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Economic valuation of ecosystem services for policy

A pilot study on green infrastructure in Oslo

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Norwegian Institute for Nature Research

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In collaboration with

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Executive Summary

Barton, D.N., E. Stange, S. Blumentrath, N. Vågnes Traaholt (2015) Economic valuation of ecosystem services for policy. A pilot study on green infrastructure in Oslo. NINA Report 1114.

This study aims to demonstrate economic valuation of ecosystem services using available data in a pilot study area in Norway. Oslo Municipality was chosen because it provides a number of gradients, spatial scales and different levels of spatial resolution in which to discuss urban ecosystem services. The EU FP7 research project OpenNESS and an ongoing collaboration with Oslo Municipality made it possible to demonstrate a number of value transfer methods. Value transfer is a rapid assessment approach that uses available studies transferred to a new context.

The study outlines a framework for evaluating the information requirements of economic valuation of ecosystem services in different decision contexts. We use the framework to discuss information requirements of economic valuation to support different decision-contexts. Ecosystem services valuation and mapping unmotivated by specific decision context risks being both irrelevant and wasteful.

In the present study we use value transfer methods for the general purpose of awareness-raising, which can be considered the least demanding in terms of requirements for accuracy and reliability. Valuation for awareness raising is illustrated with 6 different examples, four of which are economic valuation methods:

Economic valuation examples:

1. Meta-analysis of willingness-to-pay for green spaces in the built zone
2. Hedonic pricing of green infrastructure in the built zone of Oslo
3. Time use value of Marka peri-urban forest outside the built zone of Oslo
4. Liability value of urban trees in the built zone

Non-economic valuation examples:

5. Blue green factor scoring of property in the built zone of Oslo
6. Health impacts of green infrastructure in Oslo as a whole

The two methods looking at recreation in green spaces (1) and the peri-urban forest (3) found annual values between one and several billion Norwegian kroner. The value of green spaces in property prices (2) and the liability value of city trees (4) revealed capital values in the range of tens of billions of Norwegian kroner.

Despite uncertainty inherent in value transfers we feel confident that ***nature in Oslo has a total annual value of several billion kroner.*** This is conservative because we have used lower bound estimates. Furthermore, we know that our examples represent only a fraction of ecosystem services provided by green infrastructure, in our case mainly cultural ecosystem services. Regulating services remain largely unvalued in this study.

We think these economic valuation results may be awareness raising for;

- **citizens** of Oslo who use green infrastructure on a regular basis, but who may take it for granted or not recognise how their individual use contributes to overall value for Oslo's population as a whole.
- **commercial interests** in recreation and property development, who have not recognised how their business depends on green infrastructure in and around the city.
- **municipal policy-makers** providing them with additional arguments vis a vis property developers for conserving and improving green infrastructure.
- **national authorities** in environment and economics ministries the results may raise awareness regarding the economic importance of urban green infrastructure which is small in area, but intensively used.
- **research** authorities and the research community itself regarding the high 'economic returns' to research on urban ecosystem services.

In moving on from pilot study examples for awareness raising to using economic valuation for decision-support three main directions could be taken.

Widening scope for awareness raising: awareness could be raised about the economic value of a number of other ecosystem services and some green infrastructure that were not addressed in the pilot study

Increasing resolution for decision-support: in some cases valuation methods are available and data could be collected to increase the resolution of valuation studies to a point where they would be relevant in decision-support. Some hypothetical examples include, hedonic property pricing disaggregated at city district level and used to justify differential municipal fees to maintain and improve green infrastructure; recreational time use studies in Oslo's parks used to better target further upgrades in access to and quality of green infrastructure; further spatial studies of recreational opportunities, current and projected to inform plans to re-regulate parts of Oslo's peri-urban forest to recreational "activity zones"; further valuation studies of ecosystem services of city trees to justify economic liability for and regulation of trees on private land within the built zone.

Increasing scale for awareness raising across jurisdictions: the scale of a valuation study could address neighbouring municipalities of Greater Oslo to address whether there were ecosystem service benefit or cost spillovers across municipalities that could be relevant for regional planning policy.

Ecosystem services are designated as "unpriced impacts" in Norwegian guidance documents on impact assessment and economic analysis of infrastructure projects. A sustained **research programme** on ecosystem services– similar to the effort made since the 1980's on the health and economic impacts of air pollution and noise from traffic - holds out the promise of accounting for hitherto unpriced importance of green infrastructure.

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Sammendrag – extended summary in Norwegian

Kapittel 1. Økosystemer er uunnværlige for menneskelig velvære. Fra et nytteperspektiv er økosystemer verdifulle fordi de står for støttende, regulerende, forsynende, opplevelses- og kunnskapstjenester[1]. Naturens goder og tjenester kan sammenfattes i begrepet økosystemtjenester. Utgangspunktet for rapporten er en antagelse om at naturen ikke tas tilstrekkelig hensyn til av individer, næringsliv og forvaltning uten bevissthet om økosystemtjenestene, og at bevisstheten er større dersom verdiene måles i penger.

Målsettingen med denne rapporten er derfor å illustrere bruk av økonomiske verdsetting av økosystemtjenester til folkeopplysning. Rapporten diskuterer også hva mer som må til for at verdsettingsmetodene skal brukes som beslutningsstøtte av forvaltningen – fra bevisstgjøring til beslutningsstøtte.

Det ligger betydelig større utfordringer i anvendelse av økonomisk verdsetting av økosystemtjenester som underlag for å fatte politiske beslutninger enn i bruk til bevisstgjøring. Dersom økonomisk verdsetting av økosystemtjenester oppnår sitt mål med bevisstgjøring, vil den oppnå større legitimitet, og det vil kunne komme ytterligere etterspørsel etter metodene i fra forvaltningen. Økonomisk verdsetting av økosystemtjenester for folkeopplysning betyr ikke nødvendigvis en tilslutning til 'prising' av økosystemtjenester som politisk virkemiddel.

Rapporten tar i den forstand utgangspunkt i anbefalingene fra NOU 2013:10. Med utgangspunkt i regneeksempler fra Oslo, tar rapporten et steg videre og spør hva som skal til for at økonomisk verdsetting av økosystemtjenester kan brukes i ulike former for beslutningsstøtte. Dette er et relevant spørsmål for Europa de nærmeste årene. For eksempel skal EUs medlemsland frem mot 2020 kartlegge økosystemtjenester og –verdier. Denne innsatsen står i fare for å bruke betydelige ressurser på romlig datainnsamling som ikke er tilpasset behov for beslutningsstøtte på ulike forvaltningsnivåer.

Kapittel 2. Økonomiske verdier av økosystemtjenester er betinget av valg og beslutnings-sammenheng. Utgangspunktet vårt er at verdier – økonomiske og ikke-økonomiske – er uttrykk for preferanser til personer i bestemte roller, i møte med handlingsalternativer til en gitt tid og på et gitt sted. Dette betyr at verdier av natur er mangfoldige. En bevissthet om kilder til slik usikkerhet i verdsetting er nyttig når man skal vurdere om og hvordan økonomisk verdsetting skal tas i bruk. Rapporten legger frem et metoderammeverk for å beskrive kilder til usikkerhet i økonomisk verdsetting av økosystemtjenester. Den har som mål å hjelpe forvaltningen med tolkning av hvorvidt verdiestimater er nøyaktige og pålitelige nok i forhold til behovene i ulike beslutningskontekster.

Et rammeverk kan hjelpe forvaltningen i å beskrive sine forventninger til presisjon og pålitelighet for økonomisk verdsetting avhengig av kontekst. Rammeverket skiller mellom kontekstene (i) folkeopplysning, (ii) bokføring og regnskap, (iii) tiltaksprioritering og –rangering, (iv) virkemiddelutforming og (v) økonomisk ansvar. Kravene til dokumentasjon stiger også med romlig skala og oppløsning – berører beslutningen mange personer over et stort område er kravene til dokumentasjon store. Informasjonskostnadene stiger i takt med kravene til presisjon og pålitelighet i beslutningskonteksten, og i takt med krav til romlig skala og romlig oppløsning av naturinngrepet. Dokumentasjonskrav til økonomisk verdsetting av økosystemtjenester bør derfor vurderes i forhold til omfang og kompleksitet av naturinngrepet. De bør stå i forhold til kravene som stilles til dokumentasjon av økonomisk utbytte.

Ofte er usikkerheten stor på begge sider av brøken utvikling / natur. Føre-var prinsippet taler endog for at kravene til dokumentasjon av kostnader ved tap av økosystemtjenester ikke skal være så høy som for de sektorene som argumenterer for utvinning, inngrep og avvikling. Rammeverket oppfordrer forvaltningen til å differensiere informasjonskrav til verdsetting av natur og til å vurdere informasjonskostnader, avhengig av beslutningskonteksten som er til vurdering.

[1] også kalt kulturelle økosystemtjenester

Kapittel 3. På tross av NOU 2013:10 er økosystemtjenester knapt nok et forvaltningsbegrep i Norge. Det er lite integrert i forvaltningsveiledere på konsekvensutredning, samfunnsøkonomisk analyse eller grønnstruktur. På tross av flere tiår med forskning på miljø- og ressursøkonomi i Norge, er økonomisk verdsetting av økosystemtjenester bare unntaksvis anvendt i konseptvalg- og konsekvensutredninger (KVU og KU). Noe av forklaringen kan ligge i at veiledere i samfunnsøkonomisk analyse definerer økosystemtjenester som 'ikke-prisede' konsekvenser. Det kan, nærmest per definisjon, ha ført til manglende anvendelse av verdsettingsmetoder i KVU og KU, metoder som ellers har vært i relativ hyppig bruk i akademiske miljøer. Derimot har det vært flere tiår med utprøving av metoder for 'prising' av skader og dødelighet fra trafikkulykker, luftforurensning og støy i veiprosjekter. Selv om kompleksiteten er større og effektene mer indirekte for flere av økosystemtjenestene, har man sett at økonomisk verdsetting er blitt utprøvd og innpasset over tid for det som engang også var 'eksterne virkninger'.

