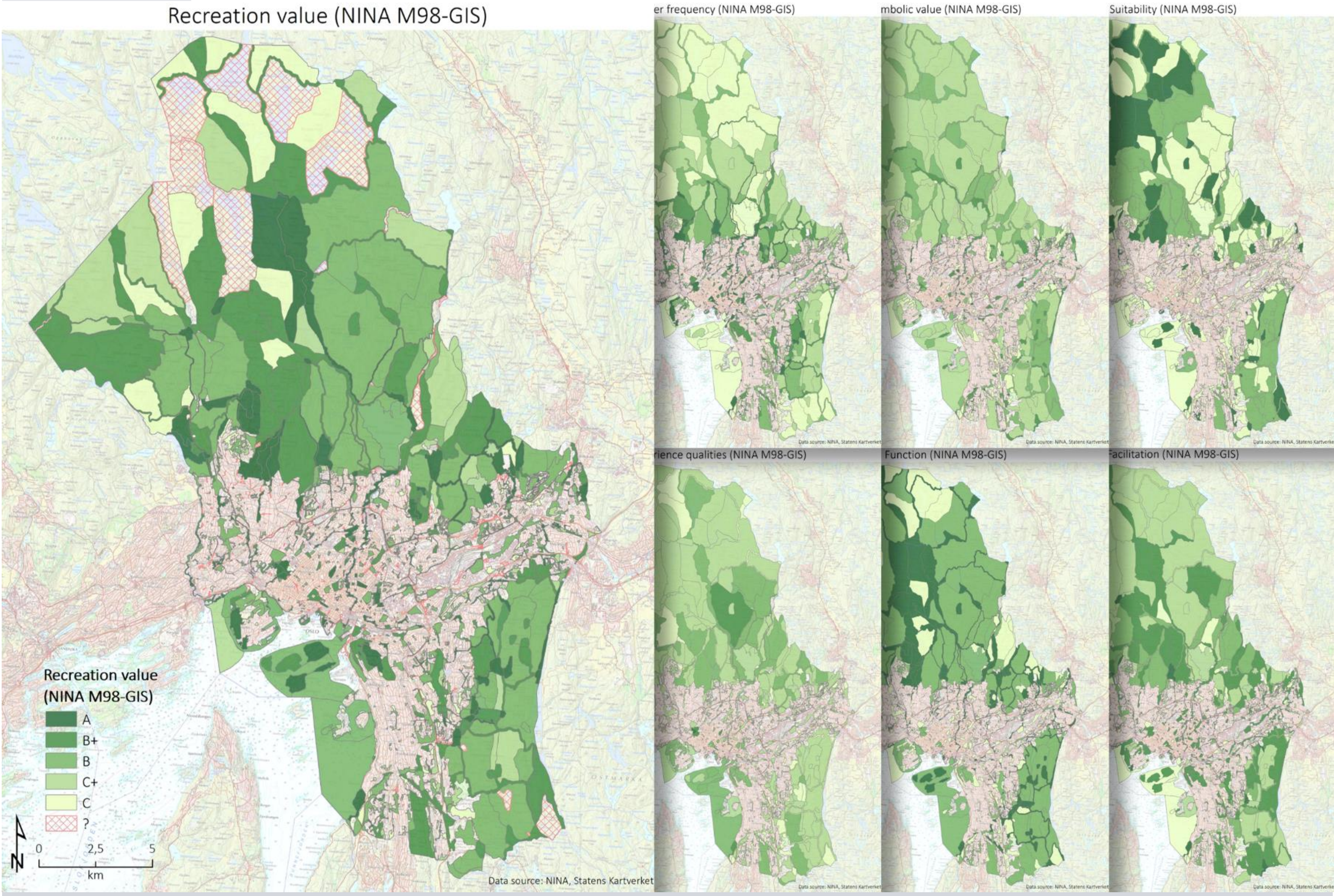
NINA Report 1931

Testing GIS data-driven mapping and valuation of recreation areas in Oslo

Spatial modelling for urban ecosystem accounting

Zofie Cimburova, David N. Barton



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Verdsettingskart basert på M98-GIS metode © NINA

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- ecosystem services

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- naturregnskap
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- naturgoder

CONTACT DETAILS

NINA head office	NINA Oslo	NINA Tromsø	NINA Lillehammer	NINA Bergen:
P.O.Box 5685 Torgarden	Sognsveien 68	P.O.Box 6606 Langnes	Vormstuguvegen 40	Thormøhlensgate 55
NO-7485 Trondheim	NO-0855 Oslo	NO-9296 Tromsø	NO-2624 Lillehammer	NO-5006 Bergen.
Norway	Norway	Norway	Norway	Norway
P: +47 73 80 14 00	P: +47 73 80 14 00	P: +47 77 75 04 00	P: +47 73 80 14 00	P: +47 73 80 14 00

www.nina.no

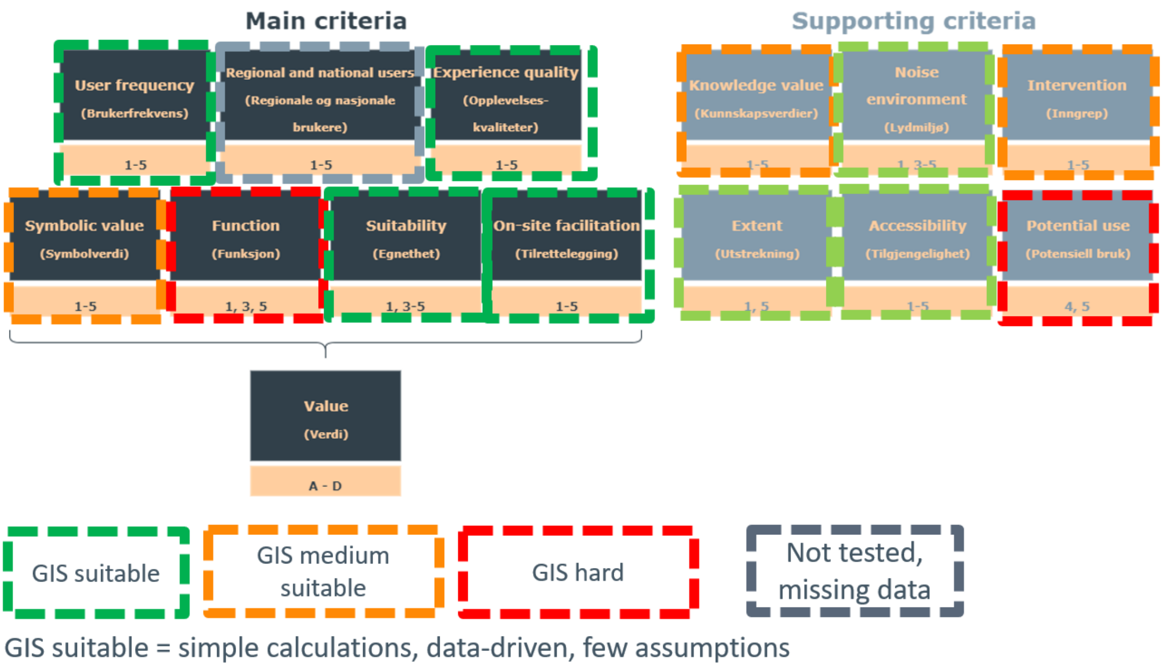
Abstract

Cimburova, Z. & Barton, D.N. 2021. Testing GIS data-driven mapping and valuation of recreation areas in Oslo. NINA Report 1931. Norwegian Institute for Nature Research.

In this report, we test the Norwegian Guidance on Mapping and Valuation of Recreation Areas – “Veileder for Kartlegging og Verdsetting av Friluftslivsområder” (Miljødirektoratet, 2013). The methodology has been developed by the Norwegian Environment Agency for implementation by all municipalities in Norway. In Oslo, the methodology was implemented under the coordination of the Urban Environment Agency (BYM) supported by the Planning and Building Agency (PBE) for GIS mapping and by recreation organizations who recruited volunteer residents into local working groups to carry out the valuation. The local groups validated the boundaries of recreation areas and valued them using 13 qualitative criteria provided by the M98 Guidance. This report is a result of NINAs URBAN SIS following the implementation of the methodology in Oslo over the three years of the project.

In Oslo, we observed that valuation groups to a limited extent made use of the available GIS data on recreation area qualities to support their valuation. In this report, we test how far the available GIS and mobility data can be used to implement the multiple criteria in the M98 Guidance. One aim is to demonstrate which criteria have a high correlation between “big data” algorithm-based scoring and local group valuation. These criteria would be candidates for algorithm-based scoring and/or more data support when recreation maps are revised in future. The results of this GIS testing by the authors are also evaluated by the recreation managers and consultants who were involved in the implementation of the method in Oslo.

In summary, our results and evaluation indicate that GIS-based methods could in many cases supplement and in some cases replace the M98 supporting criteria. For the M98 main criteria, GIS-based methods are highly suitable for modelling *user frequency* and possibly replacing subjective-based scoring.



In our opinion, GIS-based methods could also provide support to local groups in evaluating *experience qualities*, *suitability* and *on-site facilitation* criteria. GIS-based approaches are medium suitable for *symbolic value*. In the case of *symbolic value*, we lack theories about spatially defined characteristics upon which to base modelling. In the case of *function*, it was found hard to model with the current M98 definition. The present definitions are confounded with the recreation area class “green corridors”. However, there is scope for modelling the connectivity of recreation areas using spatial modelling to support the classification of corridors. For example, tree-lined and garden-fronted streets may be shown to have recreational connectivity value, although they are currently not identified as recreation areas.

The aggregation of scores into a final value in M98 Guidance based on the maximum score of any main criterion is very sensitive to computational inaccuracies in individual criteria. Moreover, a combination of high maximum score and low overall score (or the other way around) appears in 210 of the 1412 recreation areas in Oslo. The M98 Guidance does not provide a solution for this combination. We propose a combination of the maximum and overall scores to resolve this ambiguity in the M98 Guidance.

How could a GIS-based method support the next revision of the mapping and valuing of recreation areas? Overall, we think that the GIS-based criteria scoring could be used in an initial phase to pre-classify the poorest quality areas. In Oslo, a GIS-based scoring would identify all C value recreation areas with an error rate of only 11,5 %. This could be used to help local valuation groups focus on scoring/differentiating B and A value areas, thereby reducing volunteer time.

For criteria requiring knowledge of conditions outside the recreation area in question and/or spatial relationships, we think the GIS-based criteria scoring can improve the participatory method used in Oslo. We find a high statistical correlation between the M98 valuation criteria. A case can be made for simplifying the criteria system to those criteria that provide the most information about recreation value. Criteria that are correlated could be merged into a single indicator or in some cases even dropped in favor of the most clearly defined. By reducing criteria, assessment time can be saved in the participatory process, making it easier to update the maps and value categories in future.

The report also points out some general mapping challenges for GIS-based methods. They are also relevant as possible sources of bias in experience-based participatory mapping and valuation by local groups. We suggest that local groups should be made aware of these common spatial valuation biases as part of local group training in advance of participatory mapping.

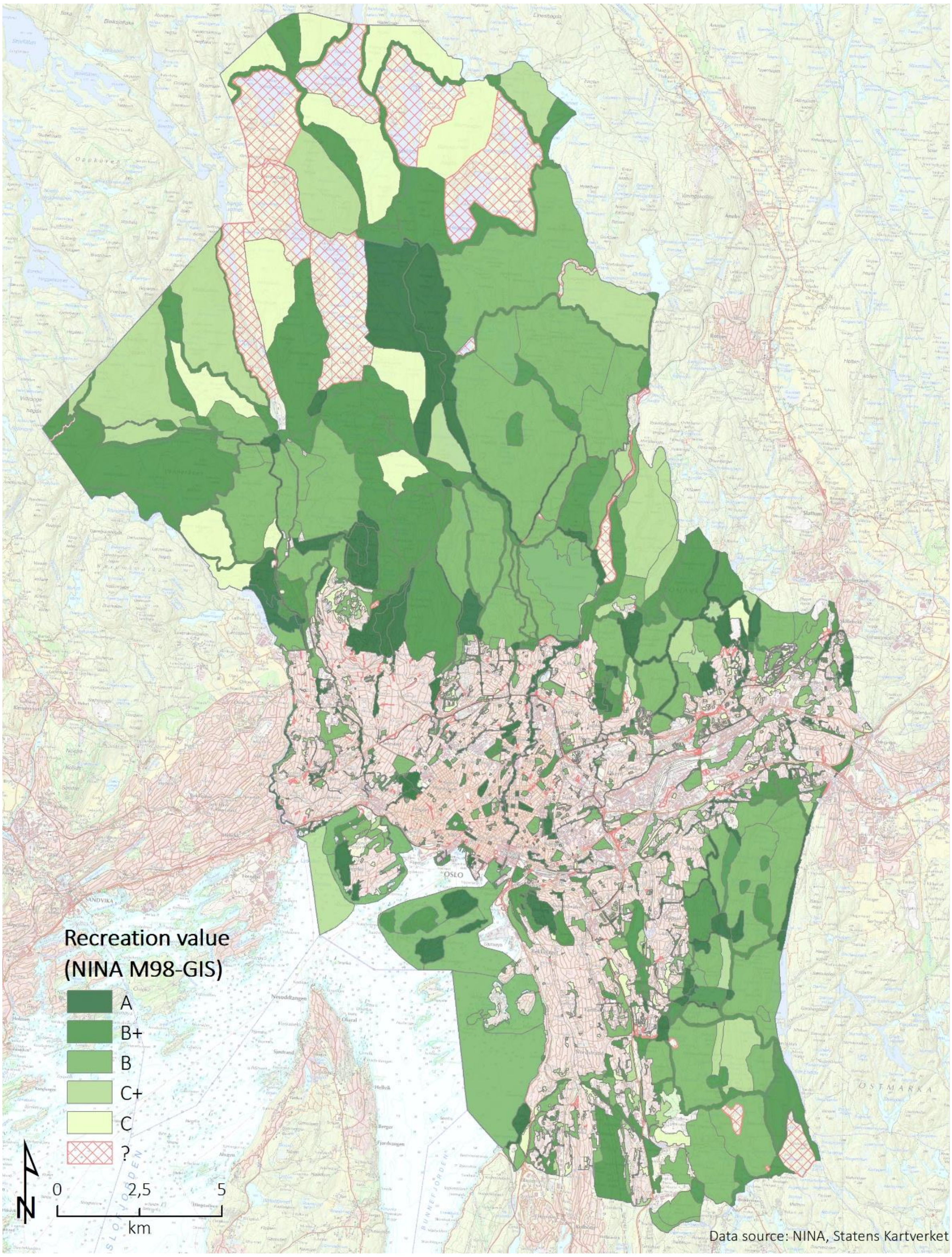
The M98 Guidance represents a practical example of recreation service mapping for municipal planning purposes. It is unique among national experiences with recreation mapping in being conducted at a municipal level, using local participatory methods and/or public consultation. It also fulfils some of the objectives of national-level ecosystem accounting currently being discussed by the UN System of Environmental and Economic Accounts (SEEA) Ecosystem Accounts (EA). M98 can be seen as a hybrid ecosystem condition and recreation service mapping approach. Norway’s M98 approach is currently “only” a recreation mapping qualitative valuation method.

If the M98 method is repeated periodically in municipalities, it has the potential to satisfy the basic requirement for national accounting of recreation ecosystem extent, condition and physical service accounting. Ecosystem condition and service accounting periodically will be facilitated by using GIS and spatial methods. Monitoring systems for actual user frequency of recreation areas – using mobile app data – will meet the requirements for physical recreation use accounting. Spatial mapping of user frequency will also go a long way to strengthening policy and planning applications of M98.

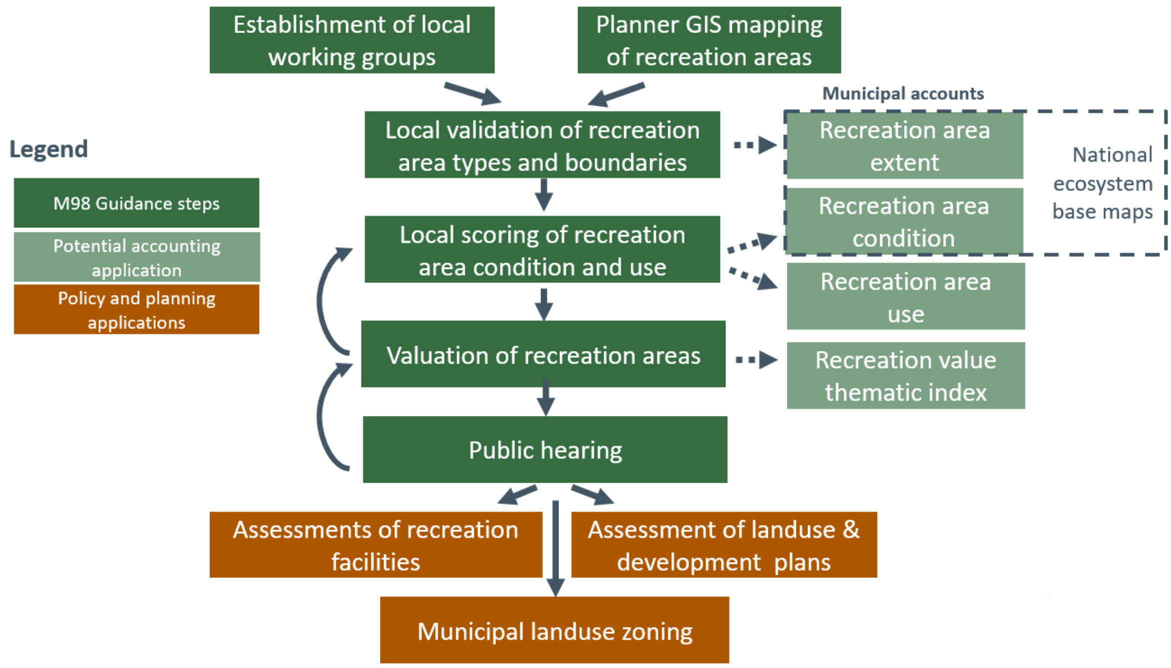
We also see M98 recreation area types and selected characteristics as contributing to fill the information gap on ecosystem condition of urban areas in the ecological base map for Norway.

Zofie Cimburova, NINA, zofie.cimburova@nina.no

David N. Barton, NINA, david.barton@nina.no



Map of recreation area values using GIS-based scoring of recreation criteria based on Norwegian M98 Guidance



Conceptual links between Norwegian M98 Guidance for Mapping and Valuation of Recreation areas, Ecosystem Accounting and Ecological Base Maps

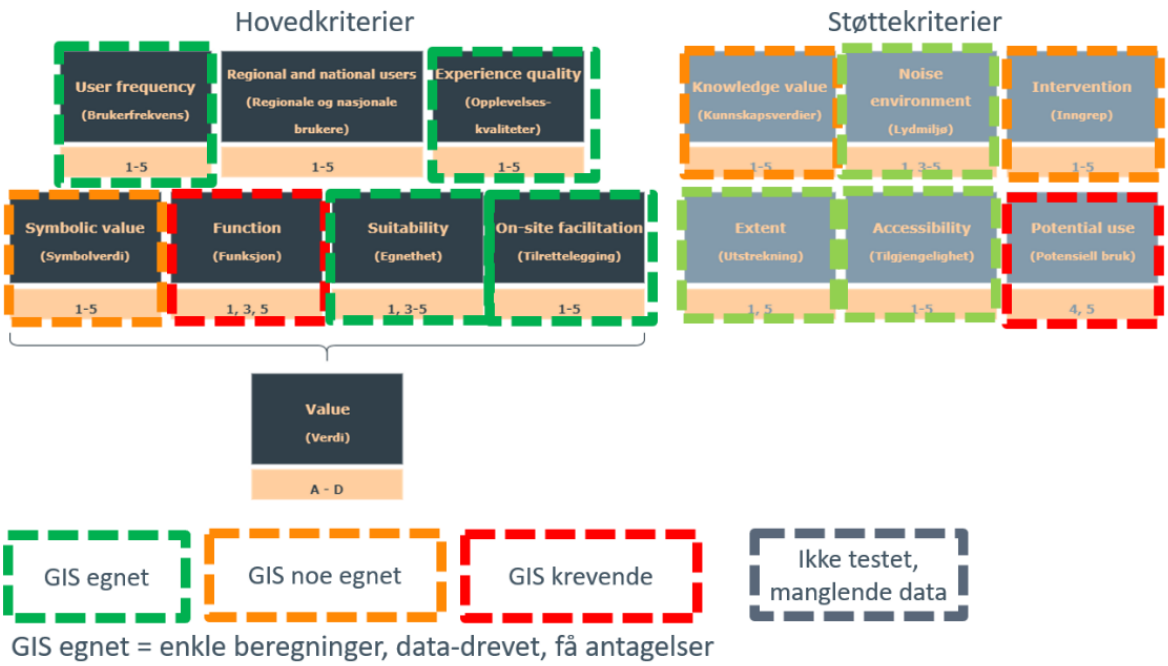
Sammendrag

Cimburova, Z. & Barton, D.N. 2021. Testing GIS data-driven mapping and valuation of recreation areas in Oslo. NINA Report 1931. Norwegian Institute for Nature Research.

I denne rapporten testet vi «Veileder for Kartlegging og Verdsetting av Friluftslivsområder» (Miljødirektoratet, 2013). Metoden er utviklet av Miljødirektoratet for implementering i alle landets kommuner. Resultatene er tilgjengelig på naturbase.no. I Oslo, ble kartleggingen gjennomført under ledelse av Bymiljøetaten, med støtte fra Plan- og Bygningsetaten. Friluftsorganisasjonene OFF, OOF, og FNF bisto med rekrutering, organisering og gjennomføring av verdsetting med lokale grupper i hver bydel bestående av frivillige friluftsinteresserte. Gruppene sjekket grenser og klassifisering av friluftslivsområder og scoret 13 kriterier i M98 veilederen for tilsammen 1412 friluftslivsområder i Oslo i alle bydelere, Marka og øyene i Oslofjorden. Prosjektet varte i tre år.

Rapporten er et resultat av en 3-årig følgestudie under URBAN SIS prosjektet finansiert av Norges Forskningsråd. I Oslo observerte vi at verdsettingsgruppene i begrenset grad brukte tilgjengelige GIS kartlag om arealkvaliteter for å støtte deres skåring av kvaliteter ved friluftslivsområdene. I denne rapporten tester vi derfor hvor langt tilgengelige GIS og digitale mobilitetsdata kan brukes i å støtte verdsetting av friluftslivsområder etter M98 Veilederen. Et mål er å vurdere hvilke kriterier har størst samvariasjon etter (i) deltagende metoder med lokale verdsettingsgrupper sammenlignet med (ii) GIS-basert scoring ved bruk av tilgjengelig “stordata” – digitale kartverk og mobilitetsdata fra applikasjoner. Kriterier med stor samvariasjon vil være kandidater for større bruk av romlige data og algoritmer for skåring i fremtidig oppdatering av kartene. Resultatene fra vår testing av GIS-basert skåring ble evaluert sammen med koordinatorene for studien i BYM, OFF, OOF, og FNF. Dette hjalp med formulering av mulige fremtidige forbedringer. Resultatene i denne rapporten står imidlertid for forskernes egen regning.

Resultatene våre viser at GIS-basert skåring kan i flere tilfelle støtte, og i noen tilfeller erstatte gruppe-basert skåring av Støttekriteriene i M98 Veilederen. For Hovedkriteriene kan GIS-basert skåring være egnet for å støtte kartlegging av *brukerfrekvens*, og muligens erstatte kvalitativ vurdering i grupper.



Vi konkluderer med at GIS-baserte metoder også kan brukes til å støtte lokale gruppers vurdering av kriteriene for *opplevelseskvaliteter*, *egnethet* og *tilrettelegging*. GIS-baserte metoder er mindre egnet for kriteriet *symbolverdi*. For *symbolverdi* som kriterium mangler definisjoner som kan kartlegges romlig. For kriteriet *funksjon* var det vanskelig å modellere med GIS. Imidlertid skyldes det delvis at kriteriet også kan forveksles med arealkategorien «grønne korridorer». Det er imidlertid muligheter for å bruke konnektivets-modellering for å identifisere grønne korridorer i fremtidige oppdateringer. For eksempel vil grønne gateløp i byer som per i dag ikke klassifiseres som friluftslivsområder kunne vise seg å ha korridorfunksjon for friluftsliv i større byer som Oslo.

I M98 kombineres scorene for hovedkriteriene til en friluftslivsverdi A-D for alle områder. Tabellen for å kombinere ulike skårer er svært følsom for beregningsfeil i individuelle kriterier fordi den avhenger i stor grad av at minst ett kriterium har maksimum skår. Videre er kombinasjonen av maksimums skår og lav skår ellers (eller motsatt) en realitet i 210 av Oslos friluftslivsområder. Etter vår erfaring håndteres ikke slike avveininger godt av verdsettingsmetoden i M98 Veilederen. I rapporten foreslår vi en revidert verdsettingstabell for å håndtere dette.

Hvordan kan GIS-baserte metoder støtte kartlegging og verdsetting av friluftslivsområder fremover? Alt i alt tenker vi at GIS-basert skåring kunne brukes innledningsvis for å pre-klassifisere friluftslivsområder med lavest kvalitet. I vår test i Oslo identifiserte den GIS-baserte metoden C-områder med en feilklassifisering på bare 11,5 %. Feilen var mye større for A og B områder og dermed ikke egnet for preklassifisering av de beste områdene. Men en slik screening av lavt verdsatte områder kunne anvendes for å få bedre disponere tiden til de frivillige i gruppene til vurdering av A- og B-områder.

For kriterier som krever kunnskap om kvaliteter i nabolaget rundt friluftslivsområdet og/eller romlige relasjoner til naboområder, tror vi at GIS-basert metode kunne bidra til å forbedre deltagende kartlegging og verdsetting i Oslo etter M98 Veilederen. Vi finner høy statistisk samvariasjon mellom ulike M98 kriterier. Vi foreslår en revidering for å se om systemet kan forenkles til de kriteriene som gir mest informasjon om verdien av friluftslivsområder. Kriterier som samvarierer mest kunne enten slås sammen til én indikator, eller i noen tilfelle droppes fra metoden om det finnes et bedre definert alternativ. Ved å redusere kriterie-antallet vil tid kunne spares i den deltagende prosessen med lokale grupper, og gjøre det lettere å rullere kartlegging og verdsetting i fremtiden.

Rapporten viser til noen utfordringer vi har hatt med romlig modellering av kriteriene. Det er noen tekniske kartleggingsfeil som også går igjen i subjektiv “manuell” kartlegging og verdsetting. Vi foreslår at noen av disse subjektive vurderingsfeilene kunne gjennomgås med deltagerne i forkant av de deltagende prosessene med de lokale brukergruppene.

M98 Veilederen er et praktisk eksempel på kartlegging av naturgoder / økosystemtjenester for kommunale formål. Det er unikt i forhold til kartleggingsprosjekter på nasjonalt nivå når vi sammenligner med andre land, først og fremst fordi verdsettingen er gjennomført lokalt av innbyggere og/eller lokale fagfolk i kommunene. Det er også gjenstand for offentlig høring. M98 oppfyller mange av målsettingene med nasjonalt naturregnskap for friluftsliv, etter mal fra FNs System of Environmental and Economic Accounts (SEEA) Ecosystem Accounts (EA). Vi tolker M98 som en hybrid mellom arealregnskap og økosystemtilstand for friluftslivsområder. Med mobilitetsdata kan dette potensielt også være grunnlag for brukerregnskap.

Per i dag er metoden “bare” éngangskartlegging og verdsetting. Ved rullering vil dette bli et friluftslivsregnskap. Periodisk naturregnskap over økosystemtilstand og -bruk for friluftslivsformål vil gjøres mye mer kostnadseffektivt med GIS-baserte metoder, supplert med deltagende validering og verdisetting slik M98 allerede legger opp til. Overvåkning av antall brukere med mobil og treningsapp-data som er kalibrerte til å representere befolkningen er under uttesting. Romlig kartlegging av brukerfrekvens vil også bidra til bedre anvendelse av M98 kartlegging og verdsetting i tiltaksanalyser og konsekvensvurdering. Vi ser også at M98 kriterier bidrar til å fylle kunnskapshullet i økologiske grunnkart, som per i dag mangler kvalitetsbeskrivelser av natur i tettsteder.

Zofie Cimburova, NINA, zofie.cimburova@nina.no

David N. Barton, NINA, david.barton@nina.no

Contents

Foreword

We wish to thank Gro Koppen (BYR, formerly BYM) for allowing NINA to follow the preparatory process for implementing M98 in the initial phase of the project. We would also like to thank Reidun Bolsø (BYM) for evaluating the results of GIS-based modelling together with consultants from recreation organizations: Gunnhild Laxaa (Oslofjorden Friluftsråd, OFF), Johan Hval (Oslo og Omegn Friluftsråd, OOF) and Adrian Mortensen (Forum for natur og friluftsliv, FNF). We thank them for comments on the methodology in this report. We thank also Nils Yngve Berg (Norwegian Environment Agency, NEA), for discussion on the purpose of the study and preliminary results. The opinions in the report to not necessarily reflect opinions of NEA, Oslo Municipality, OFF, OOF or FNF.

December 2020, David N. Barton

1 Glossary

Friluftslivsområder	Outdoor recreation areas that are subject to valuation in M98.
M98-GIS	Abbreviation of NINAs GIS-based modelling approach using M98 criteria
MAUP	Modifiable areal unit problem
Valuation	“verdisetting” in M98 refers to the algorithm by which ecosystem condition and recreation service criteria are compiled into a single recreation service score
Eventyrskog	Fairy-tale forest
Grønnkorridorer	Green corridors
Jordbrukslandskap	Agricultural landscape
Leke- og rekreasjonsområder	Playgrounds and recreation areas
Marka	Peri-urban forest
Naturterreng	Natural terrain
Store turområder med tilrettelegging	Large hiking areas with facilities
Strandsone med tilhørende vassdrag	Coastal zone and contiguous watercourses
Særlig kvalitetsområder	Exceptional quality areas
Andre Friluftslivsområder	Other recreation areas

2 Introduction to M98 mapping and valuation of recreation areas

The report tests a data-driven approach to mapping of recreation services to explore the potential for (i) supporting expert-based qualitative valuation (ii) exploring GIS-based modelling approaches that are more robust to repeated valuation for the purpose of accounting.

A schema of the implementation process is given in **Figure 1**. Implementation of the national M98 Guidance in Oslo Municipality was coordinated by the Urban Environment Agency (Bymiljøetaten, BYM) with support from the Planning and Building Agency (PBE). Three recreation organizations – Oslofjorden Friluftsråd (OFF), Oslo og Omegn Friluftsråd (OOF) and Forum for Natur og Friluftsliv (FNF) were engaged as consultants to implement the method. The consultants recruited and organized 140 residents to represent each city district and the Marka areas, also considering islands and the Oslofjord coastal areas. Recreation areas were initially mapped by PBE geospatial experts, as a basis for the local valuation groups to validate the boundaries and extent of the recreation areas and their initial classification. Local groups assessed a total of 1432 recreation areas with the mapping, valuation and validation process during 3 years (2017-2020) and an estimated 6000 hours of volunteered time (Aftenposten 13.12.20).

After validating the recreation area boundaries and types (**Figure 2**), local groups scored recreation areas condition and use along 13 different criteria (**Figure 3**). Using a predefined valuation look-up table, the criteria scores result in a valuation classification A-D of the recreation area (**Figure 4**). The resulting recreation area value maps were opened for public consultation from the 13-18 December 2020.

