 DOI:10.22616/RRD.29.2023.032

LANDSCAPE QUALITY EVALUATION USING CULTURAL ECOSYSTEM SERVICE ASSESSMENT METHODS

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Abstract
Ecosystem services (ES) have been widely researched for several years, but cultural ecosystem services (CES) have gained importance in recent years due to pressure on human well-being and public health. This literature review aims to continue research about ES assessment methods used in the valuation of landscape quality, analysing methods for CES assessment. The most assessed CES is aesthetic value being one of the most appreciated and widely known CES. Landscape quality assessment is complicated and rarely assessed, but several methods evaluate separate features of landscape quality, which gives an insight into accessible methods for landscape valuation. In this article, methods are analysed and categorised into four groups – economic, spatial evaluation, social and statistical analysis. Most analysed articles use several methods in one assessment giving more precise results. In CES assessment, the most used method is surveys and questionnaires and usually incorporating mapping methods to spatially explicitly represent the data.
Key words: cultural ecosystem services, landscape quality, assessment.

Introduction

The ecosystem services (ES) approach has become widely researched and mentioned in different contexts since the Millennium Ecosystem Assessment (2005) was published. After publishing the ES concept every year several new articles and methods appeared for ES assessment, and it had a snowball effect (Brzoska & Spaǵe, 2020). Since the beginning of the ES phenomenon, regulatory and provisioning services were the most assessed due to straightforward methods and easy data collection for assessment and valuation. Recently more and more attention has been drawn to cultural ecosystem services (CES) and their benefits to human health (Spage, 2022). The importance of ES to human well-being has been pointed out by several authors (Havinga *et al*., 2021; López Sánchez, Tejedor Cabrera, & Linares Gómez del Pulgar, 2020; Millennium Ecosystem Assessment, 2005; Van Berkel *et al*., 2018; Zoeller, Gurney, & Cumming, 2022), especially when talking about CES (Hermes *et al*., 2018; Martín-López *et al*., 2012; Sikora & Kaczyńska, 2022). Even though researchers have pointed out this crucial role of CES, this ES section still has been falling behind regulatory and provisioning services due to difficulties in indicator selection, data collection and method choice (Pleasant *et al*., 2014; Vihervaara, Rönkä, & Walls, 2010), there are still complications in CES quantification (Swetnam, Harrison-Curran, & Smith, 2017). CES encompasses multiple benefits that people derive from ecosystems and nowadays with a high rate of urbanisation, constant agricultural intensification (Van Berkel & Verburg, 2014) and urban sprawl processes many of those ES are endangered.

People's perception and understanding of ES delivery from landscapes are closely linked to awareness of the social perspective of the ES concept (Martín-López *et al*., 2012), but overlooking socio-cultural values can become an obstacle in landscape development or protection to maintain a high-quality landscape for future generations. Landscape quality perception is dependent on the understanding of landscape, cultural and historic values, landscape character features and personal attitudes towards landscape (Gottero, Cassatella, & Larcher, 2021; Solecka *et al*., 2022; Wartmann *et al*., 2021). Rising awareness of CES can help to promote public understanding of biological diversity (Assandri *et al*., 2018; Lindemann-Matthies, Junge, & Matthies, 2010), cultural landscapes and heritage sites (Sikora & Kaczyńska, 2022), protected areas and specific landscape values (Sowińska-Świerkosz & Michalik-Śniezek, 2020; Thiele *et al*., 2020).

CES assessment and the importance of landscape quality preservation and improvement have formed the aim of this research to explore methods for CES assessment to evaluate landscape quality in large-scale non-urban territories, and to analyse the most suitable methods for landscape quality valuation using CES assessment.

Materials and Methods

Previously performed systematic literature review (Spage, 2022) was a basis for further exploration of methodology to evaluate landscape quality using the ES approach in non-urban, large-scale territories. As the results of previous research pointed out that the most assessed ES section was CES regarding landscape quality that was a starting point for further research of methods specifically for CES assessment based on references used in the previous article.