Kapittel 4. Pilotstudien ser på økosystemtjenester innenfor Oslo Kommune. I hvilken grad omtales økosystemfunksjon og -tjenester fra grønnstruktur i kommunale planleggingsdokumenter og veiledere? Kommunens planleggingsdokumenter og veiledere er omfattende på kunnskaps- og opplevelsestjenester og på støttende tjenester som vern av habitat for biomangfold. Regulerende økosystemtjenester er mye omtalt innenfor byggesonen (f.eks. overvannshåndtering), men noe mindre angående hvilken rolle landskapet rundt byen spiller for innbyggernes velferd. Regulerende tjenester er ikke så godt dokumentert når det gjelder grønnstrukturens rolle i karbonlagring og opptak, pollinering og demping av støy og luftforurensing.

Kapittel 5. Verdsettingseksemplene fra Oslo utgjør rapportens kjerne. Vi har valgt ut fire eksempler på økonomisk verdsetting og to eksempler på metoder for verdsetting uten bruk av penger. Eksemplene på økonomisk verdsetting er valgt ut basert på tilgjengelighet av data og en gjennomgang av verdsettingsstudier fra andre byer som antyder hvilke økosystemtjenester som kan representere store økonomiske verdier. Eksemplene er i hovedsak verdioverføringer. Verdioverføring betyr bruk av eksisterende verdsettingsestimater i en ny beslutningssammenheng, ofte på et annet sted enn den opprinnelige studien ble gjennomført. Verdioverføring er nødvendig om økonomisk verdsetting av økosystemtjenester skal gjennomføres når man ikke har tid eller ressurser til ny datainnsamling. Rapporten viser hvor langt vi kunne komme ved å bruke forholdsvis enkel metoder som ikke krever nye undersøkelser.

Rekreasjonsverdien av parker og grøntområder. Til sammen utgjør grøntområdene i Oslos byggesone om lag 28 km^2 fordelt på mer enn 500 ulike lokaliteter i byen. Oslos totale grøntareal i byggesonen er anslagsvis verdt minst 1 milliard kroner per år, hvis vi legger til grunn betalingsvillighetsstudier gjennomført blant bybefolkninger i andre land. Dette tilsvarer i snitt en betalingsvillighet på kr. 1 985 per år for alle innbyggere over 15 år. Man antar at Oslos befolkning faktisk ville være villig til å betale det samme som befolkninger i en rekke andre land har sagt at de er villige til å betale for grøntområder. Vi har kalibrert tallene fra utenlandske studier for faktorer som inntektsnivå, befolkningstetthet og størrelse på grøntområdene.

Kapitalverdi av blågrønne arealer i eiendomspriser. Vi har gjennomført en statistisk analyse av sammenhengen mellom leilighetspriser i Oslo og grønnstruktur, basert på dokumentasjon for alle leiligheter solgt i Oslo i perioden 2004-2013. Innenfor 500 meter fra en bypark øker i gjennomsnitt verdien av leiligheten med kr. 162-368 per meter (alt etter hvor nær parken leiligheten er). Det finnes 160 722 leiligheter innenfor 500 meter fra offentlige parker i Oslo. Samlet sett er merverdien for nærhet til park for alle disse leilighetene mellom kr. 8,3 og 18,9 milliarder. Hvis parken har et vannelement er den enda mer verdifull. Den ytterligere merverdien for leiligheter i nærheten av parker med vannelement ligger på mellom 2,8 og 6,6 milliarder. Store parker har videre en tilleggsverdi på 0,3-2,3 milliarder kroner. Nærhet til fjorden, til markagrensen, og til kirkegårder har også samlet merverdi i milliardklassen, viser eiendomsstatistikken. Til sammen er et forsiktig anslag på merverdien grønnstruktur har på leilighetspriser i Oslo per 2013 om lag 19 milliarder kroner.

Fritidsverdien av Marka. Basert på en spørreundersøkelse om fritidsvaner har vi funnet at Oslos befolkning over 15 år bruker omlag 73 millioner timer per år i den bynære skogen. Verdien av denne tiden kan anslås med forskjellige metoder, for eksempel reisekostnadsundersøkelser eller vurderinger av om alternativ tidsbruk er trening eller arbeid. De ulike metodene gir et anslag på verdien av Marka-bruk på 2,3-13,3 milliarder kroner per år. Verdien er usikker fordi det finnes flere måter å beregne reisekostnader, verdien av fritid, og verdien av hvert besøk. Likevel kan vi med ganske stor sikkerhet si at rekreasjonsverdien av Marka er på flere milliarder kroner per år.

Verdien av erstatningsansvar for bytrær. Det finnes 0,7-1,2 millioner bytrær med høyde over 5 meter i Oslos byggesone. Hver Osloborger deler byrommet med 1-2 store trær. Oslo Kommune krever at skade på bytrær eid av kommunen erstattes etter en bestemt takstmodell som tar høyde for treets tilstand og stedsspesifikke kvaliteter, deriblant økosystemtjenester. Takstmodellen viser at gjennomsnittsverdien av Oslos bytrær er på ca. 40 000 kroner på kommunal grunn. Vi har anvendt takstmodellen på alle bytrær (både på privat og offentlig grunn) i byggesonen for å anslå deres samlede verdi. Samlet erstatningsansvar for alle store bytrær i byggesonen blir da på mellom 28 og 42 milliarder kroner (avhengig av antall og kvaliteten på bytrærne).

Sett under ett har eksemplene på økonomisk verdsetting et klart budskap, **"Naturen i Oslo er verdt milliarder av kroner"** (Barton et al., 2015b). Verdsettingseksemplene i denne rapporten dekker likevel bare en brøkdel av urbane økosystemtjenester i Oslo.

Rapporten ser på fire ulike økonomiske verdsettingsmetoder. I tillegg omtaler vi to eksempler på ikke-økonomisk dokumentasjon av verdien av grønnstruktur.

Blå-grønn faktor (BGF) er et system for scoring av blå og grønne strukturer i nye bygge-prosjekter. BGF ble utviklet av Oslo og Bærum kommuner i samarbeid med rådgivningsfirma innen landskapsarkitektur, overvannshåndtering og eiendomsutvikling (Framtidens Byer 2014). BGF kan brukes av utbyggere til å dokumentere i hvilken grad byggeprosjektet leverer økosystemtjenester med fokus på naturlig overvannshåndtering, og kan brukes av kommunen til å sette minstekrav til eiendomsutvikling differensiert etter behov for blågrønnstruktur i hver bydel. BGF er således et godt eksempel på både en verdsettingsmetode og et mulig virkemiddel i arealforvaltning.

Det siste verdsettingseksemplet er en gjennomgang av litteratur på betydningen av grønnstruktur for **fysisk og mental helse**. Et voksende antall internasjonale epidemiologiske studier viser betydelige helseeffekter av grønnstruktur i by. Oslo har så vidt vi vet ingen slik epidemiologisk studie for betydningen av grønnstruktur for byens befolkning. Likevel har studier av lokale parker i Oslo vist at innbyggerne har klare preferanser for blå- og grønnstruktur for fysisk og mental 'rekreasjon'. Litteraturgjennomgangen gir grunn til å tro at fremtidige studier på sammenhengen grønnstruktur-helse i Oslo vil vise store verdier. Det vil være bevisstgjørende om betydningen av støttende økosystemtjenester fra bynatur som habitat for mennesker.

Ytterligere diskusjon om antagelser og data som er brukt i de ulike eksemplene, kan finnes i Barton et al. (2015) Materials and methods appendix for valuation of ecosystem services of green infrastructure in Oslo. NINA Report 1115.

Kapittel 6. Rapporten foreslår i siste kapittel mulig videre bruk av økonomisk verdsetting av økosystemtjenester i Oslo i en rekke hypotetiske forvaltningssammenhenger.

Øke romlig oppløsning for beslutningsstøtte. For noen økosystemtjenester har vi tilgjengelige verdsettingsmetoder og kan samle nye data til et detaljnivå som kunne gjøre dem relevante for beslutningsstøtte i forvaltning. Eksempler på dette kunne være:

- hedonisk prising av betydningen av grønnstruktur for eiendomspriser på bydelsnivå som grunnlag for kommunale avgifter for vedlikehold (på lik linje med andre avgifter for kommunale tjenester);
- beregning av fritidsbruk i ulike parker som grunnlag for nytte-kostnadsvurderinger av nye parker, oppgradering- og tilretteleggingstiltak for grønnstruktur;
- romlig kartlegging av fritidsbruk i markas randsone som grunnlag for beslutninger om, plassering eller utforming av 'aktivitetssoner' i forslag til ny kommuneplan;

- verdsetting av økosystemtjenester av bytrær som grunnlag for å fastsette erstatningsansvar for store bytrær også på privat eiendom i byggesonen.

Utvide studieomfang for bredere bevisstgjøring. En rekke økosystemtjenester fra grønnstruktur ble ikke dekket av denne pilotstudien. Mest grunnleggende er sammenhengen mellom grønnstruktur og menneskelig helse – støttende økosystemtjenester fra vårt urbane habitat. Det gjelder også kunnskapstjenester fra grønnstruktur for barns læring. Studien dekket ikke opplevelsestjenester for friluftsliv til sjøs og på øyene i Oslofjorden. Spesielt regulerende økosystemtjenester er ikke dekket av denne studien. De viktigste kan være naturlig overvannshåndtering, avløpsrensing, vannrensing, reduksjon av støy og luftforurensning fra grønnstruktur. Betydning av grønnstruktur for biomangfold i byen ble ikke dekket. For eksempel har pollinatorer betydning for flere økosystemtjenester samtidig.

Øke skala for bevisstgjøring på tvers av kommunegrenser. Ved å øke den romlige skalaen på fremtidige studier av økosystemtjenester kunne man se på i hvilken grad nabokommuner i Stor-Oslo 'utveksler' økosystemtjenester på tvers av kommunegrensene. Hvis det er en betydelig skjevhet i byrde- og fordelsfordeling i forsyning og bruk av økosystemtjenester mellom kommunene, kunne dette være gjenstand for en fremtidig 'økosystemtjeneste-justering' av nøkkelen for tildeling av statlige ressurser til kommunene.

Metodeutvikling for verdsetting økosystemtjenester i Statens Veivesens Håndbok 140. Håndbok 140 beskriver hvordan samfunnsøkonomisk analyse skal ta hensyn til effekter av naturinngrep av samferdselsprosjekter. HB140 brukes også av andre sektorer. Med bakgrunn i en gjennomgang av samfunnsøkonomisk analyse i veiledere for KVU og KU ser vi mangleri forhold til økosystemtjenester. Et forskningsprogram over lenger tid på konsekvensene av infrastruktur på økosystemtjenester vil sannsynligvis gjøre det mulig å 'prise' flere av dagens 'ikke-prisede' konsekvenser, spesielt innen helse og rekreasjon. Denne påstanden er inspirert av forskningen på helseøkonomiske konsekvenser av ulykker, støy og luftforurensning som har pågått siden 1980-tallet, og som er tatt i bruk i dagens HB140.