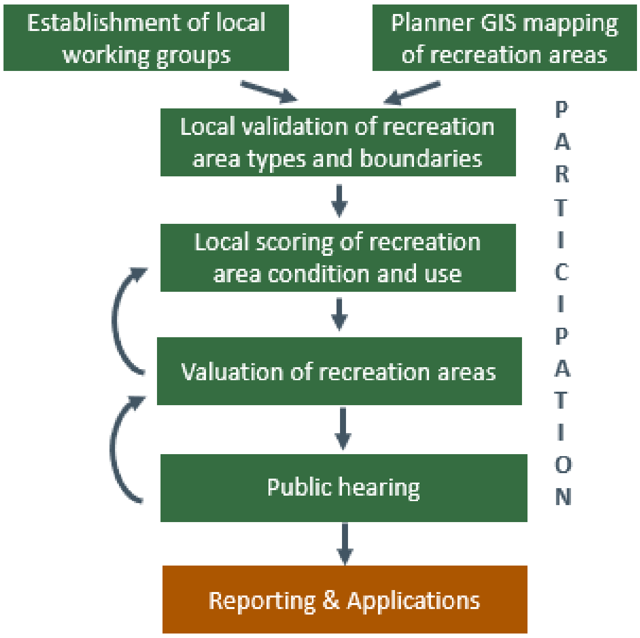


***Figure 1** M98 Guidance process of mapping and valuing outdoor recreation areas*

For purposes of the Public Hearing of the Urban Environment Agency, we made it clear that mapping and valuation were carried out independently of ownership or regulation plans. The public was informed that results of the project will be thematic maps which are not legally binding. Thematic maps can be used as a knowledge basis and tool for evaluation of recreational interests in all types of land-use planning as well as individual cases. The knowledge base is expected to be used to develop and facilitate recreation. The finished maps will also be a basis for the 4 year Municipal Plan. The validated maps are available on the Municipality's webpages and the Environmental Agency's map portal naturbase.no[1].

Recreation areas were classified as shown in **Figure 2**:

- Green corridors (Grønnkorridorer)
- Agricultural landscape (Jordbrukslandskap)
- Playgrounds and recreation areas (Leke- og rekreasjonsområder)
- Peri-urban forest (Marka)
- Natural terrain (Naturterreng)
- Large hiking areas with facilities (Store turområder med tilrettelegging)
- Coastal zone and contiguous watercourses (Strandsone med tilhørende vassdrag)
- Exceptional quality areas (Særlig kvalitetsområder)
- Other recreation areas (Andre Friluftslivsområder)

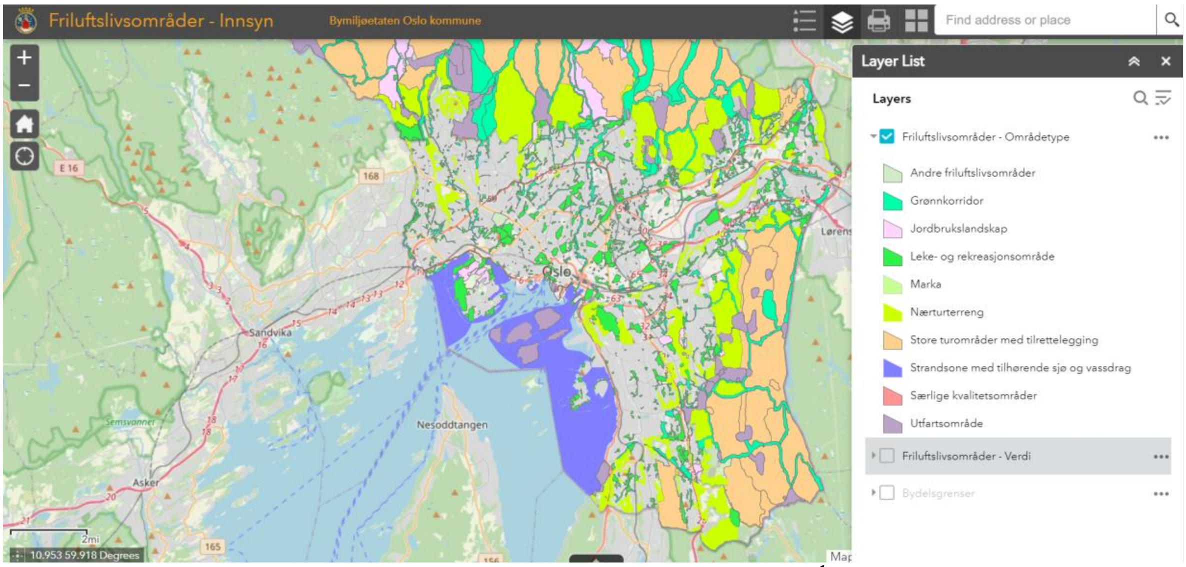


***Figure 2** Classification of recreation areas Source: Bymiljøetaten* [1]

Thirteen valuation criteria were used to assess the qualities of the recreation areas (**Figure 3**).

[1] https://www.oslo.kommune.no/etater-foretak-og-ombud/bymiljoetaten/kunngjoringer/horing-kartlegging-og-verdsetting-av-friluftsomrader-i-oslo-kommune#gref

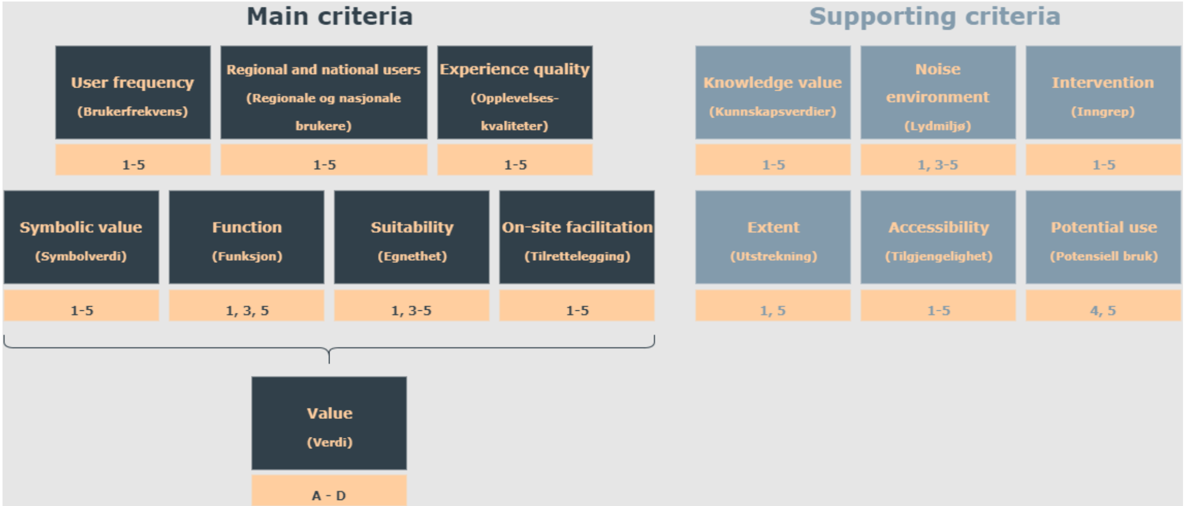


Figure 3 *M98 Guidance main criteria and supporting criteria for mapping and valuing outdoor recreation area*

A look-up table was then used to classify aggregate scores for each recreation area into four value categories A-D (**Figure 4**).

A	B	C	D
Very important recreation area	Important recreation area	Registered area	Unclassified area
Score 5 in at least one indicator. Generally high scoring.	Score 3 or 4 in at least one indicator. Generally medium scoring.	Score 2 in at least one indicator. Generally low scoring.	Areas not scored A, B or C.

Figure 4 *Valuation of outdoor recreation areas into A-D value categories according to M98 Guidance*

The modelling exercises in this report aim to test the scoring and valuation approaches explained above using available GIS data and spatial modelling. We explore whether by using methods of spatial analysis on top of available municipal, national and open-source data, the suggested valuation criteria can be approximated.

Chapter 3 discusses some general challenges with GIS-based scoring of recreation area qualities. Chapter 4 presents the maps resulting from the M98-GIS method for each of the 13 criteria. Each map was presented to the team at BYM coordinating the local working groups. For each criterion, we made a note of their comments on strengths and weaknesses of the GIS-based method compared to the scoring done by local working groups. Chapter 5 presents the valuation results. Chapter 6 discusses the results, comparing them to other previous recreation modelling for Oslo, as well as analysing the criteria with the greatest explanatory power for predicting value. Chapter 7 concludes. Chapter 8 includes a detailed technical appendix of how GIS-M98 criteria were modelled in GIS.

3 Methodology – general mapping challenges

3.1 Modifiable areal unit problem

Quantification of area-based criteria in M98 is sensitive to the delineation of recreation areas. A small change in the area border might result in significant changes in criteria scoring. Since the boundaries of recreation areas are not legally defined and in most cases are not visible in the nature, this issue is particularly significant in GIS-based modelling of criteria in M98. **Figure 5** illustrates the modifiable areal unit problem (MAUP).

In principle, the MAUP is a challenge for any area-based valuation method, but with the qualitative scoring in the process of local experts participating in valuation groups, it is not identifiable. However, it may be one explanation for why a scoring methodology may not be robust over time – new local valuation groups may not reach similar scoring because they are basing their valuation of an area on experience on only a subset of the area that they know.

In GIS-based modelling modelling, a solution would be to change the scoring approach from scoring areas to scoring surfaces and using these surfaces to delineate areas of uniform values (see section 7.3). This is at least possible where areas have observable condition data representative for the whole mapping areas.

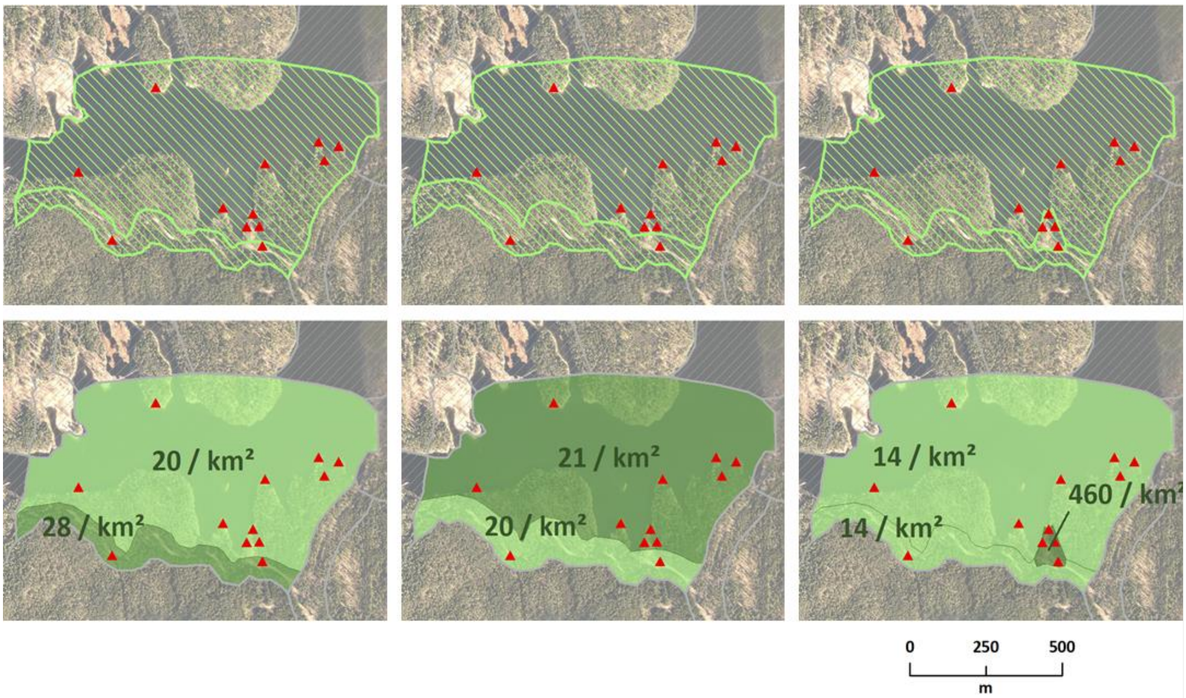


Figure 5 *Illustration of the modifiable areal unit problem. The number shows facility elements per area unit. Small changes in the definition of recreation area borders (shift, delineating new area) might lead to significant changes in scoring.*

3.2 Aggregation problem

Because the recreation areas do not have constant size, it is important to be cautious when modelling criteria based on feature count. The *count of elements* within an area depends on the delineation and size of recreation areas. Larger areas are likely to contain more elements than small areas. This effect might be avoided by taking the *density of elements* into account, that is e.g. the number of elements per hectare (**Figure 6**).

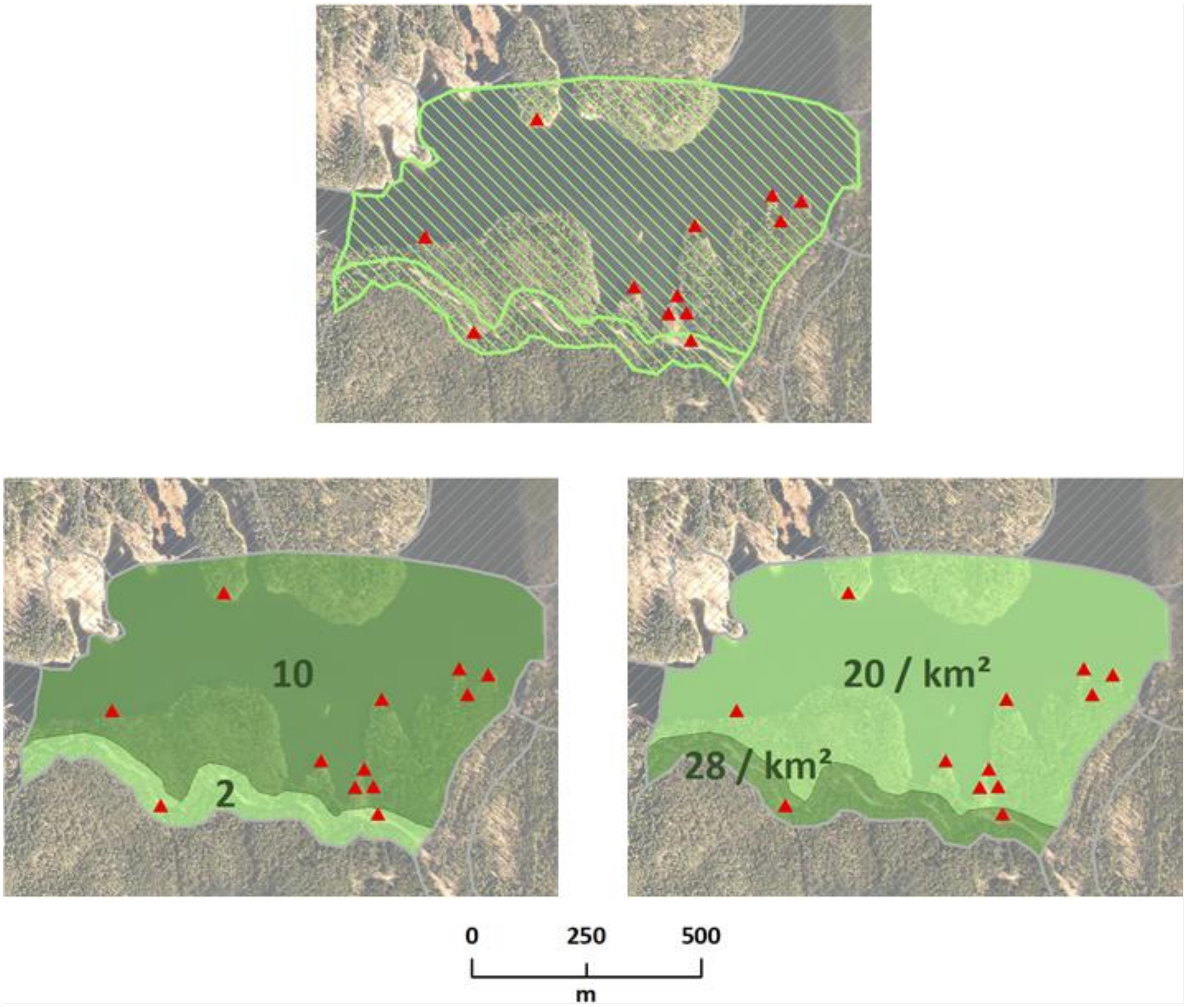


Figure 6 *Illustration of the aggregation problem. When the count of facilities (red triangles) is used (left), the larger area scores higher. However, when the density of facilities is used (right), the larger area scores lower.*

This phenomenon applies to both point features (e.g. memorials, rocks, caves), line features (e.g. paths) and polygon features (e.g. fairy-tale forest); the latter also opening the question whether the *number* (presence/absence), *area* (size of the polygon within recreation area) or *density* (proportion of polygon area to recreation area) should be counted.

Density-based measures of condition easily control for recreation area size. However, when scoring areas in a participatory group process such as M98, it is important to be aware of these simple biases.

These general mapping challenges are relevant in the GIS-based modelling methods used in the report. They are also relevant as possible sources of bias in experience-based mapping and valuation by local groups using participatory mapping. We suggest that local groups should be made aware of these common spatial valuation biases as part of group training in advance of mapping and valuation of recreation areas.

3.3 The scoring problem for recreation condition

For many criteria in the M98-GIS method, a score is assigned based on the relative ranking of recreation areas. Scoring of these criteria often refers to “low”, “medium” and “high” number of observed phenomena. To convert the absolute number into a 1-5 score, a decision needs to be made to determine how much is “low”, “medium” or “high”.

If these classes are not predefined, a data-driven approach might be used to classify the numbers into intervals. Various classification methods might be utilized, such as equal interval classification (intervals with identical range), quantile classification (identical number of features in each class) or natural breaks classification (an algorithm aiming at discovering natural grouping in data) (**Figure 7**). However, these approaches are sensitive to the distribution of values in the studied population. If areas are added or removed, the population changes and so do the classification intervals.

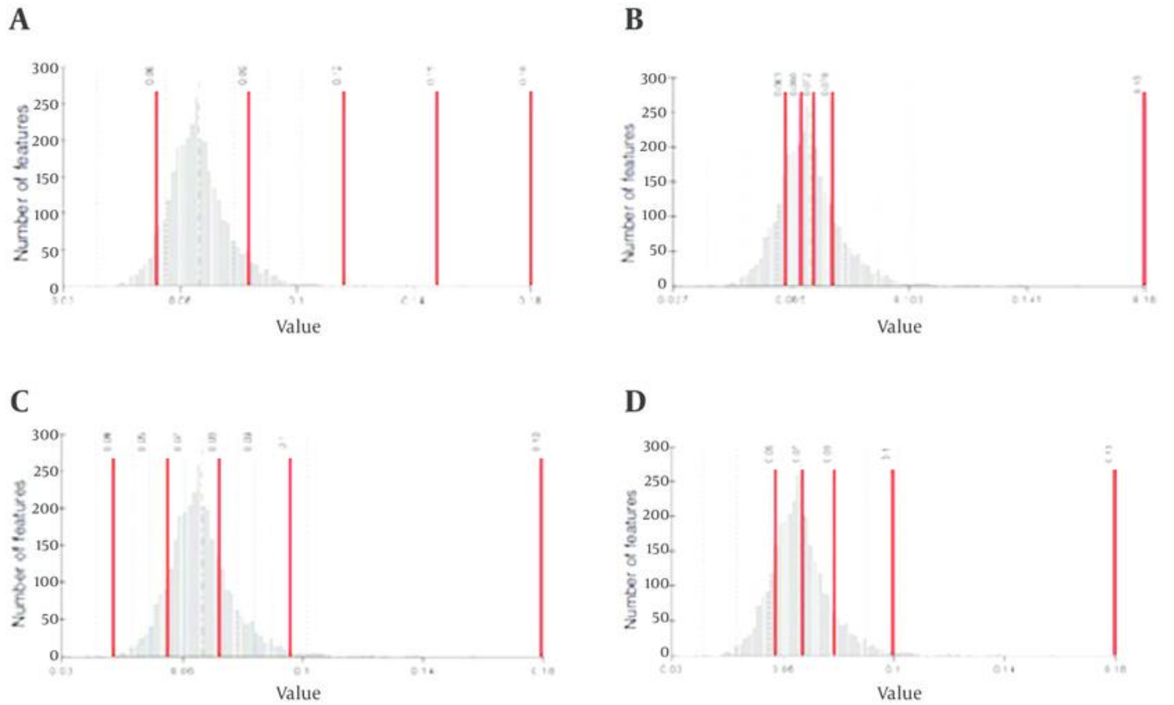


Figure 7 *Illustration of various classification methods. A – Equal intervals, B – Quartiles, C – Natural breaks, D – Standard deviation. Source*[2]

This is a feature of ecosystem condition classification based on quantitative data, in which the breaks are a subjective decision. In principle, it applies to any scoring of ecosystem condition service, but will not be visible for qualitative expert-based mapping.

3.4 Correlation between criteria

Many criteria in the M98-GIS method are modelled using similar underlying spatial data or the observed concepts are similar. If criteria are summed to arrive at an ecosystem service index, then correlated criteria can lead to double-counting. To avoid double-counting, a clear distinction between individual criteria and data used is needed. In Chapter 6, we evaluate criteria correlation and their relative information value in relation to the value A-D.

[2] https://www.researchgate.net/publication/301601403_Developing_a_WebGIS_for_Geo-Visualization_of_Cancer

4 Results

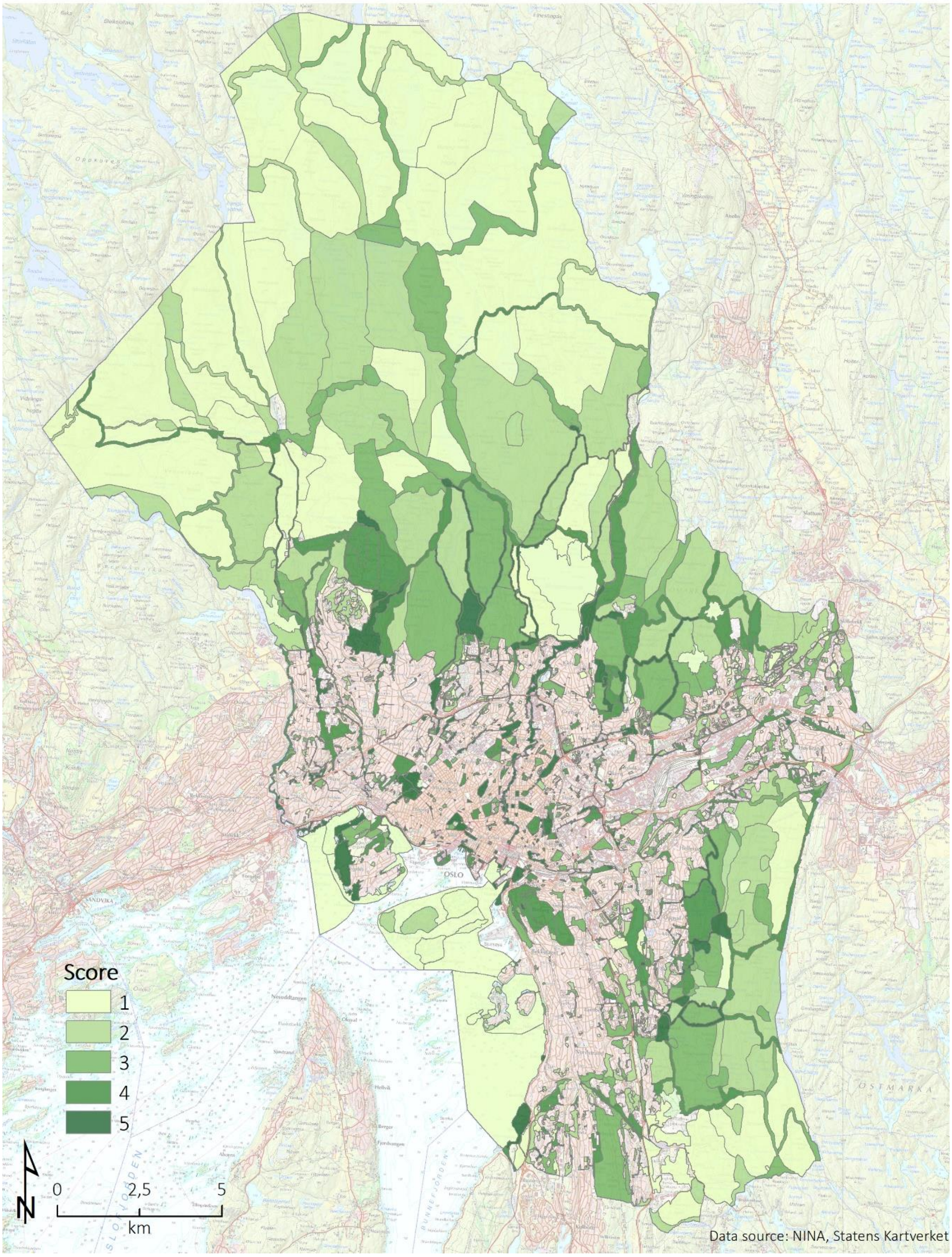
Each criterion for recreation mapping and valuation in M98 leverages different GIS datasets.

In the following section, we present the maps resulting from the M98-GIS method. Each map is followed by (i) a table showing the criteria and scoring in the M98 Guidance and the NINA-tested M98-GIS method; (ii) feedback from the Urban Environment Agency staff and consultants who coordinate M98 in Oslo (M98 practitioners) and (iii) a proposal for further work and research by NINA researchers.

Data and modelling assumptions are detailed in the Appendix to this report. We collectively refer to this approach as "M98-GIS" in the rest of the report.

4.1 User frequency (Brukerfrekvens)

M98 valuation of recreation areas in Oslo municipality
User frequency (NINA M98-GIS)



	Score	1	2	3	4	5
M98	**How large is the current user frequency?**	Small	Some	Medium	Relatively large	Large
NINA	**Not modelled due to a missing data source**					

User frequency is assessed on a 5 point scale in M98. We considered four alternative approaches to quantifying this criterion before choosing Alternative 4.

Alternative 1: Density of Open Street Map public GPS tracks. This was discarded as only older data from 2012 are available and the density of tracks is low.

Alternative 2: Density of INSTAGRAM and Flickr photo. Havinga et al. (2020) demonstrated the mapping of Photo-User-Day-Viewshed (PUSD) using the density of Flickr photo points and the perspective viewshed of the photos. They have shown how the Flickr API can be used to download geo-located photos. This may also be a source of future data for assessment of the *experience qualities* criterion.

Alternative 3: Mobile phone position data. Statistics Norway has explored obtaining mobile phone position data from Telenor (60 % market share). The costs of this data for all greenspaces in a municipality the size of Oslo were prohibitive for a research project. For example, obtaining visitor data per hour for one year – including visitor overnight origin and mobile phone origin – for one recreation location in Oslo was priced at 160 000 NOK.

Alternative 4: STRAVA GPS tracks. In 2020 NINA became a subscriber to STRAVA data for Norway. A comparison of STRAVA data to available counters from Oslo Municipality data by Venter et al. (2020a) shows that STRAVA data represent about 1 in every 30 pedestrians and bikers on trails at Sognsvann and Rustadsaga (**Figure 8**).

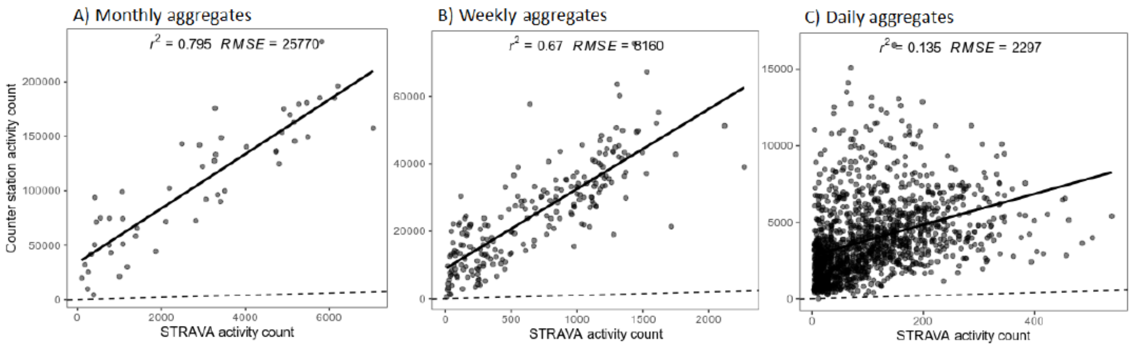


***Figure 8** What proportion of recreation population is represented by STRAVA mobility app data? Source: Venter et al. (2020a)*

While STRAVA frequency data may be scaled to a total use population, there are no counter data to evaluate time-in-path or time-on-site. Initial tests show that STRAVA data represent short trip lengths of under 1 hour per activity, while survey data suggest the use of peri-urban trip lengths of up to several hours. STRAVA data will therefore be better at representing frequency than temporal trip length. There is a stable relationship between STRAVA and the total pedestrian frequency at monthly levels. Therefore we can use aggregate annual STRAVA visitation frequency as an indicator of relative total use. Further testing is required to see at what scale STRAVA observations can quantify the use of smaller recreation areas typical for Oslo's built-up area, as well as remote areas in Marka. We could expect that STRAVA data under-represents the total use in small green spaces in inner-city areas which are not of adequate size for high mobility training but are important e.g. for sun-bathing and children's play.

Comments by M98 practitioners to the approach:

The following limitations to mobile phone position data and STRAVA GPS track were identified by Oslo recreation managers and consultants:

- Use of outdoor areas close to home may be carried out without mobile phones.
- Children and the elderly are not covered by sports mobility app data such as STRAVA and only partially by mobile phone position data.
- Similarly, a mobile phone position may represent a number of household members.
- Mobile phone position data cannot evaluate differences in the use of recreation areas between the sexes or correlation with cultural backgrounds (both lacking data and personal data protection).

Overall assessment of method: spatial GIS-based data for criteria scoring is very suitable.

4.2 Regional and national users (Regionale og nasjonale brukere)

	Score	1	2	3	4	5
M98	**Use of area by people who are not local?**	Never	Almost never	Medium	Quite often	Often
NINA	**Not modelled due to a missing data source**					

We did not assess the origin of users due to lacking GIS data at the time of the pilot test in 2019. Among alternative approaches to quantifying use, only mobile phone position data offer a quantitative approach. This data can be used to identify the country of origin of mobile phone owners. However, as above, the costs of this data are prohibitive for all recreation areas in a city.

