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Ecosystem Accounting Table

Improving nature-based tourism accounts: The importance of national data for robust ecosystem service estimates

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Abstract

The new EU regulation on ecosystem accounting requires Member States to report annually on the supply and use of seven ecosystem services. To support this process, Eurostat provides a voluntary INCA tool along with default datasets and methods. While these resources enable basic compliance with the reporting requirements, the top-down, centrally provided input data and assumptions are generic, not fully comprehensive and may lack accuracy in many national contexts. Integration of national data and context-specific assumptions is, therefore, recommended to improve reliability and national relevance of accounts.

In this study, we assessed how input data choices affect nature-based tourism accounts in Finland. We compiled two sets of accounts with the INCA tool: one using the default dataset and one with nationally sourced input data. Improvements in the nationally adjusted dataset include high-resolution travel statistics, spatial information on accommodation locations and adjusted proxies for recreational attractiveness. The comparison of resulting accounts revealed substantial differences: the default approach underestimated domestic nature-based tourism volumes – mainly due to missing non-

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commercial accommodation use – and produced unrealistic spatial patterns that overlooked several key destinations. National data provided markedly higher and more plausible estimates, with a broader and more accurate distribution across the landscape and a shift in ecosystem-level supply from forest-dominated to a more balanced contribution of lakes, marine areas and other ecosystems.

Our findings demonstrate that using more comprehensive inputs, with higher spatial accuracy and closer alignment with national realities, can substantially change the magnitude and spatial distribution of estimated ecosystem service supply. Incorporating national expertise and datasets is essential to go beyond minimum compliance and to produce ecosystem accounts that are robust enough to support informed policy-making.

Keywords

cultural ecosystem services, ecosystem accounting, recreation potential, spatial modelling

Introduction

Nature-based tourism is one of the ecosystem services that EU countries will be required to report under the amended EU regulation on environmental accounts (EU 691/2011). In this context, nature-based tourism refers to the ecosystem contribution – through the biophysical characteristics and qualities of ecosystems – that enables people to use and enjoy the environment through direct, in situ, physical and experiential interactions. The compilation of ecosystem accounts included in the amendment follows the System of Environmental-Economic Accounting (SEEA) framework, which provides a standardised approach to ecosystem accounting. However, the accuracy and relevance of the resulting accounts depend heavily on the data sources used. To support implementation, Eurostat provides the INCA plugin for QGIS (European Union 2023) as a voluntary modelling tool, together with default input datasets. While these generic inputs may misrepresent local conditions, the developers emphasise that the INCA tool is designed to be open and to support the integration of national data sources (Buchhorn et al. 2022). Reliance on generic defaults can overlook national and regional institutional contexts, including rules, norms, property rights and governance structures that influence ecosystem use and the valuation of services (Artell et al. 2019, Barton 2022). National datasets and models can also offer more detailed and comprehensive information on the physical supply and use of services than pan-European defaults. A pilot application in Norway, for example, showed that INCA results require careful evaluation beyond minimum reporting requirements when accurate national data and models are lacking (Immerzeel and Korkou 2024). In Finland, this reliance on national context is particularly important for nature-based tourism, where extensive and accessible outdoor recreation opportunities are supported by freedom to roam and a strong tradition of free-time residences, especially along freshwater and marine coastlines (see, for example, Huhtala and Lankia (2012), Ahtiainen et al. (2022), Neuvonen et al. (2022), Ervola et al. (2024)).

Nature-based tourism accounts can provide information for policy-making by linking tourism and recreation to environmental, economic and institutional dimensions, but their value depends on precise and timely data. Integrating the accounts with environmental quality indicators, such as water quality or forest clear-cutting, helps assess how policies affect the supply of recreational ecosystem services. National nature recreation strategy 2030 for Finland (2022) highlights access to nearby nature, health and wellbeing and sustainability, while the Finland's tourism strategy for 2022-2028 (2022) identifies sustainability as the main priority for growth. The provision of ecosystem services and good environmental status are, therefore, essential both for sustainable tourism and for the well-being of citizens.

This paper examines how the use of national datasets and country-specific approaches influences the compilation and policy relevance of Finland's nature-based tourism accounts. We focus on domestic travel, where detailed tourism statistics allow a more accurate representation of the supply and use of services. Nationally adjusted input data also capture institutional contexts, such as freedom to roam, extensive forestry practices and the importance of free-time residences in outdoor recreation. Integration of nationally relevant GIS data provides enhanced spatial insights into accessibility, facilities and attractiveness for nature-based tourism, with connections to environmental quality. By integrating these sources, we seek to improve the accuracy and policy relevance of nature-based tourism accounts in Finland and to evaluate the added value of the approach compared to the generic default approach of the INCA tool. The results contribute to ongoing discussions on advancing ecosystem accounting methodologies and data within the SEEA EA and EU environmental accounting frameworks.

Data and methods

In line with the amendment to EU Regulation 691/2011 on ecosystem accounts, nature-based tourism is defined as overnight stays in accommodation attributable to ecosystem visits. The methodology applied in this study follows the Guidance Note on Tourism Ecosystem Services (Eurostat 2024) and the INCA Tool User Guide (European Union 2023). The primary outputs of nature-based tourism accounts are the supply and use tables. Supply refers to the total number of overnight stays attributed to twelve ecosystem types (ET), following the Level 1 classification of the SEEA EA ecosystem typology. In the reporting tables, use is divided into domestic household consumption and export, corresponding to tourism by domestic and foreign travellers. In this study, domestic nature-based tourism accounts were compiled for 2023 using the INCA tool (v.2.1.1). The compilation involved three main steps:

1. **Compilation of overnight stay statistics** – Establishing the total number of overnight stays;
2. **Attribution to nature-based tourism** – Estimating the proportion of overnight stays linked to nature-based tourism;
3. **Spatial modelling and ecosystem attribution** – Modelling the spatial distribution of overnight stays and overlaying the result with an ET map.

Two versions of the accounts were produced: one applying the default data provided by Eurostat and one using nationally adjusted input data complemented with relevant elements missing from the default dataset, as recommended in the Guidance Note.

Step 1: Tourism statistics and number of overnight stays

For the default accounts on domestic tourism, European travel statistics on nights spent in hotels, holiday and other short-stay accommodation and camping grounds for 2023 were used (Eurostat 2025). The statistics exclude small establishments (< 20 beds) and non-commercial accommodation and are provided at the NUTS-3 level, corresponding to the 19 regions (administrative units) of Finland.

For the nationally modified accounts, municipality-level statistics from Statistics Finland (2024) were used. These travel statistics are derived from representative sample surveys of Finnish residents and cover all accommodation types, including small establishments and unpaid accommodation, such as stays at own free-time residences. This distinction is particularly important in the Finnish context, where approximately 0.5 million holiday homes exist (population 5.6 million) and are used on average 85 days per year (Myllymäki et al. 2025). In 2023, 46% of domestic overnight stays occurred at own free-time residences, 14% at rental holiday homes and 13% in hotels.