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Foreword

We gratefully acknowledge the Norwegian Environment Agency for their financial support for preparing this report. The contents and evaluations in this report are entirely the responsibility of the authors.

This report responds to a tender in November 2014 from the Norwegian Environment Agency for a report on valuing ecosystem services in a pilot case study area, to be completed within a few weeks before the end of 2014. As a pilot case study NINA proposed valuation of ecosystem services in Oslo, based on work in progress as part of the EU FP7 financed project "OpenNESS – Operationalisation of natural capital and ecosystem services."

The report would have not have been possible to write in a few weeks were it not for the ongoing collaboration since 2013 in the OpenNESS project between NINA, VISTA Analyse A/S and Oslo Municipality.

We gratefully acknowledge the collaboration with Oslo Municipality's Urban Environment Agency (BYM), Planning and Building Agency (PBE) and Water and Sewage Agency (VAV) in making this study possible, both through the contribution of databases and for discussions with their experts at regular meetings regarding the role of economic valuation of ecosystem services in Oslo Municipality. In particular, we acknowledge the Future Cities Project coordination at BYM which has been the OpenNESS project's main facilitator of contacts with other colleagues within Oslo Municipality.

The report owes an intellectual debt to the OpenNESS project collaboration. All the valuation examples discussed in the report were developed during 2014 as part of an ongoing study on ecosystem service values. They have been largely reproduced here from an OSLOpenNESS case study report by Barton et al. (2014) "Er naturen i Oslo verdt milliarder? Verdsetting av utvalgte urbane økosystem-tjenester fra blågrønn infrastruktur. NINA Rapport 1113. The framework for policy-relevant ecosystem service valuation was developed as part of the methodological framework for valuation of ecosystem services in OpenNESS. Further discussion of the framework and valuation assumption can be found in Barton et al. (2015) Materials and methods appendix for valuation of ecosystem services of green infrastructure in Oslo. NINA Report 1115 available at www.nina.no.

A number of researchers have contributed to the case study in different ways. Erik Stange reviewed municipal policy documents in relation to ecosystem services, as well as ecosystem service mapping methods. Nora Vågnes Traaholt (former M.Sc. University of Copenhagen) and Stefan Blumentrath conducted the hedonic pricing study on which parts of the report is based. Erik Gómez-Baggethun (NINA) participated in development of the framework for policy relevant valuation. Anders Often (NINA) and Sergi Nuss Girona (Ph.D. student, U. of Girona), contributed to the tree valuation model. Vegard Gundersen (NINA) contributed to the study of recreational time use in the Marka forest. Oscar Haavardsholm (M.Sc. student UiO) helped collect data on time use in Oslo's parks. Berit Köhler (NINA) participated in discussions on a planned survey on recreational use of Oslo's green infrastructure. Henrik Lindhjem (NINA) contributed to the analysis of time use in Marka forest and in discussions about valuation in a planned stated preference survey. Emma Soy Massoni (Ph.D. student, U. of Girona) accessibility and population density around Oslo's parks. Graciela Rusch(NINA) participated in discussions on valuation of biodiversity of Oslo's green infrastructure. Signe Nybø and Henrik Lindhjem (NINA) conducted quality assurance of the study.

February 2015
David N. Barton

1 Introduction

This report responds to a tender in November 2014 from the Norwegian Environment Agency for a report on valuing ecosystem services in a pilot case study area. As a pilot case study NINA proposed valuation of ecosystem services in Oslo, based on work in progress as part of the EU FP7 financed project "OpenNESS – Operationalisation of natural capital and ecosystem services."

Oslo Municipality was proposed as a pilot study area because it provides a number of gradients, spatial scales and different levels of spatial resolution in which to discuss urban ecosystem services. Oslo Municipality contains both intact nature and ecosystems (e.g. the peri-urban Marka forest and its watersheds), managed cultural landscapes (e.g. farming in the Maridal landscape protected area), as well as an urban mosaic of forest, farming and built land. Within the city nature is present as 'green infrastructure' in between artificial landuses, or represented as individual structures such as city trees. Oslo is also an interesting pilot because it represents individual ecosystems and their services that can be found in most of Southern Norway.

At the same time the urban area and its peri-urban landscape represent a number of pedagogical and methodological challenges in how to operationalize ecosystem services in planning and policy. Population growth and urbanisation are a common phenomenon in Oslo, Norway and globally. Ecosystems are going through a more or less regulated de construction. Choosing a city for a pilot project on ecosystem services provides a challenging context for discussing trade-offs between multiple services from ecosystems versus manmade alternatives. The urban context challenges both the role of economic valuation of ecosystem services and benefit-cost analysis, as well as precautionary principles and the very definition of sustainability.

Accounting for ecosystem services in policy and planning requires spatially explicit modelling of ecosystem function that can be highly data intensive depending on the requirements for spatial resolution, accuracy and reliability in the decisions at hand. Towards 2020 EU member states are carrying out ecosystem service mapping and valuation. This effort runs the risk of expending considerable resources collecting spatial data that is not targeted at specific decision-problems.

The Norwegian Climate and Environment Ministry aims to follow closely how the EU implements valuation of ecosystem services as part of the "EU Biodiversity Strategy to 2020" and "Green Infrastructure (GI) — Enhancing Europe's Natural Capital" (KMD, 2014). One aim is to exchange experiences with EU member states regarding Norway's follow-up of the Official Norwegian Report NOU 2013:10 on "Natural benefits – on the values of ecosystem services".

Given the interest in learning from EU experiences in applying valuation of ecosystem services it is worth pointing out that "ecosystem services" is not a legally recognised concept or principle in the main legislation on nature management in Norway - the Norwegian Nature Diversity Act. NOU 2013:10 recognises some fundamental challenges with the ecosystem services concept in the context of Norwegian environmental policy (Box 1).

NOU 2013:10 argues that "[..] nature values must be demonstrated, but not necessarily in terms of monetary value"; "[..] some ecosystem services can and should be valued in monetary terms, while others can at best be highlighted quantitatively." Further the report underlines " [..] that an ecosystem services approach does not, in principle, favour a certain type of policy instrument. The fact that nature delivers services that are useful to human beings is not in itself an argument for or against the use of economic policy instruments, or for or against the use of legislation and regulations."

Box 1. Challenges and limitations of the ecosystem services approach

"The ecosystem services approach can be viewed as a supplement to ecological, ethical and social science arguments. The Norwegian Nature Diversity Act is based on nature being assigned fundamental values such as utility and use value, experience value, value in relation to sense of identity and belonging, ecological value and intrinsic value. In certain situations, values in nature can be strengthened by highlighting utility values in parallel with nature's intrinsic value, while, in other situations, it will be more expedient to apply the two types of values separately. As in any other environmental and natural resource management, there are challenges relating to the ecosystem services approach. Ecological complexity, ethical considerations, conflicts of interest and short-term thinking are particularly relevant. There is a distinction between economic valuation aimed at demonstrating the values of nature and the facilitation of new markets for ecosystem services at the expense of legal instruments. The ecosystem services approach must also be seen in a broader social and management context that takes account of Norwegian management traditions and environmental policy instruments, and that strengthens the basis for better cooperation between sectors and more coherent (ecosystem-based) management."

Source: NOU 2013:10

The choice of ecosystem services that have been valued in this report is largely opportunistic, conditioned by (i) available valuation studies, (ii) the aim of demonstrating a variety of economic valuation methods and (iii) the aim of assessing ecosystem services with potentially large values. The pilot study therefore represents a 'quick, cheap and dirty' approach to valuation of ecosystem services (Barton, 1999), using mostly value transfer[2] methods, for the purpose of awareness raising. Awareness raising can be considered the simplest policy context for the economic valuation of ecosystem services, requiring lower accuracy and reliability than contexts where decision-support is needed. Economic valuation refers to assessing the importance of ecosystem services using monetary measures. Non-economic valuation refers to quantification of social or ecological importance of ecosystem services using metrics other than money (Gómez-Baggethun et al., 2014).

The aim of the report is also to look beyond the awareness-raising role of economic valuation. If economic valuation of ecosystem services succeeds in raising awareness, it gains legitimacy and there will be a demand for applying the methods more specifically. There will be considerable practical challenges if that happens. As an example, despite several decades of environmental economic research in Norway, economic valuation of ecosystem services is only practiced to a very limited extent as part of Norwegian EIA regulations under the Planning and Building Act (Catrinu-Renström et al., 2013).

We aim to raise questions about 'policy-relevant' valuation throughout the report. What is required in moving from awareness raising to natural capital accounting, priority setting, instrument design and natural resource damage assessment and even valuation in litigation? It is important to underline here that the decision-contexts discussed in the report will be hypothetical and do not necessarily represent actual policy questions in Oslo. We also agree with NOU 2013:10 in that testing the relevance of economic valuation for policy analysis, does not imply that economic valuation itself is a policy instrument, nor an endorsement of market-based instruments.

We hope that the discussion of 'policy-relevant valuation' will show that there is no single definition of 'reliable and accurate valuation of ecosystem services' - what is acceptable to the decision-maker depends on the decision-making context. We hope that this discussion will assist authorities in deciding when and to what extent to scale up valuation of ecosystem services.

[2] Value transfer takes estimates of ecosystem service values from an existing study site and applies them to new policy context and/or a new policy site. Value transfer is discussed further in a companion study to this report: Barton, D.N., Vågnes Traaholt, N., Blumentrath, S., 2015a. Materials and methods appendix for valuation of ecosystem services of green infrastructure in Oslo. NINA Report 1115..

Green infrastructure terminology

The natural system terminology used for urban ecosystem services depends on the scale of analysis, ranging from individual blue and green structures and spaces at property and street level to blue-green infrastructure and urban ecosystems at neighbourhood, city and landscape level. For example, Oslo Municipality has emphasised the role water in its blue-green factor (BGF) methodology at property level. For ease of presentation we use the term ‘green infrastructure’ to cover all these concepts. In some places we refer to ‘structures’ and ‘spaces’ when it is necessary to be more precise about the spatial resolution of the examples.