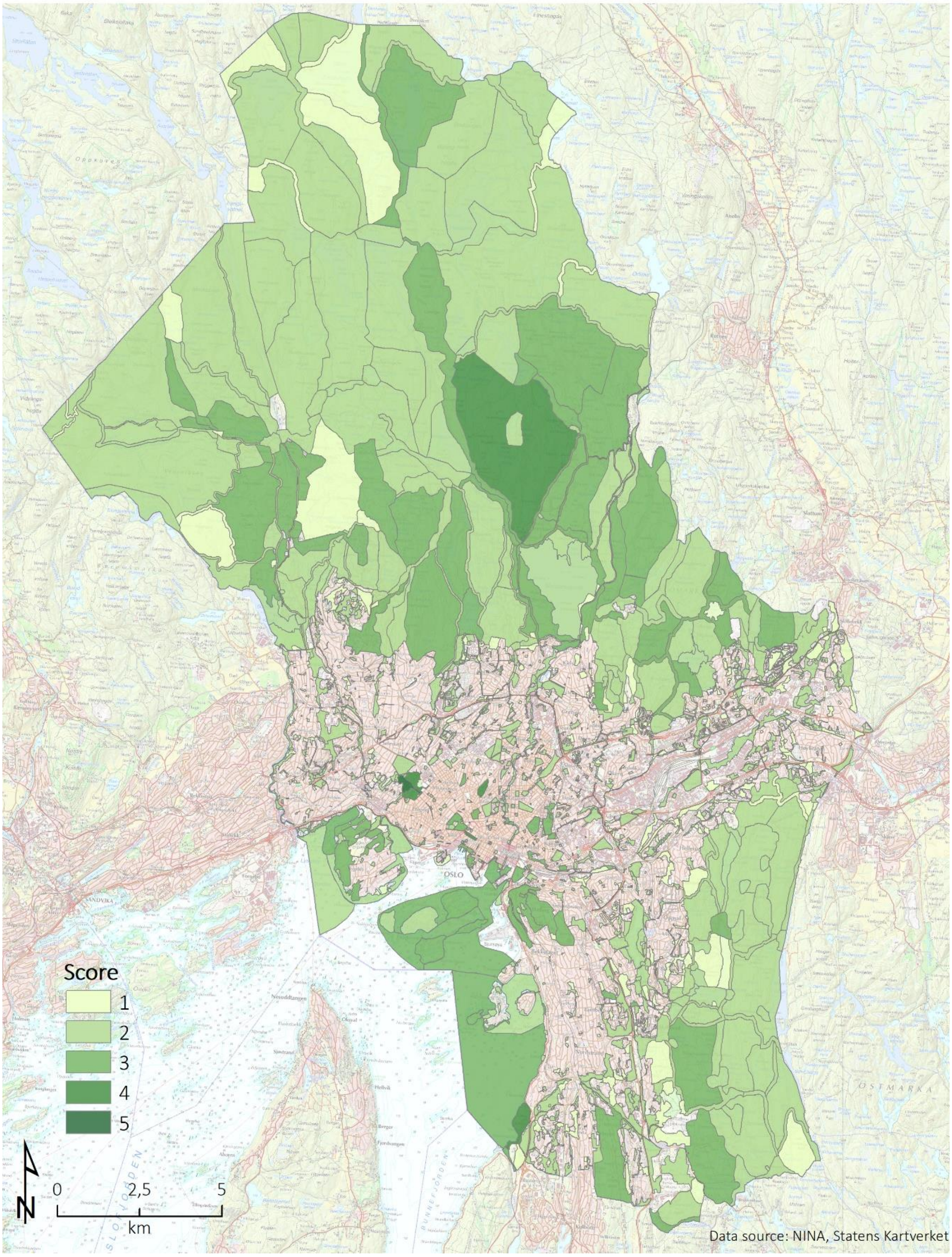
Comments by M98 practitioners to the approach:

- In Oslo, there was a correlation between *symbolic value* and locations with high *regional and national users*.
- Few areas in Oslo were rated as high regional or national recreation value. In some of the valuation groups in city districts, they define visitors from other city districts as regional visitors.

Overall assessment of method: spatial GIS-based data for criteria scoring is potentially suitable (not tested here).

4.3 Experience qualities (Opplevelseskvaliteter)

M98 valuation of recreation areas in Oslo municipality
Experience qualities (NINA M98-GIS)



	Score	1	2	3	4	5
M98	Does the area have special natural or cultural history experiences?	None	Few	Medium	Relatively many	Many
	Does the area have a special landscape?	None	Some	Medium	Relatively large	Large
NINA	Number of features	0	1-3	4-6	7-14	> 14

Experience quality is expressed as an index of the number of quality elements present within a recreation area, including sites of cultural heritage (e.g. old buildings, bridges/constructions, war memorials, historically important places), cultural elements (e.g. related to agricultural landscapes, such as rock walls/fences, flower beds), special nature/biology (e.g. special species-rich areas, fairy-tale forests) and special geology/landscape formations (e.g. "giants kettles", canyons, caves, fossils, special bedrock). The M98-GIS method combined data from BYM, Kartverket (FKB), Riksantikvaren and OSM to collect a representative dataset (see Appendix for details).

Comments by M98 practitioners to the approach:

- In the M98-GIS method, the size of an area does not influence its experience qualities, for example, the Bygdøy forest is a unique large forest area within Oslo's built-up area.
- Why were nature types not included as experience values?
- Fairy-tale forests should be registered as areas with experience value.
- Signposting can increase experience values, but some cultural heritage sites are not signposted in order to protect them.
- Architecture on the "yellow list" (wooden houses) increases experience value.
- In the M98-GIS method, data on natural qualities are not included in the modelling of experience quality, for example, the presence of water.
- Vista/observation points could be included but are hard to model (use DNT and Skiforeningen maps in future).
- Homogeneity of experience qualities has been used to adjust the boundaries of recreation areas/polygons in Oslo, in collaboration with local valuation groups. This step was not conducted in other municipalities (e.g. Bærum).
- The quality of available maps is a challenge.

Future work

While GIS-based modelling approaches are technically feasible, this is still a challenging criterion for mapping because the experience is subjective. Future work can explore proxy indicators:

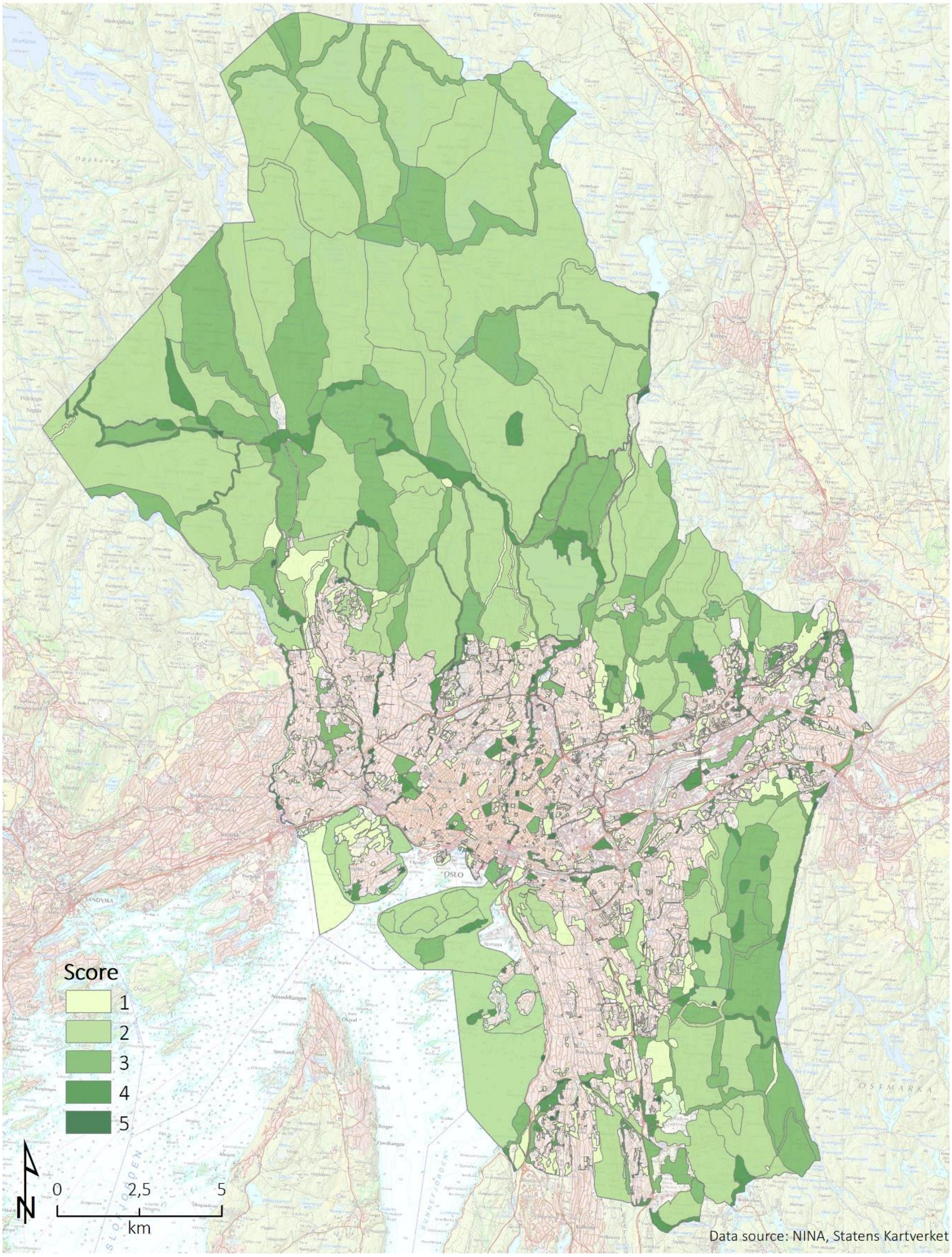
- Time-on-site using STRAVA speed mobility – the longer a user is on-site, the longer the experience.
- Social media photo viewshed density, as in Havinga et al. (2020). Indicating the amount of information recorded and shared about a location.

Overall assessment of method: spatial GIS-based data for criteria scoring is medium suitable.

4.4 Symbolic value (Symbolverdi)

M98 valuation of recreation areas in Oslo municipality

Symbolic value (NINA M98-GIS)



	Score	1	2	3	4	5
M98	**Does the area have special symbolic value?**	No	Little	Medium	Relatively many	Many
NINA	**Density of place names (#/km2)**	**0.0**	**0.1 – 4.7**	**4.8 – 8.0**	**8.1 – 18.6**	**> 18.6**

In the M98 methodology, places have symbolic value if they are recreation or tourist destinations. The *symbolic value* is represented in the M98-GIS method as the density of place names with natural and cultural features. The rationale is that a place that is a destination will have a place name indicating the destination. In literal terms also place names (symbols) give places symbolic value. Please see Appendix for details on data sources.

Comments by M98 practitioners to the approach:

- How well an area is known may be indicated by the number of hits in Google searches of place names.
- There are a number of destinations for unorganized and/or specialized recreation that have symbolic value. These may be registered in specialized map databases, but will not be in official maps.
- Specialized sports with local destinations known to specialized users include
    - «bouldering» climbers will prepare locations and give boulders their own names,
    - Off-road cyclists will make trails with their own names,
    - Skate ramps,
    - Bicycle jumps,
    - Randonnée and “off-piste”.
- Old sporting locations may have symbolic value although no longer in use, these include
    - Old ski jumps,
    - Old ski lifts.
- Children playing in areas will have symbolic value, but not be identified in official place names.
- A weakness of the “destination names” approach is that different maps have different registration of place names.
- Local place names take a long time to be integrated into maps (e.g. Appelsinhaugen, Lekern, Juletretomta, Haugtjern).
- The *symbolic value* criterion was the most difficult criterion in the M98 implementation in Oslo. It was often given a low value or scored in relation to the number of users – which leads to double counting with *user frequency*.

Future work

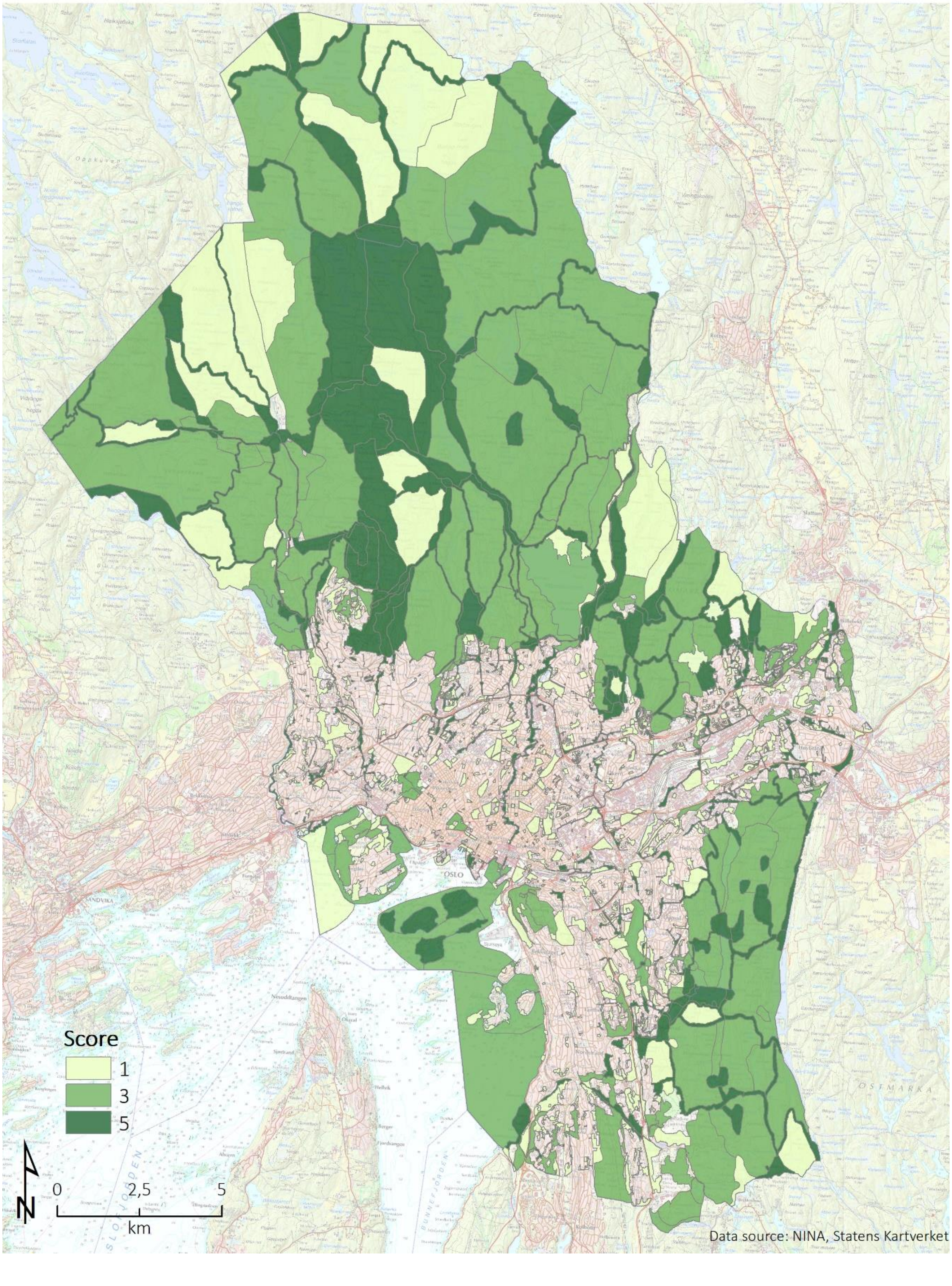
- At what level of local use are destinations registered as having *symbolic value* (>0)?

- The scoring of *symbolic value* is defined in relation to how widely a destination is known, tending thereby to correlate with *user frequency*. Independent criteria are needed. Steder (2017) proposed independent criteria to define *symbolic value* (ritual use, historical identity of a particular group, traces of history).

Overall assessment of method: spatial GIS-based data for criteria scoring is less suitable.

4.5 Function (Funksjon)

M98 valuation of recreation areas in Oslo municipality
Function (NINA M98-GIS)



	Score	1	2	3	4	5
M98	**Does the area have special function (entrance zone, main hiking trail, corridor etc.)?**	No special function	-	Medium function	-	Special function
NINA	**Is the area an access zone, green coridor or has high betweenness of hiking trails?**					

Areas with high functional value support the use of adjoining recreation areas – create connectivity between areas. E.g. entrance zones, green corridors and (main) hiking trails. In the M98-GIS method, areas classified by the Municipality as "green corridors" or "excursion areas" are scored highest. Medium connectivity function is assigned to paths with high connectivity (betweenness score) or areas that are identified as access zones to Marka.

Comments by M98 practitioners to the approach:

- The use of areas identified by their function to also score the area is not logically consistent. In particular, "green corridor" is a type of recreation area classified for its function.
- In Oslo's implementation of M98, some "green corridor" areas were reclassified as "near recreation terrain" if their function was more a destination than a corridor.
- Areas are classified according to their most important function.
- From the consultants' experience with the valuation process: How areas are labelled was of little importance for how they were valued.

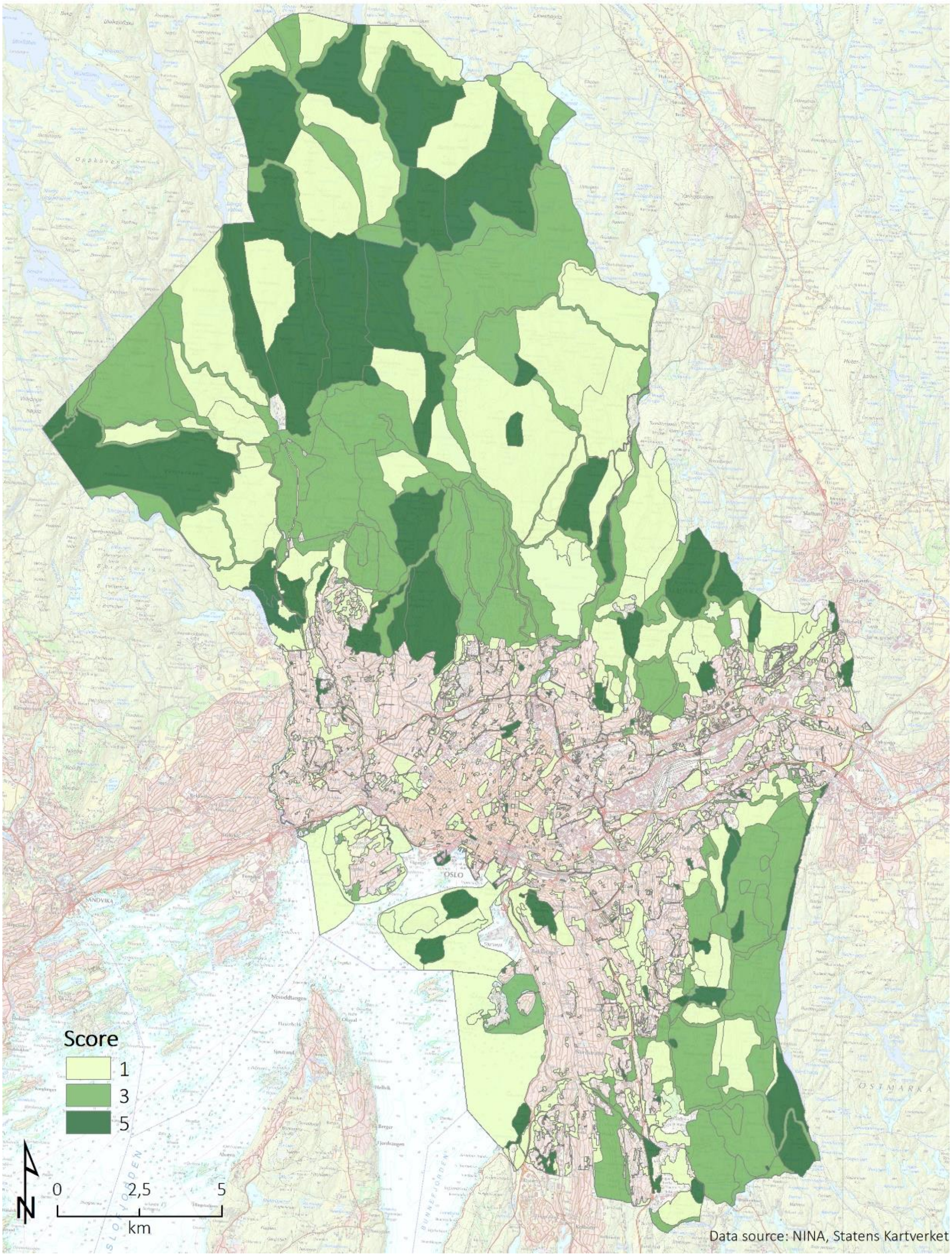
Future work

- Avoid the use of functional classifications to score areas.
- Consider how delimitation of the boundaries of recreation areas is also a form of valuation.
- BYM has made a new trail map which could be used in future implementations of the method.
- A corridor function could be scored by the speed at which users use path segments. This data is available in STRAVA. Higher speed of users suggests that the area is a corridor.
- Improvement of mapping and modelling of functionality requires a definition of entrance and exit points.

Overall assessment of method: spatial GIS-based data for criteria scoring is less suitable with the present confounding of "green corridor" class and *function* criterion.

4.6 Suitability (Egnethet)

M98 valuation of recreation areas in Oslo municipality
Suitability (NINA M98-GIS)



	Scoring	1	2	3	4	5
M98	**Is the area particularly suitable for one or more activities, which have no alternative nearby?**	Bad	-	Medium	-	Good
NINA	**Operationalization – number of activities**	**0 a.**	-	**≥ 1 activity**	-	**≥ 1 unique activity**

A recreation area is assigned a score 1 if it contains no special activities, score 3 if it contains at least one special activity, but none of these is unique (>1 km from a similar activity) and score 5 if it contains at least one special activity and at least one of these is unique. Special activity sites are derived from mainly BYM thematic data on recreation (climbing site, fishing lake, rowing club, camping place, sports field) and supplemented by OSM (bridleways). See Appendix for details.

Comments by M98 practitioners to the approach:

- What is an alternative site? There are many natural characteristics of a location which are not visible in digital images or maps, such as bathing locations with diving possibility, substrate, child-friendliness, safety for small children, sledging slopes in the winter.
- The M98 implementation using local valuation groups has varied with respect to evaluating proximity to alternative sites. It was not clear that the proximity of alternative/substitute sites was always considered. The focus has been on mapping locations that require special terrain for recreation. Score 4-5 has been used depending on proximity to alternatives.
- Suitability should be evaluated for different recreation user types and ability levels. This has been a difficult criterium to implement because of the diversity of users.
- M98 in Oslo has also adjusted boundaries of recreation areas to represent homogenous areas for suitability.

Future work

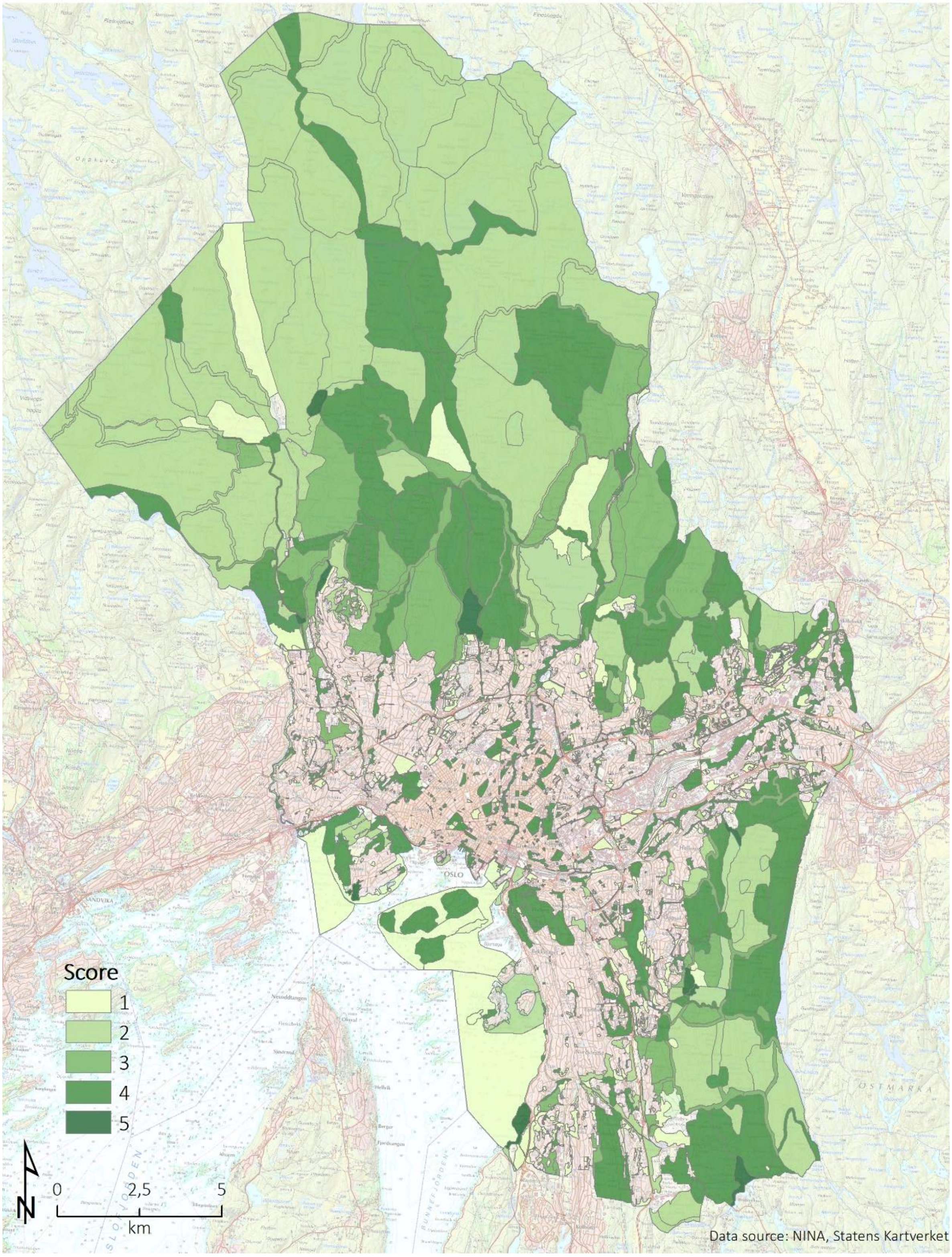
- The distinction between the *suitability* and *on-site facilitation* criteria needs further clarification in the M98-GIS method.
- *Suitability* does not currently consider the minimum size of an area in relation to a specific activity. The relative suitability for a specific recreation activity is not compared across sites, just presence/absence.
- Preferences for natural features could be used. URBAN SIS has developed results regarding preference for green views, tree canopy and remoteness of trails that could be used in future modelling.

Overall assessment of method: spatial GIS-based data for criteria scoring is suitable.

4.7 On-site facilitation (Tilrettelegging)

M98 valuation of recreation areas in Oslo municipality

Facilitation (NINA M98-GIS)



	Score	1	2	3	4	5
M98	**Is the area organized for special activities or groups?**	Not facilitated	Little facilitated	Moderately facilitated	Well facilitated	Very well facilitated
NINA	**Maximum facilitation score**					

This criterion concerns built structures that facilitate special activities or are suited for special user groups. Examples are signposting and marking, benches, fireplaces, toilets, waste management, infrastructure for wheelchairs and baby strollers. Data are from BYM thematic maps, OSM and N50 Transportation (Samferdsel). See Appendix for further details.

Comments by M98 practitioners to the approach:

- In M98 implementation, it has been challenging to account for built infrastructure. City district administrations upgrade facilities themselves and it has been difficult to have up to date information available for work in the valuation groups. These facilities are not updated in the BYM facilities dataset either.
- Private installation and management of infrastructure are not recorded in the BYM facilities dataset.
- Different thematic layers are continually updated by BYM for needs assessments (e.g. approved fireplaces, grills, bathing places).
- The city is under continuous development and the maps are not updated regularly until an assessment of needs is carried out (behovsplan).

Future work

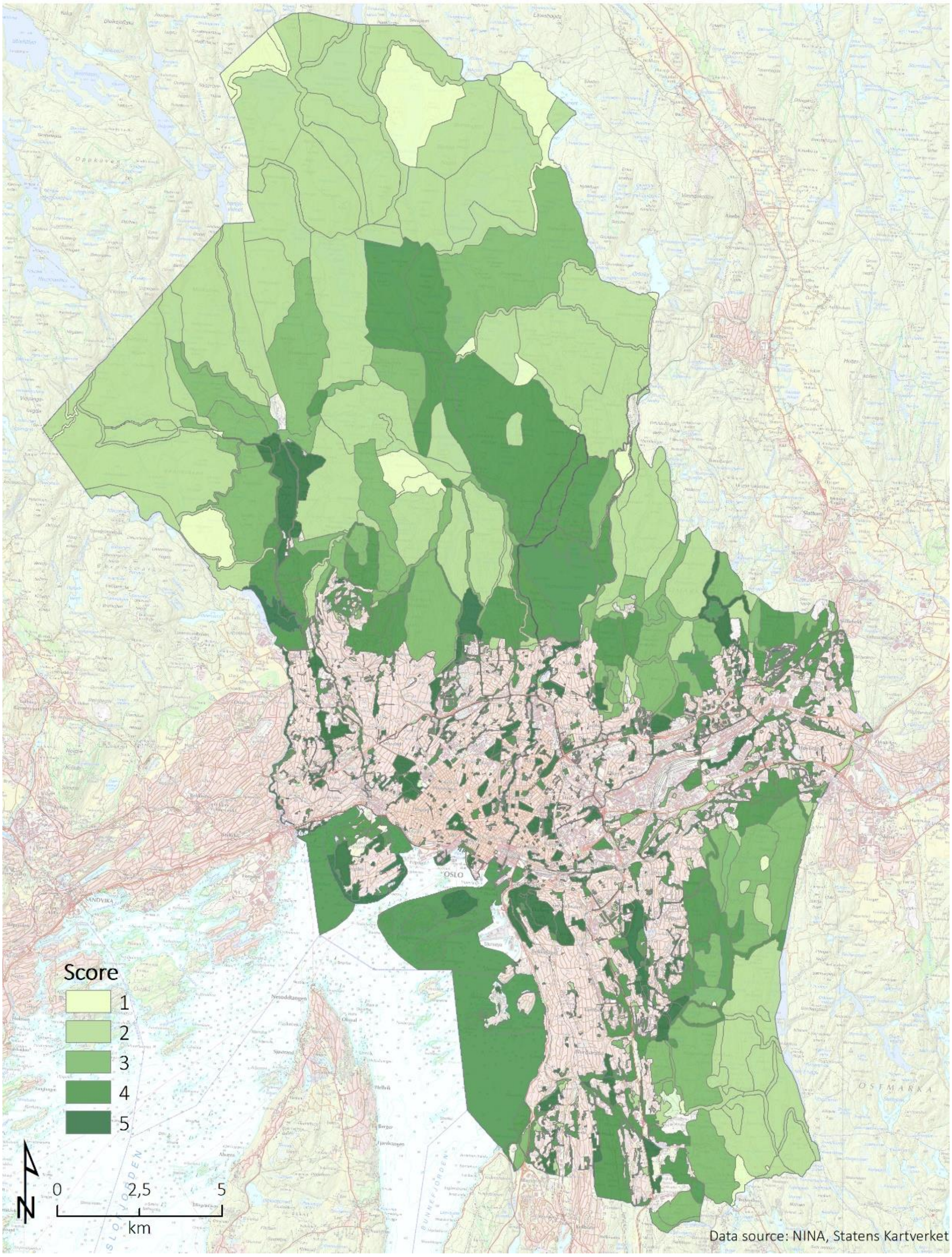
- The facilities data is required at a high spatial resolution, unobservable in remote sensing data. This relies on register data. The costs of obtaining the mapping information are high and consequently, maps are not updated. Facilities are built and managed by a number of actors. The kind of facilities considered “large” enough to be considered needs further definition.

Overall assessment of method: spatial GIS-based data for criteria scoring is suitable.

4.8 Knowledge values (Kunnskapsverdier)

M98 valuation of recreation areas in Oslo municipality

Knowledge value (NINA M98-GIS)



	Score	1	2	3	4	5
M98	Is the area suitable for educational purposes or does the area have special natural or cultural science qualities?	Few	Quite a few	Medium	Quite many	Many
NINA	Distance to schools and occurrence of endangered species					

The M98-GIS method uses species richness data to represent special natural features with knowledge value potential. Recreation areas have a higher value if they are in the vicinity of a school or kindergarten. The *knowledge value* criterion is scored based on a combined matrix of species richness and distance to recreation areas. See appendix for further details.