Municipality-level accuracy in the Finnish data improves accounting, but has survey-based uncertainties in municipalities with low number of overnight stays. To obtain a robust representation of the spatial distribution, we aggregated five years of data (2019–2023) to form a proxy of municipality-level overnight stay intensity. This proxy was then used to allocate annual region-level totals to municipalities, preserving spatial detail, while maintaining year-to-year variation.

Step 2: Attributing overnight stays to nature-based tourism

In the default approach with default data and assumptions, nature-attribution percentages (i.e. the proportion of tourism attributable to nature-based recreation) are estimated for NUTS-3 regions using the Recreation Potential Map (RPM) developed by the Joint Research Centre (Vallecillo et al. 2018). The share of land classified as having medium or high recreation potential within each region is assumed to equal the ecosystem contribution percentage. In Finland, this approach yields high percentages in densely populated southern and western regions and low percentages in sparsely populated northern and eastern areas (Fig. 1A).

In the nationally adjusted accounting approach, nature-attribution percentages were derived from Travel statistics (see Step 1). These surveys include a question on travel motives, allowing respondents to indicate whether nature motivated their choice of destination. Due to statistical uncertainty at the municipality level, percentages were calculated at the region level. Motivations differed substantially amongst traveller groups using different accommodation types; therefore, separate nature-attribution percentages were applied for hotels, other paid accommodation (rental cottages and camping sites)

and unpaid accommodation (mainly free-time residences). National averages for these groups were 21%, 55%, and 70%, respectively. The highest percentages were observed in provinces of northern and eastern Finland (Fig. 1B). The nature attribution-percentages for each province were applied as input data for calculation of the nature-based overnight stays.

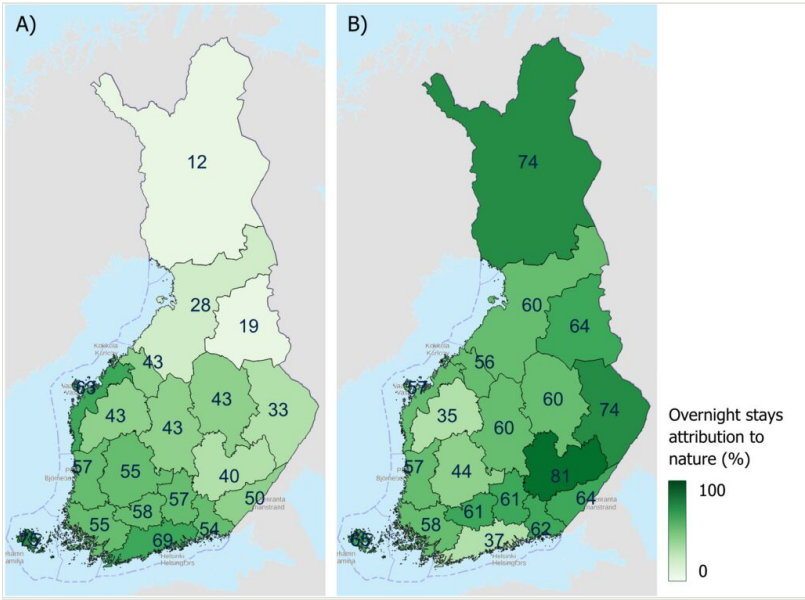

Figure 1.

Attribution of overnight stays to nature (%) derived from the default RPM-based modelling (A) and from the national survey-based statistics (B).

Step 3: Spatial modelling and attribution to ecosystem types

The spatial distribution of the overnight stays within a region (NUTS-3 region or municipality) was modelled using three raster maps representing proxies for recreation potential (RP): accessibility, landscape attractiveness, and recreation facilities. These layers serve as inputs to the INCA tool, which multiplies them to produce a final RP proxy map. This map is then used to distribute overnight stays spatially within each NUTS-3 region or municipality. The resulting high-resolution spatial distribution is overlaid with an ecosystem type (ET) map (100 or 20 m grid) to quantify the contribution of different ecosystem types to the supply of the ecosystem service.

In the default approach, spatial modelling relies on the RPM layers compiled from pan-European datasets (Vallecillo et al. 2018). Each RPM layer classifies raster cells into low, medium or high recreation potential, with corresponding default weights of 0, 0.5 and 1. In the nationally adjusted approach, we compiled the three input maps using national spatial data and adjusted feature-specific weights (Table 1). The three input factors and their methodological background are described in detail in the following sections. These

adjusted RPM layers for Finland are available in the project repository (https://doi.org/10.5281/zenodo.18336303).

Table 1.

Map features, data sources and cell weights for the nationally modified version of the Recreation Potential Map.

Recreation potential factor	Map features	Dataset	Raster cell weights
Accessibility	Hotels and free-time residences	Finnish Building and Dwelling Register (Digital and population data services agency 2023)	Equal to the number of accommodation buildings within 200-m distance/within 20-km distance
Facilities	Recreation areas, nature trails and point features	National Database of Sport Facilities LIPAS (Lamberg and Laakso 2023)	Within recreation areas: **10** Near routes: **30**, Near points: **250**
Attractiveness	Shorelines: proximity to waterbodies	Shoreline10 (Finnish Environment Institute 2021)	Near waterbodies: **2**
	Ecological and chemical condition of waterbodies	Water Framework Directive assessment (Finnish Environment Institute 2023)	Depending on condition: **0-4**
	Forest management: clear cuttings	Global Forest Watch (Hansen et al. 2013)	Forest loss within the last twenty years: **0**
	Proximity of main roads	Digiroad (Finnish Transport Infrastructure Agency 2024)	Near main roads: **0**

Accessibility

The default RPM uses distance to settlements and main roads as a proxy for accessibility, excluding smaller roads. Its weighting ignores large areas classified as poorly accessible and emphasises proximity to residential areas (Fig. 2A and C).

For the nationally adjusted approach, we used spatial data on hotels and free-time residences to create the accessibility layer. Overnight stays were distributed within buffer zones around accommodation buildings in two steps, reflecting different behavioural patterns in nature-based tourism. For example, recreation may be concentrated in the surroundings of a free-time residence or hotel, particularly if near a waterbody, whereas many nature-based tourism activities occur across a wider landscape, such as skiing routes or hiking trails within reasonable travel distance. To balance these patterns, we allocated half of the overnight stays to the surroundings of accommodations using a 200 m buffer and the other half to attractive areas within a 20 km buffer. The 20 km distance is consistent with the approach used in the nature attractiveness index developed by Parks and Wildlife Finland (2024). In the resulting accessibility map, only a few areas are marked as inaccessible, while hotspots emerge in regions with a high density of holiday accommodations, together with smaller-scale hotspots surrounding each individual accommodation location (Fig. 2B and D).