Structure of this report

The report is structured as follows.

In chapter 2 we present a framework for identifying the decision-contexts of the economic valuation of ecosystem services. The different policy contexts of valuation are the ‘red thread’ running through the report.

Chapter 3 provides background on the extent to which valuation of ecosystem services is considered in national level policy on urban green infrastructure and impact assessment guidelines. The chapter links the relatively new ecosystem services concept to the more established ‘unpriced impacts’ and ‘green structure’ terminology of national guidance documents.

Chapter 4 reviews municipal policy and planning documents for the City of Oslo. Here we discuss the extent to which ecosystem services categories identified at national level (NOU, 2013:10) are addressed by municipal plans. We identify some potential ecosystem service information gaps that could be subject to further study.

Chapter 5 constitutes the main body of the report containing four economic and two non-economic valuation examples. The economic valuation estimates are summarised, followed by a discussion of what further information would be needed to address a series of hypothetical policy applications. For the interested reader, the four economic valuation examples are documented more extensively in a companion report (Barton et al., 2015a).

Chapter 6 provides recommendations for further economic valuation of ecosystem services in and around Oslo.

Chapter 7 concludes the report with the main methodological lessons learned from the valuation examples and a synthesis of future research needs.

Methodological appendix

Further discussion of the methodological framework, the data and assumptions behind the valuation examples can also be found in Barton et al. (2015) Materials and methods appendix for valuation of ecosystem services of green infrastructure in Oslo. NINA Report 1115 available at www.nina.no.

2 Valuation of ecosystem services for policy

In this chapter we provide the conceptual framework for the examples of valuation of urban ecosystem services to follow in the rest of the report. We discuss the ecosystem services cascade and the importance for economic valuation of identifying the incremental impacts of decisions with costs. We then go deeper to outline a number of ways in which economic values of ecosystem services are context dependent. We discuss how the context dependence of values – value heterogeneity – is the principle source of uncertainty in economic valuation of ecosystem services. We then briefly discuss the notion that economic values are not "fixed" – neither in space nor in time. We argue that economic values of ecosystem services have a limited 'shelf life' because they are specific to decision-making at particular times in the policy cycle. Different stages in the policy cycle require different types of values with varying demands on reliability and accuracy. This leads to the framework for policy-relevant valuation of ecosystem services at different scales. The framework brings together the notions that economic valuation is specific to particular spatial scale and resolution, and to different policy uses of valuation.

2.1 Values in the ecosystem services cascade framework

The ecosystem services cascade emphasises the links between biodiversity, ecosystem services and different measures of human well-being (Haines-Young and Potschin, 2010). In its most basic sense economics is about choice between decisions with costs that have outcomes with different welfare impacts. Costs and (values of) benefits are compared to aid in selecting decisions with most welfare and least cost (***Figure 2.1***).

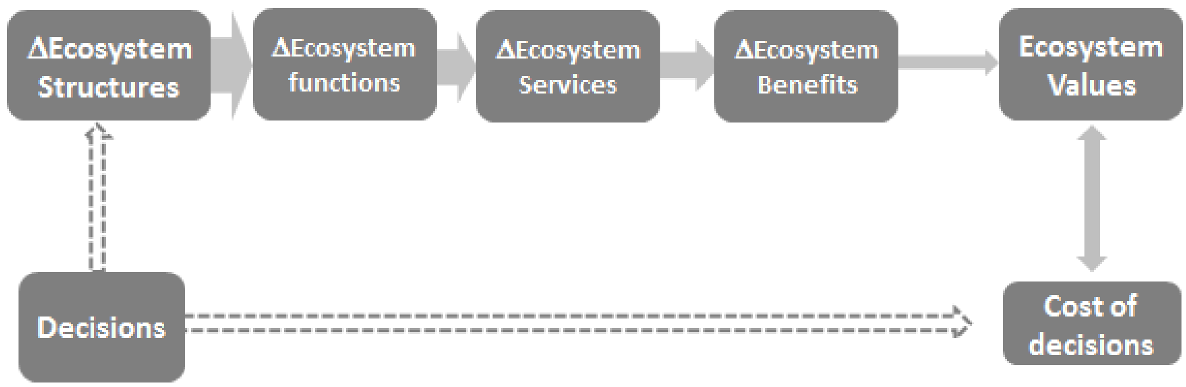


Figure 2.1 *Ecosystem services cascade – ecosystem values are determine by decisions*

Valuation of ecosystem services is decision-context specific because values are an expression of preferences for alternative courses of action with alternative benefits and values. In this sense "total economic valuation" of ecosystems has limited usefulness for decision support (Brouwer et al., 2013). While total economic valuation is relevant only for the special case of total loss of the ecosystem in question, we argue below that such a scenario may still play a role for awareness-raising.

How do we know if economic valuation is decision-relevant? From the simple framework in ***Figure 2.1*** we can guess that the «benchmark» requirement for accuracy and reliability of ecosystem values is conditional on the accuracy and reliability of the costs of decisions. We want to know with a certain level of confidence whether the value of benefits exceeds costs. The «benchmark» accuracy and reliability requirement for ecosystem services values cannot be established until the decision context and our confidence about costs of decisions is identified.

2.2 Context specific values of ecosystem services

Next we go deeper to outline a number of ways in which economic values of ecosystem services are context dependent. We discuss how the context dependence of values – value heterogeneity – is the principle source of uncertainty in economic valuation of ecosystem services.

Figure 2.2 summarises in a conceptual diagram the different ways in which ecosystem service values are conditioned by context. Lacking knowledge in each of the ecosystem service cascade steps is one way of thinking about sources of uncertainty in economic valuation. "Integrated valuation uncertainty" is the combination of these factors. Here we argue that awareness of sources of uncertainty is important in knowing the appropriate decision-support contexts for economic valuation. It is also a useful conceptual tool for thinking about potential errors in value transfer.

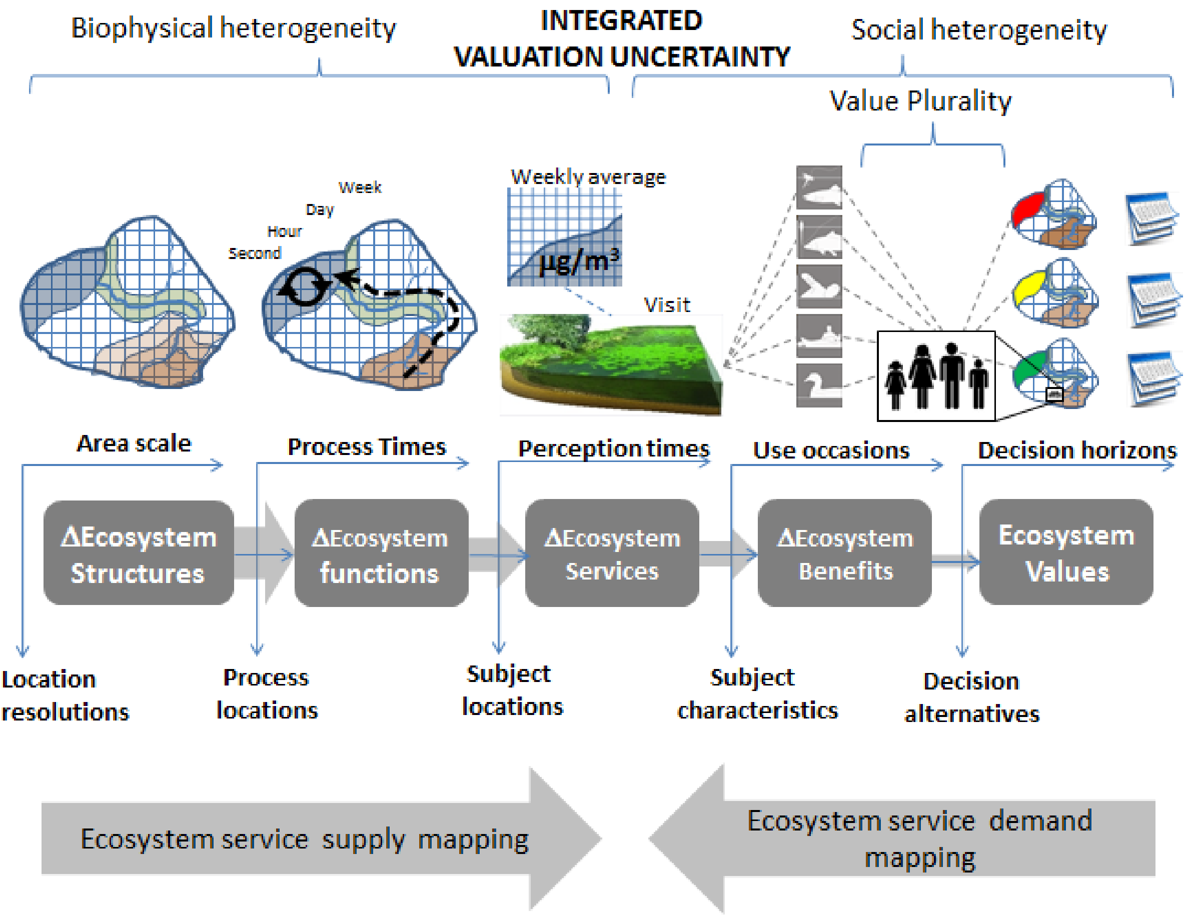


Figure 2.2 *Ecosystem service values are context specific. Cities are high context density environments.*

Figure 2.2 can be explained with an example from a relatively simple example of lake eutrophication in a rural setting. Starting at the left in the figure, the watershed and lake constitute the study area. The combination of spatial scale and resolution determines information about *ecosystem structure*. A change (Δ) in ecosystem structure through watershed management measures such as artificial wetlands, buffers strips, reduced tillage, winter stubble reduces nutrient run-off relative to a baseline landuse situation. Nutrient run-off, the run-off mitigation function of new vegetation and waterways, and the lake processes that lead to reduced nutrient concentrations are specified across a number of locations and time steps using dynamic models. The number of locations and time steps in the catchment monitoring programme determine the information about *ecological function* of the catchment system. Reduced nutrient concentrations (Δ $\mu g/m^3$) result in reduced algal blooms at specific places and times in the lake. These can be perceived by people and so constitute the basis for an ecosystem service. The number of locations and times we record perceptions determine the extent of our knowledge about the *ecosystem services* of nutrient mitigation provided by blue-green structures in the catchment. The combined variation across ecosystem structures, function and service end-points describe *biophysical heterogeneity*. Ecosystem service supply mapping aims at describing this heterogeneity. Heterogeneity that is not described is uncertainty.