Distance to barnehage or school	> 1 km	100 m - 1 km	< 100 m
Natural and cultural knowledge qualities			
low	1	2	4
medium	2	3	4
high	4	4	5

Comments by M98 practitioners to the approach:

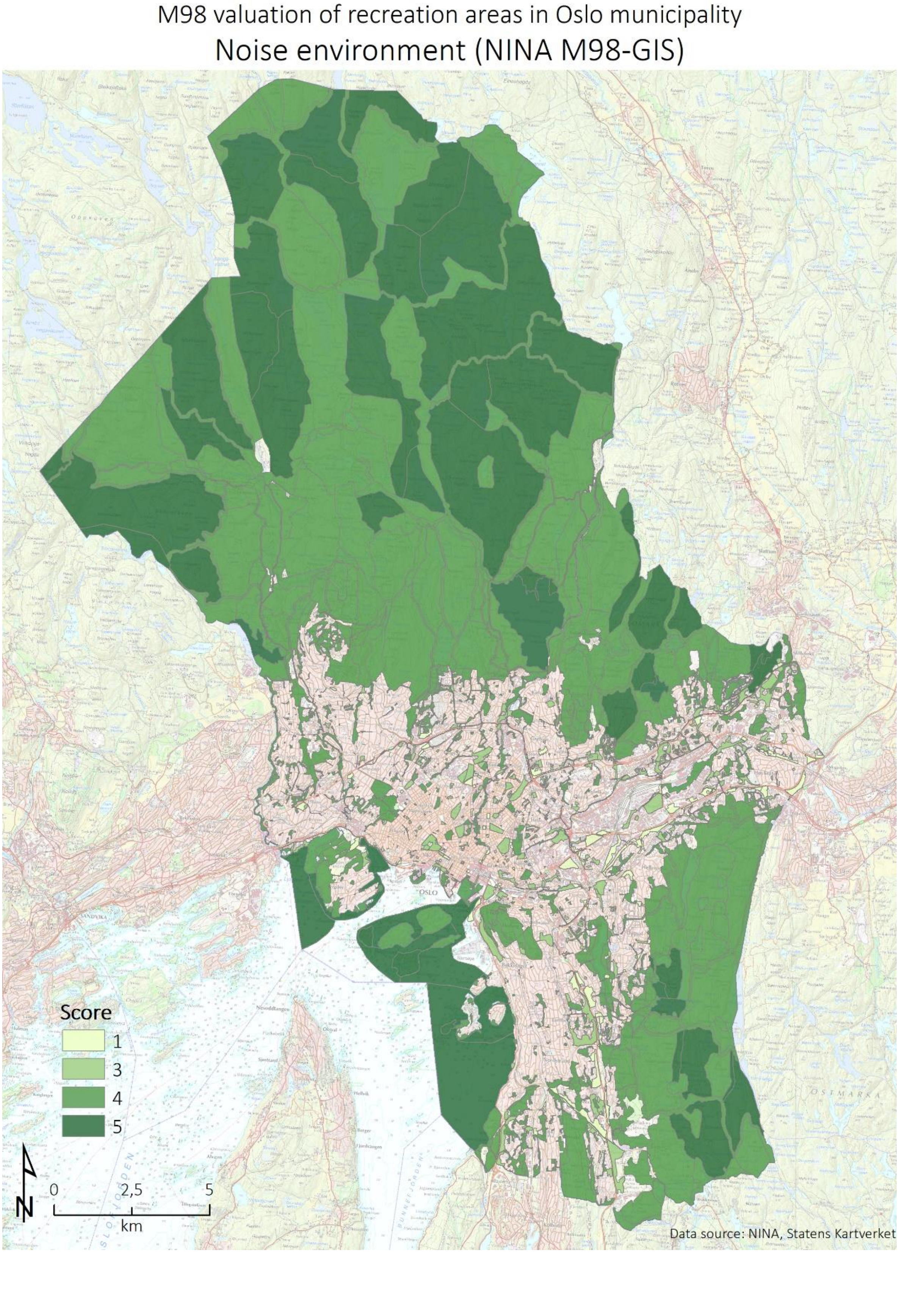
- The M98-GIS method uses average species richness.
- The method uses Euclidean distance and physical proximity. Accessibility for kindergartens will often be measured by public transport accessibility. At a certain public transport distance, many areas become substitutes (e.g. excursion to Oslofjord islands).
- Areas within 15-20 minutes walking distance can be considered accessible (< 1 km).
- *Knowledge values* in M98 were mapped according to the level of use, not how rich the learning experience was.
- Important nature types and cultural heritage sites increased the score from 4 to 5.
- Proximity to school or kindergarten is more important than species richness – outdoor education can take place in locations with no special natural qualities.
- Natural qualities can include geology (e.g. Malmøya).
- In the valuation groups, what was considered suitable for education varied. Physical suitability of the terrain was considered important.
- Should kindergartens be excluded from the modelling because it is the potential for education more than play, that is being considered?
- *Accessibility* of nature is not a sufficient criterion for schools to make use of outdoor teaching. The ability to use near-nature depends on how schools implement teaching plans.

Future work

- Schools may use only a part of a recreation area closest to the school. Recreation area should not be assigned.
- Species data are mainly for plants. Consider how knowledge about animal migration patterns could be included (e.g. lyn).
- Differentiate red list species with a higher score.
- Map forest camps, tree house and leantoo – “gapahuk” building densities.
- Need to discuss indicators further with educators.

Overall assessment of method: spatial GIS-based data for criteria scoring is suitable.

4.9 Noise environment (Lydmiljø)



	Scoring	1	2	3	4	5
M98	Does area have a good noise environment?	Poor	-	Medium	Rather good	Good
NINA	Noise level and distance to path	> 60 dB	-	50 – 60 dB	< 50 dB & d. ≤ 180 m	< 50 dB & d. > 180 m

The M98-GIS method implements a quantitative classification of noise modelling provided by Oslo Municipality. Average noise in an area is used to derive the score.

Comments by M98 practitioners to the approach:

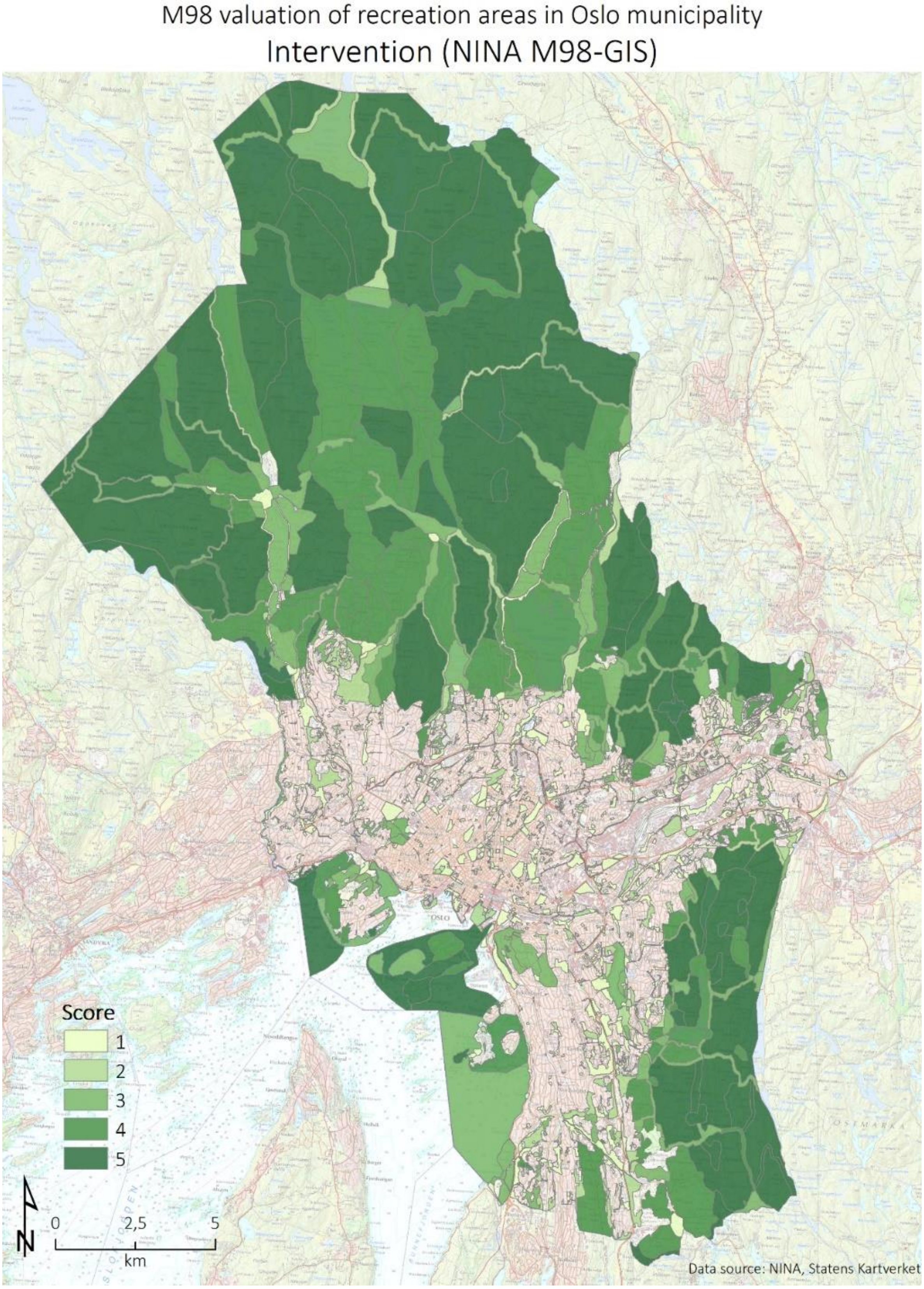
- In the M98 method with valuation groups, this criterion was skipped because participants had very different perceptions of noise.
- The recreation areas to be mapped are too large to reach agreement on a single value.
- Groups often discussed too specific locations. People associated “a lot of noise” with particular paths.
- When assessments were made, the built areas were scored 2-3; 4 for “surprisingly quiet”. 1 was seldom used.
- *Noise environment* evaluation is expectation-based. Different expectations in the centre of the city imply different subjective assessments of objective sound levels. There are different expectations in different populations due to conditioning.
- Despite difficulties of assessment, participants in M98 considered regulated “quiet zones” to be important for recreation.
- Noise from power cables and airplanes in Marka were not considered in the M98-GIS method.
- Noise by other recreation users was considered in M98. In the M98-GIS method, this is considered through modelling distance to hiking paths.
- The use of objective noise to differentiate recreation areas is difficult as Oslo is lacking datasets for non-vehicular noise.

Future work

- Include noise from power cables.
- Consider how recreation area boundaries would be redefined by noise gradients to demonstrate how the recreation area extent and condition are interdependent.

Overall assessment of method: spatial GIS-based data for criteria scoring is very suitable.

4.10 Intervention (Inngrep)



	Score	1	2	3	4	5
M98	**Is the area intervention free?**	Developed	Quite developed	Medium	Quite intervention free	Interventi on free
NINA	**Average influence of technical intervention**	2.7-3.0	2.3-2.7	1.7-2.3	0.8-1.7	0.0-0.8

Data from Kartverket was used to map a 100m buffer around technical infrastructure (roads, rail, power lines, buildings). Average proximity to infrastructure was used to score recreation areas.

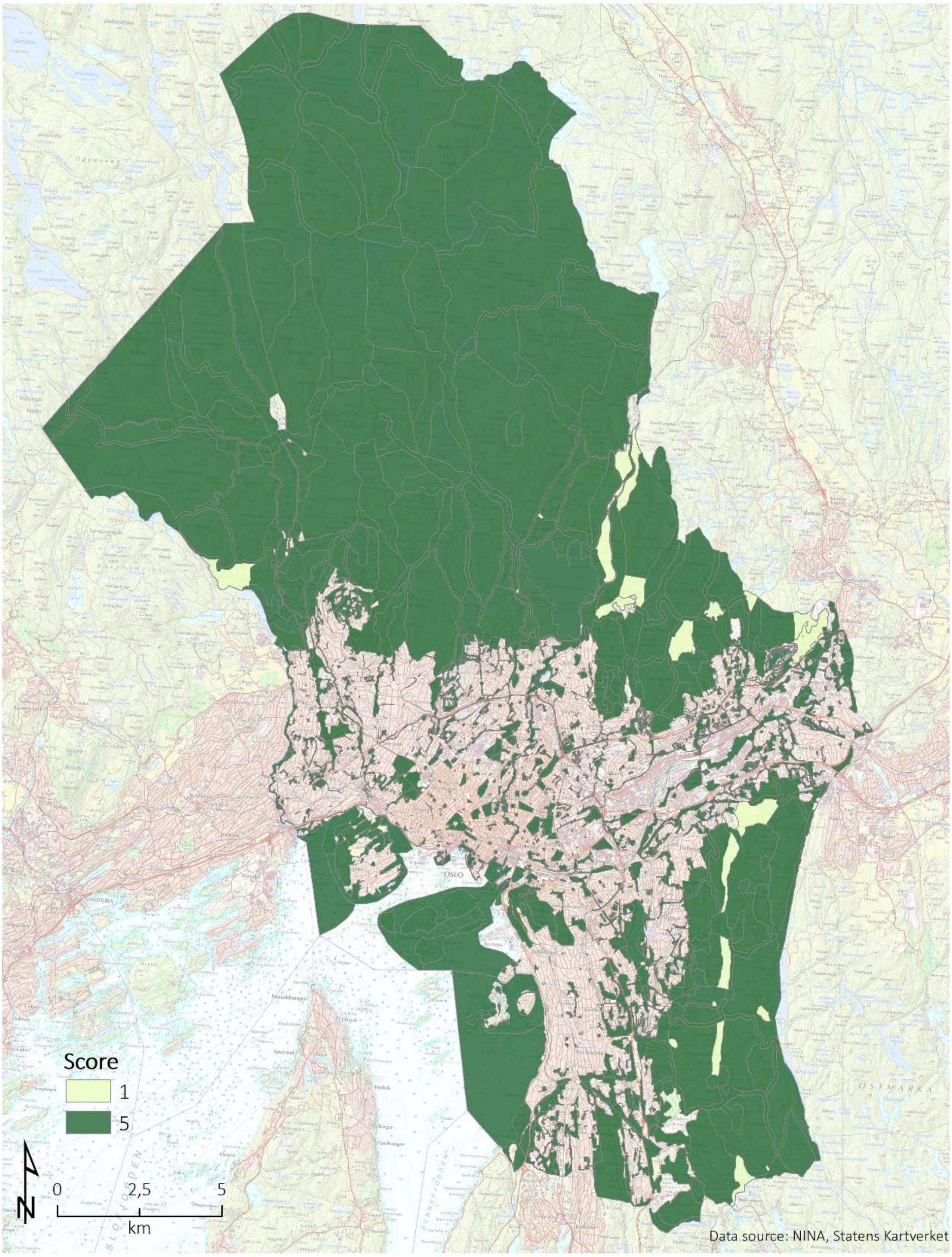
Comments by M98 practitioners to the approach:

- The criterion was not used in central Oslo. No additional comments to the M98-GIS method.

Overall assessment of method: spatial GIS-based data for criteria scoring is very suitable.

4.11 Extent (Utstrekning)

M98 valuation of recreation areas in Oslo municipality
Extent (NINA M98-GIS)



	Score	1	2	3	4	5
M98	**Is the area large enough to exert the desired activities?**	Too small	-	-	-	Large enough
NINA	**Is the area within 25 % of smallest areas of its type**	Yes	-	-	-	No

The recreation areas identified in M98 were ranked according to size. The smallest 25 % of areas were labelled as too small.

Comments by M98 practitioners to the approach:

- The intention of the criterion is to assess size relative to specific recreation use. There is no single minimum size for all uses.
- The M98-GIS method is data-driven (lowest quartile 25 %).
- This criterion was dropped or given a default value of 5 in the scoring work in Oslo (areas were considered large enough).
- No areas were observed to be too small for an activity (because by definition observing activity in a site means that it is large enough).
- There is a general planning perception that there is insufficient greenspace.

Future work

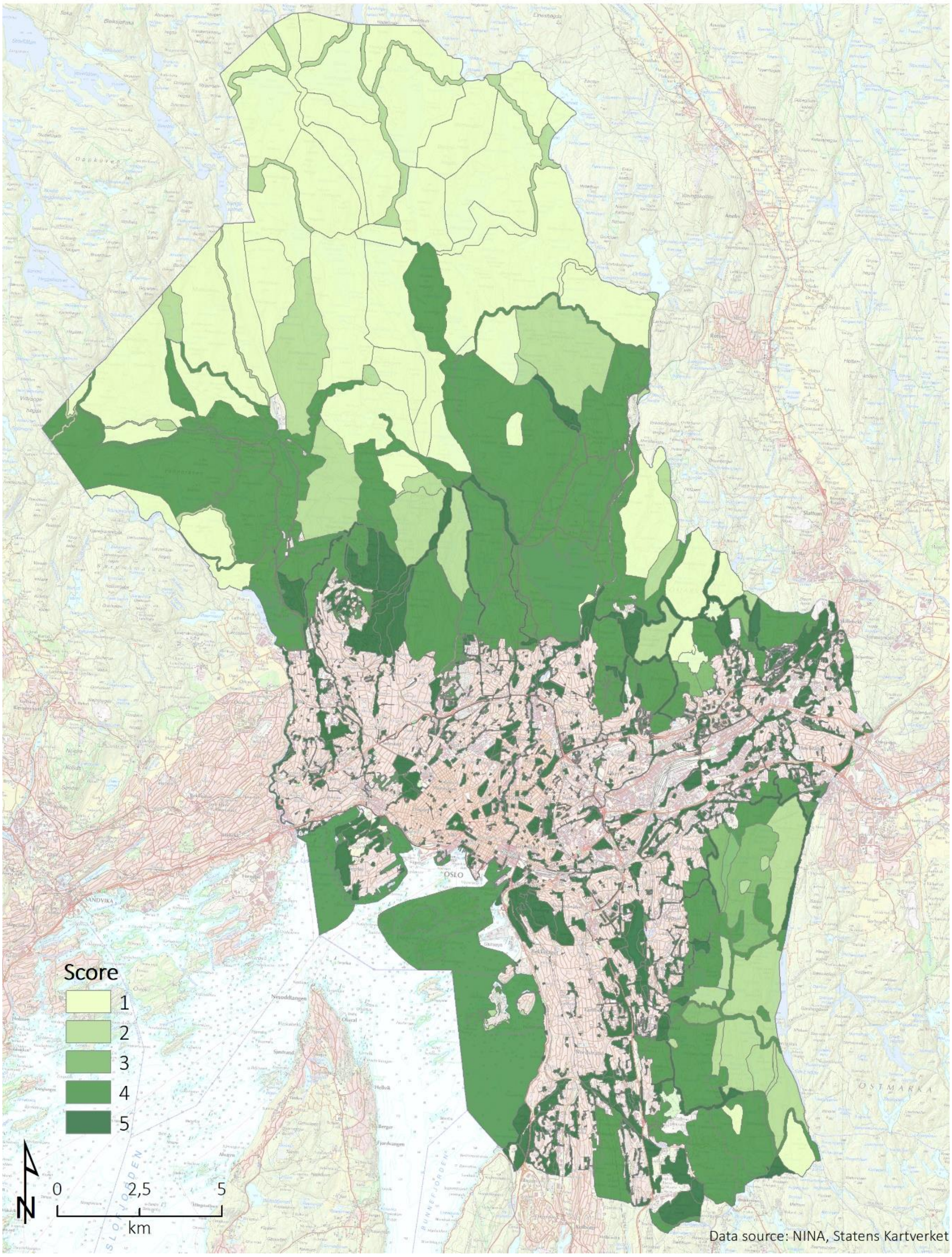
- Consider how accounting statistics should be prepared for recreation area extents, given that the boundaries are determined by recreation valuation assumptions.
- Consider urban open spaces (streets with trees) as recreation areas.

Overall assessment of method: spatial GIS-based data for criteria scoring is very suitable.

4.12 Accessibility (Tilgjengelighet)

M98 valuation of recreation areas in Oslo municipality

Accessibility (NINA M98-GIS)



	Score	1	2	3	4	5
M98	Is availability good or could it be good?	Poor	Rather poor	Medium	Rather good	Good
NINA	Distance to residential areas, parking lots and public transport	Yes	-	-	-	No

The M98-GIS method maps minimum distance to parking lots, path density, residential or public transport stops.

Comments by M98 practitioners to the approach:

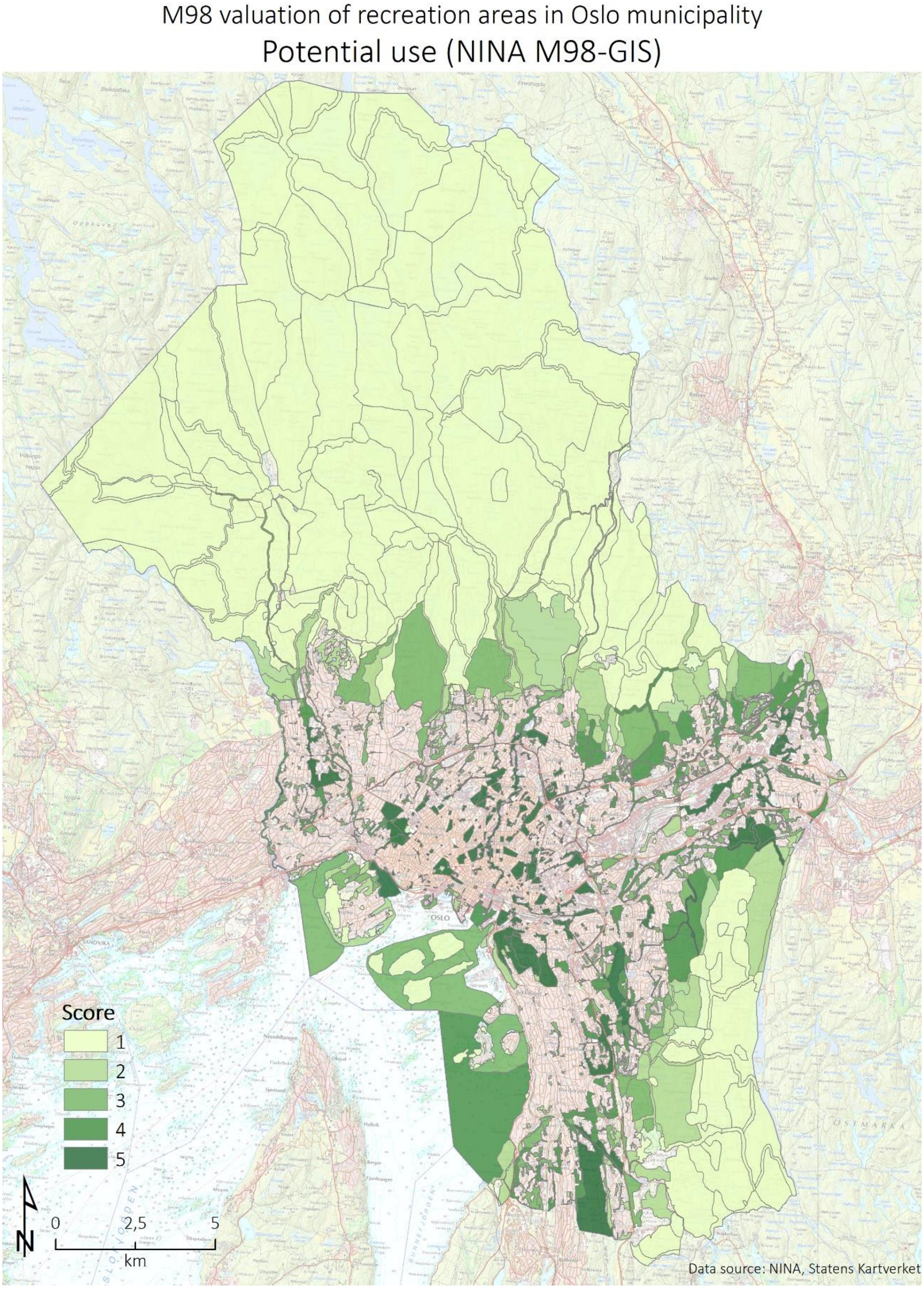
- M98 criteria are easy to translate to geospatial analysis.
- Topography/steepness is not accounted for (Bekkelaget to Ekeberg).
- Barriers such as motorways (Mosseveien) not accounted for.
- Paths along the coastline are not considered.
- In the built-up area, all recreation areas get a high score in the M98 valuation groups.
- M98 valuation groups valued Marka and Oslofjord access on a different scale.
- Allotment gardens have opening hours.

Future work

- No proposals

Overall assessment of method: spatial GIS-based data for criteria scoring is very suitable.

4.13 Potential use (Potensiell bruk)



	Score	1	2	3	4	5
M98	**Does the site have potential beyond current use?**	Small	Relatively small	Medium	Relatively large	Large
NINA	**Population within 1 km from area**	0-5 000	5 000-10 000	10 000-15 000	15 000-20 000	> 20 000

The population within 1 km from the recreation area was evaluated using Statistics Norway demographic data. Greater population reflects greater potential use if an area is made suitable and accessible.

Comments by M98 practitioners to the approach:

- Generally not evaluated in Oslo's M98 implementation.
- Difficult to assess in a method looking at current status.
- The method quantifies potential users, not potential use types.
- Requires local knowledge of past uses, current management and potential within the current regulation plan.
- The current situation is that BYM has limited funds to manage small local forests (100 metersskoger).
- Knowledge of use potential within the regulation plan is not available to local groups.

Future work

- Clarify what M98 mapping will be used for by Oslo Municipality. To what extent will it be used to evaluate potential recreation value?

Overall assessment of method: spatial GIS-based data for criteria scoring is very suitable.

5 Valuation of recreation areas

The final value of recreation areas is based on the seven main criteria. A scoring scheme is summarized in **Table 1**. It follows the M98 Guidance.

Table 1 *Proposal for a scoring scheme*

Value	Recommended scale
A: Very important recreation area	Score 5 in at least one criterion. Generally high scoring.
B: Important recreation area	Score 3 or 4 in at least one criterion. Generally medium scoring.
C: Registered area	Score 2 in at least one criterion. Generally low scoring.
D: Unclassified area	Areas which were not scored A, B or C.

General score is expressed by the median score of both main and supporting criteria. It is classified into three groups:

- Generally high scoring: 3.6-5
- Generally medium scoring: 2.5-3.5
- Generally low scoring: 1-2.4

The requirement for "at least one score equal to value" is interpreted as the maximum score of any main criterion. We use **Table 2** to assign the final score:

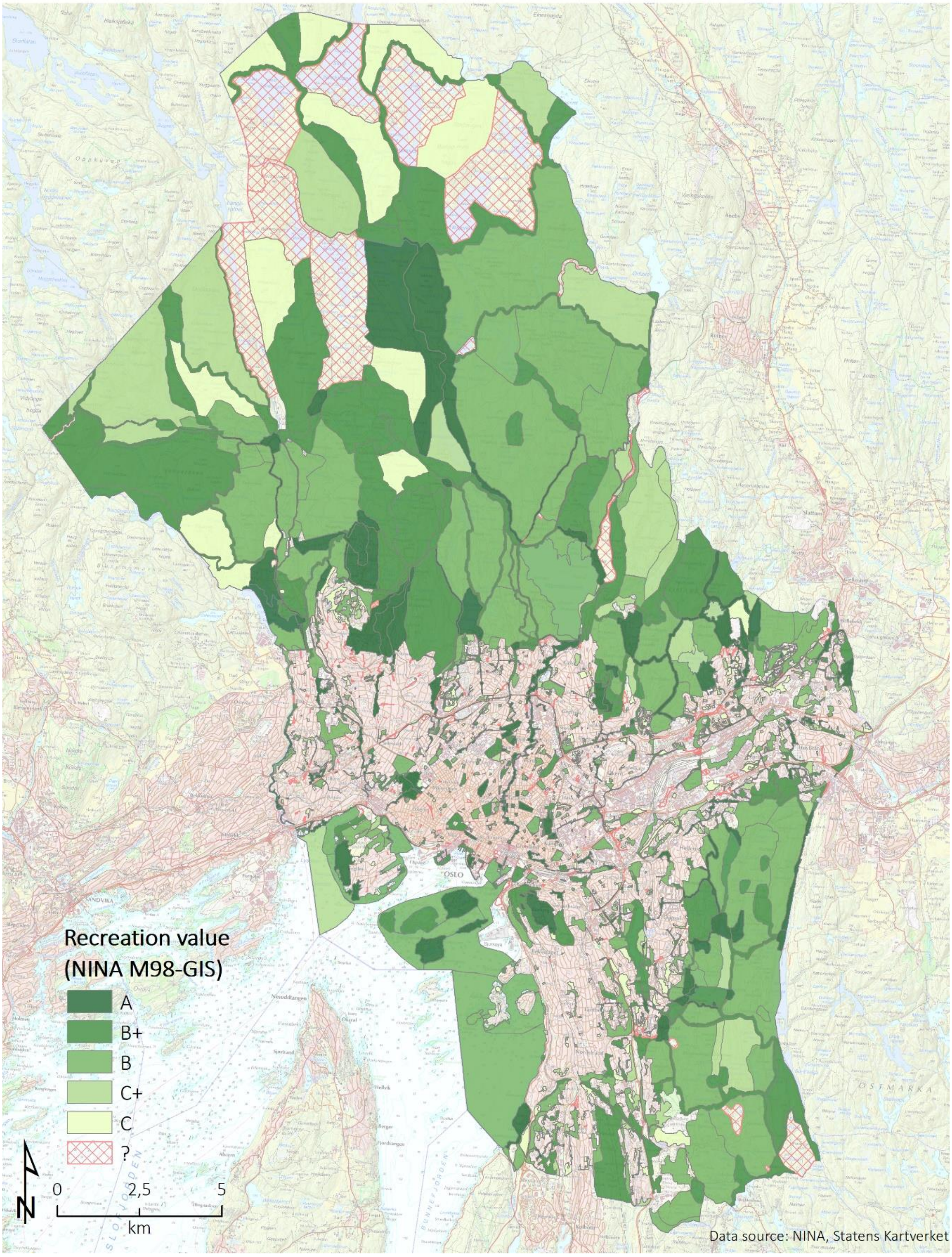
Table 2 *Alternative valuation function proposal for M98*

		Median score		
		3.6-5	**2.5-3.5**	**1-2.4**
Maximum score	**5**	A	B+	?
	4 or 3	B+	B	C+
	2 or 1	NOT PRESENT	C+	C

The scoring mechanism as suggested in the M98 Guidance does not explain combinations of high maximum score and low general scoring and other cases. As a temporary solution of this issue, an "intermediate" class (B+ or C+) is assigned. For combinations of very different scores, no class was assigned.

M98 valuation of recreation areas in Oslo municipality

Recreation value (NINA M98-GIS)



6 Discussion

6.1 Suitability of the M98-GIS method

In Chapter 5 we presented the results of NINAs GIS-based implementation of the M98 criteria (NINA M98-GIS method) and the evaluation by practitioners. Considering (i) simplicity of GIS calculations, (ii) data-driven rather than subjective-driven information and (iii) number of assumptions, we ranked the 13 criteria into (1) Very suitable for GIS, (2) Suitable for GIS or (3) Less suitable for GIS (**Figure 9**).