The first step of the used review method was to do a thorough analysis of references used in the previous research, gather all research articles that are used as a source for method, indicators or data and all repeating articles were excluded from the list. The second step was the reading of all abstracts to define if the selected article corresponds to landscape quality assessment

using the CES approach. The abstract could not specifically mention the term 'landscape quality' as it could serve as a restrictive element but should correspond to the evaluation of landscape features or the landscape as a whole. Articles that assess landscape features in an urban environment were excluded from the research as the aim of the research is to analyse methods for non-urban landscapes.

After a preliminary analysis of the reference list, additional searches in databases 'Web of Science' and 'Scopus' were conducted to find the latest articles in this very specific research field. The search was conducted with specific keywords 'cultural ecosystem services' and 'landscape quality' in the title, keywords or abstracts. The search was limited to the time frame from April 2022 to February 2023, as the other articles corresponding to the same criteria were already assessed in the previous literature review (Spage, 2022). Search for the most recent research articles concluded with 16 results in the Scopus database and 58 in the Web of Science database. Major difference in the results can be explained due to the Web of Science database search engine not allowing search by specific month, only year. Similarly, abstracts of articles were read and analysed if the topic of research corresponds to the same criteria as in step 2.

After combining both article selection methods research concluded with 37 articles to be analysed for this paper. Analysis of all selected articles was performed and combining all used methods and assessed CES classes in the database. Some of the selected articles were literature reviews (Hermes *et al*., 2018; López Sánchez, Tejedor Cabrera, & Linares Gómez del Pulgar, 2020), which gave insights into the topic, but were not included in the result section.

The research method was selected based on the results of a previous literature review on this topic and this paper gathers an overview of a very specific research field that uses CES for landscape quality assessment. This research aims to analyse methods of CES assessment for landscape quality assessment and to which ES class these methods are used. As the methods of CES valuation vary in the indicator and data usage additional research article would be necessary to analyse these categories and are not included in this paper.

Results and Discussion

For an easy representation of research results, CES were classified according to the Common International Classification of Ecosystem Services (CICES) version 5.1 (European Environment Agency, 2018) classes, but the names of these ES were simplified and few classes have been combined. Based on the CICES classification there are 11 defined CES, but their division is too narrow to be assessed on a large scale and several articles (López Sánchez, Tejedor Cabrera, & Linares Gómez del Pulgar, 2020; Thiele *et al*., 2020) have been joining several classes to not confuse and misdirect the results. CICES classification provides recreation divided into two separate ES (passive and active) as well as education ES (researching and studying nature) and values for preservation and future enjoyment are classified separately. As none of the researched articles breaks down these ES in such classes, for this research these classes were combined and concluded with eight CES to be examined.

Table 1 represents the results of the literature research, and there are clear trends shown in the results. The main assessed CES class was the aesthetic value of the landscape, which was pointed out also in the previous article as the most assessed ES when talking about landscape quality (Spage, 2022). Although landscape quality is a complex feature, landscape aesthetics is still most associated with landscape quality indicators. Several authors point out an interesting connection between landscape aesthetics and biodiversity (Assandri *et al*., 2018; Lindemann-Matthies, Junge, & Matthies, 2010) when biodiversity can serve as an indicator of appreciation of landscape aesthetics. Also, recreation, tourism and cultural and heritage ES were assessed in several articles (e.g. De Vreese *et al*., 2016; Hermes, Albert, & von Haaren, 2018; Mäntymaa *et al*., 2021; Pleasant *et al*., 2014; Ruskule, Klepers, & Veidemane, 2018; Thiele *et al.*, 2020) where data collection is more straightforward. The least assessed CES classes are symbolic values and values for future generations, as these ES are complicated to assess and are time-consuming to evaluate.

The usual method division includes biophysical, monetary and social method groups (Martín-López *et al*., 2012; Yoshimura & Hiura, 2017); however, in this research biophysical method group more corresponds to the mapping of ES, and for this reason, it has replaced the biophysical method group. Also, statistical analysis has been added separately from other methods as in ES assessment a large number of articles used statistical analysis methods (e.g. Assandri *et al.,* 2018; De Vreese *et al.*, 2016; Jovanovska *et al*., 2020; Martín-López *et al*., 2009; Zoeller, Gurney, & Cumming, 2022) as an addition to other methods. For that reason, statistical analysis methods were not broken down in more detail but assessed as one method group.

