BOOK OF ABSTRACTS

This Book of Abstracts provides a comprehensive overview of the session content and is structured into three main sections:

I. Session Description – an introduction to each session, including its objectives and expected outputs
II. Session Program – a detailed schedule for each session, including speakers and timing
III. List of Abstracts – a complete compilation of all accepted abstracts

I. SESSION DESCRIPTION

ID: T19

New data, new tools, new challenges: next steps in advancing cultural ecosystem services research in the digital realm

Hosts:

	Name	Organisation	E-mail
Host (s):	Andrea Ghermandi	School of Environmental Sciences, University of Haifa	aghermand@univ.haifa.ac.il
Co-host(s):	Johannes Langemeyer	Institute of Environmental Science and Technology, Universitat Autonoma de Barcelona	johannes.langemeyer@uab.cat
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Abstract:

Cultural ecosystem services research is experiencing a digital transformation. New forms of digital data and computational methods have begun to reshape how human-nature relationships are studied. This evolution encompasses fundamental changes to both data collection and data processing, drawing on new sources—such as mobile technologies and social media networks—and on advances in modelling and artificial intelligence—allowing qualitative data analysis at scale. These technological innovations have opened unprecedented opportunities for quantitative and spatial assessments of cultural ecosystem services, especially at large geographical scales.

Significant challenges remain, however, that must be addressed before these approaches can become standard tools in sustainable environmental management. This includes the complex task of integrating insights from conventional cultural ecosystem services assessment techniques with big data approaches. Challenges that are well-documented in the literature—but still not satisfactorily addressed—include representativeness of sampled users, potential biases in content sampling, and critical issues surrounding data accessibility and privacy protection, particularly as continued availability of passive social media data remains uncertain.

This may call for a more participation-centered approach to data generation, in which users better understand what they share, for what purpose, and what value they receive in return. On the other hand, emerging challenges include, for instance, the use of artificial intelligence applications, particularly large language models, to data analysis, including algorithmic biases, the lack of agreed-upon standards for human supervision, and localized vs. universal understandings of cultural ecosystem services.

This session invites contributions that offer critical, forward-looking reflections on both the challenges and opportunities presented by new data sources and processing techniques in cultural ecosystem services research, including novel metrics, participatory mechanisms and integration with Earth observation tools.

Goals and objectives of the session:
This session aims to provide forward-looking reflections that can guide both established researchers and newcomers in navigating and shaping the future of cultural ecosystem services research, helping to ensure that these innovative approaches are applied rigorously, responsibly, and effectively in our increasingly digital world.

Planned output / Deliverables:
Position paper or commentary, jointly drafted with the session attendants.

Session format:
Depending on the number of submitted abstracts, we plan for a series of 10-15 minutes presentations, followed by a half-hour roundtable discussion involving the session participants and attendants.

Related to ESP Working Group:
TWG 19 - Big data & Digital communication

II. SESSION PROGRAM

Room: A3
Date of session: Friday 22, May 2026
Time of session: 09:00 – 12:30

Timetable speakers:

Time	First name	Surname	Organization	Title of presentation
9:00-9:06	Co-hosts of Session T19			Introduction to the Session
9:06-9:18	Svetlana	Khromova	ICTA-UAB	From big data to deep meaning: Large Language Models in the evolving landscape of cultural ecosystem services research
9:18-9:30	Julien	Barrere	INRAE	Leveraging deep learning to classify social media images by cultural ecosystem services: Methods, challenges, and applications
9:30-9:42	Carolina	Pozzi	Roma Tre University	Interpreting cultural ecosystem services using Google Maps Reviews and AI: Evidence and perspectives from Rome's III district
9:42-9:54	Francesc	Comalada i Pla	Catalan Institute for Water Research	Using Wikiloc data and deep learning to analyze post-COVID changes in freshwater recreation
9:54-10:06	Oleksandr	Karasov	Aalto University	Mapping "Time Well Spent": A Telegram-based participatory approach for democratising and automating cultural ecosystem services data collection
10:06-10:18	Fruzsina	Stefan	BOKU University	Origin–destination flow clustering for participation-centred digital CES mapping of forest recreation access (Vienna, Austria)

