosystem services for riparian forests in Latvia accounts for air purification and is 1332.5 euro ha^{-1} y^{-1}.
4. For valuation of such ecosystem services as “water retention” (flood control), it is necessary to conduct an interdisciplinary study by creating hydrological model for riparian forests.

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