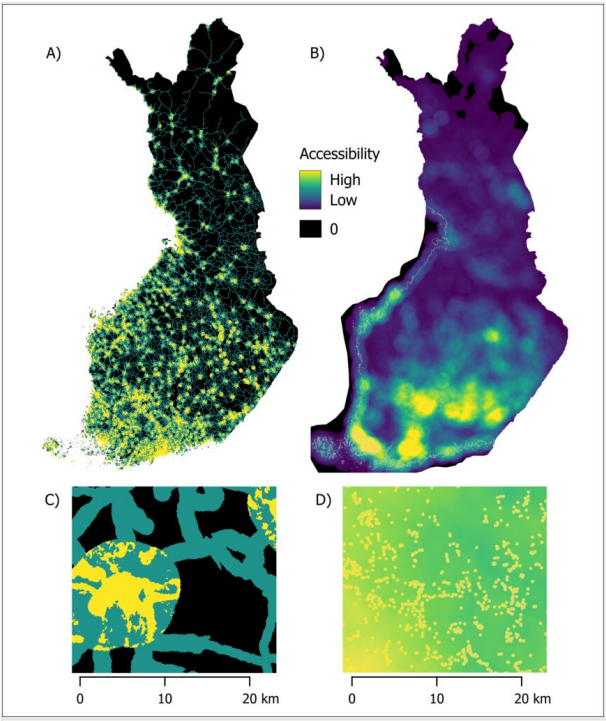

Figure 2.

The default accessibility map of the RPM, based on proximity to roads and settlements (A, C) and the nationally adjusted version based on proximity to accommodation locations (B, D).

Facilities

Trails and areas where facilities support outdoor activities are significant attractors for nature-based recreation. However, spatial data on recreation facilities are not available at the European level and is, thus, not included in the default input datasets. Some facility types are represented in the RPM attractiveness layer, such as national parks.

For the nationally adjusted approach, we integrated an extensive map of facilities (Fig. 3B and E). Relevant spatial features were extracted from the National Database of Sport Facilities (LIPAS; Lamberg and Laakso (2023)), which contains information on sport and recreation areas and facilities, such as national parks, nature trails and lookout towers. Raster map cells within recreational areas were assigned a weight of 10, implying ten times higher attractiveness than a random landscape. For trails and facility points, 100 m buffer zones were applied to include adjacent ecosystems. The cells within the buffers were assigned weights of 30 and 250, respectively, reflecting their relatively higher expected intensity of recreational use compared to broader recreational areas. The weighting scheme was designed to account for the strong differences in spatial extent between recreational areas, trails and facility points, so that all infrastructure types contribute meaningfully to the final aggregated result. When extent and weights are

considered together, all three facility types have same magnitude of effect on the final aggregated ecosystem contribution.

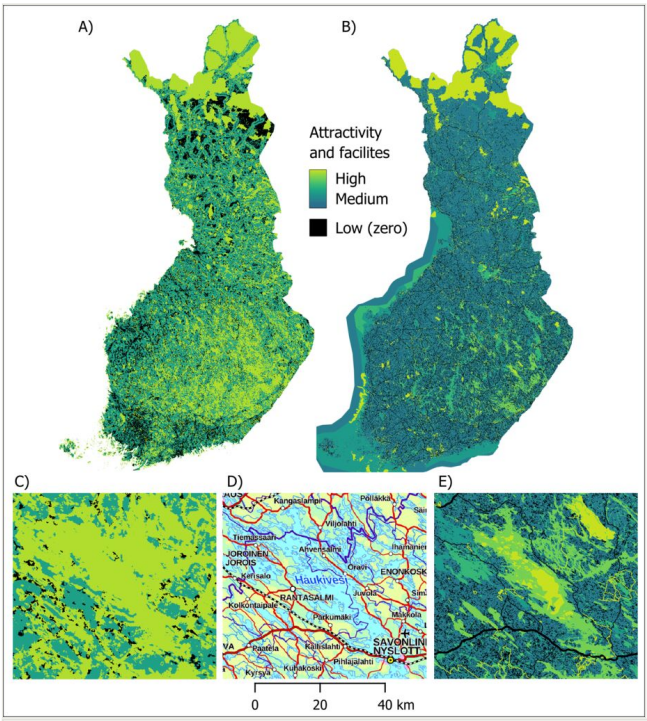

Figure 3.

The default attractiveness layer of the RPM (A, C) and the nationally adjusted attractiveness and facilities layers combined into a map for visualisation (B, E), where roadsides and clear-cuts have low attracti (black), waterbody attractiveness depends on environmental quality and facilities such as trails and national parks have the highest values. Topographic map by National Land Survey of Finland (D).

Attractiveness

The attractiveness layer of the default RPM (Fig. 3A and C) consists of various European datasets. Cells are assigned low, medium or high attractiveness values. For the nationally adjusted layer (Fig. 3B and E), we included similar attractive elements, such as waterbodies and shorelines, but used national data sources (Table 1) and assigned condition-based weights for all main waterbodies, not only swimming sites. We also adjusted the coastline buffers so that more emphasis was given to water ecosystems themselves and less for the terrestrial ecosystems of a coastline. This adjustment was made because recreational access and use of shorelines are already represented through the facilities layer, whereas the attractiveness layer aims to reflect the contribution of the waterbody itself as a landscape feature. Roadsides were more consistently designated as non-attractive for the nationally adjusted map.

As a novel element, we incorporated the effect of forest management, particularly clear-cuttings, which may locally have impacts on the recreation experience and potential in a country with freedom to roam in all forests. Forests of perceived natural appearance, without visible traces of forestry operations, are generally considered more pleasant and large-scale clear-cutting, in particular, is perceived as having a negative impact on the landscape and recreational experience (Tyrväinen et al. 2003, Gundersen and Frivold 2008, Silvennoinen et al. 2010, Tyrväinen et al. 2016, Silvennoinen 2017). Forest management influences ecosystem service potential, for example, in the surroundings of free-time residences. In our map, forests that lost tree-cover between 2003 and 2023 were set as non-attractive (see the fragmented black areas in Fig. 3) for nature-based recreation in 2023, using Global Forest Watch data on forest loss (Hansen et al. 2013). This dataset has previously been applied by PEOPLE-EA (2024) to demonstrate the use of earth observation data for improved RPMs.

Validation of the RPMs

To evaluate how well the default and nationally adjusted RPMs reflect the spatial potential for nature-based tourism, we compared them with the most spatially accurate reference data available: municipality-level estimates of nature-based overnight stays derived in Step 2. We assume that municipalities with higher actual recreation potential should attract larger volumes of nature-based tourism. Accordingly, better alignment between the RPM and observed overnight stays indicates stronger performance of the spatial proxy. For each municipality, we calculated the mean RPM score (separately for the default and national RPMs) and the intensity of nature-based overnight stays relative to municipality area. Spearman's rank correlation was then used to assess the strength of the spatial relationship between the RPM values and nature-based tourism intensity.

Attribution to ecosystem types

The INCA tool automatically models spatial distribution of overnight stays, based on input data and overlays the output with an ET map to calculate contributions by ET. By default, INCA uses the pan-European CORINE Land Cover (CLC)-based accounting layer from the European Environment Agency (EEA) (2019).

For the nationally adjusted approach, we used the Finnish ET map (Vihervaara 2024), which has a higher 20-m resolution compared to the 100 m default map. It is based on the harmonised national High-Resolution CLC time series (HR-CLC; Syke (2023)), previously identified as the most suitable source for producing standardised and consistent ecosystem extent accounts in Finland (Costadone et al. 2024).