Ecosystem benefits are determined by how well we can identify potential lake user occasions and the population of lake users' personal characteristics (child, man, woman, family, single etc.). Different catchment management measures determine the potential improvement in lake suitability according to a classification system) for a potential lake use (red-yellow, red-green etc.). Individual willingness-to-pay for nutrient mitigation measures depends on how the management decisions are framed in terms of the number of management choice alternatives and the time between payment and improvement in use suitability. The extent to which researchers know decision alternatives and horizons and the different individuals' reactions to them determine their knowledge of *ecosystem values*. Values are therefore place, time, group and person specific. The combined variation from ecosystem service end-point, benefits and values is called *social heterogeneity* in ***Figure 2.2***. Ecosystem service demand mapping aims at describing this heterogeneity. Heterogeneity that is not described is uncertainty.

The combination of uncertainty about biophysical and social heterogeneity constitutes *integrated valuation uncertainty in* ***Figure 2.2***. Even for this relatively simple example of a rural catchment experiencing lake eutrophication we can envisage a large number of value contexts.

We now invite the reader to image an urban context with higher fragmentation of green structures, higher population density and higher cultural diversity. Cities are high context density environments. They represent one of the most challenging contexts for ecosystem service valuation (Gómez-Baggethun and Barton, 2013).

2.3 Values in the policy cycle

We now briefly discuss the notion that the contexts in which economic value estimates are to be used is not "fixed" either – neither in space nor in time. This means that economic values of ecosystem services have a 'shelf-life'. Values are specific to decision-making at particular points in the policy cycle. Different stages in the policy cycle require different types of values with varying demands on reliability and accuracy.

Starting in the top right hand corner of ***Figure 2.3***, ecosystem services valuation is typically seen as being the assessment of *final ecosystem services outcomes* of landuse planning decisions. Valuation is seen as an "end-point" in benefit-cost analysis of what policy is most *efficient* to implement. When valuation of final ecosystem service outcomes is not possible or too expensive, we move 'back' in the policy cycle to simpler *cost-effectiveness* analysis of *intermediate outcomes* or of policy *outputs* is a commonly used approach. This is the part of the policy cycle focusing on evaluating the ex post results of policy.

However, in a policy cycle ecosystem services valuation may also be seen as a starting point. Starting in the left hand upper corner of ***Figure 2.3***, valuation may be conducted for awareness raising and as scoping exercise before identifying ecosystem service *needs and wants*. Used in this way economic valuation can provide arguments for policy formulation. Economic valuation may also help to assess *goals*, justify the use of *resources* and assess costs of *implementation* (***Figure 2.3***).

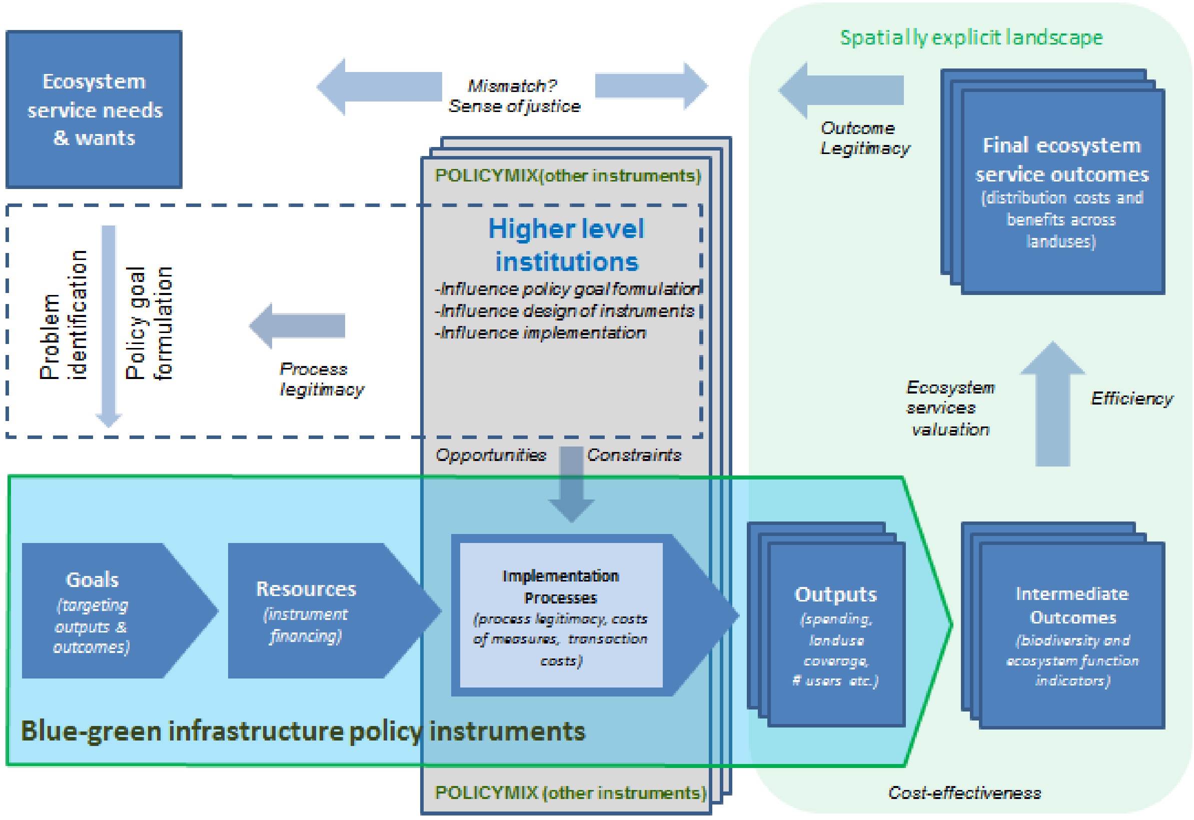


Figure 2.3. *What is the role of ecosystem services valuation in the policy cycle? Source: Barton et al. (2014)*

The policy cycle perspective helps us place the role of economic valuation of ecosystem services in perspective. In a policy cycle there are also other types of arguments than “economic value” that support decisions (*sense of justice, process legitimacy, opportunities and constraints imposed by other policies*). Economic valuation of ecosystem services has to compete as just one more argument on the table. Nor is there “one right” answer regarding the economic value of ecosystem services. Ecosystem services values – when they are available – should continuously be updated by new information as new decision contexts arise. Even in the special case of the “total economic value“ (TEV) of ecosystem services, TEV needs to be updated as landuse opportunities shift and policy priorities are updated as a result.

2.4 A framework for decision-contexts of economic valuation

There is a need to continually update economic valuation of ecosystem services as the policy cycle proceeds from awareness raising towards decision support. This leads us to a proposal for a framework for decision-relevant valuation of ecosystem services adapted to the urban context (Gómez-Baggethun and Barton, 2013) . The framework brings together the notions that economic valuation is specific to particular spatial scale and resolution, and to different decision contexts with increasing requirements for accuracy and reliability of economic valuation.

Figure 2.4 presents a framework in which to identify ecosystem service valuation fit for different decision-support purposes. The framework has three axes. Geographical scale of the study increases with the vertical axis from a study of a single property to a study of a whole region such as Greater Oslo. On the depth axis, spatial resolution indicates at what level of detail ecosystem services are mapped, for example with data on every single property right up to simple aggregate values for regions. The highest mapping information requirement comes with a regional scale map with information on every single property. On the horizontal axis suggests that decision-support contexts will have increasing requirements for reliability and accuracy of economic valuation.

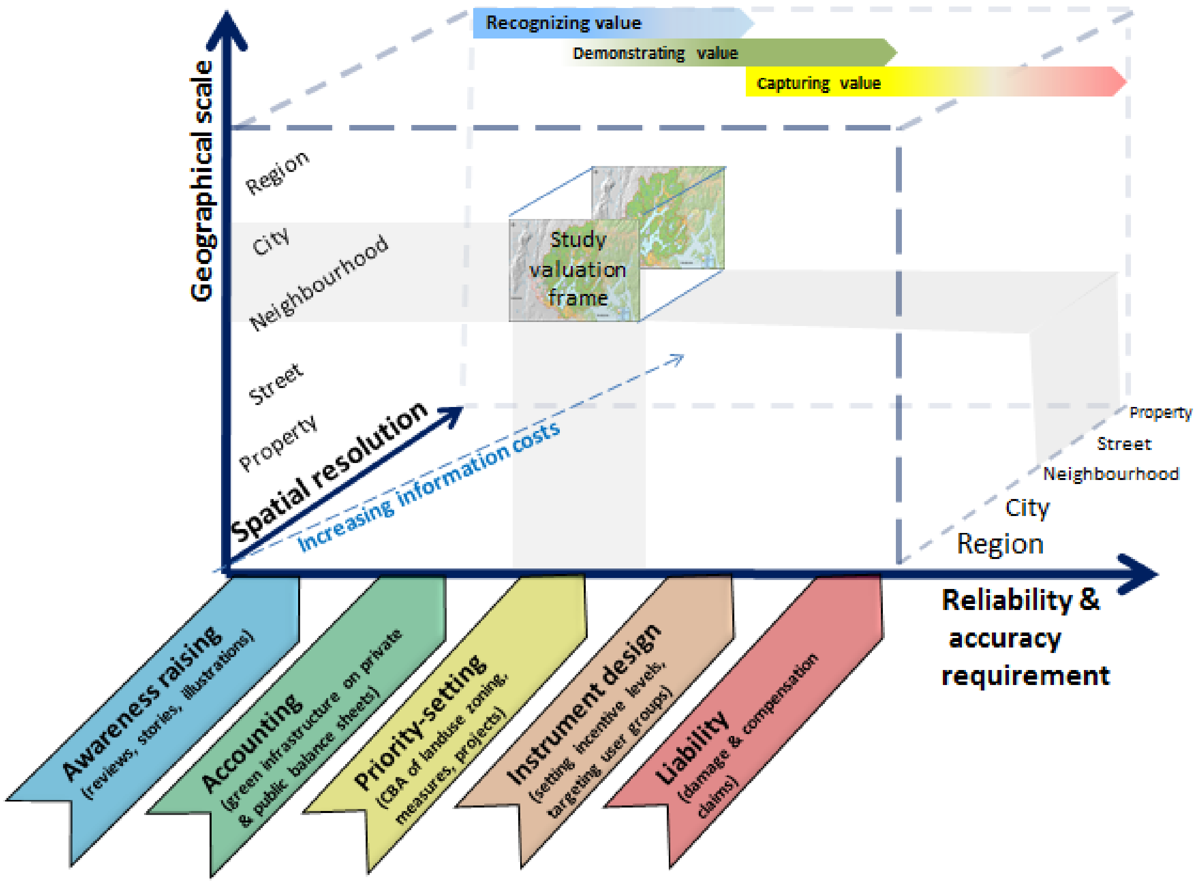


Figure 2.4. *A Framework for policy-relevant valuation of ecosystem services at different scales Source:adapted from Gómez-Baggethun and Barton (2013)*