10:18-10:30	Xueyuan	Liang	ICTA-UAB	Mapping digital relational values in urban ecosystems: Evidence from social media text data in Shenzhen, China
10:30-11:00			Coffee Break	
11:00-11:12	Andrea	Ghermandi	University of Haifa	Human-nature interactions through a digital prism: Cross-platform heterogeneity in social media user socio-demographics and content in a nature park
11:12-11:24	Laura	Costadone	Old Dominion University	From reviews to value: Harnessing crowdsourced data to capture visitor perceptions and economic benefits of recreation
11:24-11:36	Michael	Sinclair	University of Glasgow	Are people visiting better parks? What mobile app data tells us (and what it doesn't)
11:36-11:48	Mariusz	Ciesielski	Forest Research Institute	Spatial modeling of tourist movement in forest areas based on big data
11:48-12:00	Anna	Hausmann	University of Jyväskylä	Digital technologies and the appreciation of nature experiences
12:00-12:30	Discussion and networking opportunities (moderator Johannes Langemeyer)			

III. ABSTRACTS

The first author is the presenting author unless indicated otherwise

1. From Big Data to Deep Meaning: Large Language Models in the Evolving Landscape of Cultural Ecosystem Services Research

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The digital transformation of Cultural Ecosystem Services (CES) research calls for new analytical paradigms capable of interpreting complex, value-laden human–nature interactions at scale. This study explores the methodological frontier of applying large language models (LLMs) to CES assessment, leveraging user-generated social media content as a lens on landscape perception and meaning-making. Building on a dataset of Flickr posts, we implemented a prompt-based, zero-shot learning framework to classify CES categories and identify nature-related features from textual and visual data. Comparative experiments across model type and prompt designs were conducted to evaluate model sensitivity, interpretability, and alignment with human-coded benchmarks.
Our findings demonstrate that LLMs can capture subtle linguistic and contextual cues that traditional keyword-based approaches might overlook, thereby revealing latent dimensions of aesthetic, recreational, social and other values. Yet, model behavior proved highly contingent on prompt formulation and training context, exposing issues of semantic bias, reproducibility, and epistemic transparency. By systematically dissecting these dependencies, the study provides both empirical and conceptual insights into how generative AI can augment but not replace human interpretation in CES research.
This work contributes to the emerging discourse on integrating artificial intelligence into environmental social science, outlining a pathway toward hybrid analytical frameworks that combine computational scalability with critical reflexivity, and advancing the use of LLMs as tools for participatory, evidence-based landscape planning.

Keywords: Cultural Ecosystem Services, Large Language Models, Social Media Analytics, Landscape Perception

2. Leveraging Deep Learning to Classify Social Media Images by Cultural Ecosystem Services: Methods, Challenges, and Applications

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The focus of forest management objectives is shifting increasingly towards ecosystem multifunctionality rather than timber production. However, cultural ecosystem services (CES) are not adequately accounted for in current management frameworks due to the difficulty of quantifying these services and their relationship with forest attributes. The growing availability of social media data offers new possibilities for quantifying forest CES, but significant methodological challenges remain, such as sorting and classifying social media pictures into defined CES categories. The development of deep learning and artificial intelligence (AI) methods offers the prospect of moving beyond manual classification and developing models that can process the ever-growing volume of social media images available online. In this presentation, I will demonstrate the potential of AI for CES classification by presenting a convolutional neural network model that has been trained using over 13,000 annotated Flickr images extracted from 16 natural sites across Europe. I will conclude by discussing the associated methodological challenges and introducing the newly funded RESOTEC project. The project intends to apply our CNN model to classify pictures of forested natural parks in France on Flickr into pre-defined CES categories, and to compare the density of pictures associated with each CES category with forest attribute metrics (structure and composition) estimated by remote sensing. The project will demonstrate how the combination of AI, social media data, and remote sensing technologies can enhance our capacity to quantify CES and their relationship with environmental attributes, facilitating their integration into management frameworks.