In the default accounting, artificial areas (1), croplands (2) and marine ecosystems (10, 12) are excluded with a weight of zero. In the nationally adjusted approach, cropland and marine ecosystems were considered to contribute to nature-based tourism and, therefore, only artificial areas were excluded.

Implementing nationally adjusted accounting in INCA

All national datasets were successfully integrated into the INCA tool, enabling a harmonised and partly automated accounting process. Consequently, most of the implementation work consisted of preprocessing the spatial data layers and adapting the national statistical tables into formats suitable for INCA. Spatial data were gathered from multiple national sources (Table 1), rasterised and cell values were reclassified according to the weighting schemes. Finally, the feature layers were merged into a single map for each of the three recreation potential factors. The preprocessing steps were semi-automated using QGIS Model Designer to enable easy experimentation and fine-tuning of weights and processing parameters.

To retrieve the accounting result for one year, multiple INCA runs were conducted and summarised in post-processing to apply separate accessibility layers for hotels and free-time residences and to apply the two different accessibility buffer distances.

Accounting tables and results

The resulting ecosystem service supply estimates for the two approaches are presented and compared at the national level and at the regional level, together with the spatial modelling results and the distribution across ecosystem types.

Total volume of nature-based tourism

Table 2 compares ecosystem service supply estimates derived using the INCA default and nationally adjusted datasets and accounting approaches. Ecosystem service use was attributed entirely to domestic tourism, because the national tourism statistics used here include only overnight stays by Finnish citizens. The comparison shows that the choice of input data and assumptions has a substantial influence on the estimated total volume of domestic nature-based tourism. The default approach with transnational datasets and assumptions attributes 8.1 million domestic overnight stays to nature-based tourism, whereas the nationally adjusted approach attributes nearly three times as many – 21.5 million overnight stays.

The volume difference stems from both the total volume of domestic tourism in the statistics and the proportion of stays attributed to nature (Steps 1 and 2). In the default European statistics, 17.1 million domestic overnight stays are reported, of which 47.4% are attributed to nature-based tourism in the default modelling approach. Finnish travel statistics estimate a total of 41.9 million domestic overnight stays. Of these, 51.5% are attributed to nature-based tourism, based on survey data. Although the estimated proportions of nature-based trips at the national level are relatively similar, the much higher domestic tourism volumes in national data result in a substantially larger estimate of ecosystem service flows.

Table 2.

Comparison of estimated ecosystem service supply (number of overnight stays) between the default and nationally adjusted accounting for domestic nature-based tourism in 2023.

	INCA Default accounting	Nationally adjusted accounting
Total	8 099 903	21 564 133
Settlements and other artificial areas	-	-
Cropland	-	973 478
Grassland (pastures, semi-natural and natural grassland)	8 173	11 349
Forest and woodland	6 588 041	8 827 483
Heathland and shrub	1 742	154 730
Sparsely vegetated ecosystems	8 970	110 344
Inland wetlands	106 500	780 184
Rivers and canals	20 844	331 431
Lakes and reservoirs	1 346 116	8 231 795
Marine inlets and transitional waters	-	-
Coastal beaches, dunes and wetlands	19 517	210 045
Marine ecosystems (offshore coastal shelf and open ocean)	-	1 933 294

Spatial distribution of nature-based tourism

At the regional level, the two approaches differ substantially in their estimates of nature-based overnight stays (Table 3), reflecting differences in both tourism statistics and regional nature-attribution percentages (Fig. 1). For some regions, the differences are particularly large: in Etelä-Savo, the nationally adjusted accounting estimates over nine times more overnight stays than the default approach and, in Lapland, nearly twenty times more. Conversely, in Uusimaa, the default accounting estimates about five times more overnight stays than the nationally adjusted approach. European statistics over-emphasise regions with high commercial tourism infrastructure, such as the capital region of Uusimaa and underestimates important free-time residence regions, such as Etelä-Savo, where nature-based tourism is largely associated with non-commercial accommodation.

Beyond the regional-level difference, there are also notable differences in the spatial distribution of overnight stays within regions, particularly in the location of supply hotspots (Fig. 4).

Table 3.

Comparison of estimated numbers of domestic nature-based overnight stays by region (NUTS 3), using the INCA default and nationally adjusted accounting approaches.

NUTS_ID	NUTS_NAME	Overnight stays (Default)	Overnight stays (Nationally adjusted accounting)
FI193	Keski-Suomi	407 659	1 069 292
FI194	Etelä-Pohjanmaa	328 209	278 611
FI195	Pohjanmaa	199 492	170 888
FI196	Satakunta	199 806	426 532
FI197	Pirkanmaa	908 304	1 521 763
FI1B1	Helsinki-Uusimaa	2 699 616	1 026 774
FI1C1	Varsinais-Suomi	681 214	2 311 470
FI1C2	Kanta-Häme	212 731	683 906
FI1C3	Päijät-Häme	303 460	708 791
FI1C4	Kymenlaakso	135 728	555 297
FI1C5	Etelä-Karjala	278 235	772 855
FI1D1	Etelä-Savo	220 731	2 100 407
FI1D2	Pohjois-Savo	329 869	1 175 354
FI1D3	Pohjois-Karjala	153 393	1 073 408
FI1D5	Keski-Pohjanmaa	51 707	148 840
FI1D7	Lappi	192 028	3 833 008
FI1D8	Kainuu	171 377	1 534 087
FI1D9	Pohjois-Pohjanmaa	460 806	1 904 273
FI200	Åland	165 533	268 577
	all regions	8 099 898	21 564 133

Supply contributions by ecosystem type

Both the default and nationally adjusted approaches identify forests and lakes as the main suppliers of nature-based tourism in Finland (Table 2, Fig. 5). However, the estimated relative contributions differ substantially. In the default account, 82% of supply is allocated to forests, with most of the remainder attributed to lakes. Other ETs contribute 1% or less and marine ecosystems are excluded entirely.

In the nationally adjusted approach, the forest share decreases to 41%, while lakes account for 38% and marine ecosystems for 9%. Other ETs, such as croplands, inland

wetlands,and rivers, are also represented, with larger contributions than in the default account. Overall, ecosystem service supply is distributed more evenly across a wider range of ETs

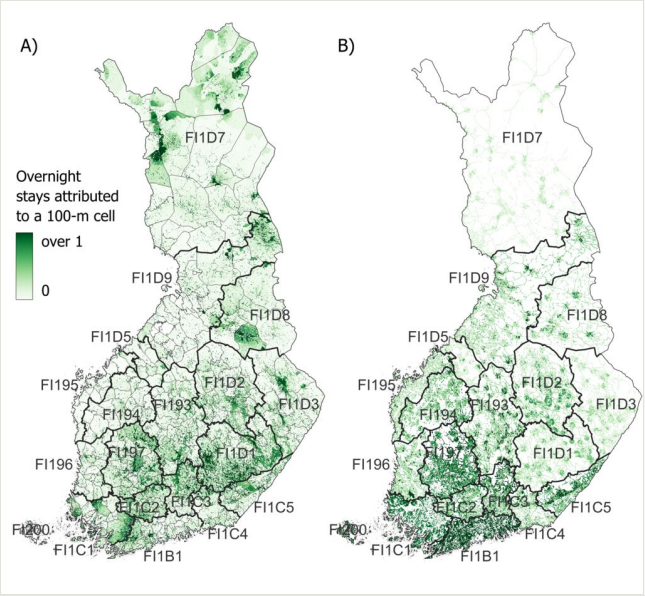

Figure 4.