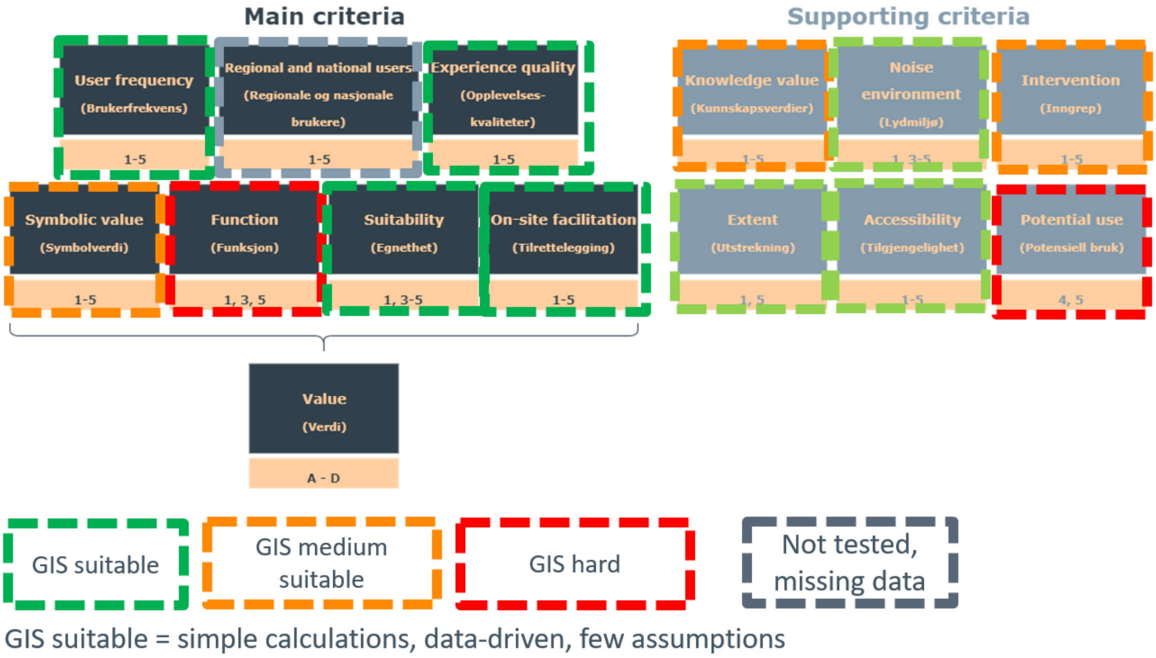


Figure 9 *Summary evaluation of NINA M98-GIS method*

In summary, our results and evaluation indicate that GIS-based methods could in most cases supplement and in some cases replace the supporting criteria. For the Main criteria, GIS-based methods are highly suitable for *user frequency* possible replacing subjective-based scoring. In our opinion, GIS-based methods could also provide support to local groups in evaluating *experience qualities*, *suitability* and *on-site facilitation* criteria. GIS-based approaches are less suitable for *symbolic value* and *function*; in the case of *symbolic value* because we lack theories about spatially defined characteristics upon which to base modelling. In the case of *function*, there is scope for modelling the connectivity of recreation areas using spatial modelling, but in the present definitions of M98 this is confounded with the recreation area class "green corridors".

6.2 Final recreation value

The aggregation of scores into a final score based on the maximum score of any main criterion is very sensitive towards computational inaccuracies in individual criteria. Moreover, a combination of high maximum score and low overall score (or the other way around) appears in 210 areas. The M98 Guidance does not provide a solution for this combination.

As mentioned at the beginning of this report, the way scores of individual criteria are aggregated to derive the final value of recreation areas – A, B or C – might moreover lead to accentuating the above-mentioned issues. Neglecting the inner variation of each criterion might lead to over- or underestimating the scoring and thereby to biased final values for recreation areas. In **Table 2** we proposed a matrix-based approach which is more transparent regarding the importance given to extreme values versus the spread (median) scores.

Also, analysing the surfaces and not areas and postponing the aggregation of observed criteria to the last step, would help to avoid this problem.

6.3 Correlation between M98 and ESTIMAP recreation models

The ESTIMAP is a model used widely within the EU at the European scale (Zulian et al., 2018). Applied at this scale it lacks ground-truthing or validation by local inhabitants. It was used in Oslo as an exploratory research method by Suárez et al. (2020). NINAs M98-GIS method is also based on spatial modelling but uses the criteria from the official Norwegian recreation area method, rather than the EU research-driven ESTIMAP method. For research purposes, we assess here to what extent the GIS-based ESTIMAP methods tell the same story as ground-truthed data.

A correlation between the M98 valuation of recreation areas and ESTIMAP Recreation valuation (Suárez et al., 2020) was assessed by means of correlation coefficients. In order to compare a value for entire recreation are, the ESTIMAP Recreation values – both Recreation potential (RP) and Recreation opportunity spectrum (ROS) – were aggregated by computing their average, sum and maximum in each recreation area.

The aggregated values of RP and ROS were correlated to the median, maximum and overall scoring of a recreation area using Spearman's correlation coefficient.

In all cases, the highest correlation occurs when the sum of RP / ROS values in a recreation area is compared. In addition, the largest correlation (0.62) was observed when using median scoring (i.e. median of all M98 valuation criteria) (**Table 3**).

The sum of ESTIMAP RP / ROS values in a recreation area is, unlike average, highly correlated to the size of the area. The higher correlation coefficient of sum rather than average implies that M98 scoring is to a large extent influenced by the size of a recreation area. This hypothesis is further confirmed when computing the correlation coefficient between the area and value of M98 recreation areas – the correlation coefficient is equal to 0.65.

Table 3 *Correlation of M98 and ESTIMAP recreation valuation*

	M98 Valuation		
	Median score	**Maximum score**	**Final score**
ESTIMAP Recreation potential			
Average	0.31	0.16	0.28
Sum	0.60	0.32	0.53
Maximum	0.44	0.24	0.38
ESTIMAP Recreation opportunity spectrum			
Average	0.22	0.10	0.18
Sum	0.62	0.30	0.53
Maximum	0.30	0.17	0.27

6.4 Correlation between participatory and GIS-based scoring

To what extent do valuation results of the GIS-based approach implemented by NINA and described in Chapter 5 coincide with the participatory valuation approach using local working groups implemented by Oslo Municipality?

Figure 10 shows the scoring of areas using participatory valuation method versus GIS-based method. There is a relatively high coincidence for very low (1.0) and very high scored areas (3.0). For areas of intermediate score, the GIS-based method tends to score criteria lower than the participatory method.

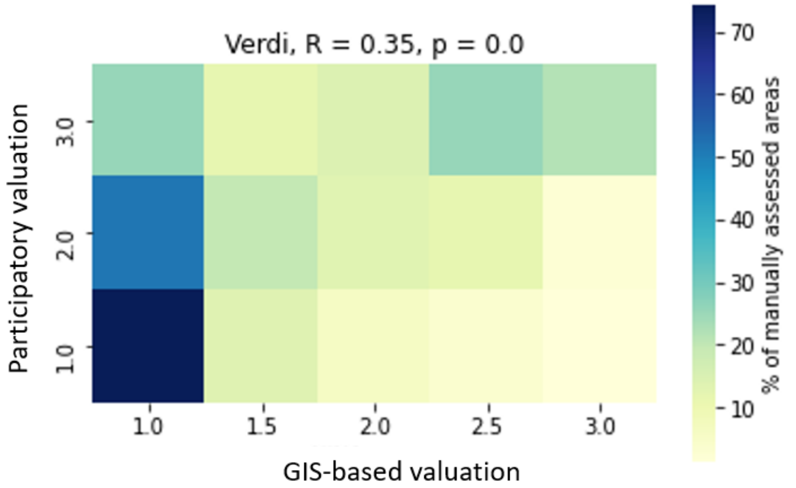


***Figure 10** Coincidence of participatory and GIS-based valuation*

As discussed above, the value of recreation areas in M98 is a combination of maximum scores and the general level of scores. **Table 4** compares the value of recreation areas using M98 participatory scoring by valuation groups with value category of recreation areas using GIS-based scoring.

***Table 4** Correspondence of recreation area value using participatory versus GIS-based scoring.*

		Value category using GIS-based scoring				
		A	B+	B	C+	C
Value category using participatory scoring	A	21,9 %	25,6 %	14,7 %	12,0 %	25,8 %
	B	2,6 %	12,1 %	13,7 %	20,0 %	51,6 %
	C	1,3 %	3,8 %	6,4 %	14,1 %	74,4 %

With perfect correspondence, we would expect to see 100 % in the diagonal cells for A and the sum of B/B+ and sum of C/C+. If we take the participatory method as the ground truth benchmark, the GIS-based method does well in identifying the lowest quality areas. We see a 88,5 % (14,1 %+74,4 %) correspondence in the valuation of C/C+ areas. For B/B+ areas, the GIS-based method only coincides win 25,8 % (12,1 %+13,7 %). For A areas, the coincidence is only 21,9 %. In fact, for areas classified as A using the participatory method, the GIS-based method is more likely to value the area as C (25,8 %) than A (21,9 %). Overall, we note that the GIS-based method could be used in an initial phase to pre-classify the poorest quality areas, in our case with only an 11,5 % error rate. This could be used to help local valuation groups focus on scoring/differentiating B and A value areas, thereby reducing volunteer time.

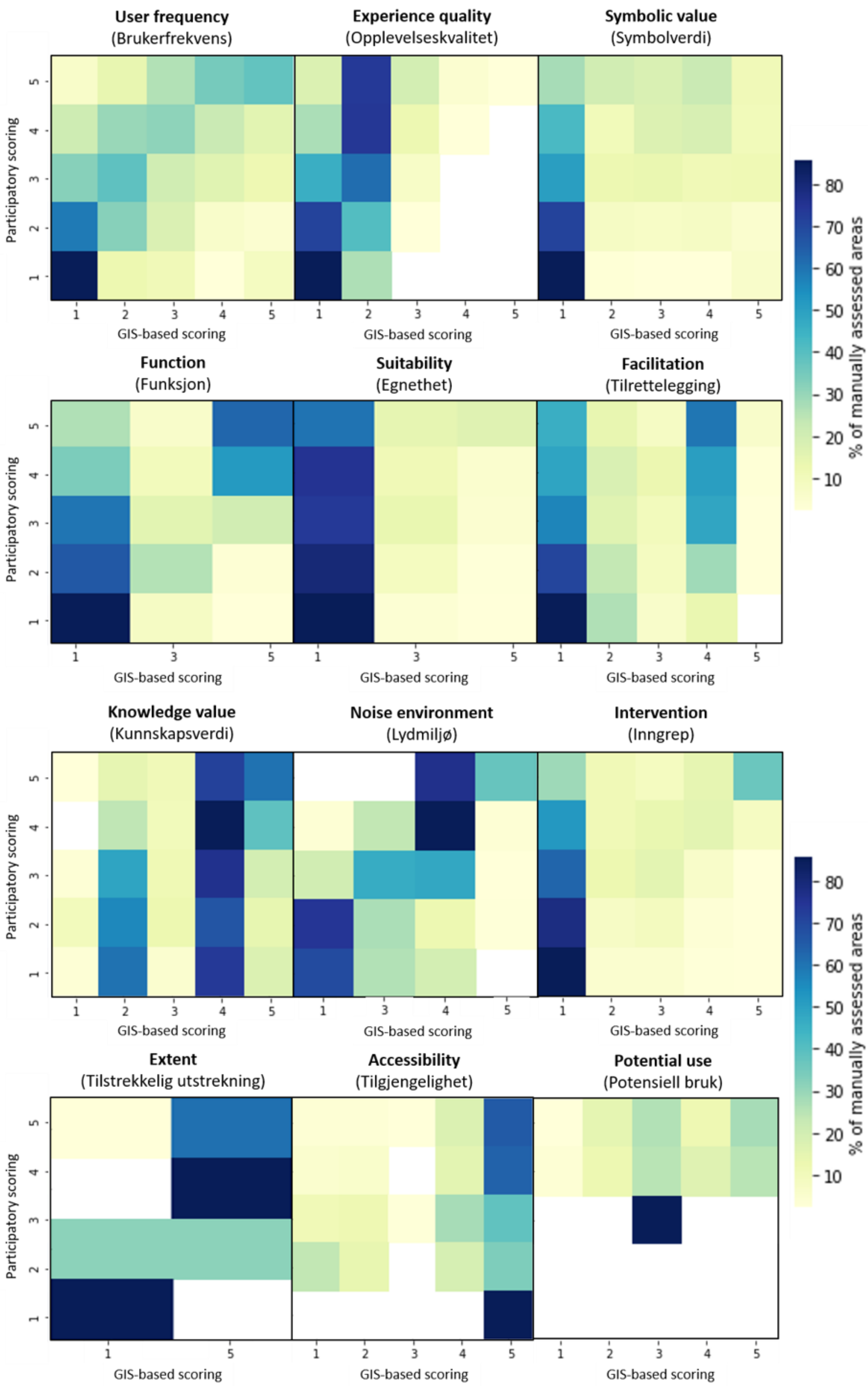


Figure 11 *Correspondence between participatory (manual) scores and GIS-based (NINA) scores criteria*

Figure 11 illustrates the correspondence in criteria scoring and for the 12 criteria we were able to implement using a GIS-based scoring method. The rank ordering of correlations between the participatory and GIS-based scoring methods is illustrated in **Table 5**.

Table 5 *Rank of variable correlations between participatory and GIS-based scoring methods*

Criterion	Correlation coefficient (Spearman)	Rank
User frequency	0,49	3
Experience qualities*	0,46	4
Symbolic value*	0,33	6
Function*	0,54	2
Suitability*	0,20	9
On-site facilitation*	0,26	8
Knowledge values	0,28	7
Noise environment	0,58	1
Intervention	0,41	5
Extent	0,04	11
Accessibility	0,19	10
Potential use	0,01	12

The observant reader will note that our recommendations in section 6.1 do not necessarily reflect the degree to which the GIS-based method can replicate the participatory scoring method. Why is this? For criteria requiring knowledge of conditions outside the recreation area in question and/or spatial relationships, we think the GIS-based criteria can improve the participatory method. Examples include *potential use* which is a function of the population living within walking distance (as well as site characteristics) and *accessibility* which is a function of road and path network leading to the recreation area.

The criterion *extent* is to consider whether the area is large enough for recreation. This was not evaluated in all recreation areas in participatory mapping in Oslo (scoring 5 if sufficiently large), whereas in GIS it was based on a statistical rule. This criterion is confounded with the initial step of identifying a recreation area (a decision has already been made that it is to be mapped, i.e. assumed sufficient for at least one unspecified use). The criterion also needs to specify the types of uses in order to be identifiable. We, therefore, suggest dropping *extent* as a supporting valuation criterion.

6.5 Looking forward: revising the recreation value function

The valuation function/lookup table (**Figure 4**) assumes no functional linkages between variables. All variables are assumed to be independent and of equal weight in determining recreation area value. As discussed in section 3, there are reasons to think that the individual criteria are in fact functionally related and therefore correlated. **Figure 12** provides a visualisation of possible functional relationships between variables. It assumes that *user frequency* and *regional and national users* depend on subjective experience criteria, on the situation making use possible and on actual characteristics of the site and the neighbourhood.

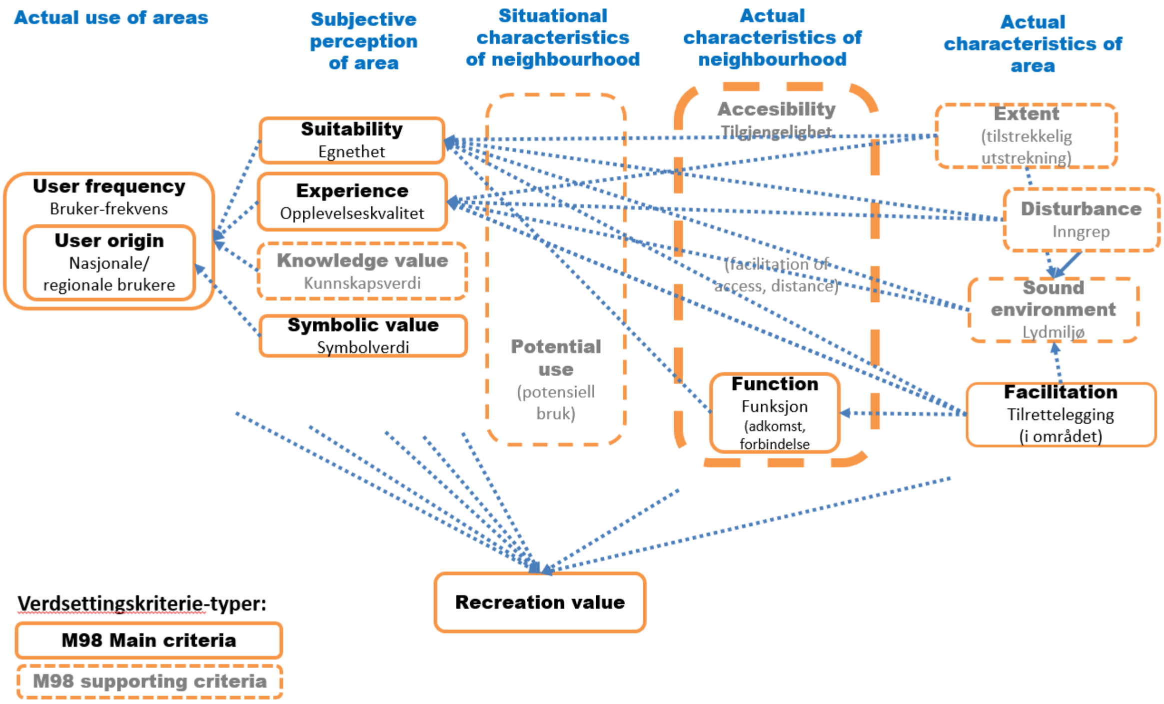


Figure 12 *Developing hypotheses about functional relationships between M98 recreation valuation criteria*

If functional relationships are identified between the M98 valuation criteria, a case can be made for simplifying the criteria system to those criteria that provide the most information about recreation value and to eliminate or recombine those that are correlated. By reducing the number of criteria, assessment time can be saved in the participatory process. Based on the logic of **Figure 12**, if *user frequency* strongly predicts value, then it may be a proxy e.g. for criteria about subjective perception of suitability and experience. Or in another hypothetical example, *suitability* criteria may, in turn, be explained by site *function* and *on-site facilitation* characteristics, rather than evaluated as three separate main criteria.

In the following example, we use a statistical network model to evaluate correlations between variables to test the relationships suggested in **Figure 12**. We also use statistics to do information value analysis (IVA) to find which criteria contain the most information about recreation value.

Figure 13 shows the data from Oslo's participatory recreation area valuation with some of the significant correlations between variables illustrated in the network. The network was built by letting the algorithms in the statistical model suggest causal patterns. The arrows are data-driven and not necessarily reflections of cause-effect directions. The purpose here is to illustrate that there is a lot of covariation between criteria and to suggest that some of the strongest of these "statistical overlaps" could be used to simplify the participatory valuation work in future.

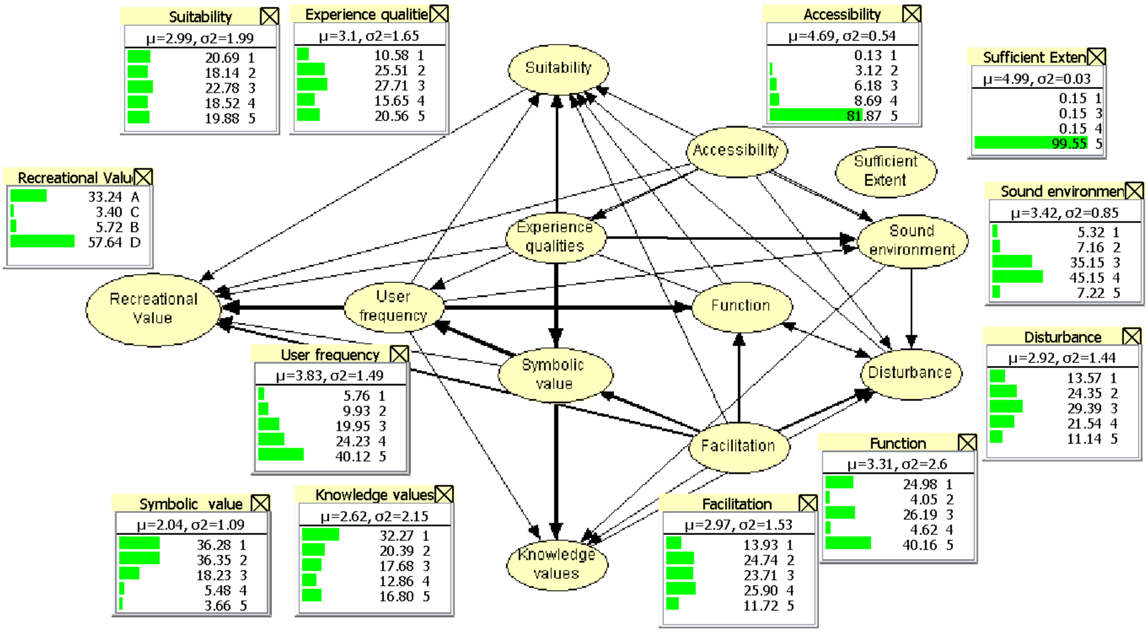


Figure 13 *A network model of the participatory recreation valuation data for Oslo showing some correlations between criteria (using Bayesian networks).*

Some superficial features to note in the network model;

- The subjective criteria *suitability*, *experience qualities*, *symbolic value* and *knowledge values* are correlated and they, in turn, are represented to some degree by the physical characteristics of the areas.

- *Extent* criterion has no significant correlation with other criteria. Looking at the distribution of the data in the node monitor next to it, we see that almost all areas were scored 5 by valuation groups, confirming the observation by the group coordinators that the criterion was not used/redundant. All identified recreation areas had sufficient *extent* for some kind of recreation activity. If a reference recreational activity is specified with some minimum mobility/space requirement defined, this criterion could easily be assessed using GIS.

- Similarly, *accessibility* has a very small variation with almost all areas scoring 5. This is another example of subjective assessment being inferior to spatial analysis. We can see that groups struggled to differentiate areas and ended up scoring over 80 % as most accessible.

- *Potential use* does not even identify in the model because it was evaluated in only 82 out of more than 1412 recreation areas. *Potential use* could be quantified by a population density and “service area” criteria using a spatial model prior and provided as supporting information to participatory working groups.

In **Figure 14** we show the results of a value of information (VoI) analysis (Kjærulff and Madsen, 2013) for all the criteria are considered in relation to the recreation value (A-D). VoI considers all the correlations between the criteria and the direct contributions to explaining recreation value. VoI expresses the relative amount of information one additional observation of a variable contributes to explaining recreation value relative to other variables.

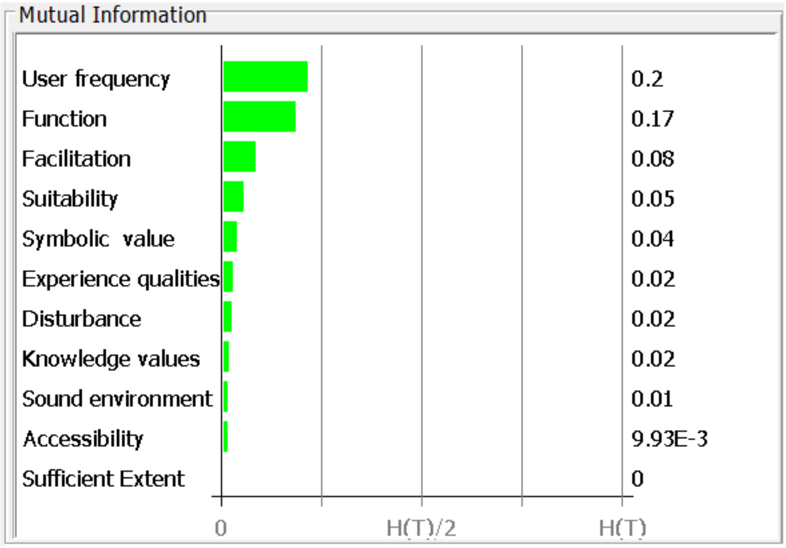


Figure 14 *Value of information analysis of criteria relative to recreation area value (participatory valuation)*

Figure 14 shows that local working groups time is twice as well spent determining *user frequency* or *function* compared to *on-site facilitation*. Determining *user frequency* is four times as effective as *suitability*; five times as effective as *symbolic value*; 10 times as effective as *experience qualities*, to mention the core criteria. Determining the supporting criteria *intervention* and *knowledge values* is as effective in terms of time spent as determining the core criterion *experience qualities*.As already stated using participatory valuation, to determine *accessibility* and *extent* is a waste of groups time relative to other criteria.

Table 6 *Spearman correlation coefficients for core criteria in M98 (Note: correlations in bold font are the three highest among core criteria and all r>0.5)*

	User frequency	**Experience qualities**	**Symbolic value**	**Function**	**Suitability**	**Accessibility**
User frequency	1.0000					
Experience qualities	0.1414 (0.0000)	1.0000				
Symbolic value	0.3827 (0.0000)	**0.6533** (0.0000)	1.0000			
Function	**0.5270** (0.0000)	0.0877 (0.0013)	0.2338 (0.0000)	1.0000		
Suitability	0.4339 (0.0000)	0.3791 (0.0000)	0.4682 (0.0000)	0.0997 (0.0002)	1.0000	
Accessibility	**0.5949** (0.0000)	0.0261 (0.3377)	0.2726 (0.0000)	0.3555 (0.0000)	0.4042 (0.0000)	1.0000

The above analysis supports the discussion in chapter 5 that some criteria could be dropped from the participatory process because they are represented well by other criteria. Table 6.5 reports the Spearman correlation coefficient between the 6 core criteria which were used in Oslo.

We see that *experience qualities* and *symbolic value* have the highest correlation (0.65). Challenges in distinguishing them and proposal for how to do so in practice were explored by Steder (2017) in Østmarka. An option is to remove the least well-defined criteria or combine them for the purpose of participatory valuation.

Furthermore, we see that *user frequency* explains over half of the variation in *function* and *accessibility*. This suggests that use statistics and spatial accessibility analysis may be good support for participatory groups to assess *function*.

6.6 Proposals for new recreation area criteria – nature visibility indices

Exposure to vegetation is one of the principle contextual qualities of recreation with positive effects for mental and physical health (Bratman et al., 2012; Keniger et al., 2013; Velarde et al., 2007). Vegetation cover has been shown to regulate the local ground temperature in Oslo, mitigating health exhaustion impacts of expected increases in the urban heat island effect with climate change (Venter et al., 2020b) (**Figure 15**). Vegetation cover and tree canopy cover has been shown to correlate with pedestrian and cyclist use of green spaces under the 2020 covid-19 mobility restrictions in Oslo (Venter et al., 2020a) (**Figure 16**). Regulation of air quality in Oslo has been shown to be the most economically valuable ecosystem service provided by urban tree canopy (Cimburova and Barton, 2020). Tree canopy can be mapped in detail in Norwegian urban areas using LiDAR data (Hanssen et al., 2021) (**Figure 17**). Visual exposure to tree canopy can be quantified and modelled as a "greenview index" e.g. based on street view imagery (Li et al., 2015) or using GIS-based modelling (**Figure 18**). Visual exposure to tree canopy can be mapped in discreet points as well as in continuous areas (Error! Reference source not found.). Greenview indices can be limited to tree canopy for recreation areas or extended to cover visibility of all vegetation in publicly accessible areas. Following similar thinking, a "blueview index" could be calculated for ground-level visibility of water surfaces in streams, ponds, fountains, lakes and Oslofjord in the built-up area. We propose that these nature visibility indices could be computed for the recreation areas classes currently in the M98 Guidance. In future, they could also extend the idea of recreation areas from polygons with boundaries to a surface gradient concept, as discussed in section 7.3. Tree canopy viewsheds would also constitute a basic dataset for urban ecological base maps (NBIC, 2020), as proposed in section 7.5.

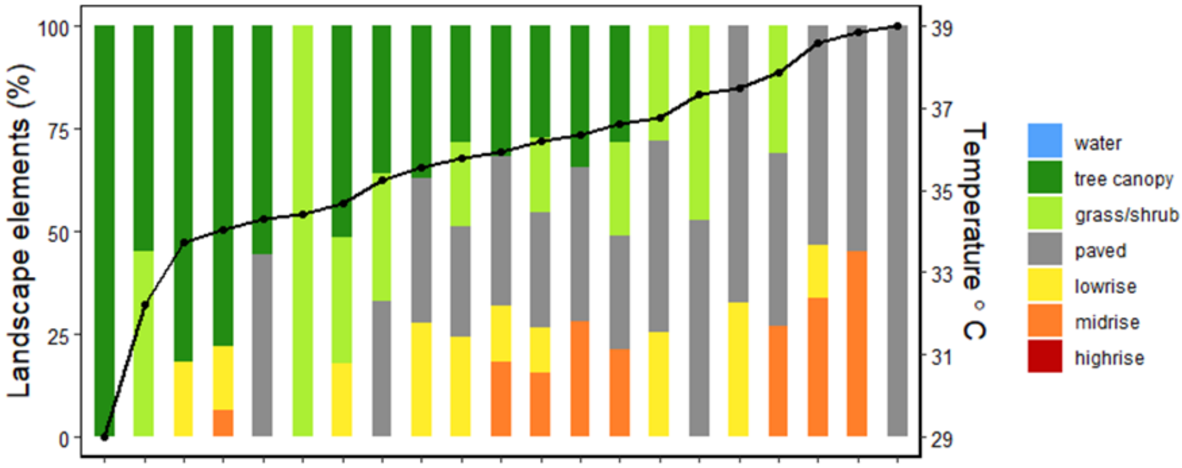


***Figure 15** Ground temperature regulation of vegetation cover in Oslo during the urban heatwave of July 2018 (Venter et al., 2020b)*

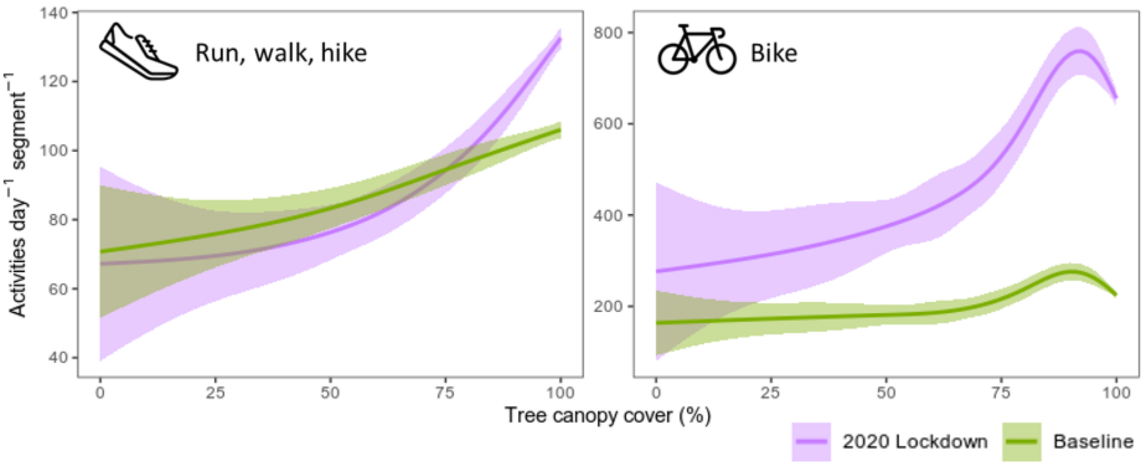


Figure 16 *Correlation between tree canopy cover and recreational mobility in Oslo based on STRAVA app data (Venter et al., 2020a)*

Figure 17 *Tree canopy can be mapped in detail in Norwegian urban areas using LiDAR data (Hanssen et al., 2021). Map source: Urban Nature Atlas https://nina.earthengine.app/view/urban-nature-atlas*

Figure 18 *Assessing visual exposure to tree canopy using GIS analysis*

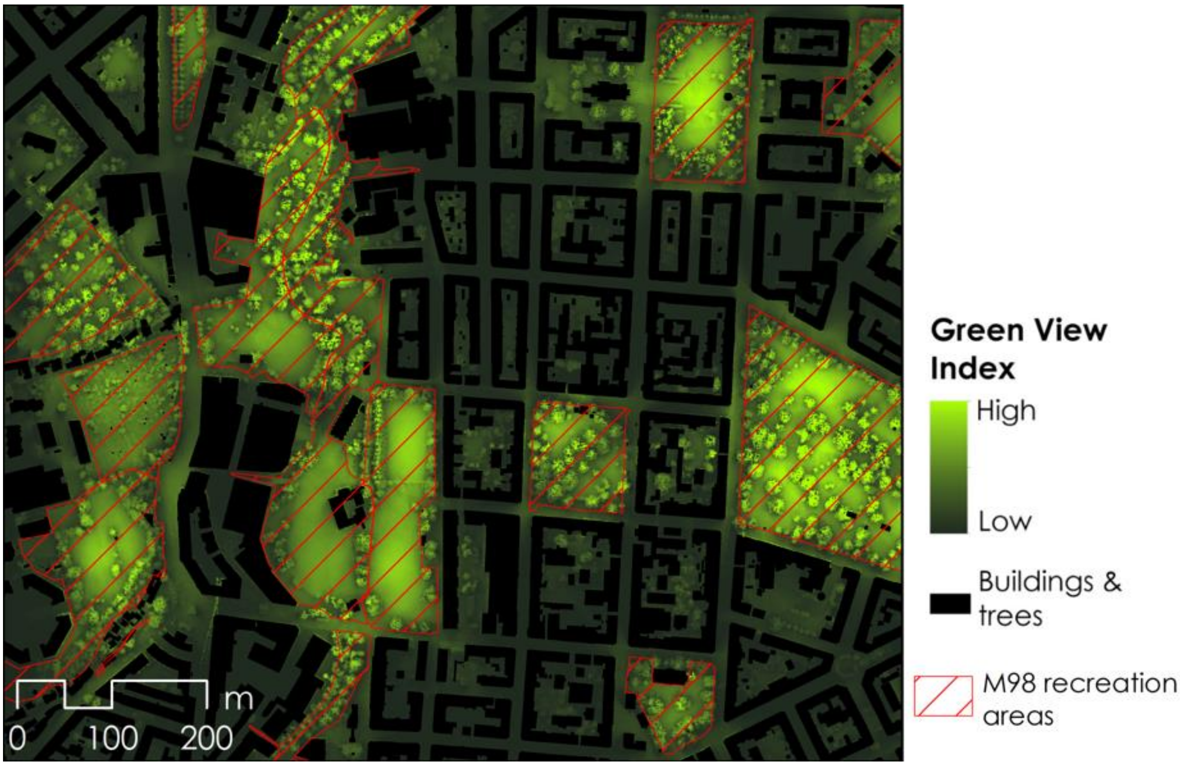


Figure 19 *Visual exposure to tree canopy mapped in continuous areas (here example from the neighbourhood of Grünerløkka). M98 recreation areas highlighted in red.*

7 Conclusions and recommendations

In this chapter, we summarise our recommendations regarding future scope for GIS-based scoring of recreation criteria. Since the focus of this report has been on GIS-based scoring methods for recreation, we highlight some outstanding spatial modelling questions that would need resolution. They speak to Oslo Municipality's initial delineation of recreation areas as input to the local working groups. These issues are also generally relevant for recreation mapping for the purpose of ecosystem accounting (Barton et al., 2019).