Keywords: cultural ecosystem services, deep learning, social media, convolutional neural network, Flickr

3. Interpreting Cultural Ecosystem Services Using Google Maps Reviews and AI: Evidence and Perspectives from Rome's III District

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Cultural Ecosystem Services (CES) research is increasingly shaped by the availability of digital data and advanced computational tools, opening new possibilities for spatially explicit, scalable, and repeatable assessments.
This paper presents the results of the development and testing of an innovative model for mapping and evaluating CES in urban and peri-urban contexts, integrating deep learning techniques with GIS-based spatial analysis and using Google Maps reviews as the primary data source.
The novelty of the model lies in the systematic analysis of georeferenced textual reviews rather than images, allowing the assessment of not only the intensity of human–nature interactions but also users' perceptions and experiences in greater detail. Compared to existing social media–based approaches and tools, the use of long-form textual content from Google Maps enables a richer qualitative–quantitative interpretation of CES.
Methodologically, the model is structured in four phases: (1) definition of strategic CES and an interaction-based analytical protocol (physical recreation, social relations and cohesion, education and inspiration, aesthetic and cultural values); (2) acquisition and cataloguing of Google Maps reviews and spatial data via Google Places API; (3) CES evaluation through automated text analysis using a generative Large Language Model; and (4) spatial mapping and visualization of CES indicators in a GIS environment.
The model was tested in Rome's III District, analysing over 21,800 reviews related to urban green spaces.

The integration of AI-driven text analysis enables the efficient processing of large datasets and supports the automated, flexible, and replicable evaluation of multiple CES dimensions.
Overall, the proposed approach offers a scalable decision-support system for urban green infrastructure planning, contributing to the advancement of CES research in the digital realm.

Keywords: cultural ecosystem services, urban green infrastructure, urban planning, artificial intelligence, public green spaces

4. Using Wikiloc data and deep learning to analyze post-COVID changes in freshwater recreation

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COVID-19 restrictions led to a rise in outdoor recreation, but how these changes persisted and spatially reorganized afterwards has rarely been explored. We analyze post-COVID freshwater recreation spatial patterns in Catalan river basins using 136,455 georeferenced photographs from Wikiloc (2016–2024). Data was extracted using web-scraping and classified with a deep learning model to isolate freshwater-related images, enabling high-resolution monitoring of freshwater recreation. Freshwater recreation increased strongly during the COVID period and remained substantially higher after mobility restrictions ended in May 2021. Mean daily activity rose from 21.3 photo-user-days before March 2020 to 54.3 during COVID and stabilized at 60.8 in the post-COVID period. Hiking reinforced its dominance, while cycling declined, indicating a move toward more casual activities. After COVID, spatial clustering increased only moderately (Moran's I = +0.03), but recreational use expanded into 28% more freshwater spaces. A spatial Poisson model fitted with INLA captured the new spatial structure of outdoor recreation. Increases were strongest in peri-urban and moderately modified freshwater environments, where road access and trail availability facilitate visitation. Protected areas experienced substantial growth. The model also revealed localized hotspots that emerged independently of accessibility or environmental gradients, suggesting complementary social or site-specific drivers of recreation. Findings show a sustained increase in freshwater recreation after the pandemic, characterized by more casual, clustered use concentrated in easily accessible areas. Wikiloc metadata enabled a spatially and temporally explicit analysis of these shifts, opening new opportunities for managers to detect emerging pressures and adapt freshwater planning to rapidly changing recreational patterns.

Keywords: social-media data; outdoor recreation; COVID-19; Freshwater Ecosystems; wikiloc

5. Mapping "Time Well Spent": A Telegram-Based Participatory Approach for Democratising and Automating Cultural Ecosystem Services Data Collection

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Operationalising Cultural Ecosystem Services (CES) remains a critical sustainability challenge because quantifying non-material benefits is difficult without reducing them to monetary or other proxies, or relying on increasingly scarce big data sources (e.g., location-based social media). This study introduces a novel, scalable metric for CES assessment - personal time quality, defined as the subjective valuation of time spent in connection with the environment. Recognising that traditional participatory mapping often requires offline data-collection campaigns or faces other data-collection challenges, we present a data-collection approach that uses a custom Telegram bot, a popular messaging app in Ukraine.
Tested in the context of the Russian invasion of Ukraine, where data deserts are prevalent, the Telegram bot successfully democratised CES mapping in the city of Kremenchuk by allowing users to easily rate the quality of their time outdoors on an interactive map. This work demonstrates that leveraging popular