Modelled spatial distribution of nature-based domestic overnight stays, calculated with the nationally adjusted accounting (A) and INCA default accounting (B), showing region/NUTS-3 borders with NUTS-IDs. Municipality borders (A) by National Land Survey of Finland.

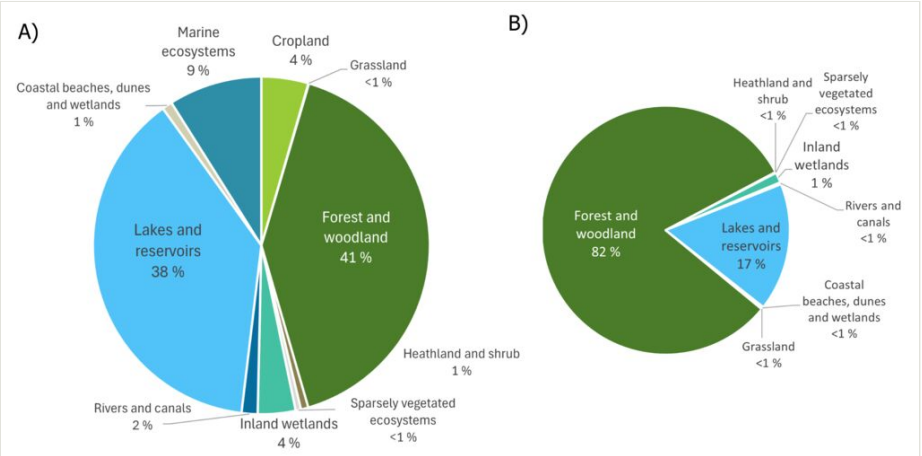

Figure 5.

Estimated supply distribution of domestic overnight stays using the nationally adjusted approach and data (A) and INCA default approach and data (B).

Discussion

Comparison of the default and nationally adjusted accounting results

Total and regional supply

The discrepancy between estimates of the national total supply of the ecosystem service is mainly explained by the differing coverage of the tourism statistics and the prominence of non-commercial accommodation in Finnish travel culture. Finnish statistics on domestic travel are based on population-level sample surveys, which allow all types of travel and accommodation to be captured, including non-commercial accommodation such as stays at free-time residences (46% of domestic holiday travel in 2023). In contrast, Eurostat statistics rely on commercial accommodation data, which leads to a significant under-representation of domestic tourism in Finland. Finnish travel statistics also show that the proportion of nature-motivated trips is particularly high for stays at own free-time residences. The results highlight the importance of including non-commercial accommodation types in nature-based tourism accounting in countries where use of free-time residences is common, such as Norway and Sweden (Aubrunner et al. 2025, Svae et al. 2025).

Although the estimated national-level nature-attribution percentages are similar in both approaches (around 50%), they show considerable disagreement at the regional level, as noted in the Methods section (Fig. 1). The Recreation Potential Map (RPM) used in the default approach appears to underestimate contribution of remote regions to nature-based tourism and over-emphasise more densely populated areas, likely due to strong reliance on accessibility. For example, large areas of estimated low accessibility in Lapland substantially reduce its RPM-based nature-attribution percentage, despite the presence of several major nature-based tourism hotspots. In the Finnish case, the use of national survey data instead of the default RPM had a significant impact on the results. Similar findings have been reported in Norway, where dedicated surveys were used to compile nature-based tourism accounts, leading to improved accuracy (Svae et al. 2025). This is consistent with earlier recommendations that nature-based tourism accounting should be supported by detailed national datasets and tourism surveys to improve the representation of local conditions and visitor behaviour (Zulian and La Notte 2022).

Assessing the RPMs and modelled spatial patterns

As expected, the ecosystem service map resulting from the nationally adjusted approach (Fig. 4) appears more plausible, based on expert judgement, reflecting a more detailed understanding of the characteristics of nature-based tourism and its institutional context (Barton 2022). In the default output map, accessibility is strongly emphasised, with hotspots clustered around towns and cities. Large zero-contribution areas appear where accessibility is assumed to be low, although the national data show that many of these areas include dense clusters of free-time residences that are accessible via smaller roads.

In contrast, the nationally adjusted results show tourism more evenly distributed across the landscape, with concentrations of overnight stays in areas of good environmental condition, recreational facility areas and local hotspots around free-time residences and hotels. Unlike in the default approach, accessibility is not limited to proximity to main roads. Key nature tourism regions – particularly free-time residence areas – as well as known attraction hotspots are well represented in the adjusted map, whereas the default map is not able to capture most of these features. National data inputs in this case seem to provide crucial additional information.

Additional confirmation of default vs. adjusted RPM reliability was gained by using Finnish Travel Statistics as a reference. Municipalities with high numbers of nature-based overnight stays in the statistics are likely to have high nature-based recreation potential in reality. A comparison between the reference statistics and mean RPM values calculated as municipality-level averages (Fig. 6) shows a stronger Spearman correlation for the nationally adjusted RPM (0.54) than for the default RPM (0.27), indicating that the adjusted RPM might better capture the spatial variation in nature-based tourism potential.

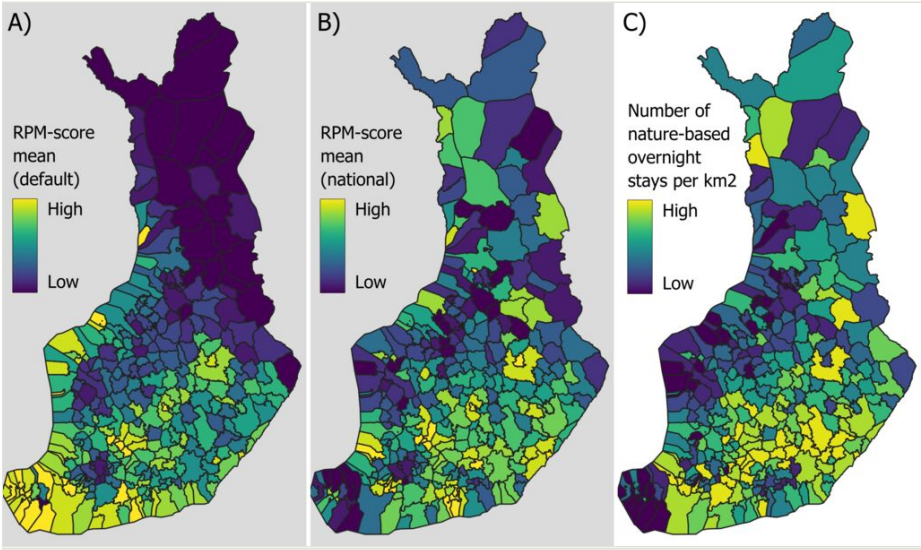

Figure 6.