7.1 Scope for GIS-based scoring of M98 recreation criteria

Table 7 summarizes our experiences regarding the suitability of GIS-based scoring of M98 criteria as they are currently defined in the Guidance. Difficulties in spatial modelling are due to a lack of ideal spatial data, assumptions required to use available data, as well as technical challenges. In some cases, the M98 definitions are difficult to implement also in a participatory valuation setting. Where difficulties are mainly driven by lacking definition or data, we suggest possible revision options for the future.

Table 7 *Summary of the suitability of spatial modelling of M98 criteria*

Criterion	GIS feasibility	GIS feasibility Comment	Revision options to increase the future potential
User frequency Brukerfrekvens	Suitable	Calibrated mobility app user frequency density (STRAVA, possibly mobile GSM)	Further calibration of STRAVA data needed with path counters representative of recreation area types
Origin of users Regionale og nasjonale brukere	Not tested		Possibly in future user point of origin data from mobile GSM
Experience qualities Opplevelseskvaliteter	Suitable	Simple operations, data-dependent	
Symbolic value Symbolverdi	Medium	Requirements on data (names)	Drop/combine with experience value
Function Funksjon	Hard	Aggregation of hiking trails	Avoid confounding classification and scoring by using connectivity to identify "green corridors"
Suitability Egnethet	Suitable	Simple operations, data-dependent	
On-site facilitation Tilrettelegging	Suitable	Simple operations, data-dependent	
Knowledge values Kunnskapsverdier	Medium	Simple operations, data-dependent	Specify spatially observable definitions such as distance to school, species observation density
Sound environment Lydmiljø	Suitable	Simple operations, aggregation has to be defined	
Intervention Inngrep	Medium	Aggregation of interventions has to be defined	Use infrastructure intervention index
Extent Tilsrekkelig Utstrekning	Suitable	Geometry-driven approach	

Accessibility Tilgjengelighet	Suitable	Simple operations, aggregation has to be defined	
Potential use Potensiell bruk	Hard	Requirements on data (users)	Define in terms of population density within a service area

7.2 Delineation of recreation areas

The individual criteria scores are to a large extent dependent on the delineation of recreation areas. From a spatial modelling point of view, the scoring methodology requires a score of particular criterion to have a low variation within an area. If the variation of a score within an area is high and it needs to be aggregated, the resulting value (e.g. an average) might not be representative.

A possible solution would be to depart from the spatial distribution of scores and use these to delineate areas with a low inner variation. These would then represent an alternative delineation of recreation areas (**Figure 20**).

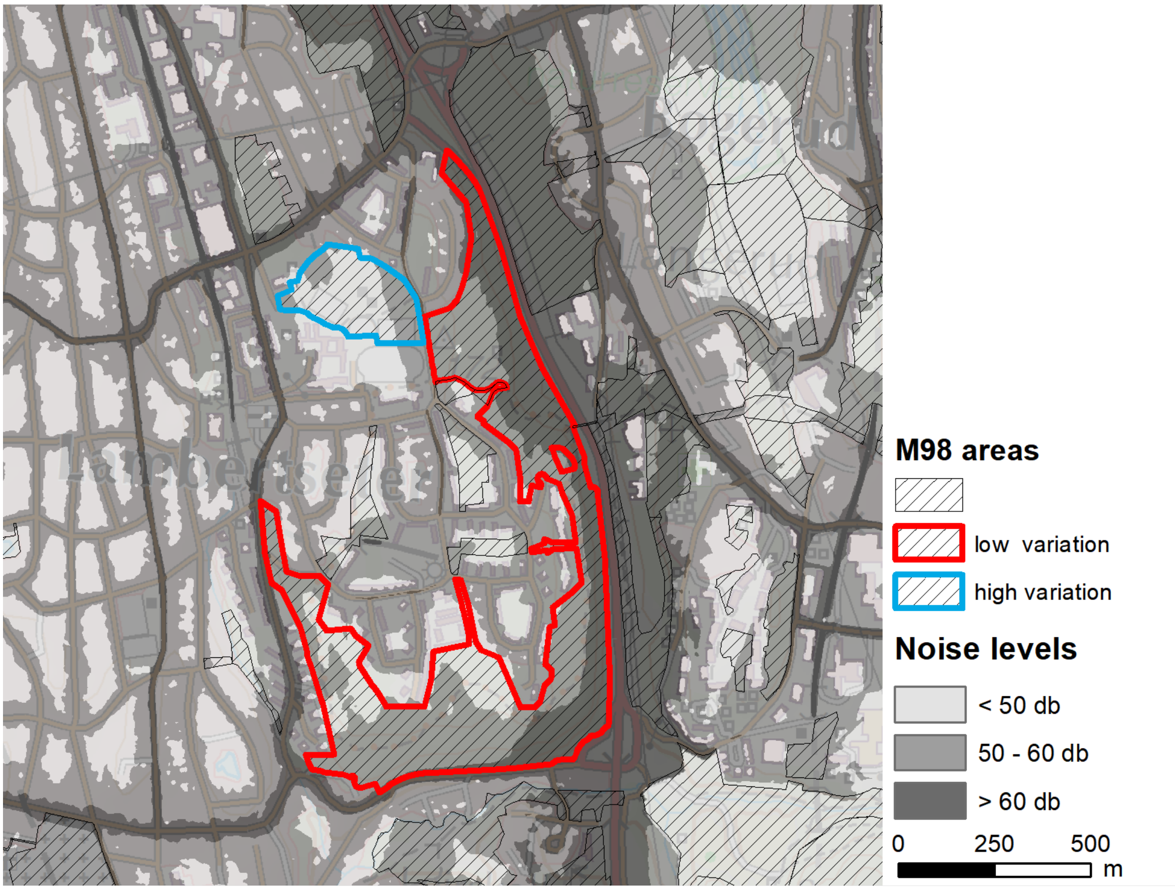


***Figure 20** Illustration of areas with low (blue) and high (red) variation of observed criterion* (noise environment*).*

7.3 Scoring approach

Due to the issues described above, the current scoring approach is more adaptable for spatial evaluation of surfaces (individual pixels) than entire recreation areas. Valuation of surfaces would ease the modelling of spatially varying phenomena such as noise, distance from public transport or level of intervention and at the same time allow for modelling of influence zones of facilities and attractions. An influence zone of a feature might be more suitable compared to counting its simple presence/absence. The surroundings of a feature (e.g. canyon) might benefit from its presence. This phenomenon might be particularly interesting when a feature is located close to a border between two areas – both the intersecting area and neighbouring area might benefit from the presence of a feature.

The way scores of individual criteria are aggregated to derive the final value of recreation areas – A, B or C might moreover lead to accentuating the above-mentioned issues. Neglecting the inner variation of each criterion might lead to over- or underestimating the scoring and thereby to a biased scoring and valuation. Analysing surfaces and not areas and postponing the aggregation of observed criteria to the last step would help to avoid this problem.

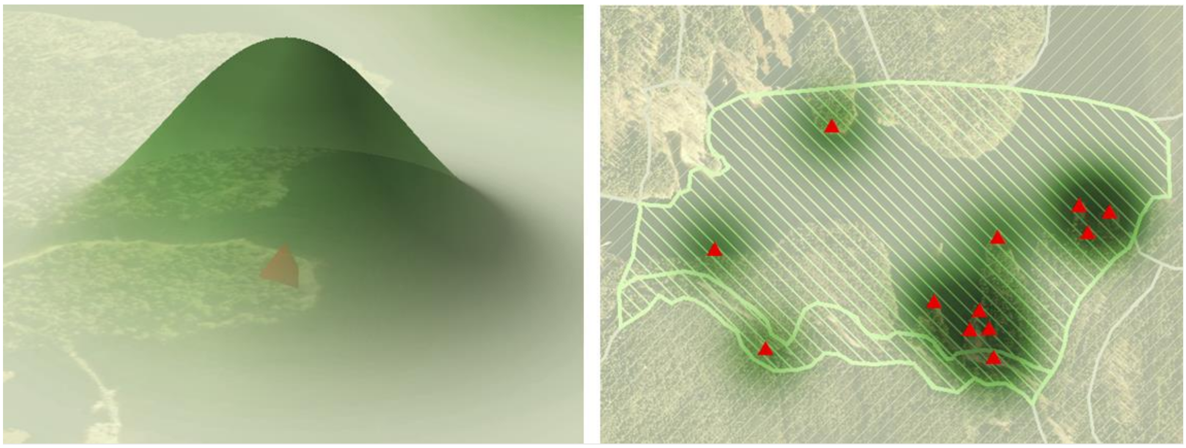
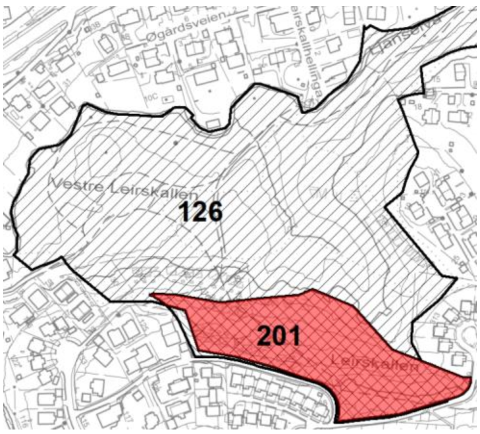


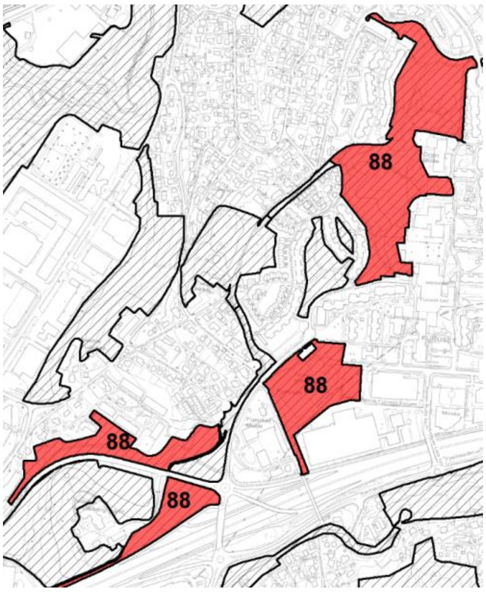
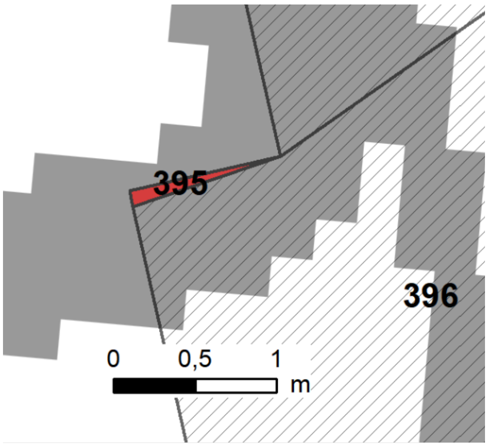
Figure 21 *Illustration of surface valuation method. Each facility (red triangle) creates an influence zone. Nearby facilities create overlapping influence zones.*

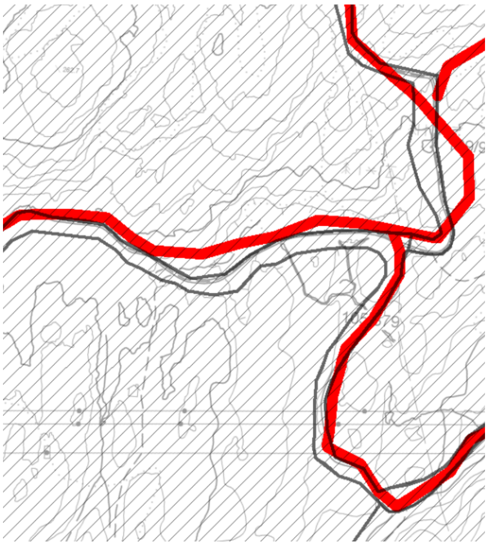
7.4 Geometry issues

The current spatial representation of recreation areas suffers from several geometry issues. These should be tackled before an analysis is carried out in order to avoid issues such as double counting (due to overlapping recreation areas) or over-scoring (due to very small areas). These issues are also generally relevant in ecosystem extent mapping and accounting for urban areas. In Oslo Municipality's final recreation area map, these are expected to be resolved. An overview of the issues is provided in **Table 8**.

Table 8 *Geometry issues in mapping the extent of recreation areas*

Issue	Illustration	Why is it a problem	Solution
Intersec-tion		Double counting of features located in overlap	Draw common border

Multipart		Individual parts might have different values	Split to single-part
Self-intersection	-	Might cause issues in analysis	Remove self-intersections
Gaps		Does not represent reality	Fill gaps
Small areas		Does not represent reality	Delete or merge with neighbouring areas

Poor delinea-tion		Leads to incorrect counting of features	Delineate properly or use surfaces instead of areas

7.5 Prospects for urban ecosystem accounting of recreation services

In this last section, we argue that the M98 Mapping and Valuation methodology of the Norwegian Environment Agency can be understood as ecosystem condition accounting for recreation services within the UN System of Environmental and Economic Accounts (SEEA) Ecosystem Accounts (EA) (UN, 2020). Barton et al. (2019) discussed recreation services mapping and valuation in the context of SEEA EA. Havinga et al. (2020) reviewed methods for mapping cultural ecosystem services for the purpose of ecosystem accounting. **Figure 22** sketches the conceptual potential of developing M98 system into inputs to ecological base maps for Norway (NBIC, 2020), municipal and national ecosystem accounts.

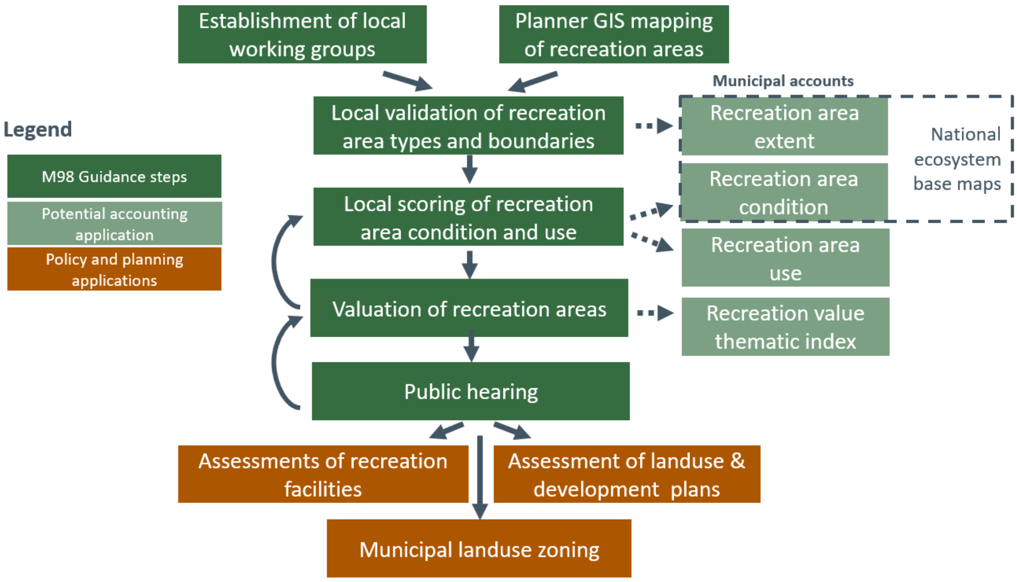


Figure 22 *Potential for developing M98 mapping and valuation of recreation areas into municipal and national ecosystem accounts for Norway*

In light of the above studies, M98 can be seen as a hybrid ecosystem condition and recreation service mapping approach. Norway's M98 approach is currently "only" a recreation mapping qualitative valuation method. It is unique among national experiences with recreation mapping in being conducted at the municipal level, using local participatory methods and/or public consultation. When it is repeated periodically, the M98 Guidance methodology will have the potential to satisfy the basic requirement for national accounting purposes for both recreation ecosystem extent, condition and physical service accounting. Ecosystem condition and service accounting periodically will be facilitated by using GIS and spatial methods. Monitoring systems for actual user frequency will meet the requirements for physical recreation use accounting. The M98 recreation area value can be understood as a thematic indicator within a wider "dashboard" of indicators at the national level generated based on ecosystem accounts. Spatial mapping of user frequency will also go a long way to strengthening policy and planning applications of M98. We also see M98 recreation area types and selected characteristics as contributing to fill the information gap on ecosystem condition of urban areas in the ecological base map for Norway (NBIC, 2020). The proposals in section 6.6 for tree canopy height and cover, vegetation cover, water surfaces and their ground-level visibility, are an example of such urban ecological base maps.

8 Appendix – M98 valuation criteria

Each criterion is assessed and modelled separately. Where possible, we tried to follow the M98 Guidance and rules for suggested scoring.

The translation of the M98 Guidance to English is provided at the beginning of each section. Section Method outlines the analysis procedure and section Data summarizes the used sources of spatial data. Section Points of decision provides an overview of the main methodological and data source questions, often referring to the overall questions and recommendations from the beginning of the report.

8.1 User frequency (Brukerfrekvens)

Whether a recreation area is a lot or a little used is important for the value of the area. It is also important if the area can be developed to be widely used. Furthermore, one should consider whether it is seasonal variations or daily variations.

The extent of use is relative. For example, a "Small Use" area in Oslo could have many more users than a "widely used" area in Rendalen. There may also be variations between activities and seasons. Areas that are mainly used by children and young people often become very important as they have a short range of action and cannot move far to find a similar area.

8.1.1 Evaluation

	1	2	3	4	5
How large is the current user frequency?	Small	Some	Medium	Relatively large	Large
Operationalization **It is difficult to estimate the number of outdoor users in an area.** **Therefore it is proposed to provide a type description of the use, which says something about whether the area is little or widely used.**	Recreation area where you rarely or never meet others.	Recreation area where you usually meet a few other users.	Recreation area used by more users, but where there may be seasonal variations, variations between weekend and working day and daily variations.	The recreation area is used by many throughout the year, but there may be variations between weekend and working day and daytime variations.	The recreation area is used by many, all year round, both weekdays and weekends.

8.1.2 Method

User frequency was modelled as a density of activities carried out over 2019 within a recreation area. The activity count is registered in STRAVA data which NINA has recently gained access to. The activity count number reflects the total number of individual activities over the entire year and is associated with a segment of Open Street Map path. We included all three types of activities used in STRAVA – pedestrian, winter and ride.

Path segments were first intersected by recreation areas and activity counts were recalculated proportionally to an eventual decrease in segment length. Then, the total number of activities within each area was calculated by summing activity counts from all paths segments within that area. Finally, activity density was calculated by dividing the total number of activities by the total surface area of the recreation area.

Scoring was assigned by classifying resulting density of activities into 5 classes of equal counts (quantile classification).

8.1.3 Data

We have used yearly aggregation of STRAVA data (edges_rollup_year_total) and extracted all activity types for 2019. We then joined the count data to the spatial dataset of Open Street Map paths (norway_osm_20191217).

Alternative datasets:

- Alternative 1: Density of OSM public GPS traces scaled to 1-5
- Alternative 2: density of INSTAGRAM and Flickr photos (we don't have this data)

8.1.4 Points of decision

8.1.4.1 Methodology

Two important methodological decision points should be considered. First, expressing *user frequency* as either counts or density will lead to different scoring (aggregation problem). In this exercise, we used the latter option because, in our opinion, density better reflects general differences in *user frequency* between areas, while counts would to a large extent be affected by the size of recreation areas. Second, resulting densities can be classified using various methods (scoring problem). In this exercise, we use a data-driven approach and assign scores 1-5 to an equal number of recreation areas. Thus, the scoring cannot be e.g. used to compare recreation areas outside the spatial extent of this exercise. Different classification methods would lead to different scoring.

8.1.4.2 Data

Activity counts in STRAVA data only represent a fraction of the total number of visits in recreation areas. However, if the counts are highly correlated to the total actual number of visits, i.e. if the data allow for relative comparison between areas, the impact on final scoring should be low.

8.2 Regional and national users (Regionale og nasjonale brukere)

Who uses the area and where do they come from? Is the area used mainly by locals or are most users from a larger region or large parts of the country?

8.2.1 Evaluation

	1	2	3	4	5
Use of area by people who are not local?	Never	Seldom	Medium	Quite often	Often
Operationalization	The recreation area is used exclusively / principally by persons living in surrounding residential areas.	The recreation area is used primarily by persons living in surrounding residential areas, in other residential areas of the district.	The recreation area is used primarily by persons living in surrounding residential areas, in other residential areas of the district or in neighbouring districts.	A large proportion of those who use the recreation area lives in other districts or outside Oslo.	A large proportion of those who use the recreation area lives in other districts, outside Oslo or in other parts of the country. The area is also used by tourists.

8.2.2 Method

Due to missing data, this criterion was not modelled.

8.2.3 Data

We do not seem to have any relevant data source.

8.3 Experience qualities (Opplevelsekvaliteter)

Central to the definition of outdoor life lies the experience aspect. Features such as **cultural monuments**, **special natural phenomena**, **landforms**, **landscaping and nature**, **cultural landscapes** are important to outdoors practitioner. The experience qualities must be clearly visible in the landscape so that they are available to recreational practitioners.

8.3.1 Evaluation

	1	**2**	**3**	**4**	**5**
Does the area have special natural or cultural history experiences?	No	Little	Medium	Relatively many	Many
Does the area have a special landscape?	No	Some	Medium	Relatively large	Large
Operationalization Whether the outdoor life is considered to have "no", "little", "medium", "relatively many" or "many" special natural or cultural-historical experience qualities is affected to a certain extent by the size of the area. Can also use "none, anything, medium, large and large" to visualize the areas where there are individual / few experience qualities, but where these are of a certain size or importance to the area's use.	Cultural heritage e.g. old buildings, bridges/constructions, war memorials, historically important places, etc. Cultural elements e.g. related to agricultural landscapes, such as rock walls/fences, flower beds, etc. Special nature / biology e.g. special species-rich areas, fairy-tale forests, etc. Special geology/landscape formations e.g. such as "giants kettle", canyons, caves, fossils, special bedrock, etc. Viewpoints / water				

8.3.2 Method

Experience qualities are expressed as an index of a number of quality elements present within a recreation area. We count the number (occurrence) of both point and polygon features within each recreation area. Moreover, when two points from distinct layer are located closer together than 10 m (implying they could be duplicates), only one of them is taken into account.

To assign scores, we use natural breaks classification. The recreation areas were categorized so that areas with no features obtain score 1, areas with less than three features obtain score 2, areas with less than six features obtain score 3, areas with less than 14 features obtain score 4 and areas with more features obtain score 5.

8.3.3 Data

Data from BYM, Kartverket (FKB), Riksantikvaren and OSM were combined in order to collect a representative dataset of features expressing *experience qualities*.

8.3.3.1 Cultural heritage

E.g. old buildings, bridges/constructions, war memorials, historically important places, etc.

OSM		**BYM**		**FKB**		**Riksantikvaren**	
Points of interest		**-**		**N5 text points (_0301_tekst1000_punkt)**		**Kulturminner – Lokaliteter**	
code	**fclass**	fountain		**Description**	**NAVNTYPE**	**all**	

2723	monument	sculpture		Tømmerrenne	202		
2724	memorial			Fløtningsanlegg	204	**Kulturminner – SEFRAK buildings**	
2725	artwork			Gammel bosetting-splass	206	**all**	
2731	castle			Offersted	207		
2732	ruins			Melkeplass (sæterplass uten hus)	224	**Kulturminner – FREDA buildings**	
2733	archaeolog-ical			Annen kulturdetalj	225	**all**	
2734	wayside cross						
2735	wayside shrine			**N5 text points (old)**			
2736	battlefield			**all**			
2737	fort						
2904	fountain						
2955	lighthouse						
2962	water_well						
2963	water_mill						

Relevant Points of Interest from Open Street Map were selected. Some questionable points of interests were excluded (e.g. windmill, water well) due to their unclear positive/negative effect on *experience qualities*. These can be added after discussion.

8.3.3.2 Cultural elements

E.g. related to agricultural landscapes, such as rock walls/fences, flower beds, etc.

OSM		**BYM**		**FKB**		**Riksantikvaren**	
-		**GUA_Nature_A**		-		-	
		Flowerbeds					
		Old big trees					

8.3.3.3 Special nature / biology

E.g. special species-rich areas, fairy-tale forests, etc.

OSM		**BYM**		**FKB**		**Riksantikvaren**	
-		**Firy-tale forest**		-		-	
		all					

8.3.3.4 Special geology/landscape formations

E.g. such as “giants kettle”, canyons, caves, fossils, special bedrock, etc.

OSM		BYM		FKB		Riksantikvaren	
Natural Features		-		-		-	
4101	spring						
4112	cliff						
4132	cave entrance						
4141	beach						

The occurrence of fairy-tale forest is used. This means that an area gets a +1 higher score in case a fairy-tale forest is present. There is developed and tested a separate model for registration of fairy-tale forests (Gundersen et al., 2011), including the presence of landscape elements (e.g. stone, canyon), forest structures (e.g. old trees, multi-layered canopy) and landscape features (steepness, recreational facilities). Løset et al. (2012) field monitored and reported in all 32 potential fairy-tale forest areas in Oslo using this methodology.

Features *glacier*, *volcano* from OSM were excluded for obvious reasons. Feature *peak* was excluded because both significant and insignificant peaks are recorded in OSM, the latter often being forested and not creating attraction. Feature *tree* was excluded, because individual trees are mapped very randomly and the result is not representative. Feature *mine* was excluded due to its unclear positive/negative effect on *experience qualities*.

8.3.3.5 Viewpoints / water

OSM		BYM		FKB		Riksantikvaren	
Points of interest		**Utsiktspunkt**		**N5 text points (_0301_tekst1000_punkt)**		-	
2742	viewpoint	Not used		Not used			
2950	tower						
2953	observation tower						

8.3.3.6 Other

OSM		BYM		FKB		Riksantikvaren	
Points of interest		-		**N5 text points (_0301_tekst1000_punkt)**		-	
2721	attraction			**Description**	**NAVNTYPE**		
				Severdighet	208		

8.3.4 Points of decision

8.3.4.1 Methodology

The methodology if affected both by aggregation problem and by the scoring problem. The aggregation problem concerns both point features (count or number per unit area) and line and polygon features (number, number per unit area or unit per unit area). The scoring problem occurs because the scoring classes are not predefined and scoring is derived from the relative value of recreation areas.

8.3.4.2 Data

The accuracy, as well as the availability of data, is crucial to model this criterion. A decision about including/excluding a dataset might lead to substantial differences in results.

Furthermore, it is not clear whether some data sources should be included – such as fountains and sculptures (as cultural elements). From the definition, it is not clear whether viewpoints and water bodies should be used and if so, whether these should be combined.

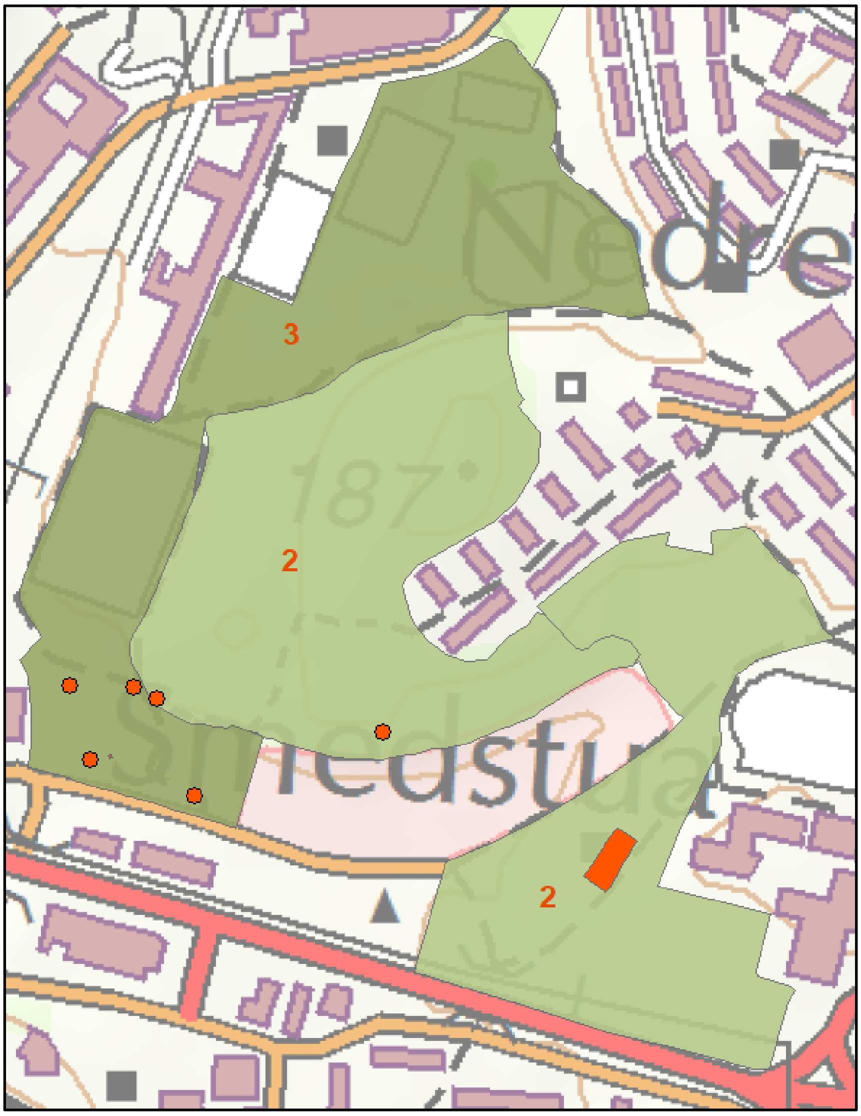


Figure 23 *Illustration of methodology for* experience qualities *criterion. The leftmost area contains four point features and one very small polygon feature. The final scoring is 3 (medium). The middle area contains two point features. The final scoring is 2 (little). The rightmost area contains one polygon feature. The final scoring is 2 (little).*

8.4 Symbolic value (Symbolverdi)

A recreation area may be important for people's sense of belonging or having long traditions as a destination. Such an area becomes more valuable than a corresponding area without this symbolic value. Landmarks, such as high and/or old trees or historical memorials, can help give an recreation area a symbolic value.