messaging platforms can rapidly generate spatially explicit datasets on how people value outdoor time. Crucially, this methodology lays the groundwork for a self-sustaining CES data infrastructure. By integrating collaborative filtering algorithms, future iterations of this tool will evolve from passive data collection into a recommendation service. Just as digital media platforms optimise engagement, this system aims to optimise "time well spent" in nature, creating a feedback loop where users voluntarily contribute high-quality data to receive personalised outdoor recommendations. This shift eliminates the need for costly, repeated survey waves, providing planners with a dynamic, bottom-up stream of information to manage urban green spaces and protected areas. This reciprocal mechanism would support participation, address the "cold start" problem of data availability, and enable researchers to maintain a self-sustaining, real-time monitoring system of human-nature interactions without the recurring costs of traditional survey campaigns.

Keywords: non-material nature's contributions to people, big data, participatory mapping, crowdsourcing

6. Origin–destination flow clustering for participation-centred digital CES mapping of forest recreation access (Vienna, Austria)

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automated processing, opening new possibilities for spatially explicit assessments at scale. The next step is ensuring these approaches can be combined with established CES methods and applied responsibly in practice through transparent workflows, privacy-aware design, and clear value back to participants and stakeholders.
We contribute a participation-centred pathway that links survey-based CES assessment with computational mobility metrics to show how metropolitan residents actually reach urban and peri-urban forests. We analyse a quota-based Public Participation GIS (PPGIS) survey from the Vienna Metropolitan Area (n = 3,121). Participants mapped approximate home locations and forest gateways, reported their usual travel mode(s), and stated visit frequency. We derive origin–destination (OD) flows from origins to mapped entrances and combine density-based clustering (DBSCAN/HDBSCAN) of OD flows with mode-specific door-to-forest network travel times for walking, cycling, public transport, and car.
The analysis identifies six corridor and visitor types and a clear distance–decay: each additional kilometre between home and forest corresponds to about 11% fewer annual visits, with the steepest decline within the first 5 km. Corridors with strong cycling and public-transport connectivity along Vienna's forest fringe keep many trips within roughly 60 minutes and support regular use. In contrast, more peripheral patterns depend more on car access and show markedly lower visitation. Importantly, several northern and eastern districts remain underused despite nearby forest cover, pointing to gaps in connectors, gateways, or last-mile conditions.
We translate these insights into planning outputs (priority gateways, missing links, and mode-specific access opportunities) and close with practical guidance for responsible digital CES assessment, including clear documentation of assumptions and limitations, privacy-aware design, and accessible feedback products that return value to participants.

Keywords: cultural ecosystem services; participatory GIS (PPGIS); spatial clustering; mobility accessibility; urban and suburban forests

7. Mapping Digital Relational Values in Urban Ecosystems: Evidence from Social Media Text Data in Shenzhen, China

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Parks and other urban green spaces provide city dwellers with opportunities to interact with natural environments, encouraging outdoor activities and promoting physical and mental health. However, rapid urbanization, particularly in countries like China, has led to shrinking green and blue areas, making it increasingly difficult for urban residents to experience nature directly. This “extinction of experience” can negatively impact human well-being and lead to sedentary lifestyles. As internet-based social networks evolve and their user bases expand, digital relational values (DRVs) shaped through human-nature interactions in virtual communities may help counteract this trend. DRVs are defined as fundamental and eudaimonic values developed within virtual communities. Nevertheless, research on DRVs remains in its infancy. Current studies primarily focus on the identification and classification of DRVs, while their spatial distributions and patterns remain underexplored. Moreover, in the context of rapid urbanization, DRVs associated with urban ecosystems have received particularly limited attention.
Similar to Twitter (currently X), Weibo, the most popular social media platform in China, also forms a unique virtual community where DRVs are expressed and shaped. This study utilizes the city of Shenzhen, China, as a case study employing Weibo text data to explore the spatial distributions and patterns of DRVs, as well as differences in their expression across multiple urban ecosystems. The Weibo “Check-in” function was used to obtain geo-referenced posts from 2023. Natural Language Processing and Machine learning methods were applied to identify DRVs expressed in different urban ecosystems. The frequencies and distribution patterns of DRVs were revealed by Global Moran's I and Local Moran's I. This research furthers the understanding of human-nature interactions in virtual environments, thereby promoting the sustainable development of urban areas and the wellbeing of their inhabitants.