Recreation Potential Map (RPM) correlation to tourism statistics at municipality-level. Mean RPM values aggregated at the municipality-level using cell values from A) the default RPM, B) the nationally adjusted RPM, and C) the actual density of nature-based overnight stays (per km²) per municipality as a reference. Nature-based tourism intensity shows a stronger Spearman correlation with the nationally adjusted RPM. All maps are visualised using a quantile classification to enable comparison of relative rankings.

The results and their evaluation support the idea that nationally adjusted data inputs can bring additional value to modelling of nature-based recreation in national contexts. Recreation facilities information seems to be an integral national input for modelling and also using contextually relevant data for the accessibility component appears essential

for nationally adjusted accounting. While the RPM may be suitable for estimating accessibility for daily recreation (occurring in proximity of residential areas), accessibility for nature-based tourism is better represented using spatial information on recreation accommodation locations. In addition, municipality-level statistics, with higher spatial accuracy than NUTS-3 level data, better identify the municipalities with genuinely high volumes of domestic tourism, whereas the default approach relies on RPM-modelling for within-region distributions. Our results indicate that replacing and complementing generic default maps with nationally relevant data – covering key aspects such as accessibility from accommodation, recreation facilities and nationally relevant attractiveness proxies – produces spatial distribution estimates that better reflect existing knowledge, statistics and national travel characteristics. These findings are consistent with Zulian et al. (2024), who conclude that European-scale biophysical maps cannot fully capture national-scale characteristics and that national implementations should incorporate locally relevant data and knowledge. They further identify traveller behaviour and the representation of ecosystem types, such as lakes, wetlands, coastal areas and marine ecosystems, as important areas for future development.

Assessing the ecosystem type contributions

Accurate spatial estimation is critical for ecosystem accounting, as INCA attributes overnight stays to ecosystem types (ETs), based on the modelled spatial distribution. Given that the spatial estimates appeared more accurate under the nationally adjusted approach, we assume that the resulting ET distribution (Fig. 5) also better reflects reality.

The choice of ecosystem extent data (national HR-CLC, 20 m, vs. pan-European CLC, 100 m) had only a minor effect on relative ET contributions at the national scale (differences of 1–2 percentage points), which is expected given that the CLC is an aggregated version of the HR-CLC. At finer spatial scales, however, the higher resolution and smaller minimum mapping unit of the HR-CLC allow a more realistic and detailed representation of ET distribution, particularly in heterogeneous landscapes, where spatial resolution can strongly influence ecosystem mapping and accounting outputs (Kokkoris et al. 2024).

The default accounting approach excludes marine ecosystems from the modelling process entirely. Although ecosystem service reporting is not mandatory for marine ecosystems, we argue that they should, nevertheless, be included in the modelling phase and excluded later if required, consistent with recent recommendations to improve the representation of marine and coastal ecosystems in nature-based tourism accounting (Zulian et al. 2024). Otherwise, municipalities with substantial marine areas risk severely skewed representations of nature-based tourism and ET contributions.

Detecting change in ecosystem service flows over time

Policy-relevant ecosystem service accounting should capture temporal change, yet the default approach is partly limited in this respect. Although our analysis covered only a

single year, some conclusions can be drawn from the characteristics of input data. Both default and Finnish overnight stay statistics are annual, but in the default approach, the share attributed to nature-based tourism depends solely on changes in recreation potential (RPM). As a result, changes and trends in the volume of nature-based tourism may remain undetected, especially if they are not linked to land-use change. Finnish survey data show that the proportion of nature-based domestic travel increased notably during the COVID-19 pandemic (from 53% before the pandemic in 2019 to a peak of 71% in 2020), a trend that the default approach would likely miss.

For both approaches, changes in landscape attractiveness are likely reflected in the modelled distribution of supply between ETs. The national proxy datasets used here can be updated annually, except for surface water condition, which follows the six-year update cycle of the Water Framework Directive. The ET map will be updated every three years for extent accounting. While the INCA tool enables semi-automated annual accounting and integration of national spatial data, national implementation still requires substantial effort in preprocessing input data. Sufficient resources should, therefore, be allocated to data preparation and, where possible, to the automation of these workflows. More broadly, the quality and comparability of ecosystem accounts depend on the availability of datasets with appropriate spatial and temporal resolution and update frequency (Kokkoris et al. 2024).

Remaining limitations and development needs

While the national adjustments improve the realism of the accounts, they do not eliminate all sources of uncertainty that should, therefore, be considered when interpreting the results. These uncertainties arise from both data limitations and incomplete knowledge needed for the robust spatial modelling and estimation of ecosystem contributions. The main sources of uncertainty identified in this study include:

- **Data reliability**: Some input datasets may be partly outdated or incomplete. For instance, the building register used to identify accommodation locations may contain outdated or incomplete records and the LIPAS dataset might not capture all recreational infrastructure;
- **Limited scope of spatial proxies**: The modelling relied on a selected set of spatial proxies to represent recreation potential. Many other landscape characteristics may also influence nature-based tourism, including topography, forest structure, hunting and fishing opportunities, ecosystem rarity and habitat diversity;
- **Buffer distances and weighting of spatial layers**: Assigning appropriate weights to different layers – accessibility, attractiveness, recreational facilities and the individual components within them – remains a challenge. The same applies to the choice of buffer distances around accommodation or facilities, the relative significance between facility points, trails and areas and relative importance of accommodation surroundings versus attractions of the area. Ideally, the parameterisation would be grounded on scientific literature, behavioural survey

data or other reliable sources, but often these are lacking. Additionally, converting existing knowledge, such as preference for waterbodies, to parameter values for spatial modelling is not straightforward;

- **Contributions by ecosystem type (ET)**: Uncertainties in allocating ecosystem service contributions amongst ETs in the case our study remain, due to lack of suitable quantitative reference information for validation. Additionally, possible uncertainties in the results arise from the complexity of spatially-based modelling, as the resulting contributions depend not only on the spatial distribution of tourism flows, but also on assumptions and parameterisation regarding ET weighting, ecosystem extent and visitor preferences.

The last issue warrants further discussion, as contributions by ecosystem type (ET) are a central reporting output of ecosystem service accounts. Although the INCA tool allows the use of ET-specific weights, the principles for selecting such weights are not discussed in detail in the guidance notes. In the default approach, ET weighting is used primarily to exclude certain ETs from accounting and we largely followed this approach. Without additional weighting, ET contributions depend mainly on RPM-based recreation potential and the spatial allocation of overnight stays. This approach captures well the relative proportions of different ETs that visitors are likely to encounter. At the same time, however, the resulting contributions are strongly influenced by ET extent, favouring common and spatially dominant ecosystems, while potentially under-representing smaller, but recreationally important ETs. Cultural ecosystem services are influenced by human preferences and perceived importance of landscape features and visitors may be attracted primarily by lakes, beaches or fells even when these occupy only a small share of the landscape. For water ecosystems, representation may be further biased by the fact that most recreation-related infrastructure is located on land, even when waterbodies are the primary attraction, such as along coastal nature trails. These points arise a question, whether ET-specific weighting should be applied to compensate for the contributions for highly attractive, but relatively small-scale ETs, to guarantee fair representation of different types of eosystems.