Monetary valuation of CES is still a rarely used method due to complications to address specific value to intangible things. Proxies for landscape value like willingness to pay or travel cost are frequently used to assess CES. Economical evaluation methods were mostly connected with other methods in the same research, for example, surveys (Mäntymaa *et al*., 2018; Martín-López *et al*., 2009; Niedermayr *et al*., 2018; Van Berkel *et al*., 2018) or mapping of geospatial data (Hatan, Fleischer, & Tchetchik, 2021). The willingness to pay method is directly

connected with people's perception of landscape and their willingness to pay for the improvement or loss of some features in landscape (Niedermayr *et al*., 2018; Mäntymaa *et al*., 2021; Van Berkel & Verburg, 2014). Another economical method used in researched articles was the travel cost estimation method where the estimation of travel costs for travelling to a specific landscape and appreciation of it was calculated based on survey results from landscape visitors (Martín-López *et al*., 2009; Van Berkel *et al*., 2018). A novel method in economic CES assessment is the discrete-choice equilibrium model which allows the estimation of the value of CES in natural and agricultural landscapes and value loss due to urban sprawl and agricultural expansion (Hatan, Fleischer, & Tchetchik, 2021). Overall, economic methods are not widely used in CES assessment, and it is still complicated to use economic methods in this field due to lack of data or data collection being time-consuming.

The most used method group for CES assessment is spatial evaluation or mapping. Methods that assess the most CES are field observations and GIS mapping, which incorporates different tools. Field observations include systematic fieldwalking (Bieling & Plieninger, 2013), direct observations (Pueyo-Ros, Ribas, & Fraguell, 2018) and on-site inventory (Sikora & Kaczyńska, 2022). Systematic fieldwalking has a strict indicator list and precise method for the assessment of all landscape features and elements that point to CES supply (Bieling & Plieninger, 2013), but can be subjective while based only on surveyor experience and evaluation. Also, the method was employed on orchard territory, which is an open landscape and this method would not be applicable to landscapes where the view can be obscured (Bieling & Plieninger, 2013). On-site inventory used several criteria of eight CES assessment, afterwards using statistical analysis to analyse the data (Sikora & Kaczyńska, 2022). Such methods assess several CES, but these methods are time and source consuming and that can be an obstacle for city planners or decision makers to use such methods. Self-explanatory is the visual quality index (Jovanovska *et al*., 2020; Swetnam, Harrison-Curran, & Smith, 2017; Swetnam & Tweed, 2018) or landscape aesthetic quality index (Hermes, Albert, & von Haaren, 2018), which are methods for landscape aesthetical value. Visual quality index have been used as a method for several research articles but with a different approach to data collection and usage.

Table 1

Used methods for CES evaluation and CES classes (simplified)

Cultural ES	Method															
	Economic methods			Spatial evaluation (mapping)							Social methods					
	Discrete-choice equilibrium model	Travel cost estimation method	Willingness to pay	Field observations (species mapping, inventory, structured walkthrough)	Photo-based method (Geotagged photos, social media photos)	Visual quality index (Landscape aesthetic quality index)	Landscape quality index	CAESaR indicator framework	Viewshed modelling	GIS mapping (Hot spot/cold spot analysis, route mapping, buffer zones)	Survey, questionnaire	Workshops	Interviews	Experiment	Expert assessment	Statistical analysis
Recreation, tourism value		■	■	■			■	■		■	■		■		■	■
Nature education, knowledge value		■		■							■		■		■	■
Cultural and heritage value		■	■	■			■	■		■	■		■		■	■
Aesthetic value	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■
Symbolic value															■	
Spiritual or religious value		■	■	■						■	■					■
Entertainment value				■											■	
Values for future generations											■					

Note: in the table, it is marked in green whether the specific CES has been assessed by the specific method. Explanation of acronyms: CAESaR – Cultural Ecosystem Services of River landscapes; GIS – Geographic Information System.