Figure 2.4 suggests 5 main types of decision context[3] from *awareness-raising*, *accounting, priority-setting*, through *instrument design* to calculation of economic *liability.* The framework suggests that requirements for accuracy and reliability should increase successively when moving from a policy setting requiring simply awareness raising (e.g. regarding costs of ecosystem service loss); to including ecological infrastructure in accounting of municipal assets; to priority-setting (e.g. for location of new neighbourhoods); to instrument design (e.g. user fees to finance public utilities); or finally to calculation of economic liability for damage compensation in a litigation case (e.g. destruction of city trees due to negligence). This logic is reflected in the TEEB reports'(TEEB, 2010) reference to first recognizing value, then demonstrating value, and finally capturing value.

Information costs increase with the increasing demand for accuracy and reliability of valuation methods. Information costs of economic valuation increase as we successively when moving from a policy setting requiring simply awareness raising (far left) to calculation of economic liability that is evaluated in a court of law. Information demands also increase with increasing geographical scale and spatial resolution of the decision-support context[4]. Recall ***Figure 2.2*** – the requirements for accuracy and reliability encompass uncertainty of integrated valuation across the ecosystem services cascade, not just to the uncertainty of the final economic valuation step.

[3] In the methodological appendix to this report ibid. we review frameworks that have other ways of looking at policy contexts of economic valuation.
[4] In the methodological appendix to this report ibid. we give further examples from Oslo of decision contexts at the different spatial scales and resolutions referred to in ***Figure 2.4***.

We argue that specification of the decision context is a condition for carrying out valuation that is perceived as plausible and useful relation to the quality of decision-making. It also encourages the decision-maker to think through whether it is plausible that economic valuation will provide credible decision-support, before commissioning a study.

In Chapter 5 a number of examples illustrate value transfer with available information for “awareness raising” purposes. We then use the framework to discuss how far we think the available information can be used for more demanding types of decision-support.

.

3 Urban ecosystem services of green infrastructure at national level

In the previous section we discussed the importance of decision-making contexts in ecosystem service valuation. Now we will examine some typical public policy decision-contexts in Norway where further application of economic valuation of urban ecosystem services may be particularly relevant in future; concept choice assessment, impact assessment and green structure planning. The aim of this chapter will be to determine what requirements currently exists for economic valuation of ecosystem services, with emphasis on urban settings.

3.1 Concept choice assessment ("konseptvalgsutredning")

Projects of more than 500 MNOK are subject to concept screening of alternatives following Ministry of Finance guidance (Finansdepartementet, 2010). This involves conducting an "economic analysis" also following the Ministry of Finance's guidance (Finansdepartementet, 2005). The guidance on social economic analysis discusses valuation methods for public goods not traded in markets. These impacts are 'externalities' to the investment decision and the guidance argues that they will be mainly 'unpriced impacts'.

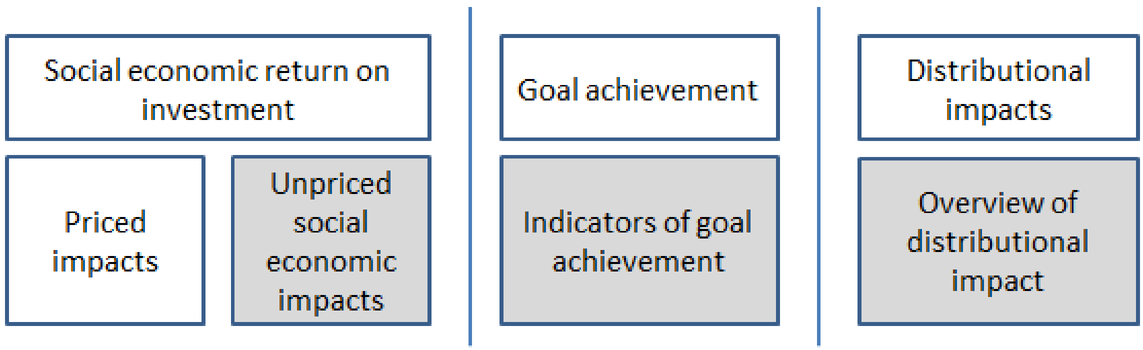


Figure 3.5. *Recommended separation between project economic analysis, analysis of goal achievement and distributional impacts in choice of concept assessments.*

Source: translated from Bull-Berg et al. (2014)

Bull-Berg et al. (2014) reviewed "unpriced impacts" in social economic analysis in choice of concept studies. They found that assessments of 'unpriced impacts' were often confounded with multiple criteria assessment (MCA) of goal achievement and assessment of distributional impacts. They recommend a clear distinction between these types of assessments (***Figure 3.5***).We think that confounding is in part due to the ecosystem function that links different parts of landscape and landusers. We think that ecosystem service assessment methodology might contribute to better classification of impacts.

For 'unpriced impacts' the Ministry of Finance recommends using the Roads Authority´s Impact Evaluation Handbook 140 (StatensVegvesen, 2006). 'Unpriced impacts' in Handbook 140 are defined as impacts on landscape, local environment and recreation, natural environment, cultural environment, natural resources (forest, farming, drinking water etc) (***Figures 3.6*** - ***3.7*** below).

We also see a problem in how a 'cascade of guidance documents' from the Ministry of Finance to the Roads Authority's guidance constrains assessment of impacts on ecosystem services in practice. What NOU 2013:10 defines as regulating, cultural[5] and supporting ecosystem services are categorised by definition by the Roads Authority's Handbook 140 as 'unpriced', independently of

[5] NOU 2013:10 uses the Norwegian translation of "experiential & knowledge-based services" instead of cultural ecosystem services.

whether there is site-specific data and methods available to value impacts monetarily. Furthermore, the guidance terminology of 'priced' ('prisede') impacts is somewhat at odds with the conclusions of NOU 2013:10 that valuation of ecosystem services does not necessarily imply an endorsement of pricing as a policy instrument (e.g. through payments for ecosystem services). In our opinion the 'pricing' terminology used in Handbook 140 makes it more challenging to communicate cases where 'valuation' of assessing ecosystem services is feasible and relevant.

3.2 Impact assessment ("konsekvensutredning")

As there are no Norwegian EIA guidelines of more general nature, the standard procedure for environmental impact assessment also outside also outside the road sector is the Roads Authority Impact Evaluation Handbook 140 (StatensVegvesen, 2006). Ecosystem service terminology is not employed in Handbook 140. The impact terminology focuses on making clear operational distinctions between 'priced impacts' and 'unpriced impacts' (***Figure 3.6***). What we would call ecosystem services impacts according to NOU 2013:10 – impacts on landscape, local environment and recreation, natural environment, cultural environment, natural resources (forest, farming, drinking water) – are defined as 'unpriced impacts' (***Figure 3.7***).

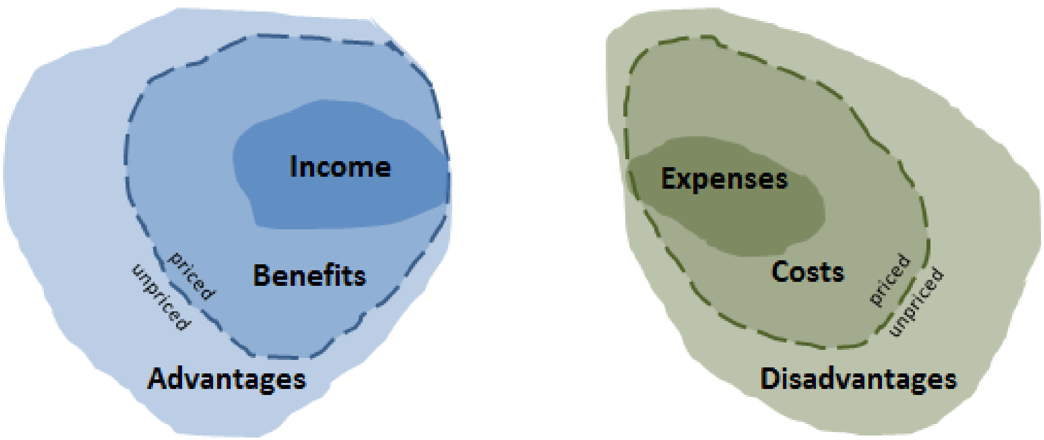


Figure 3.6 *Terminology for priced and unpriced impacts in Norwegian impact assessment. Ecosystem services are defined as 'unpriced' advantages and disadvantages, even where methods are available to value costs and benefits.*

Source: adapted from Impact assessment Handbook 140 (StatensVegvesen, 2006).

Magnussen and Lindhjem (2013) review the arguments for social economic pricing of the loss of farmland and other natural resources in Handbook 140. They recommend that the fixed evaluation categories / criteria for 'unpriced impacts' used in Handbook 140 be more flexible in terms of what impacts are grouped together. More flexibility would make it possible to employ economic valuation techniques that jointly 'price' several different 'unpriced impacts' associated with loss of particular farmland and forest. Furthermore, they find that current impact categories can lead to double counting of impacts. They suggest that 'pricing' of hitherto 'unpriced impacts' will improve transparency in accounting of impacts and may reduce double counting. 'Pricing' impacts requires more rigour in the definition of what biophysical impacts are included in the analysis. They also find the distinction between ''priced and unpriced impacts' artificial as many impacts on natural resources such as farmland and forest are currently include as 'priced impacts'. They recommend further exploring ecosystem services as concepts for impact assessment.