Keywords: Digital relational values, Urban ecosystems, Social media platform, Machine Learning Method, Spatial analysis

8. Human-nature interactions through a digital prism: Cross-platform heterogeneity in social media user socio-demographics and content in a nature park

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User-generated content from social media platforms offers valuable insights into human-nature interactions, yet research frequently relies on data from only one or a few social media platforms. This limitation raises concerns about representation and measurement biases, especially as different platforms vary in user demographics, type of supported media, and content-sharing norms. To address these gaps, we conducted a comparative analysis of user-generated content related to nature experiences across 13 social media platforms, using Ramat Hanadiv nature park in Israel as a case study. We analyzed platform-specific socio-demographic characteristics, including users’ geographic origin, gender, and language, and evaluated differences in textual and visual content shared on each platform. Results were cross-validated against on-site survey data to assess whether combining data from multiple sources could reduce socio-demographic and content-related biases and whether textual, visual, or combined data more accurately reflects visitor preferences. Our findings reveal substantial variability across platforms. While data integration yielded a more balanced demographic representation, the combined content did not uniformly improve alignment with survey data. Textual content analysis offered closer alignment with survey responses, suggesting that it may more accurately capture visitors’ preferences than visual content alone. This study advances social media-based environmental research by showing that accounting for platform and content-type differences is essential for extracting reliable insights to guide environmental management and conservation planning.

Keywords: Digital footprints, passive crowdsourcing, nature experiences, nature-based recreation, Israel

9. From Reviews to Value: Harnessing Crowdsourced Data to Capture Visitor Perceptions and Economic Benefits of Recreation

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Quantifying the recreational benefits of protected natural areas is essential for sustainable management, conservation finance, and informed policymaking. Yet traditional approaches such as on-site surveys remain costly, geographically constrained, and limited by regulatory restrictions. This study shows how emerging digital data streams can strengthen cultural ecosystem services assessments by integrating multiple forms of crowdsourced information to evaluate both visitor perceptions and the economic value of nature-based recreation. We combined georeferenced data and user-generated content from four online platforms (Flickr, TripAdvisor, Yelp, and AllTrails) together with supplemental survey data to examine visitation patterns, sentiment, experiential attributes, and travel-cost estimates in a National Wildlife Refuge in Virginia, USA. Sentiment analysis using multiple lexicons revealed consistently positive emotions across platforms, particularly toward wildlife sightings, scenic landscapes, and the site's uncrowded experience. Travel-cost estimates derived from 1,289 crowdsourced visits yielded an average trip cost of $527, far higher than the $91 average derived from survey respondents, reflecting the broader geographic distribution and inclusion of international visitors captured by digital traces. The corresponding annual recreational value based on crowdsourced data was $74.7 million, compared to $13 million from survey-based estimates. The novelty of this work lies in integrating multiple heterogeneous digital platforms and coupling monetary valuation with non-monetary indicators of visitor experience, offering a multidimensional perspective rarely achieved in cultural ecosystem services assessments. This integrated approach broadens the spatial, demographic, and behavioral representation of visitors, offering a scalable and cost-effective complement to conventional methods while providing a more comprehensive understanding of both the experiential and economic dimensions of nature-based recreation for park managers, planners, and policymakers. Our findings also illustrate both the opportunities and persistent challenges associated with big-data approaches in CES research including issues of representativeness, platform bias, and the need for transparent, responsible analytical protocols.

Keywords: Crowdsourced data; Nature-based recreation; Travel cost valuation; Sentiment analysis; Ecosystem services

10. Are people visiting better parks? What mobile app data tells us (and what it doesn't)

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Urban parks support physical activity, mental wellbeing and social connection in cities. Yet access alone is an incomplete story: parks vary in amenities, facilities, attractions, accessibility and biodiversity, and these differences shape use. Less is known about whether objectively "better" parks are visited more, because surveys, audits and manual counts are resource-intensive and rarely available at the scale needed for comparing many sites over time. Mobile phone location technologies offer a scalable alternative, but what they tell us (and what they don't) needs exploration.