The initial article using the visual quality index method in Wales (Swetnam, Harrison-Curran, & Smith, 2017) was based on large datasets and high-quality GIS data, assessing landscape visual quality based on five indicator categories – blue space, greenspace, physical, human and historic. The same method in different renditions was performed in Iceland (Swetnam & Tweed, 2018) where the evaluation was performed by field observations of 32 specific landscape views. Jovanovska et al. (2020) were combining two data collection methods and adapted the visual quality index method once again by using remote and field observations of the Shar Planina mountain landscapes. Two other methods are based on landscape visual values, viewshed modelling which calculates the object diversity in a view and the views from specific points in landscape (Swetnam, Harrison-Curran, & Smith, 2017; Van Berkel *et al*., 2018; Yoshimura & Hiura, 2017) and nowadays more and more popular geo-tagged photo analysis method derived from social media (Havinga *et al*., 2021; Sottini *et al*., 2019; Van Berkel et al., 2018; Yoshimura & Hiura, 2017). Social media photo analysis methods can give an insight into tourist and local inhabitant preferences regarding landscape aesthetics and also point out the demand and supply of CES (Yoshimura & Hiura, 2017). Such methods are useful for mapping people's preferences but could be complicated to use in data-scarce areas or areas that are not so widely used for recreation. The photo-based method could include different assessments of photos and landscapes, for example, taking photos from roads and analysing them (Martín *et al*., 2018). Senes et al. developed a landscape quality index method, where multiple ES were assessed including spiritual, recreation and cultural values, by using several geodata sources and using ArcGIS software to calculate the landscape quality index to point out the most precious landscapes to protect them from future land take (Senes *et al*., 2020). A new approach for CES assessment was the CAESaR indicator framework (Thiele et al., 2020), the method applied evaluation of several CES with several indicators for each CES. Method aimed to evaluate river landscapes on a national and local scale (Thiele et al., 2020). The most frequently used method was GIS-enabled mapping which incorporates different tools in GIS software, for example, hot spot/ cold spot analysis (Van Berkel & Verburg, 2014; Vannoppen, Degerickx, & Gobin, 2021), polygon mapping with participation from local inhabitants (De Vreese *et al*., 2016) and several authors used GIS mapping after gathering data from surveys and interviews (De Vreese *et al*., 2016; Plieninger *et al*., 2013; Ruskule, Klepers, & Veidemane, 2018) to spatially represent data. The spatial evaluation method group is the most diverse in method choice, but also very varied in data usage starting from very time-consuming collection and massive amounts of data to simplified methods with publicly available data. Simplified methods with no detailed data are good for estimation and overall understanding of CES supply, but these methods can be biased and not correspond to real-life situations in detail.

Widely used methods for CES assessment are qualitative surveys and interviews (Bieling & Plieninger, 2013) to gather trustworthy information about landscape perception and demand from local people, tourists and stakeholders. As mentioned before several authors that used the survey method incorporates some sort of GIS mapping tools to visually represent data or include separate assessment layers (De Vreese *et al*., 2016; Dramstad et al., 2006; Plieninger *et al*., 2013; Ruskule, Klepers, & Veidemane, 2018). Zoeller, Gurney, & Cumming (2022) method incorporated statistical analysis and researched an interesting connection between bird occurrence and people's perceptions of landscape. The same approach was used together with a questionnaire, species mapping and using statistical analysis for data processing (Assandri *et al*., 2018). Research by Pleasant *et al*. (2014) used surveys and interviews with environmental managers from local municipalities. Few authors used experiments as a method for visual choice assessment (Ungaro *et al*., 2016) or to assess plant diversity appreciation (Lindemann-Matthies, Junge, & Matthies, 2010). Results from surveys and questionnaires which do not incorporate spatial mapping and data that is not spatially explicit can be difficult to incorporate in further evaluation of landscape (Bieling & Plieninger, 2013).

Interesting that methods based on social media data which is becoming more and more popular nowadays are used only for the aesthetical value assessment, but location data collection could be used for recreation, tourism or other CES evaluation. As mentioned before, the aesthetic value is the most assessed CES and multiple methods have been adapted to measure aesthetic landscape quality, but overall landscape quality is still not addressed widely. Several authors stressed the importance and influence of people's perception on CES assessment (Hermes et al., 2018; Martín-López et al., 2009; Plieninger et al., 2013; Thiele et al., 2020), which include several interesting points for future research, for example, perception of cultural landscape (Plieninger et al., 2013; Van Berkel & Verburg, 2014).