In this study, we partly addressed this issue by applying ET-specific weighting to water ecosystems, reflecting their well-established importance for recreation and free-time residences (e.g. Myllymäki et al. 2025). This resulted in more realistic ET contribution patterns, particularly in coastal and lake-rich municipalities. Fells and coastal ecosystems were identified as ETs that might similarly benefit from additional weighting, but comparable information on visitor preferences was not available from existing literature or datasets for these types. Recent work in Norway has explored the use of survey-based information to link nature-based tourism activities directly to Level 1 ecosystem types (Svae et al. 2025). Further research, including surveys and emerging data sources such as mobility or social media data, could help refine the modelling assumptions. Moreover, it would be important to validate the modelled supply and its ET distribution with suitable reference information, as recommended by Zulian and La Notte (2022).

Conclusions

The nationally adjusted accounting approach provides a more accurate and policy-relevant representation of nature-based tourism than the default transnational methodology. Integrating national datasets, spatial information and survey-based data on travel motivations enhances both the reliability and contextual relevance of the accounts. In Finland, comprehensive travel statistics allow direct attribution of overnight stays to nature-based tourism, reducing reliance on purely modelled estimates of the proportion. Similar integration of survey data on travel motivations/activities is recommended for other countries seeking to improve the accuracy of national tourism accounts.

Using national data is crucial to capturing country-specific institutional contexts, such as freedom to roam, extensive public recreational infrastructure and the role of free-time residences. Excluding these elements – as well as marine ecosystems – leads to systematic underestimation and spatial misallocation of tourism activity, thereby biasing the perceived contributions of ecosystem types.

Further methodological development is needed to refine spatial weighting and buffer parameters and to validate the distribution of supply across ecosystem types. Stronger integration of ecosystem condition indicators, such as water quality or forest management practices, should also be prioritised. In Finland, assessments could be broadened to include foreign visitors and same-day trips and to explore the sensitivity of results to temporal changes. Many national datasets are not updated annually, which may affect account quality.

Despite these remaining limitations, the nationally adjusted approach demonstrates that incorporating national data substantially improves the interpretive and policy value of ecosystem service accounts. The resulting accounts should be viewed as indicative representations of tourism flows and ecosystem service supply, suitable for providing information for policy and planning rather than providing precise measurements. While Finland represents a distinctive case due to its travel culture, institutional setting and data availability, the methodological insights and results presented here are transferable to other countries where national conditions diverge from pan-European assumptions. The results also illustrate the value of the flexible accounting framework provided by the INCA tool, which allows the integration of national datasets and contextual information to improve the relevance of accounts for national applications.

Grant title

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Ethics and security

The study did not involve human participants or personal data. Data from the national Building Register were accessed in an official capacity and used only in non-sensitive, aggregated and visualised form. All data were used in aggregated form and obtained from official statistical sources or publicly available datasets.

Author contributions

Tytti Jussila: Conceptualisation, data, methods and analysis, writing, reviewing and editing the manuscript; Pekka Hurskainen: Ecosystem extent data, reviewing and editing the manuscript; Marjo Neuvonen: Conceptualisation, writing, reviewing and editing the manuscript; Janne Artell: Conceptualisation, reviewing and editing the manuscript; Marianne Laalo: Statistics Finland data, reviewing and editing the manuscript; Liisa Saikkonen: Funding Acquisition, supervision, conceptualisation, writing, reviewing and editing the manuscript.

Conflicts of interest

The authors have declared that no competing interests exist.

References

- Ahtiainen H, Lankia T, Lehtonen J, Lehtonen O, Bertram C, Meyerhoff J, Pakalniete K, Rehdanz K, Pouta E (2022) Welfare effect of substitute sites for coastal recreation – evidence from the Baltic Sea. Journal of Environmental Economics and Policy 11 (4): 375-395. https://doi.org/10.1080/21606544.2022.2043188
- Artell J, Ahtiainen H, Pouta E (2019) Distance decay and regional statistics in international benefit transfer. Ecological Economics 164 https://doi.org/10.1016/j.ecolecon.2019.106383
- Aubrunner A, Back A, Marjavaara R (2025) From cabins to caravans: expanding the horizons of second-home tourism in Sweden. Journal of Policy Research in Tourism, Leisure and Events 17 (4): 1017-1034. https://doi.org/10.1080/19407963.2025.2476696
- Barton D (2022) Recognising institutional context in simulating and generalising exchange values for monetary ecosystem accounts. One Ecosystem 7 https://doi.org/10.3897/oneeco.7.e85283
- Buchhorn M, Smets B, Danckaert T, van Loo M, Broekx S, Peelaerts W (2022) Establishing a reference tool for ecosystem accounting in Europe, based on the INCA methodology. One Ecosystem 7 https://doi.org/10.3897/oneeco.7.e85389
- Costadone L, Lai T, Hurskainen P, Kopperoinen L (2024) Co-creating urban ecosystem accounting: Physical and monetary accounts of runoff retention service provided by urban green spaces. Ecosystem Services 65 https://doi.org/10.1016/j.ecoser.2023.101576