8.4.1 Evaluation

	1	2	3	4	5
Does the area have special symbolic value?	No	Little	Medium	Relatively many	Many
Operationalization	The recreation area has no special symbolic value and is not known to anyone other than residents living in surrounding areas.	The recreation area is a famous tourist destination for the people in the district.	The recreation area is well known and is of great importance to the population in the district and nearby districts.	The recreation area has long traditions as a tourist destination and is well known to most people living in Oslo.	The recreation area has long traditions as a tourist destination and is well known also outside of Oslo.

8.4.2 Method

In this criterion, we slightly diverge from the suggested evaluation methodology. Our assumption is that the higher the symbolic value of a place, the higher the density of local place names. Names of natural features (rivers, lakes, marshes, valley), as well as cultural features (tourist hut), are considered.

Most of the names refer to point features and in this case, the number of names in an area is considered. Names of water bodies (rivers, lakes, streams) refer to the entire area/line and in that case, each particular name is assigned to appropriate water body and counted as one in each intersecting area. In the end, the density of place names, that is the number of place names divided by the area, is computed.

To assign scores, we use quantile classification. The recreation areas were categorized so that areas with no features obtain score 1, areas with less than 4.7 place names per square kilometer obtain score 2, areas with less than 8 place names per square kilometer obtain score 3, areas with less than 18.6 place names per square kilometer obtain score 4 and areas with more place names per square kilometer obtain score 5.

8.4.3 Data

BYM Stedsnavn dataset was used as the source of local place names. An overview of used categories is provided in the table below, along with their spatial representation form.

Norsk	English	Type	Norsk	English	Type
Badeplass	Bathing place	Point	Jorde	Field	Point
Bekk	Stream	Line	Kai	Quay	Point
Berg	Hill	Point	Li	Lia hillside	Point
Dam	Pond	Point	Mo		Point

Dal	Valley	Point	Myr	Swamp	Point
Elv	River	Line	Nes	Headland	Point
Foss	Waterfall	Point	Nes i sjø	Headland in sea	Point
Gammel bosetting-splass	Old settlement	Point	Os		Point
Gard	Farm	Point	Park	Park	Point
Gravplass	Graveyard	Point	Pytt	Pool	Point
Haug	Hill	Point	Skar		Point
Holme	Island	Point	Skog	Forest	Point
Holme i sjø	Sea island	Point	Sund	Channel	Point
Høyde	Height	Point	Sund i sjø	Channel in sea	Point
Søkk	Depression	Point	Utmark		Point
Terrengdetalj	Terrain detail	Point	Vann	Water	Polygon
Tjern	Pond	Point	Vik	Bay	Point
Tjern i gruppe	Group of ponds	Point	Vik i sjø	Bay in sea	Point
Turisthytte	Tourist hut	Point	Ås	Hill	Point
Øy i sjø	Island in sea	Point	Øy	Island	Point

8.4.4 Points of decision

8.4.4.1 Methodology

Similarly to the *experience qualities* criterion, the methodology if affected both by aggregation problem and by scoring problem. The aggregation problem concerns both point features (count or number per unit area) and line and polygon features (number, number per unit area or unit per unit area). The scoring problem occurs because the scoring classes are not predefined and scoring is derived from the relative value of recreation areas.

8.4.4.2 Data

The accuracy and selection of data are crucial to model this criterion. A decision about including/excluding a place name category might lead to substantial differences in results. Special care needs to be taken when counting place names of area or line features, such as water bodies. In this case, the name refers to the entire object and there might be several areas overlaying the object. In general, all place names refer to an area feature, but due to the scale of analysis, most of them may be generalized as point features.

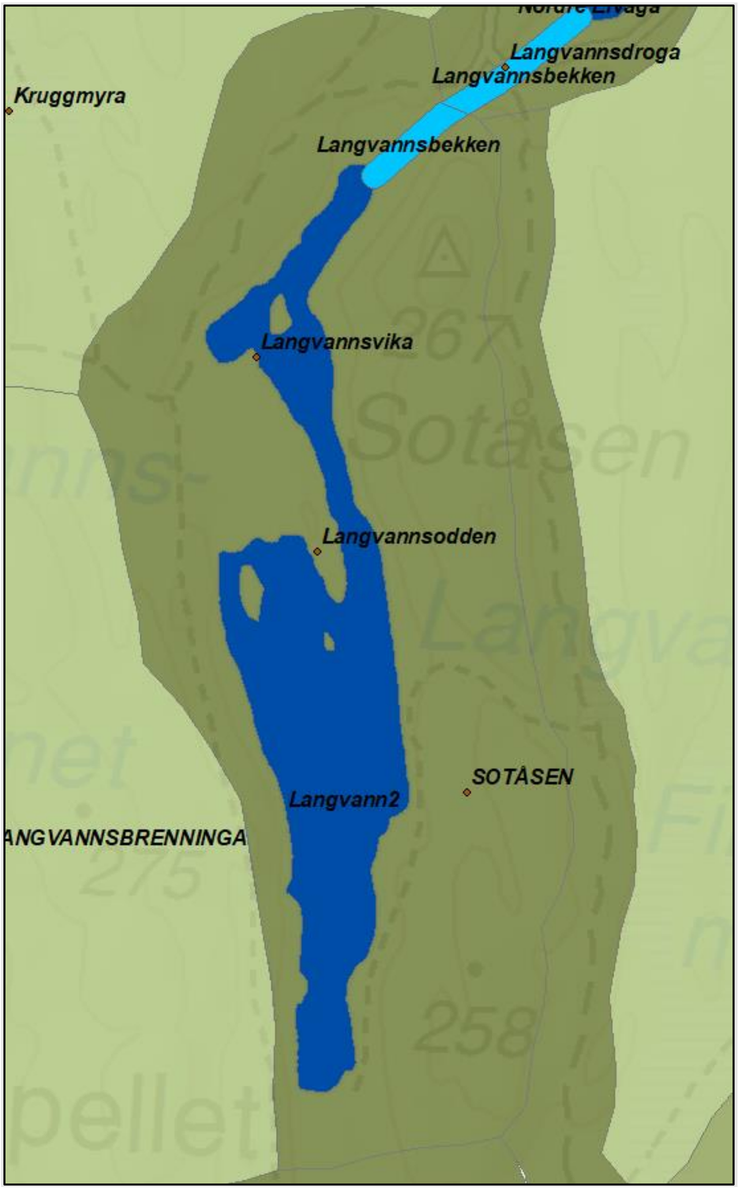


Figure 24 *Illustration of methodology for* symbolic value *criterion. The recreation area in the middle contains three names of point features (Sotåsen, Langvannsodden and Langvannsvika), one name of a stream (Langvannsbekken) and one name of a lake (Langvann).*

8.5 Function (Funksjon)

Function refers to features that support the use of adjoining recreation areas. Entrance zones, green corridors and (main) hiking trails are important features. These features create context (connectivity) between recreation areas and may therefore increase the use/benefit of an adjoining recreation area. It may be a useful exercise to imagine what will happen if the outdoor area is removed.

8.5.1 Evaluation

	1	2	3	4	5
Does the area have a special function (entrance zone, main hiking trail, corridor etc.)?	No special function	Some special function	Medium function	Rather special function	Special function
Operationalization	The recreation area has no special function.	-	The recreation area serves as an access zone but is not organized like this. Or: The recreation area is a hiking trail that creates cohesion in the trail network.	-	The recreation area is organized as an access zone to another recreation area. Or: The recreation area is a main hiking trail.

8.5.2 Method

To model the *function* criterion, individual methods were applied for each of scores 1, 3, 5.

8.5.2.1 No special function – Score 1

Score 1 is given to all areas which do not fall into the categories below.

8.5.2.2 Medium function – Score 3

Access zone not organized like access zone

To model access zones, a layer of “entrance areas” (Innfallsporter til marka) was used. If the recreation area intersects this layer, it is scored 3. A limit needs to be set for minimum coverage of an access zone in a recreation area. This can be either limit area or limit area ratio. In this exercise, we set a rule that at least 50 % of a recreation area must be defined as an entrance area in order to give this area score 3.

A hiking trail that creates cohesion in the trail network

There are (at least) two different methods of how to evaluate cohesion.

The first idea is that if an M98 area contains paths with high betweenness, this area creates cohesion between the recreation areas. Betweenness is a measure of centrality. It is an approximation of *user frequency* – it computes, how many times each segment occurs on the shortest path between any vertices (crossroads).

In the first step, segments suitable for walking are selected from N50 transport routes. The topology of this path network is cleaned using QGIS RCL Cleaner. For example, the disconnected segments are deleted. Before running the analysis, the geometry of part network is simplified with 10 m tolerance. On this cleaned and simplified network, a choice (betweenness) centrality is computed using Space syntax toolbox for QGIS.

A decision needs to be made about how to aggregate the betweenness of paths in each area. It is possible to compute the average betweenness of all paths (omitting the total length of paths and the size of the area), weighted (weight = length of path) average betweenness of all paths (omitting size of area and distribution of betweenness values), an average of betweenness per by unit area or the occurrence or sum of the length of paths with betweenness above a certain threshold. There are many other ways of aggregation.

In this exercise, we computed the weighted average of betweenness (weight = length of path) in each M98 area and gave score 3 to areas containing paths with above-average betweenness. In order to avoid geometry inaccuracies, we consider only segments which are further than 10 m from the border of a recreation area and at the same time are longer than 10 m.

The second idea to model cohesion is that if a recreation area borders many other areas, it creates cohesion. A neighborhood statistic is computed and the number of neighbors is stored (10 m tolerance). The number of neighbors is counted and those areas having more than an average number of neighbors are scored 3.

A similar question to the betweenness modelling occurs, i.e. how to decide what large enough number of neighbors is.

In this exercise, we used the betweenness measure to assign score 3.

8.5.2.3 Special function – Score 5

If a recreation area is classified as a “green corridor”, i.e. it is managed according to the function, it is given score 5.

This method is rather questionable because a collision between functional classification (area type) and scoring (criterion) occurs.

8.5.3 Data

To compute betweenness, selected categories of N50 transport routes were used. Namely, the following classes of attributes are selected:

- Objtype = Gangsykkelveg,
- Objtype = Sti,
- Objtype = Traktorveg,
- Objtype = VegSenterlinje,
- Vegkategori = Fylkesveg,
- Vegkategori = Kommunal veg,
- Vegkategori = Privat veg.

Furthermore, “aktivitetssoner” and “entrance areas” were used to model access zones.

8.5.4 Points of decision

8.5.4.1 Methodology

The modelling of *function* criterion opens a number of methodological questions. We decided to use “entrance areas” to approximate access zones. This data source might be however considered inappropriate. Regardless of the data source for access zones, a decision about the minimum overlap between an access zone and a recreation area needs to be made. If only a small part of a recreation area serves as an access zone, shall this recreation area be classified as an access zone? And shall the decision be based on minimum percentage or minimum area?

To model cohesion in the network, we use the betweenness measure. This is a scientifically recognized technique for modelling *user frequency*. However, it is up for discussion, how the betweenness measures for individual path segments shall be summarized. We are using an arbitrary threshold for minimum betweenness value, but other aggregation methods may be useful as well. We also suggest an alternative approach based on the count of neighboring recreation areas.

Moreover, using the functional classification of recreation areas to assign score 5 is pointing at the issue of double counting.

8.5.4.2 Data

“Aktivitetssoner” might not be a good approximation of access zones.

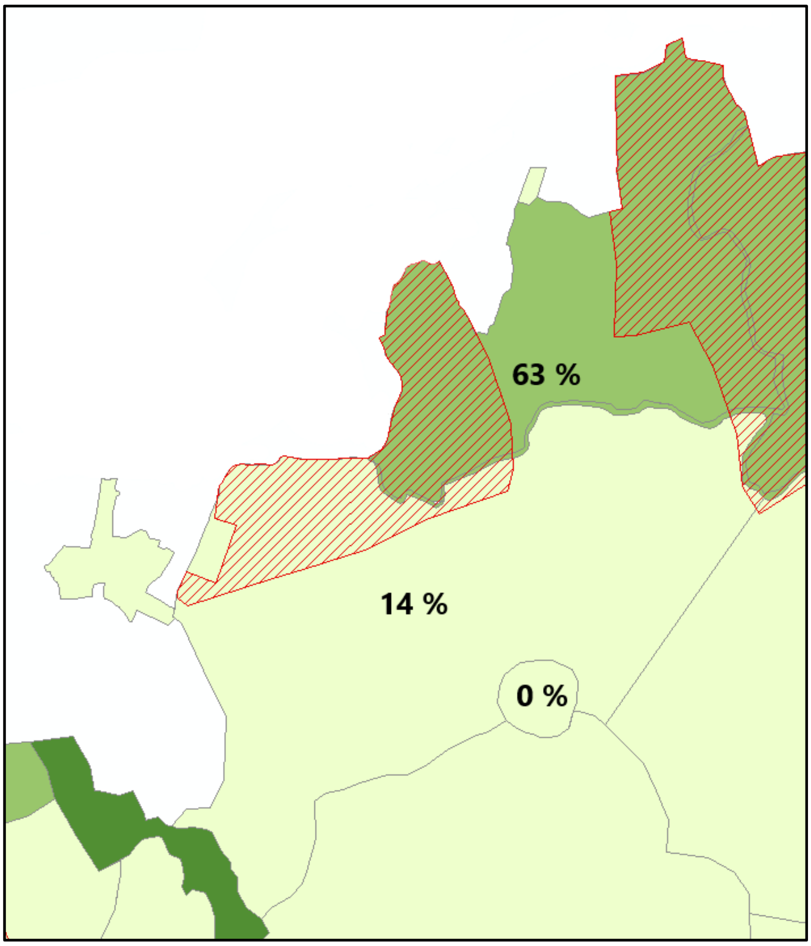


Figure 25 *Illustration of score 3 – access zones. Recreation areas (green) overlapping with “aktivitetssoner” (red) by more than 50 % are scored 3 (medium green). Recreation areas overlapping with “aktivitetssoner” by less than 50 % are scored 3 (light green).*

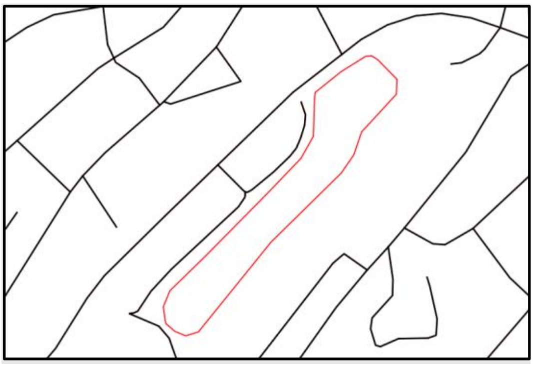


Figure 26 *Illustration of path topology cleaning*

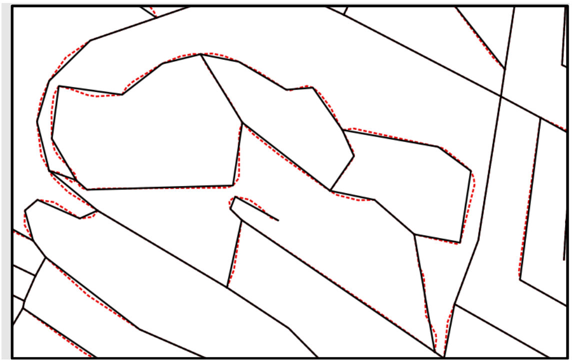


Figure 27 *Illustration of path geometry simplification*

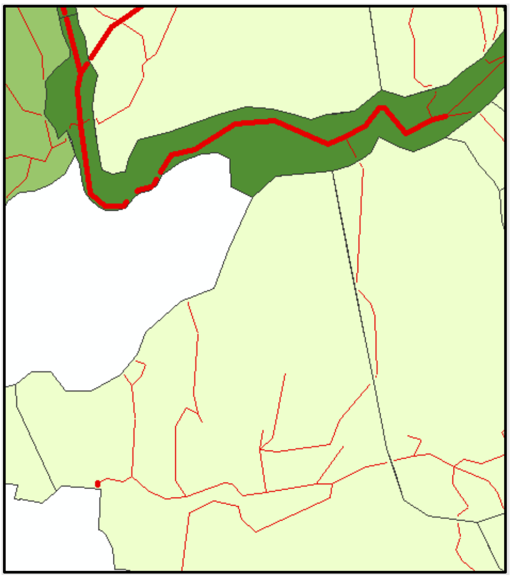


Figure 28 *Illustration of modelling cohesion in the trail network. Thick lines represent paths with above-average betweenness. M98 areas containing paths with above-average betweenness are scored 3.*

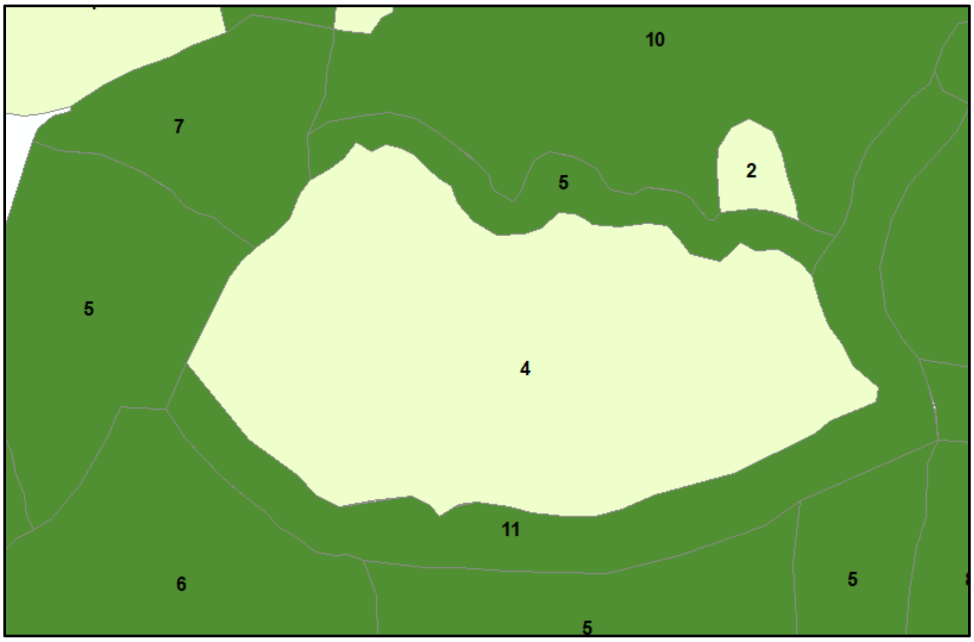


Figure 29 *Illustration neighbour count. Areas with more than 4 neighbours are scored 3, areas with less than 4 neighbours are scored 1.*

8.6 Suitability (Egnethet)

Suitably means whether a recreation area may be used for one or more specific outdoor activities. The suitability of an area is of particular importance if there are no alternative recreation areas for this / these activities in the neighborhood. Climbing is an example of an activity that is dependent on special areas and becoming unavailable makes it difficult to exercise the activity. There are usually physical/landscaping qualities in the areas that make them suitable for special activities.

8.6.1 Evaluation

	1	2	3	4	5
Is the area particularly suitable for one or more individual activities, which has no alternative nearby?	Bad	Rathe bad	Medium	Rather good	Good
Operationalization	The recreation area is not suitable for a particular single activity.	-	The recreation area can be used for one or more specific single activities, but there are other recreation areas in Oslo that are more suitable for this / these activities.	-	The recreation area is particularly suitable for one or more specific single activities and there are no alternative recreation areas that are equally suitable for this / these nearby activities.

8.6.2 Method

The methodology follows the M98 Guidance for scoring the *suitability* criterion.

Each activity place is assigned to a specific recreation area. Same activities within the same recreation area are dissolved. Afterwards, the existence of identical activities within 1 km neighborhood of activity is observed. If an identical activity exists, the observed activity is assigned score 0 – it is not unique. If there is no identical activity within 1 km neighborhood, the observed activity is assigned score 1 – it is unique.

A recreation area is assigned score 1 if it contains no special activities, score 3 if it contains at least one special activity, but none of these is unique and score 5, if it contains at least one special activity and at least one of these is unique.

8.6.3 Data

BYM datasets were supplemented by Open street map. Datasets with a question mark in the table were considered but not used in the analysis.

M98 suggestion	BYM temadata	OSM data
Mountain biking	- (only cycle paths available)	
Riding	-	Bridleway (OSM roads 5151)
Climbing	Fritid/Klatrefelt	-

Bathing	Lakes?	-
Fishing	Fritid/Fiske_krepsevann	-
Shellfish Collecting	-	-
Sledding / ski play	Fritid/Akebakke, off pists?	-
Activities on ice	Fritid/Isbane	-
Canoeing / rowing / sailing	Fritid/Roklubb	-
	Fritid/campingplass	
	Fritid/friomrade_hund	
	Idrettsanlegg/fotballbaner	
	Skog/Idrettsomrader_marka	
	Uncategorized/football, handball	

8.6.4 Points of decision

8.6.4.1 Methodology

Several decisions influence the scoring. First, the precision and accuracy of spatial representation of activities are crucial, especially for line features. In the proposed methodology, a limit of 100 m is set to take a linear activity (riding, biking) into account. If less than 100 m of riding or biking path occurs within a recreation area, such activity is not taken into account. At several cases, paths are mapped on the border between two recreation areas and it is not obvious which area they belong to (**Figure 30**).

Second, the size of a neighborhood needs to be decided to consider the activity as unique. Finally, a decision needs to be made whether to compute uniqueness in the neighborhood of an area or of an activity.

8.6.4.2 Data

The selected set of special activities might differ based on the definition of *suitability*. In this exercise, we included the natural features which make a place suitable to perform an activity. However, the border between *suitability* and *on-site facilitation* is thin and these two scored need to be assessed with special care.

Where should locations of e.g. Roklubb, Campingplass, Idrettsanlegg_marka, Fotballbaner be included?

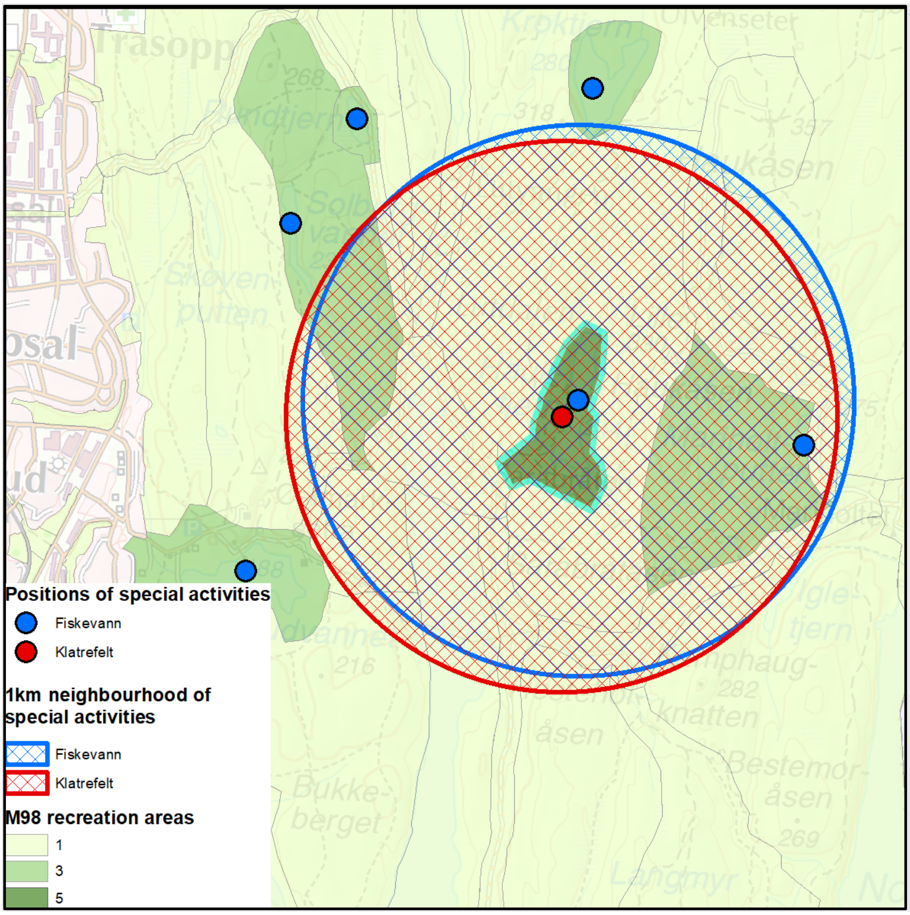


Figure 30 *Illustration of scoring of* suitability *criterion. The highlighted recreation area contains two special activities – climbing area (red) and fishing water (blue). Climbing activity is unique because there are no other climbing opportunities in 1km neighbourhood. Fishing activity is not unique, because one other fishing water exists in 1km neighbourhood. The highlighted recreation area is scored 5 because an opportunity for at least one unique activity exists. Other recreation areas containing fishing waters (blue) are scored 3 – they contain special activities, but none of these is unique. Recreation areas which contain no special activities are scored 1.*

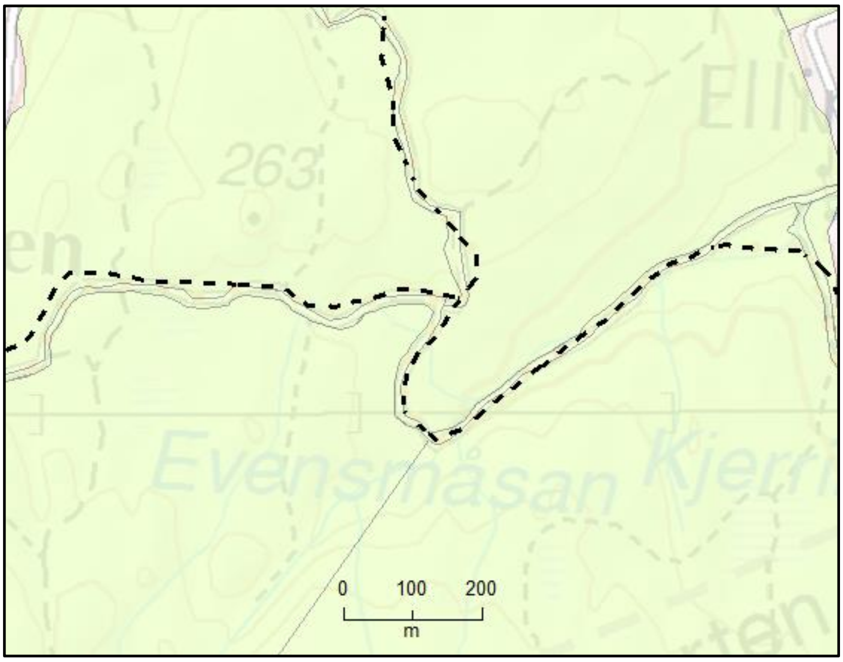


Figure 31 *Illustration of the influence of inaccurate geometry. Which recreation area does a biking path belong to?*

8.7 On-site facilitation (Tilrettelegging)

Outdoor life has long been achieved without much adaptation, but recently it has been invested to facilitate special activities and user groups. Areas where major investments have been made to facilitate **accessibility for disabled people**, for example, will be valuable to take care of. In Oslo, it has also been necessary to arrange more recreation areas in order for them to withstand considerable use.

8.7.1 Evaluation

	1	2	3	4	5
Is the area organized for special activities or groups?	Not facilitated	Little facilitated	Moderately facilitated	Well facilitated	High degree of facilitation
Operationalization	The recreation area is not organized.	E.g.: Sign-posted and marked trails and one-track ski tracks Klopper, smaller bridges Bathing places where the vegetation is cleared away.	E.g. Sign-posted and marked trails and dual-track ski tracks Bathing places with smaller piers, bathing stairs and less cut lawns	E.g. Sign-posted and marked trails and dual-track ski tracks that are well maintained and operated Adjustment-laying measures such as benches, tables, fireplaces, grills, toilets and/or activity items. Ongoing management as vegetation management and waste management.	Examples as below value 4. In addition, the area is adapted for mobility-impaired, child-cars and the like.

8.7.2 Method

Each facility is assigned a score from 2 to 5 based on the level of facilitation it provides – according to the evaluation table.

Facilities are then intersected with recreation areas and the occurrence of facilities and the sum, mean, minimum and maximum of scores are recorded. In the case of line features, only segments longer than 100 m are considered. At the current solution, the maximum score of all contained facilities is recorder as the final score for *on-site facilitation*.

8.7.3 Data

The main source of data is BYM temadata. Feature classes which represent any sort of facilitation are selected. BYM temadata were supplied by OSM points of interest. Features of similar categories were filtered so as to avoid double counting. Moreover, N50 dataset was used to supply information about marked and lighted paths and bridges.

BYM temadata	Score	BYM temadata	Score	OSM points of interest	Score	N50 Samferdsel	Score
Fritid/Badeplass	2	Fritid/skiloyper_upreparert_andre	2	Tourist info	2	Sti, merking = JA	2

Fritid/Informasjon-stavle	2	Fritid/sykkelruter_marka	2	Tourist map	2	Sti, medium = L (bridge)	2
Drift/Avfallsbeholdere	4	Fritid/tursti_byggesonen	2	Tourist board	2	Lysloype	3
Fritid/Fastgrill	4	Fritid/tursti_kommune-skogen, Type = Natursti, Kulturminnesti, Kultur-landskapsti	2	Tourist guidepost	2		
Fritid/Hytter	4	Fritid/kyststi	2	Picnic site	4		
Fritid/Lekeplass	4	Fritid/pilgrimsleden	2	Toilet	4		
Fritid/markastue	4	Fritid/skiloyper_prepa-rert, TOSPOR = Nei, 2015	2	Bench	4		
Uncategorized/Drink-ing fountain	4	Fritid/skiloyper_prepa-rert, TOSPOR = Ja, 2015	3	Playground	4		
Uncategorized/Exer-cise equipment	4	Fritid/tursti_kommune-skogen, Type = Sti for bevegelseshemmede	5				
Uncategorized/Sitting	4						
Uncategorized/WC	4						
Samferdsel/Sykkel-parkerin	4						
Skog/God-kjente_ildsteder	4						
Idrettsanlegg/Svøm-meanlegg, Frilufts-bad	4						
Fritid/Smabathavner	4						
Fritid/Badeplass, HC-	5						

8.7.4 Points of decision

8.7.4.1 Methodology

The summarization of scoring of individual facilities has a significant impact on the resulting *on-site facilitation* score. In the example, the maximum score of all overlaid facilities is recorded. However, in case an area contains a single facility with score 4, should that area be scored higher than a second area with many facilities of score 3? In other words, does the number and distribution of scores of facilities influence the final scoring? In addition, the aggregation problem occurs.

8.7.4.2 Data

As mentioned in the *function* criterion, the border between *suitability* and *on-site facilitation* is thin and these two scored need to be assessed with special care.