Conclusions

CES assessment methods for evaluating landscape quality are very diverse and differ based on data availability or resources for research. Several articles in this research combines multiple methods, which has the most spatially explicit and trustworthy data. The conclusion from research is that the most appropriate method for CES assessment to evaluate landscape quality is combination of GIS enabled

mapping and surveys with society to cover base information about land structure, usage, etc. and also demand and insights from local people and tourists. Using both methods combined and carefully choosing indicators, it is possible to point out the landscapes with the highest quality from different perspectives and apply specific management tools accordingly.

References

Assandri, G., Bogliani, G., Pedrini, P., & Brambilla, M. (2018). Beautiful agricultural landscapes promote cultural ecosystem services and biodiversity conservation. *Agriculture, Ecosystems and Environment*, 256, 200–210. DOI: 10.1016/j.agee.2018.01.012.

Bieling, C., & Plieninger, T. (2013). Recording Manifestations of Cultural Ecosystem Services in the Landscape. *Landscape Research*, 38 (5), 649–667. DOI: 10.1080/01426397.2012.691469.

Brzoska, P., & Spaģe, A. (2020). From city-to site-dimension: Assessing the urban ecosystem services of different types of green infrastructure. *Land*, 9 (5), article No. 150. DOI: 10.3390/LAND9050150.

De Vreese, R., Leys, M., Fontaine, C., & Dendoncker, N. (2016). Social mapping of perceived ecosystem services supply-The role of social landscape metrics and social hotspots for integrated ecosystem services assessment, landscape planning and management. *Ecological Indicators*, 66, 517–533. DOI: 10.1016/j.ecolind.2016.01.048.

Dramstad, W., Tveit, M., Fjellstad, W., & Fry, G. (2006). Relationships between visual landscape preferences and map-based indicators of landscape structure. *Landscape and Urban Planning*, 78, 465–474. DOI: 10.1016/j.landurbplan.2005.12.006.

European Environment Agency. (2018, January). *The Common International Classification of Ecosystem Services (CICES) V5.1.* Retrieved January 6, 2023, from https://cices.eu/.

Gottero, E., Cassatella, C., & Larcher, F. (2021). Planning peri-urban open spaces: Methods and tools for interpretation and classification. *Land*, 10 (8), article No. 802. DOI: 10.3390/land10080802.

Hatan, S., Fleischer, A., & Tchetchik, A. (2021). Economic valuation of cultural ecosystem services: The case of landscape aesthetics in the agritourism market. *Ecological Economics*, 184, article No. 107005. DOI: 10.1016/j.ecolecon.2021.107005.

Havinga, I., Marcos, D., Bogaart, P.W., Hein, L., & Tuia, D. (2021). Social media and deep learning capture the aesthetic quality of the landscape. *Scientific Reports*, 11 (1). DOI: 10.1038/s41598-021-99282-0.

Hermes, J., Albert, C., & von Haaren, C. (2018). Assessing the aesthetic quality of landscapes in Germany. *Ecosystem Services*, 31, 296–307. DOI: 10.1016/j.ecoser.2018.02.015.

Hermes, J., Van Berkel, D., Burkhard, B., Plieninger, T., Fagerholm, N., von Haaren, C., & Albert, C. (2018). Assessment and valuation of recreational ecosystem services of landscapes. *Ecosystem Services*, 31, 289–295. DOI: 10.1016/j.ecoser.2018.04.011.

Jovanovska, D., Swetnam, R.D., Tweed, F.S., & Melovski, L. (2020). Assessing the landscape visual quality of Shar Planina, North Macedonia. *Landscape Ecology*, 35 (12), 2805–2823. DOI: 10.1007/s10980-020-01122-5.

Lindemann-Matthies, P., Junge, X., & Matthies, D. (2010). The influence of plant diversity on people's perception and aesthetic appreciation of grassland vegetation. *Biological Conservation*, 143, 195–202. DOI: 10.1016/j.biocon.2009.10.003.