We test this in the UK using a multi-app mobile phone dataset spanning hundreds of apps and thousands of users. We estimate visitation for 486 public parks and gardens across five UK cities (Birmingham, Glasgow, Edinburgh, Manchester and Bristol) deriving park-level "mobile visitor-days" as a proxy for demand. We estimate users' home areas, attach small-area socio-demographic profiles, and apply post-

stratification weights to reduce sample bias. We then model weighted visitor-days against objective quality indicators across five domains (amenities, facilities, attractions, accessibility and biodiversity), measured within park boundaries and within a 100 m buffer to capture nearby features that shape use.

Count-data regression models show a strong relationship between quality attributes and visitation, with model fit around R2 = 0.68. Most predictors are statistically significant and directionally consistent with established expectations, and we observe between-city differences in how quality translates into demand.

Overall, combining mobile app data with scalable geospatial quality metrics provides a practical, repeatable way to link park supply and demand across hundreds of sites. Used well, it can help cities monitor change over time, identify which quality domains are most strongly associated with use. While app data cannot replace approaches that capture motivations or perceptions, it is a strong foundation for the future of mobile technologies in understanding use of nature at scale.

Keywords: Urban parks, Park quality, Mobile phone app data, Cultural Ecosystem Services, New Technologies

11. Spatial modeling of tourist movement in forest areas based on big data

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Forest areas located within highly urbanized regions have long played an important role in the daily lives of city residents by providing spaces for recreation, leisure, and direct contact with nature. In the context of ongoing urban expansion, increasing population density, and dynamic social and spatial transformations, the importance of these areas continues to grow. This trend is further reinforced by the rising awareness of the role of natural environments in supporting both mental and physical health. As a result, urban and peri-urban forests are increasingly recognized as essential components of green infrastructure, contributing to overall quality of life, social well-being, and urban resilience.
This paper presents a relatively novel approach to monitoring and analyzing recreational activity in forest areas of the Warsaw metropolitan region, based on the use of large-scale datasets (big data) generated by mobile phone users. Such data, which include anonymized information on location and movement patterns, enable high-resolution analyses of recreational behavior across both spatial and temporal dimensions. Compared to traditional research methods—such as surveys, interviews, or direct field observations—big data approaches offer a more comprehensive and continuous perspective on human–environment interactions.
The presentation discusses the technical aspects of data acquisition, processing, and spatial analysis of mobile-device-generated information, as well as its practical application in mapping cultural ecosystem services provided by urban and peri-urban forests. Particular emphasis is placed on identifying spatial patterns of recreational activity, including intensity of use, preferred routes, accessibility, and seasonal variability.
The results presented in this study constitute a valuable source of information for evidence-based decision-making related to forest planning, management, and conservation in urbanized areas. Moreover, they contribute to a deeper understanding of the needs, preferences, and behaviors of forest users, supporting the development of sustainable strategies that balance recreational demand with ecological protection.

Keywords: recreation, cultural ecosystem services, mobile phone, social media

12. Digital technologies and the appreciation of nature experiences

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Digital technologies increasingly mediate how nature is encountered, understood, and valued, reshaping human–nature relations. While tools such as social media, AI, remote sensing, and virtual environments expand access to environmental information and distant ecosystems, they also risk reducing sensory richness, homogenising representations, and redefining what is perceived as “real” or valuable nature. As appreciation of nature (i.e., its interpretation and valuation) becomes increasingly mediated, a growing tension emerges between experiences in nature, grounded in direct, embodied engagement, and experiences of nature, where appreciation is influenced by digital representations, data infrastructures, and curated, aestheticised media content. This work argues that this shift can lead to a reconfiguration of environmental values, influencing how nature comes to be noticed, cared about, desired, or prioritised. This implies a shift from relational and situational experiences toward anticipatory and comparative, formed in advance and evaluated against curated or algorithmically optimised expectations. This can produce derivative appreciation, where attachment to nature is shaped more by recognisable digital cues than by lived interactions, potentially steering conservation concern toward what is visually appealing, shareable, or emotionally efficient rather than ecologically vulnerable or locally meaningful. A reflexive use of digital data in ecosystem services assessment may provide critical grounding for examining how data and platforms’ logics shape how nature is valued, and what this implies for conservation.

Keywords: human-nature relations, digital conservation, environmental values