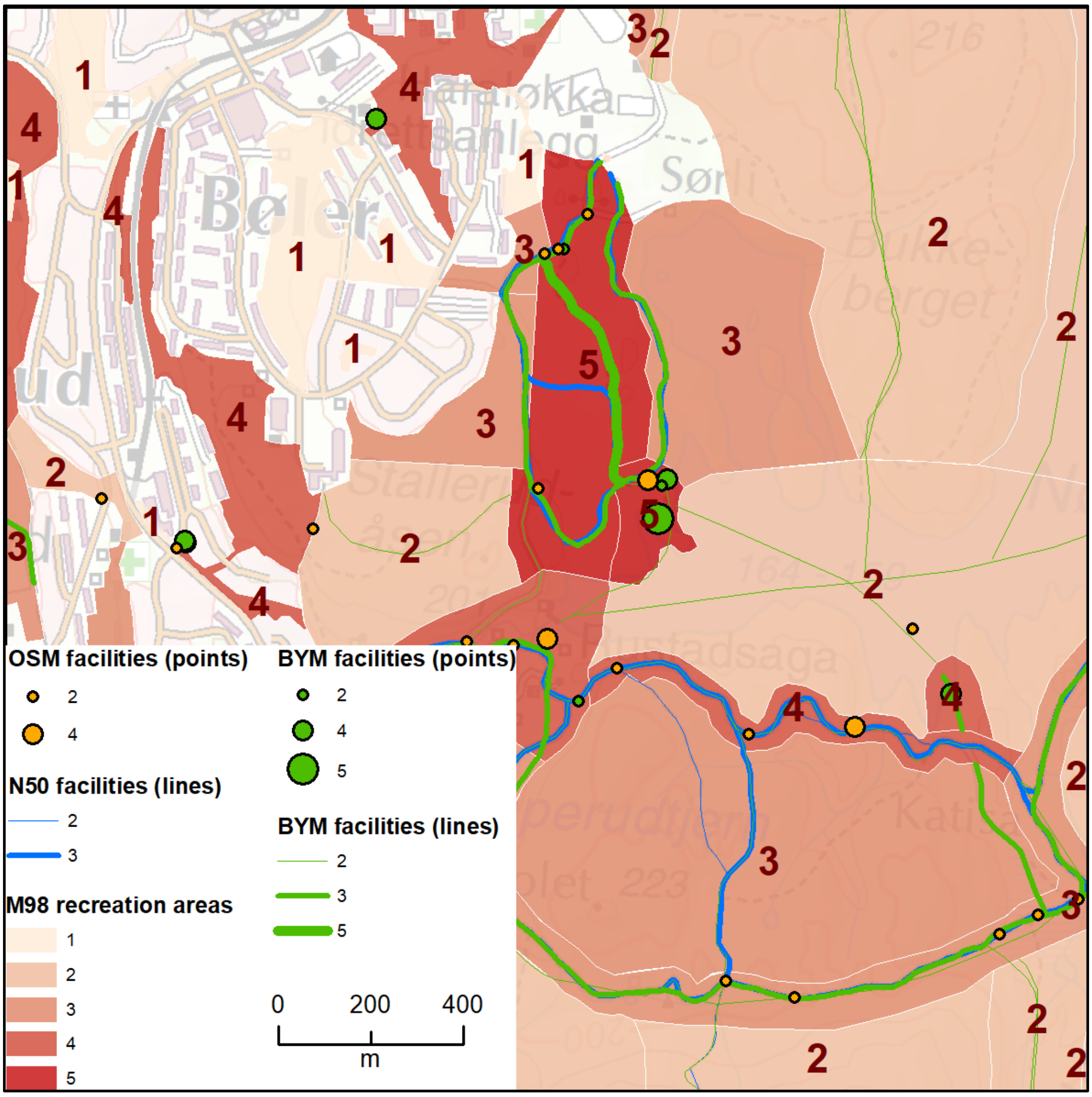


Figure 32 *Illustration of* on-site facilitation *criterion. The example illustrates the facilities taken into account. Facilities visualized in green are those mapped by BYM, facilities in orange are mapped by OSM and facilities in blue are taken from N50 map. The size of the point symbol or width of the line symbol illustrate the score assigned to this facility. A recreation area is assigned a score of the highest-scored facility.*

8.8 Knowledge values (Kunnskapsverdier)

Kindergartens, schools and other institutions use nature more and more in teaching. It is therefore important to assess the area's knowledge values and investigate whether schools/kindergartens use the area today.

8.8.1 Evaluation

	1	2	3	4	5
Is the area suitable for educational purposes or does the area have special natural or cultural science qualities?	Few	Quite a few	Medium	Quite many	Many
Operationalization	The recreation area has no special natural or cultural knowledgeable qualities And: The recreation area is far away from a school or kindergarten	The recreation area has some special natural and/or cultural knowledgeable qualities Or: The recreation area is 15-20 min. walking distance from a school or kindergarten	The recreation area has some special natural and/or cultural knowledgeable qualities And: The recreation area is 15-20 minutes. walking distance from a school or kindergarten	The recreation area has more natural and/or cultural knowledgeable qualities Or: The recreation area is located in the immediate vicinity of a school or kindergarten	The recreation area has more natural and cultural knowledgeable qualities And: The recreation area is located in the immediate vicinity of a school or kindergarten

8.8.2 Method

The methodology follows the operationalization suggested in the M98 Guidance.

8.8.2.1 Distance from schools

We compute the minimum distance between a recreation area and a school and reclassify it into one of three classes:

> 1km	far from school,
100 m – 1 km	within 15-20-minute walking distance,
<= 100 m	in immediate vicinity of school.

In this exercise, we compute the minimum distance between recreation area and school, i.e. at least one point in the area needs to be reachable within the required time.

8.8.2.2 The occurrence of endangered species

We use the occurrence of red-listed species as a proxy for natural and cultural knowledgeable qualities. The number of recorded occurrences of red-listed species per area unit is computed for each recreation area. The density of red-listed species is then classified into three classes. The intervals are set using quantile classification.

< 1 record / square kilometre	low natural and cultural knowledge values
1 – 50 records / square kilometre	medium natural and cultural knowledge values
> 50 records / square kilometre	high natural and cultural knowledge values

8.8.2.3 Combination

At the end, both criteria are combined to set a final score:

	> 1 km to kindergarten	100 m – 1 km to kindergarten	<= 100 m to kindergarten
low natural and cultural knowledge values	1	2	4
medium natural and cultural knowledge values	2	3	4
high natural and cultural knowledge values	4	4	5

8.8.3 Data

Map of occurrence of red-listed species is obtained from Artsdatabanken. Classes CR, DD, EN, NT, RE and VU are used. Schools and kindergartens are taken from BYM.

8.8.4 Points of decision

8.8.4.1 Methodology

In a recreation area, the distance to schools and kindergartens is not constant. When a requirement of 15-20 minutes walking distance from a school or kindergarten is set, shall this requirement be applied to the entire recreation area or only a certain part of it?

A general aggregation and scoring problem occurs when including the set of red-listed species. Moreover, the used map represents the occurrence of recorded species, i.e. only a sample of full species richness. The recorded location is static for plants but dynamic for animals. This fact shall not be neglected in the analysis. For example, an estimation of the action radius of certain species could be modelled instead of static point location. Finally, the red list category could be used to give higher weights to more endangered and rare species.

8.8.4.2 Data

Another approximation of natural and cultural knowledge values could be discussed.

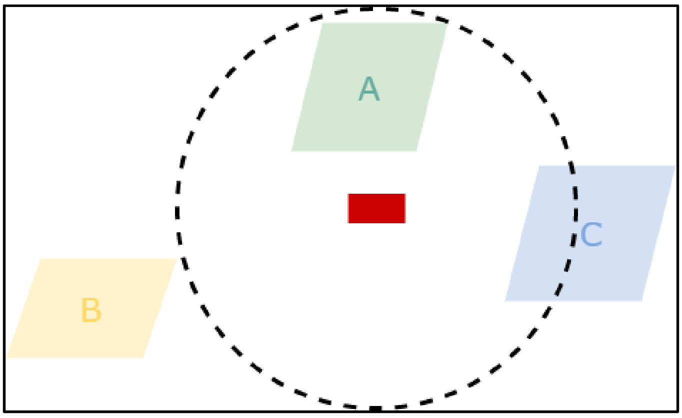


Figure 33 *Illustration of the requirement for maximum walking distance. The red rectangle represents a school building and a dashed black line represents a border of the 20-minute service area. The recreation area A will certainly be classified as "within walking distance of school" and the recreation area B as "far from school". How should recreation area C be classified? According to the methodology applied in this exercise, it will be scored as "within walking distance of school", because at least part of it is accessible in 15-20 minutes.*

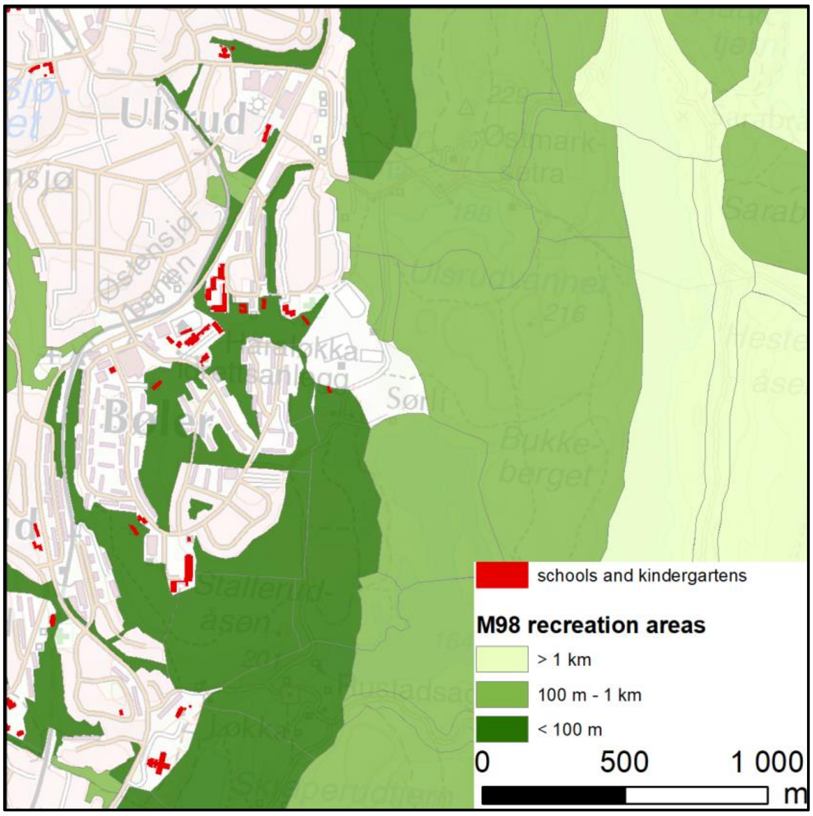


Figure 34 *Illustration of scoring based on distance from schools and kindergartens.*

8.9 Noise environment (Lydmiljø)

Silence is an important quality for outdoor life and the absence of noise is a prerequisite for most recreation areas to be regarded as attractive. Which audio levels are perceived as annoying depends on the area in which you are located, which area of use is desirable and type of audio source. What is a good sound environment will in the vast majority of cases be a discretionary assessment and will often be related to the audio environment in nearby areas.
The most important point of the criterion is that areas or sub-areas with a good sound environment are given a high value, especially where this is a quality lacking in adjacent areas.

8.9.1 Evaluation

	1	2	3	4	5
Does the area have a good noise environment?	Poor	Quite poor	Medium	Quite good	Good
Operationalization	The recreation area is located until a larger noise source (see noise map).	*Proposed not to use this value unless you are in doubt if 1 or 3 is the correct value.*	The recreation area is located in an area with moderate traffic noise (for example, the area is affected by some road traffic on smaller roads).	The recreation area is perceived as relatively quiet. Any unwanted sound is associated with other users / other activity in the area.	The recreation area is perceived as completely quiet.

8.9.2 Method

The methodology follows the operationalization suggested in the M98 Guidance.
We compute the average noise in the area and reclassify it into one of four classes.

- **1** average noise > 60 dB
- **2** -
- **3** 50 dB <= average noise <= 60 dB
- **4-5** average noise < 50 dB

This classification includes the traffic sounds. To distinguish between class 4 and 5, we include the distance from N50 paths (excluding unmarked paths), as a proxy for the probability of hearing human sounds. The average distance from paths in the area is computed. 180 m is used as the limit distance at which human voice can be heard[3].

- **4** average noise < 50 dB, average distance to paths < 180 m
- **5** average noise < 50 dB, average distance to paths > 180 m

8.9.3 Data

The noise map from Statens Vegvesen is used as an approximation of noise along roads. To approximate noise around paths, the following types of N50 traffic, suitable for walking, are selected:

Objtype = Gangsykkelveg,
Objtype = Sti,
Merking = “JA”

[3] http://www.guinnessworldrecords.com/world-records/farthest-distance-travelled-by-a-human-voice

Objtype = Traktorveg,
Objtype = VegSenterlinje,
Vegkategori = Fylkesveg,
Vegkategori = Kommunal veg,
Vegkategori = Privat veg.

Unmarked paths are not used due to their low *user frequency*.

8.9.4 Points of decision

8.9.4.1 Methodology

The resulting noise map is a raster map – a noise surface. In order to use it as a score, it needs to be aggregated per recreation area. The choice of aggregation function – average, maximum, sum – influences the result. This methodological question is a good illustration of the overall recommendation about the delineation of recreation areas.

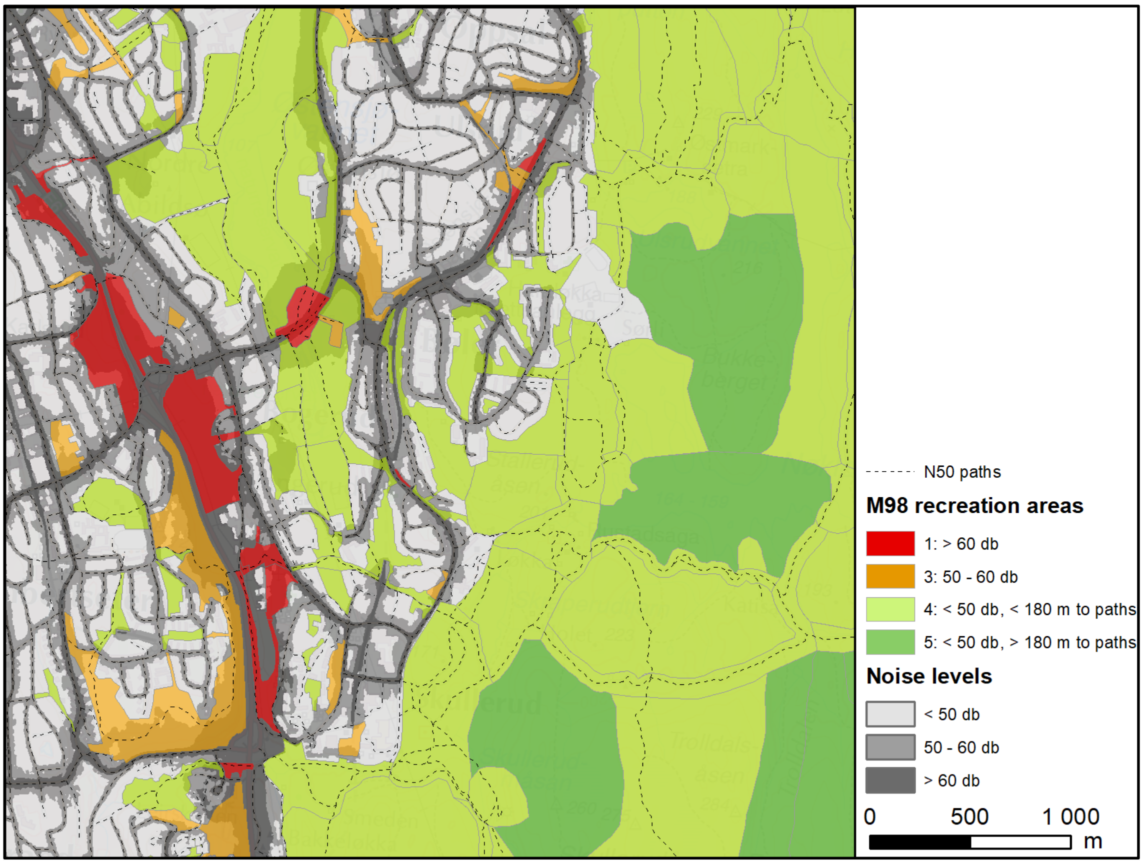


Figure 35 *Illustration of scoring of* noise environment *criterion.*

8.10 Intervention (Inngrep)

The fact that an area is intervention-free is important for the nature experience for many. There are still fewer natural areas, especially in the vicinity of population centers. Technical interventions such as wide power lines can reduce the natural experience, while old bridge constructions and driving paths can enrich the tour.

8.10.1 Evaluation

	1	2	3	4	5
Is the area intervention-free?	Developed	Quite developed	Medium	Quite intervention-free	Intervention free
Operationalization	A recreation area with major technical interventions (e.g. terrain changes or major infrastructure measures) and absence of natural vegetation.	A recreation area which in some areas has major technical interventions (e.g. terrain changes or major infrastructure measures) and the absence of natural vegetation.	A recreation area with technical intervention such as wide paths/gravel roads or lighted paths.	A recreation area with technical intervention such as smaller walks, bridges or piers. The area is essentially natural.	A recreation area without any technical intervention. However, it can be slightly organized, for example with marked/signed paths.

8.10.2 Method

The M98 Guidance is not clearly formulated, as a uniform intervention level throughout a recreation area is assumed. In case more intervention levels are combined, which score shall be assigned? An example is an area containing both technical interventions, lighted paths and bridges.

To estimate the intervention level, we develop a modified influence zone methodology. Technical interventions are divided into three categories – major, medium and minor. Major technical interventions include roads for motorized traffic, railways, power lines, as well as the lowest degree of naturalness[4]. Medium technical interventions include wide paths, forest roads and lighted paths. Minor interventions bridges, piers and narrower paths.

Each technical intervention then creates a 100 m influence zone. The influence of major technical interventions is ranked 3, medium interventions 2 and minor interventions 1. Places outside the influence zones of any interventions are scored 0.

To compute the *intervention* score, an average ranking of recreation areas is computed and a quantile classification is used to create five scoring classes.

1 average ranking 2.7 – 3.0
2 average ranking 2.3 – 2.7
3 average ranking 1.7 – 2.3
4 average ranking 0.8 – 1.7
5 average ranking 0.0 – 0.8

8.10.3 Data

We use Kartverket N50 datasets, namely Transport lines (Samferdsel) and construction and facilitation lines (Bygninger og anlegg) to rank intervention levels:

[4] Degree of naturalness expressed through Hemeroby index scoring (Suárez et al., 2020)

Class	Rank
Bygninger og anlegg – linje	
Dam	1
Flytebrygge	1
KaiBrygge	1
Ledning	3
LuftledningLH	3
Lysloype	2
Molo	2
Pir	1
Rørgate	3
Samferdsel – linje	
Bane (outside tunnels)	3
VegSenterlinje (outside tunnels) – private roads	2
VegSenterlinje (outside tunnels) – other roads	3
GangSykkelveg	1
Traktorveg	2

In addition, a map of the degree of naturalness based on Hemeroby index scoring is used. This map was originally created to be used in ESTIMAP Recreation mapping for Oslo-Akershus.

8.10.4 Points of decision

8.10.4.1 Methodology

The M98 Guidance is not clearly formulated, as a uniform intervention level throughout a recreation area is assumed. In case more intervention levels are combined, which score shall be assigned? An example is an area containing both technical interventions, lighted paths and bridges.

In the suggested methodology, the influence zone of technical interventions needs to be selected. Moreover, the influence may be modelled as functionally dependent on distance. To obtain a score, influence zones need to be aggregated per recreation area. Similarly to the *noise environment* criterion, an aggregation function needs to be selected. In addition, the final scoring is purely data-driven and a Scoring problem occurs.

The methodology is very sensitive to the delineation of recreation areas. Changes in the borders – e.g. splitting – will have a significant impact on the scoring.

8.10.4.2 Data

Chosen data include mainly linear features. An attempt was made to approximate the natural vegetation with the degree of naturalness. However, more technical interventions could be included.

8.11 Extent (Utstrekning)

The size and shape of a recreation area are often of great importance to its quality. In particular, it applies to recreation areas in cities and towns. In general, small areas of circular shape are of higher quality than oblong, narrow recreation areas of the same size. Although such areas are not so suitable for stays, they may be well suited as traffic corridors.

8.11.1 Evaluation

	1	2	3	4	5
Is the area large enough to exert the desired activities?	Too small	*Suggested not to use values 2, 3 and 4.*			Large enough
Operationalization	The recreation area is too small to exert the desired outdoor activities and is therefore used to a limited extent for these.				The recreation area is large enough to exert the desired outdoor activities

8.11.2 Method

To define too small or large enough areas for particular activities, we look at the standard size of functional classes of recreation areas. The functional classification is used as an approximation of the desired activity. Areas smaller than a size limit are scored 1. Other areas are scored 5. The bottom of size limit is set to the first quartile of the area of each functional class. An overview of the size limits is provided in the table below:

Type of area	Requirement on size
Other recreation areas	4.4 ha
Green corridors	11.0 ha
Agricultural landscape	0.6 ha
Playgrounds and recreation areas	0.7 ha
Areas for small trips	6.8 ha
Large tour areas with facilitation	20.7 ha
Beach zone with associated sea and waterways	0.2 ha
Entrance / exit areas	4.3 ha

Furthermore, we intended to incorporate a limit on the size of the area by computing the compactness of each recreation area. However, this exercise was not finished due to unavailable software.

8.11.3 Data

The functional classification of recreation areas is used.

8.11.4 Points of decision

8.11.4.1 Methodology

The output of the methodology for assessing *extent* depends on the definition of “too small” and “desired activity”. In our data-driven approach, the set limits depend very much on the delineation of areas.

8.11.4.2 Data

Moreover, using the functional classification of recreation areas to assign scores is pointing at the issue of double counting.

8.12 Accessibility (Tilgjengelighet)

In Oslo, one must sort the outdoor living areas into three groups in relation to accessibility.

1. Recreation area used by people who mainly walk or cycle

- These are usually open-air areas in the building zone or the Marka border.
- Well-accessible recreation areas in the building zone will have **safe travelling routes** and will be **less than 250 meters from residential areas**.

2. Recreation area where people mainly use public transport or car

- These are usually recreation areas in Marka or more attractive recreation areas in the built-up area and Oslofjord.
- Well-accessible recreation areas in Marka and Oslofjord will have **high-frequency public transport**, at least every 15 minutes and **well-equipped parking spaces**.

3. Recreation area in Marka

- Recreation areas where people mainly travel on skis, bicycles or foot along the passageways
- Well-accessible recreation areas within Marka have a network of marked trails, paths and ski tracks.

The distance to where people live is essential for availability. Keep in mind that multiple groups (e.g. children and adolescents) have a short action radius. For children in preschool age, the normal action radius is less than 100 meters and the 10-year-old rarely moves more than a few hundred meters away from its own house wall.

In the operationalization of *accessibility*, we have made 2 tables, one for the built-up area and one for Marka / Oslofjord. Some recreation areas will be somewhere between them.

8.12.1 Evaluation

	1	**2**	**3**	**4**	**5**
Is availability good or could it be good?	Poor	Rather poor	Medium	Rather good	Good
Built-up area					
Operationalization	The recreation area is more than 500m from the nearest residential area **and** more than 500m from the nearest public transport/parking space.	The recreation area is more than 500m from the nearest residential area **or** more than 500m from the nearest public transport/parking space.	The recreation area is between 250m and 500m from the nearest residential area **or** between 250m and 500m from the nearest public transport/parking space.	The recreation area is closer than 250m from the nearest residential area **or** closer than 250m from the nearest public transport/parking space. Public transport has a high frequency.	The recreation area is closer than 250m from the nearest residential area **and** closer than 250m from the nearest public transport/parking space. Public transport has a high frequency.
Marka / Oslofjord					

Operationalization	The recreation area is more than 500m from the nearest public transport stop/parking space. **or** The area has no well-organized routes to entrance/exit areas.	*Proposed not to use this value unless you are in doubt if 1 or 3 is the correct value.*	The recreation area is between 250m and 500m from the nearest public transport stop/ parking space. **or** The area has a medium dense and diverse network of routes to some entrance/exit areas.	*Proposed not to use this value unless you are in doubt if 1 or 3 is the correct value.*	The recreation area is closer than 250m from the nearest public transport stop/ parking space. Public transport has a high frequency. **or** The area has a dense and diverse network of routes to many entrance/exit areas.

8.12.2 Method

The methodology follows the operationalization suggested in the M98 Guidance. It consists of 5 steps:

1. Divide M98 area to those in the built-up area and those in Marka/Oslofjord. In case an area is located in several zones, the one with the largest proportion of the area is assigned.
2. Compute Euclidean distance to parking places and public transport stops. Each area is assigned the minimum distance and reclassified as follows:

   1 minimum distance > 500 m
   2 250 m < minimum distance <= 500 m
   3 minimum distance <= 250 m

3. Compute distance from residential areas. Each area is assigned the minimum distance and reclassified as follows:

   1 minimum distance > 500 m
   2 250 m < minimum distance <= 500 m
   3 minimum distance <= 250 m

4. The density of signposted hiking tracks, ski tracks, cycle paths in 100 m neighbourhood is aggregated as average per area. To distinguish between low, medium and dense network, quantile classification of areas in zone Marka or Oslofjord is used. The density value corresponds to [km] length of tracks in a square kilometre. Another approach would be to simply intersect paths with M98 areas and compute the ratio of path length per area.
5. Criteria are combined, separately for built-up area and Marka + Oslofjord zone. The aggregation table is ambiguous when certain classes are combined. The assigned score is typed in brackets in the table below.

	Built-up zone			**Marka, Oslofjord**		
	> 500 m from residential	**250 – 500 m from residential**	**< 250 m from residential**	**Sparse network of routes**	**Medium dense network of routes**	**Dense network of routes**
> 500 m from parking	1 (1)	1/2/3 (2)	1/2/4 (3)	1 (1)	1/3 (2)	1/5 (3)

/ stop						
250 – 500 m from parking / stop	1/2/3 (2)	3 (3)	3/4 (4)	1/3 (2)	3 (3)	3/5 (4)
< 250 m from parking / stop	1/2/4 (3)	3/4 (4)	5 (5)	1/5 (4)	3/5 (4)	5 (5)

Distance measures: Euclidean distance. Limit distance is the minimum distance (i.e. distance needed to enter the area).

8.12.3 Data

8.12.3.1 Built-up area, Marka, Oslofjord
The three areas – Marka, Oslofjord and built-up – are derived from Marka borders and Fjord borders, provided by BYM.

8.12.3.2 Residential areas
Residential areas are extracted from Statistics Norway dataset “Arealbruk” – hovedklasse=boligbebyggelse.

8.12.3.3 Parking lots
The main data source for parking lots is map “Inn- og Utfartsparkering” from BYM. It is complemented by OSM Parking (traffic, points, 5260, 5262, 5263).

8.12.3.4 Public transport stops
Public transport stops are obtained from map “Holdeplasser” from BYM.

8.12.3.5 Path network
The main network of marked paths from N50 (“merked sti”) is complemented by municipal data of “Sykkelruter”, “Tursti i kommuneskoger” (Type = Natursti, Kulturminnesti, Kulturlandskapsti) and “Preparert Skiløyper”.

8.12.4 Points of decision

8.12.4.1 Methodology
Equivalently to *knowledge values*, a decision about the interpretation of distance thresholds has to be made. Does the threshold imply a distance needed to access at least one place in the area (i.e. threshold is equal to minimum distance), or to access the entire area (i.e. threshold is equal to maximum distance)?

When it comes to path network density, a typical aggregation and scoring problem occurs.

Finally, the scoring, as suggested in the evaluation table, is ambiguous. An area is to be scored 1 if it is further than 500 m from a parking place or a public transport stop, but 1 if it has a dense hiking network. How should such an area be scored when both criteria are fulfilled?

8.12.4.2 Data
A data source for public transport frequency was not found.

8.13 Potential use (Potensiell bruk)

The potential value of the area can be taken into consideration, but the criterion must be used very consciously and to a limited extent. Almost all of the outskirts of the area can be used by means of facilities. In this way, "all" recreation areas can get high potential value and the criterion becomes worthless.

In some contexts, however, the criterion may be helpful, both during the valuation of the sites and in the after-use of the finished result. For example, an unused area exists. Between two recreation areas, it can have great potential as a corridor and link between the two existing areas. When planning developments such as new housing areas, cottage areas, densification areas and urban renewal, consideration should be given to potential use of adjoining recreation areas, but if only potential value for such areas is currently being added, upgrading the value of the areas should be completed after the planned measures have been completed.

8.13.1 Method

In this criterion, we depart from the M98 methodology and use ESTIMAP population accessibility index.

For each recreation area, a set of service areas is computed according to the thresholds set below and the population in these areas is recorded. Because the demographical data are aggregated in census units, a uniform distribution within the census unit is assumed.

- Population within 0 – 100 m from recreation areas,
- Population within 250 m from recreation areas,
- Population within 500 m from recreation areas,
- Population within 1 km from recreation areas.

It is not clear how scoring should be performed to consider the four different service areas. At the moment, we assign score based on the largest, 1-km, service area. We use an equal interval classification.

- 0 – 5 000 inhabitants,
- 5 000 – 10 000 inhabitants,
- 10 000 – 15 000 inhabitants,
- 15 000 – 20 000 inhabitants,
- 20 000 inhabitants.

8.13.2 Data

We use the demographical data from Statistics Norway for 2015, aggregated to census units. A uniform distribution of population within a census unit is assumed.

8.13.3 Points of decision

8.13.3.1 Methodology

To compute service areas, we use Euclidean distances. However, it might be more appropriate to use network distances instead. Network distances are harder to model but reflect reality better. At the same time, a decision needs to be made about how to approximate border of such area (results of network analysis are only intersections with network, not areas).

Shall service areas of nearby recreation areas overlap? If they overlap, the total sum of potential users might be larger than the total population. If non-overlapping is required, the exercise converges to Thiessen polygons of recreation areas and recreation areas which share borders with other areas would not get any potential users.

In order to assign scores to individual recreation areas, a method of conversion between accessible population numbers and scores needs to be developed. In the exercise, we use only the 1-km service area to assign scores. The population numbers are classified into 5 scores by equal interval classification.

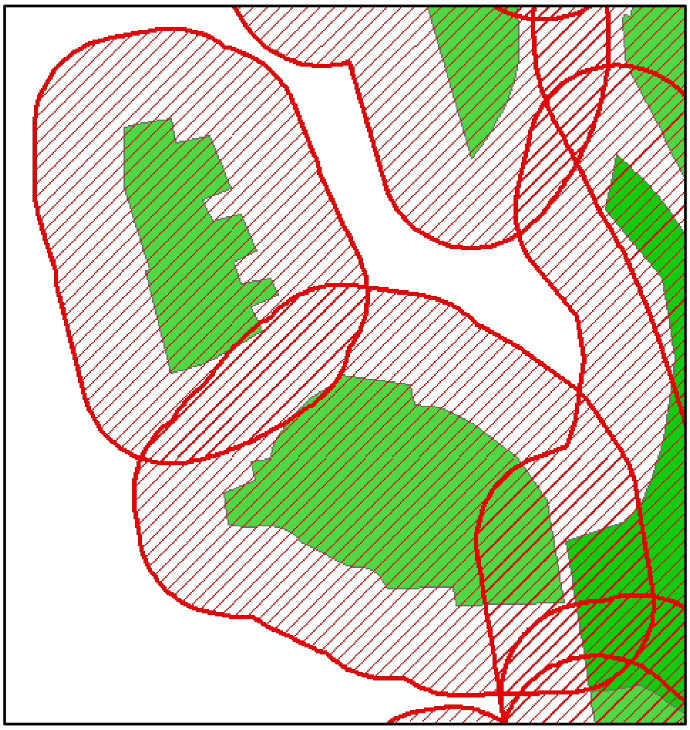


Figure 36 *Illustration of overlapping service areas*

9 References

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Norwegian Institute for Nature Research
NINA head office
Postal address: P.O. Box 5685 Torgarden,
NO-7485 Trondheim, NORWAY
Visiting address: Høgskoleringen 9, 7034 Trondheim
Phone: +47 73 80 14 00
E-mail: firmapost@nina.no
Organization Number: 9500 37 687
http://www.nina.no

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