López Sánchez, M., Tejedor Cabrera, A., & Linares Gómez Del Pulgar, M. (2020). The potential role of cultural ecosystem services in heritage research through a set of indicators. *Ecological Indicators*, 117, article No. 106670. DOI: 10.1016/j.ecolind.2020.106670.

Mäntymaa, E., Ovaskainen, V., Juutinen, A., & Tyrväinen, L. (2018). Integrating nature-based tourism and forestry in private lands under heterogeneous visitor preferences for forest attributes. *Journal of Environmental Planning and Management*, 61 (4), 724–746. DOI: 10.1080/09640568 .2017.1333408.

Mäntymaa, E., Tyrväinen, L., Juutinen, A., & Kurttila, M. (2021). Importance of forest landscape quality for companies operating in nature tourism areas. *Land Use Policy*, article No. 107:104095. DOI: 10.1016/j.landusepol.2019.104095.

Martín, B., Arce, R., Otero, I., & Loro, M. (2018). Visual landscape quality as viewed from motorways in Spain. *Sustainability (Switzerland)*, 10 (8), article No. 2592. DOI: 10.3390/su10082592.

Martín-López, B., Gómez-Baggethun, E., Lomas, P., & Montes, C. (2009). Effects of spatial and temporal scales on cultural services valuation. *Journal of Environmental Management*, 90, 1050–1059. DOI: 10.1016/j.jenvman.2008.03.013.

Martín-López, B., Iniesta-Arandia, I., García-Llorente, M., Palomo, I., Casado-Arzuaga, I., Del Amo, D., Gómez-Baggethun, E., Oteros-Rozas, E., Palacios-Agundez, I., Willaarts, B., González1, A.J., Santos-Martin, F., Onaindia, M., López-Santiago, C., & Montes, C. (2012). Uncovering ecosystem service bundles through social preferences. *PLoS ONE*, 7(6), article No. e38970. DOI: 10.1371/journal.pone.0038970.

Millennium Ecosystem Assessment. (2005). *Ecosystems and Human Wellbeing: Synthesis*. Washington, DC:

Island Press.
Niedermayr, A., Schaller, L., Mariel, P., Kieninger, P., & Kantelhardt, J. (2018). Heterogeneous preferences for public goods provided by agriculture in a region of intensive agricultural production: The case of the Marshfield. *Sustainability (Switzerland),* 10 (6), article No. 2061. DOI: 10.3390/su10062061.
Pleasant, M., Gray, S., Lepczyk, C., Fernandes, A., Hunter, N., & Ford, D. (2014). Managing cultural ecosystem services. *Ecosystem Services*, 8, 141–147. DOI: 10.1016/j.ecoser.2014.03.006.
Plieninger, T., Dijks, S., Oteros-Rozas, E., & Bieling, C. (2013). Assessing, mapping, and quantifying cultural ecosystem services at community level. *Land Use Policy*, 33, 118–129. DOI: 10.1016/j. landuse-pol.2012.12.013.
Pueyo-Ros, J., Ribas, A., & Fraguell, R.M. (2018). Uses and Preferences of Visitors to Coastal Wetlands in Tourism Destinations (Costa Brava, Spain). *Wetlands*, 38 (6), 1183–1197. DOI: 10.1007/s13157-017-0954-9.
Ruskule, A., Klepers, A., & Veidemane, K. (2018). Mapping and assessment of cultural ecosystem services of Latvian coastal areas. *One Ecosystem*, 3, article No. e25499. DOI: 10.3897/oneeco.3.e25499.
Senes, G., Fumagalli, N., Ferrario, P.S., Rovelli, R., & Sigon, R. (2020). Definition of a land quality index to preserve the best territories from future land take. An application to a study area in Lombardy (Italy*). Journal of Agricultural Engineering*, 51 (1), 43–55. DOI: 10.4081/jae.2020.1006.
Sikora, D., & Kaczyńska, M. (2022). The Cultural Ecosystem Services as an Element Supporting Manor Landscape Protection. *Sustainability*, 14, article No. 7733. DOI: 10.3390/su14137733.
Solecka, I., Rinne, T., Caracciolo Martins, R., Kytta, M., & Albert, C. (2022). Important places in landscape – investigating the determinants of perceived landscape value in the suburban area of Wrocław, Poland. *Landscape and Urban Planning*, 218, article No. 104289. DOI: 10.1016/j.landurbplan.2021. 104289.
Sottini, V.A., Barbierato, E., Bernetti, I., Capecchi, I., Fabbrizzi, S., & Menghini, S. (2019). Rural environment and landscape quality: An evaluation model integrating social media analysis and geostatistics techniques. *Aestimum*, 74, 43–62. DOI: 10.13128/aestim-7379.
Sowińska-Świerkosz, B., & Michalik-Śniezek, M. (2020). The methodology of landscape quality (LQ) indicators analysis based on remote sensing data: Polish national parks case study. *Sustainability (Switzerland),* 12 (7), article No. 2810. DOI: 10.3390/su12072810.
Spage, A. (2022). Using ecosystem services approach to assess landscape quality. *Rural and Environmental Engineering*, 37, 293–299. DOI: 10.22616/rrd.28.2022.042.
Swetnam, R., & Tweed, F. (2018). A tale of two landscapes: Transferring landscape quality metrics from Wales to Iceland. *Land Use Policy*, 76, 565–576. DOI: 10.1016/j.landusepol.2018.02.037.
Swetnam, R.D., Harrison-Curran, S.K., & Smith, G.R. (2017). Quantifying visual landscape quality in rural Wales: A GIS-enabled method for extensive monitoring of a valued cultural ecosystem service. *Ecosystem Services*, 26, 451–464. DOI: 10.1016/j.ecoser.2016.11.004.
Thiele, J., Albert, C., Hermes, J., & von Haaren, C. (2020). Assessing and quantifying offered cultural ecosystem services of German river landscapes. *Ecosystem Services*, 42, article No. 101080 DOI: 10.1016/j. ecoser.2020.101080.
Ungaro, F., Häfner, K., Zasada, I., & Piorr, A. (2016). Mapping cultural ecosystem services: Connecting visual landscape quality to cost estimations for enhanced services provision. *Land Use Policy*, 54, 399–412. DOI: 10.1016/j.landusepol.2016.02.007.
Van Berkel, D., & Verburg, P. (2014). Spatial quantification and valuation of cultural ecosystem services in an agricultural landscape. *Ecological Indicators*, 37, 163–174. DOI: 10.1016/j.ecolind.2012. 06.025.
Van Berkel, D., Tabrizian, P., Dorning, M., Smart, L., Newcomb, D., Mehaffey, M., Neale, A., Meentemeyer, R. (2018). Quantifying the visual-sensory landscape qualities that contribute to cultural ecosystem services using social media and LiDAR. *Ecosystem Services*, 31, 326–335. DOI: 10.1016/j.ecoser. 2018.03.022.
Vannoppen, A., Degerickx, J., & Gobin, A. (2021). Evaluating landscape attractiveness with geospatial data, a case study in Flanders, Belgium. *Land*, 10 (7), article No. 703. DOI: 10.3390/land10070703.
Vihervaara, P., Rönkä, M., & Walls, M. (2010). Trends in ecosystem service research: Early steps and current drivers. *AMBIO A Journal of the Human Environment*, 39 (4), 314–324. DOI: 10.1007/s13280-010-0048-x.
Wartmann, F.M., Frick, J., Kienast, F., & Hunziker, M. (2021). Factors influencing visual landscape quality perceived by the public. Results from a national survey. *Landscape and Urban Planning*, 208, article No. 104024. DOI: 10.1016/j.landurbplan.2020.104024.
Yoshimura, N., & Hiura, T. (2017). Demand and supply of cultural ecosystem services: Use of geotagged photos to map the aesthetic value of landscapes in Hokkaido. *Ecosystem Services*, 24, 68–78. DOI: 10.1016/j. ecoser.2017.02.009.
Zoeller, K., Gurney, G., & Cumming, G. (2022). The influence of landscape context on the production of cultural ecosystem services. *Landscape Ecology*, 37, 883–894. DOI: 10.1007/s10980-022-01412-0.