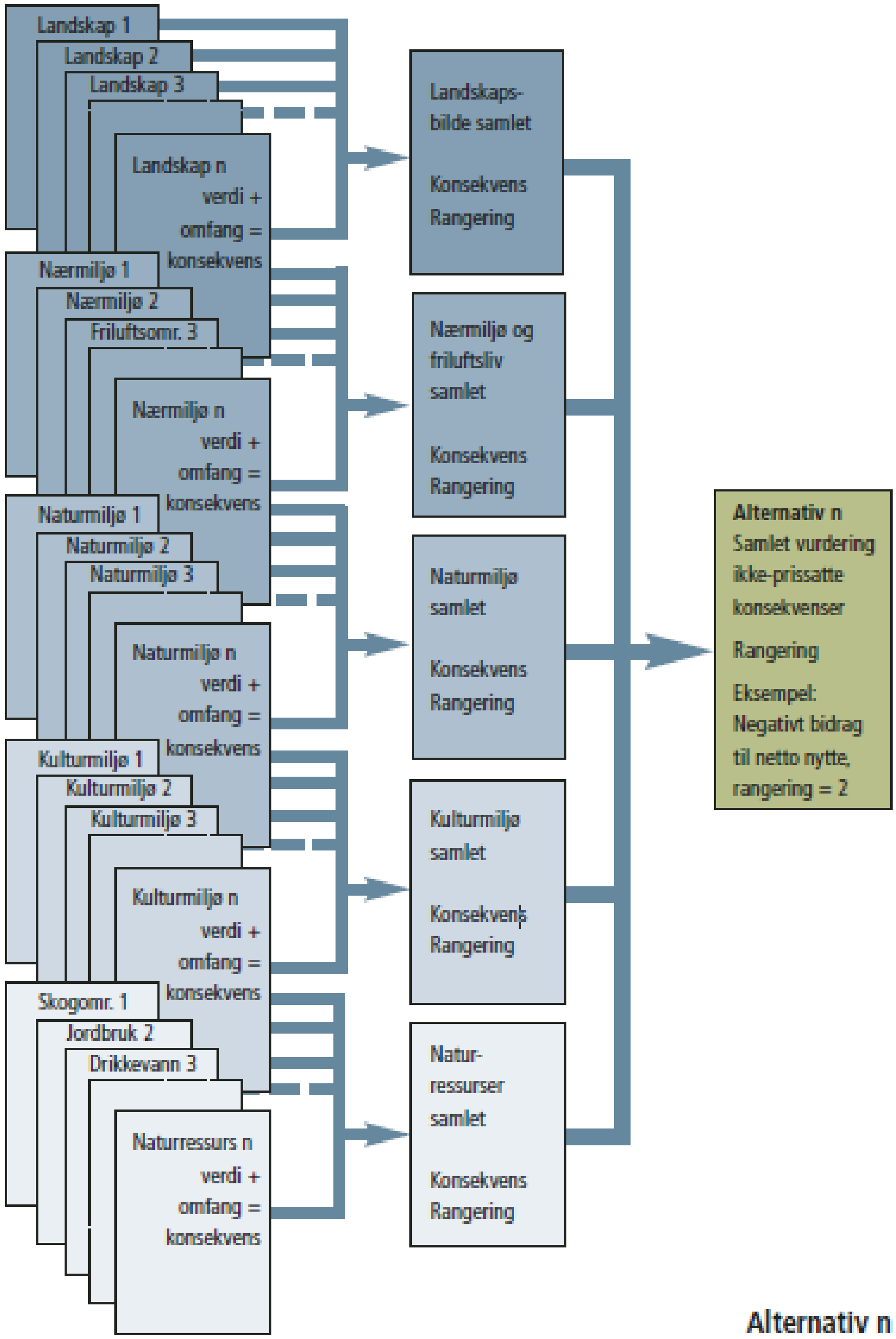


Figure 3.7 *'Unpriced impacts' in Norwegian Impact Assessment methodology.*

Source: Handbook 140, p.145 (StatensVegvesen, 2006). Landscape, local environment and recreation, natural environment, cultural environment, natural resources (forest, farming, drinking water).

Figure 3.8 provides an overview of the definition of priced and unpriced effects in Handbooks 140. Impacts on traffic and transport users, operators and the public budget are priced. Residual infrastructure value, tax financing costs are priced impacts on wider society. Mortality and morbidity due to traffic accidents, noise and pollution are also priced using methodology specifically developed for Handbook 140. Other impacts are defined as 'unpriced'.

The importance of terminology in public guidance documents is trivial in the sense that significant impacts will be evaluated in large public investment projects whatever terminology is used. However, lacking use of ecosystem services terminology is non-trivial in the sense that assessment methodologies developed under the wider the ecosystem approach (NOU, 2013:10) and economic valuation for the purpose of 'capturing value' in decision processes (TEEB, 2010) are less likely to become operational in Norwegian impact assessment. It is worth noting that before the first Impact Assessment guidance in 1988, and a revision in 1995, morbidity and mortality due to accidents, noise and pollution were 'external effects' to social economic analysis. It is worth asking whether three more decades of operational research would make it possible to price some ecosystem services, and integrate ecosystem service science into impact assessment.

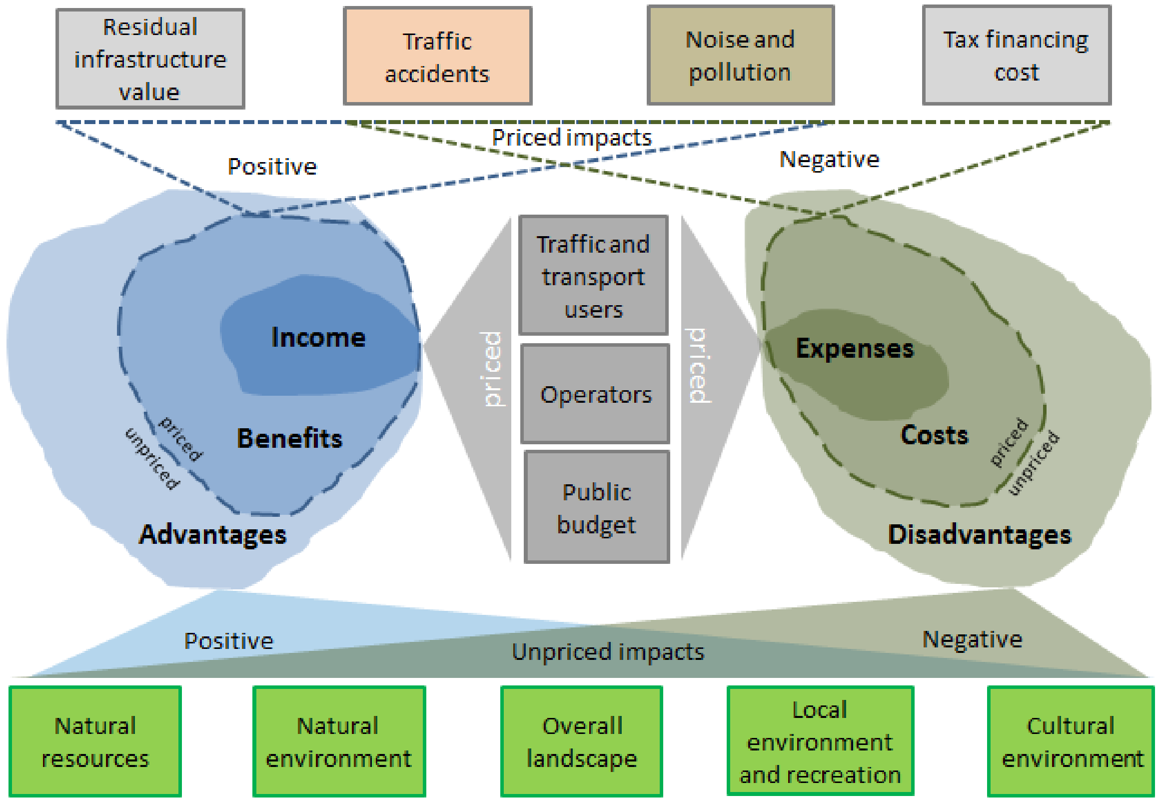


Figure 3.8 *An overview of priced and unpriced effects in Norwegian impact assessment guidance.*

Source: based on p.62 and p.64 Roads Authority Handbook 140

Looking back to the Framework in ***Figure 2.4*** it is also worth noting that this will increase information costs of impact assessment. Further work is needed on these information costs relative to the size of the public investment and the values of ecosystem services impacts.

3.3 Planning of green infrastructure in cities and urban areas

As we saw Scott (2014) argues that ecosystem services language can be alienating to professionals working with the built environment.

We therefore reviewed the use of ecosystem terminology the Norwegian Environment Agency's Guidance Document M100 on "Planning of green infrastructure in cities and urban areas" (Miljødirektoratet, 2014). Ecosystem services terminology is referred to briefly as a potential new concept to urban planning of green infrastructure in Norway. Ecosystem services terminology is referred to briefly in a single text box in the M100 guidance document. However regulating, experiential and cognitive (cultural) and supporting services are referred to throughout the planning guidance using established terminology from landscape ecology, ecosystem function and user interests (***Table A1.1*** in Appendix).

Norwegian Environment Agency Guidance Document M100 on "Planning of green infrastructure in cities and urban areas" (Miljødirektoratet, 2014)

Economic valuation of ecosystem services is not referred to anywhere as a possible type of decision-support in the planning of urban green infrastructure. One 'non-economic' valuation method - the blue-green factor (BFG) - is mentioned as a method for coarse grain evaluation of ecological effectiveness and setting minimum requirements of green structures in urban development projects. The guidance document underlines that "requirements for a blue-green factor cannot replace functional requirements for continuous green structures in area planning, coverage of different types of green space etc, nor requirements that certain areas must be preserved for biodiversity or landscape integrity" (p. 40, author's translation).

The fact that a qualitative scoring methods such as BGF are not part of municipal landuse planning approach, suggests that the integration of economic valuation methods as policy support will be an even more unfamiliar approach and at least partially in conflict with current municipal regulatory and planning approaches.