- Digital and population data services agency (2023) Building and Dwelling Register. Downloaded from Syke open data on 29/10/2024. URL: https://ckan.ymparisto.fi/dataset/vaestotietojarjestelman-rakennus-ja-huoneistotiedot-rhr
- Ervola A, Mäntymaa E, Uusivuori J (2024) Public right of access to private land: examples and considerations. Scandinavian Journal of Forest Research 39 (6): 287-297. https://doi.org/10.1080/02827581.2024.2410348
- European Environment Agency (EEA) (2019) Corine Land Cover accounting layer. accessed 25/03/2025. URL: https://www.eea.europa.eu/en/datahub/datahubitem-view/a55d9224-a326-4cb1-9b9c-3a324520341a
- European Union (2023) GIS plugin tool for ecosystem services accounts to support the reporting under Regulation (EU) 691/2011 (“INCA TOOL”). Version 2.2.1. URL: https://ecosystem-accounts.jrc.ec.europa.eu/inca-tool
- Eurostat (2024) Guidance notes on ecoystem services accounts. Technical note, version December 2024. URL: https://ec.europa.eu/eurostat/documents/1798247/12357920/Guidance+note+on+ecosystem+services+accounts.pdf/3bc39658-8de5-79e1-e9b6-afe81141446d?t=1743161354131
- Eurostat (2025) Nights spent at tourist accommodation establishments by NUTS 3 region (from 2020 onwards). (downloaded 10/02/2025). URL: https://doi.org/10.2908/TOUR_OCC_NIN3
- Finland’s tourism strategy for 2022-2028 (2022) Yhdessä enemmän – kestävää kasvua ja uudistumista Suomen matkailuun: Suomen matkailustrategia 2022–2028 ja toimenpiteet 2022–2023. (Achieving more together – sustainable growth and renewal in Finnish tourism. Finland’s tourism strategy for 2022–2028 and action plan for 2022–2023). Työ- ja elinkeinoministeriön julkaisuja. Yritykset 2022: 51.. URL: https://urn.fi/URN:ISBN:978-952-327-772-4
- Finnish Environment Institute (2021) Shoreline10 (Ranta10). (accessed 20/01/2025). URL: https://ckan.ymparisto.fi/dataset/%7BC40D8B4A-DC66-4822-AF27-7B382D89C8ED%7D
- Finnish Environment Institute (2023) WFD water bodies (VHS vesimuodostumat). (accessed 20/01/2025). URL: https://ckan.ymparisto.fi/dataset/%7BAD287567-30F9-4529-9B47-2D6573FCAA9E%7D
- Finnish Transport Infrastructure Agency (2024) Digiroad. Downloaded from Finnish Transport Infrastructure Agency’s map service on 08/10/2024..
- Gundersen VS, Frivold LH (2008) Public preferences for forest structures: A review of quantitative surveys from Finland, Norway and Sweden. Urban Forestry & Urban Greening 7 (4): 241-258. https://doi.org/10.1016/j.ufug.2008.05.001
- Hansen MC, Potapov PV, Moore R, Hancher M, Turubanova SA, Tyukavina A, Thau D, Stehman SV, Goetz SJ, Loveland TR, Kommareddy A, Egorov A, Chini L, Justice CO, Townshend JRG (2013) High-resolution global maps of 21st-century forest cover change. Science (New York, N.Y.) 342 (6160): 850-3. https://doi.org/10.1126/science.1244693
- Huhtala A, Lankia T (2012) Valuation of trips to second homes: do environmental attributes matter? Journal of Environmental Planning and Management 55 (6): 733-752. https://doi.org/10.1080/09640568.2011.626523
- Immerzeel B, Korkou M (2024) Evaluation of the INCA-Tool for the purpose of ecosystem services accounting in Norway. EU Grants Project 2022-NO-EGD-Work Package 2. URL: https://brage.nina.no/nina-xmlui/handle/11250/3170351?locale-attribute=no

- Kokkoris I, Smets B, Hein L, Mallinis G, Buchhorn M, Balbi S, Černecký J, Paganini M, Dimopoulos P (2024) The role of Earth observation in ecosystem accounting: A review of advances, challenges and future directions. Ecosystem Services 70 https://doi.org/10.1016/j.ecoser.2024.101659
- Lamberg A, Laakso T (2023) Lipas data 04/2023. JYX https://doi.org/10.17011/jyx/dataset/86773
- Myllymäki T, Turja T, Mohammed N (2025) Mökkibarometri 2025. Maa- ja metsätalousministeriö. (Maa- ja metsätalousministeriön julkaisuja 2025:19). URL: https://urn.fi/URN:ISBN:978-952-366-858-4
- National nature recreation strategy 2030 for Finland (2022) Kansallinen luonnon virkistyskäytön strategia 2030. Valtioneuvoston periaatepäätös. Valtioneuvoston julkaisuja 2022:13. 113 p.. URL: http://urn.fi/URN:ISBN:978-952-383-685-3
- Neuvonen M, Lankia T, Kangas K, Koivula J, Nieminen M, Sepponen A-, Store R, Tyrväinen L (2022) Luonnon virkistyskäyttö 2020 (Nature recreation 2020). Luonnonvara- ja biotalouden tutkimus 41/2022. Natural Resources Institute Finland. Helsinki. 112 p.. URL: http://urn.fi/URN:ISBN:978-952-380-429-6
- Parks and Wildlife Finland (2024) Valtion retkeilyalueverkoston ja Metsähallituksen monikäyttömetsien virkistyskäyttökohteiden kehittäminen 2024–2030. Metsähallitus. URL: https://julkaisut.metsa.fi/en/publication/valtion-retkeilyalueverkoston-kehittaminen/
- PEOPLE-EA (2024) Product Specification and Algorithm Theoretical Base Document: Nature-based recreation service account. URL: https://esa-people-ea.org/sites/esapeopleea/files/downloads/PEOPLE-EA_D7_ATBD_EcosystemServiceNBT_v1_3.pdf
- Silvennoinen H, Pukkala T, Tahvanainen L (2010) Effect of Cuttings on the Scenic Beauty of a Tree Stand. Scandinavian Journal of Forest Research 17 (3): 263-273. https://doi.org/10.1080/028275802753742936
- Silvennoinen H (2017) Metsämaiseman kauneus ja metsänhoidon vaikutus koettuun maisemaan metsikkötasolla. Dissertationes Forestales 2017 (242). https://doi.org/10.14214/df.242
- Statistics Finland (2024) Finnish travel. Statistics on Finnish travel. URL: https://stat.fi/en/statistics/smat
- Svae LK, Dugstad A, Lindseth M, Grimsrud KM (2025) Insights into nature-based tourism and recreation in Norway. URL: https://www.ssb.no/en/natur-og-miljo/miljoregnskap/artikler/insights-into-nature-based-tourism-and-recreation-in-norway/_/attachment/inline/6cd02774-f6f4-4b25-b7e4-091495658e8e:75b8ffdf52d324ea4f0705a42b56717751668b84/NOT2025-05.pdf
- Syke (2023) Harmonisoitu Corine-maanpeiteaikasarja muutostulkintaan (20m). (accessed 28/02/2025). URL: https://ckan.ymparisto.fi/dataset/harmonisoitu-corine-maanpeiteaikasarja-muutostulkintaan-20m
- Tyrväinen L, Silvennoinen H, Kolehmainen O (2003) Ecological and aesthetic values in urban forest management. Urban Forestry & Urban Greening 1 (3): 135-149. https://doi.org/10.1078/1618-8667-00014
- Tyrväinen L, Silvennoinen H, Hallikainen V (2016) Effect of the season and forest management on the visual quality of the nature-based tourism environment: a case from Finnish Lapland. Scandinavian Journal of Forest Research 32 (4): 349-359. https://doi.org/10.1080/02827581.2016.1241892
- Vallecillo S, La Notte A, Polce C, Zulian G, Alexandris N, Ferrini S, Maes J (2018) Ecosystem services accounting: Part I - Outdoor recreation and crop pollination, EUR

29024 EN. Publications Office of the European Union, Luxembourg. https://doi.org/10.2760/619793

- Vihervaara, et al. (2024) Finnish Ecosystem Observatory – A National Model for the Production, Synthesis, and Utilization of Biodiversity Data. Final report. Suomen ympäristökeskuksen raportteja 15 (2024). URL: http://hdl.handle.net/10138/574515
- Zulian G, La Notte A (2022) How to account for nature-based tourism in Europe. An operational proposal. One Ecosystem 7 https://doi.org/10.3897/oneeco.7.e89312
- Zulian G, Lan Notte A, Grammatikopoulou I, Zurbaran Nucci M (2024) Nature-Based Tourism Accounting. Publications Office of the European Union, Luxembourg. https://doi.org/10.2760/762803