4 Urban ecosystem services from green infrastructure in Oslo

In the previous chapter we reviewed the requirements for valuing ecosystem services currently in Norwegian national level guidance documents on assessing public policy and projects, and in urban planning. In this chapter we zoom in to the municipal level and Oslo in particular. To what extent are different ecosystem services the focus of municipal policy in Oslo? This provides backdrop for our choice of ecosystem services to value in chapter 5.

4.1 Identifying priority urban ecosystem services

Lindhjem and Sørheim (2012), based on Bolund and Hunhammar (1999), presented a list of urban ecosystem services expected to be associated with different green infrastructure in cities in Norway. Reinvang et al. (2014) developed a list of ecosystem services in collaboration with Oslo Municipality. In ***Table 4.1*** we look at the extent to which these urban ecosystem services have been mentioned[6] in the following recent key policy documents on environment and land use planning in Oslo.

Green infrastructure features prominently in many key planning documents for the municipality of Oslo. Both the current and proposed Municipal Master Plans describe how the green infrastructure located within the municipality's borders give the city its character that planning strategies must strive to maintain. For example, approximately two-thirds of the 454 km^2 within Oslo's municipal borders qualified as nature areas, with most of it located in the "Marka" 'greenbelt' woodlands that surround the built area in the city centre.

Planning policy and goals are explicit about both protecting and further enhancing the city's existing green infrastructure. Both master plans and plans for the green infrastructure specify that Oslo's future development is to occur within areas that are already developed, and should thereby not encroach upon either the borders of the peri-urban Marka or green spaces within the built zone. Initiatives in these plans also promote continued restoration and re-opening of the waterways that connect the Marka forest to the fjord.

Recreational activities constitute perhaps the ecosystem service provided by the city's green infrastructure that receives the greatest attention. All municipal policy documents we reviewed mentioned this service explicitly and in greater detail than other services. The outdoor recreational opportunities available in the peri-urban natural areas of the Marka are quite popular among Oslo residents: 42 % of Oslo's population reports visiting the Marka weekly (OsloKommune, 2013c). Policy documents lauded the existing green infrastructure's capacity for providing opportunities for recreation, aesthetic enhancements, and a sense of place/ cultural heritage: all ecosystem services that are highly correlated or "bundled". To facilitate residents' access to these bundled services from green infrastructure, planning policy address green infrastructure's dispersion within the municipality and its proximity for city residents. Planning and zoning strategies seek to ensure that a range sizes and types of green areas - from developed parks to natural areas - are within walking distance of residents' homes.

All policy documents, excluding the Action Plan for Noise Reduction, addressed the role that green infrastructure has as a supporting service for habitat for biodiversity. The current Master Plan states that "conservation of the city's biodiversity is an important premise for a sustainable development of Oslo" (p. 45)(OsloKommune, 2008). The proposed Master Plan states, "The city's biodiversity is dependent upon varied and continuous natural areas" (p. 31)(OsloKommune, 2013a). The Green Plan addresses the importance of preserving and maintaining unique or threatened habitat types

[6] In terms of ecosystem services ('økosystemtjenester') or related concepts in Norwegian such as user interests ('brukerinteresser'), nature values ('naturverdier'), nature's goods and services ('naturgoder'), health values ('helseeffekter').

as a basis for conservation of rare and threatened species including “fungi, mosses, vascular plants and insects.” (p. 42)(OsloKommune, 2006). The Urban Ecology Programme (2011) includes the target that “Oslo will protect and enhance biodiversity” (p. 15)(OsloKommune, 2011). However, any discussion of specific benefits provided by urban biodiversity is either cursory or absent.

Surface water management is another ecosystem service that features prominently in Oslo policy addressing green infrastructure. Surface water and storm water management is a service that is anticipated to have progressively increasing importance as a function of projected climate changes that will bring more frequent extreme precipitation events. “The green infrastructure filtrates and processes surface water. Especially large trees with well-developed root systems make important contributions to processing. The green infrastructure… functions as Oslo’s largest transport medium for surface water.”(p.42) (OsloKommune, 2010). Policy promotes the re-opening of Oslo’s waterways that connect the Marka woodlands with the fjord are a central measure “climate” strategy that recognizes the green infrastructure’s contributions to both surface water management and air quality regulating services. These waterways serve as transport corridors of large masses of cooler air, removing and diluting air with higher concentration of pollutants.

Table 4.1 *Urban ecosystem services of green infrastructure mentioned in selected municipal strategy and policy documents*

		PERI-URBAN blue-green infrastructure								BUILT AREA blue-green infrastructure					
		Island	Fjord	Coast-line	Forest area	Agri-culture	Lakes	Parks and sports	Other open space	Forest	Rivers and Streams	Com-munal gardens	Private gardens	City Trees	Green roofs, facade
Category	Ecosystem														
Cultural services	Recreation, physical and	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5		1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5			
	Aesthetics	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5		1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	3,4	3,4	3
	Education, cognitive	3,4	3,4	3,4	3,4		3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	
	Sense of place, heritage	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5		1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5		1,2,3,4,5	
	Tourism	2	2	2	2		2	2	2	2	2	2		2	
	Art/toys							4				4			
Regulating services	Storm water mangement		7		2,3,4,5		2,3,4,5,7	2,3,4,5	2,3,4,5	2,3,4,5	2,3,4,5,7	2,3,4,7	3,7	3	3,7
	Erosion control				3					3	3	3	3	3	
	Local climate regulation				2					3	2,3	3	3	3	3
	cleaning soil, water or air				2,3	3		3	3	2,3	2,3	2,3	3	2,3	3
	CO2 sequestration														
	Noise reduction				6			6			2, 4, 6	6			6
	Pollination and seed dispersal														
Provisioning services	Food & fiber production		4	4	4		4				4				
	Water provision				4		2,4								
Supporting services	Habitat for biodiversity	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5		1,2,3,4,5	1,2,3,4	1,3,4	1,2,3,4,5	1,2,3,4,5	1,2,3,4,5	3	2,3,4	

Sources: Icons developed by Oslo Municipality, Vista Analyse and nxt oslo reklamebyrå

Municipal documents reviewed in the table:

1. Oslo Municipal Master plan (2008): *“Kommuneplan 2008: Oslo mot 2025”*
2. Oslo Municipal Master Plan (proposed) Smart, Safe and Green: *“Smart, Trygg, Grønn. Kommuneplan for Oslo: Oslo mot 2030 (Høringsutkast)”*
3. Green Plan for Oslo. Municipal subplan for the green infrastructure (2010): *“Grøntplan for Oslo: Kommunedelplan for den blågrønne strukturen i Oslos byggesone”*
4. Plan for Sport and Outdoor recreation in Oslo (2013-2016): *“Plan for Idrett og Friluftsliv i Oslo 2013-2016”*
5. City of Oslo Urban Ecology Programme 2011-2016
6. Action Plan for Noise Reduction 2008-2013: *“Handlingsplan mot støy i Oslo 2008-2013”*
7. Strategy for Surface water management 2013-2030.

Note: municipal documents listed have not all been approved politically. Therefore, the table gives an overall impression of focus areas as ‘work in progress’ by 2014 on ecosystem service and green infrastructure topics.

4.2 Ecosystem service 'gaps' in municipal planning documents

Some ecosystem services provided by urban green infrastructure were not mentioned in any of the planning documents we reviewed (***Table 4.1***). For example, we found no mention of **CO_2 sequestration and storage,** the process by which vegetation—primarily trees—fixes carbon through photosynthesis and stores the carbon as biomass. Urban tree carbon sequestration is a function of the total amount of tree cover. Accordingly, the area capable of having the largest impact on the supply of this service is the peri-urban Marka woodlands. Most aspects of management and planning of the Marka are generally dictated by the *Markalov* or "woodland legislation." Nonetheless, the Marka is located within the municipality's borders and features prominently in policy addressing other ecosystem services like recreational opportunities and habitat for biodiversity. Tree cover is expected to be noticeably lower in urban built areas than Oslo's peri-urban Marka, but even there carbon sequestration can be substantial. Estimates of the mean carbon storage rates per square meter tree cover in US urban areas are actually slightly higher those of woodlands(Heath et al., 2011; Nowak et al., 2013).

Pollination and seed dispersal was another ecosystem service category not mentioned in the policy we reviewed. Pollination provided by domestic honeybees, wild bees and other insect groups is an ecosystem service with substantial importance to agriculture. On a global basis, approximately 35 % of food crops depend on animal pollination (Klein et al., 2007). Large or even moderate scale agriculture is virtually absent within the municipality of Oslo. Yet pollinator services have important roles outside of crop production. Animal pollination is absolutely necessary for continued existence of the flowering plants that provide aesthetic benefits, prevent erosion, increase the experiential value provide habitat or food resources for rare and threatened species or simply support the greater biodiversity. Oslo's green infrastructure includes many older villas with apple gardens that are both a food source and landscape components that provide sense of place and cultural heritage. These apple gardens depend on pollinators to produce fruit and serve as an important resource for the pollinators themselves. Natural regeneration of certain tree and herbaceous plant species is also dependent upon animals that disperse seeds across the urban and peri-urban landscape. One such example with potential relevance for Oslo is the Siberian jays that enable natural regeneration of the oak dominated landscape in Stockholm's National Urban Park (Hougner et al., 2006). In some contexts, however, animal dispersal of seeds is also a clear ecosystem disservice that facilitates the spread of undesirable plant species within the urban environment.

Planning documents addressed the capacity for green infrastructure to provide **noise-reduction**. However, the exact role of green infrastructure in reducing noise was ambiguous. The noise action plan and the green plan both explicitly recognize the role that Oslo's pockets of undeveloped land have in terms of providing refuges from noise, but the plans seem to imply that this is because these areas are devoid of roads and industrial activities that would produce noise. We found no recognition that the biophysical attributes of green infrastructure might actually ameliorate noise, either absorbed by the vegetation found within large continuous green areas or as elements within the built environment such as green walls, as has been demonstrated(Fang and Ling, 2003; Wong et al., 2010) (Fang and Ling 2003, Wong et al 2010). In settings where the vegetation itself is not sufficient to provide adequate noise attenuation, the presence of vegetation also may be used in combination with technological measures that reduce noise pollution to produce a psychological effect that increases the overall perception of the setting.

5 Valuation of ecosystem services from green infrastructure in Oslo

In this chapter we discuss four examples of economic valuation of ecosystem services of green infrastructure and their potential policy applications. We end the chapter with two sections on non-economic valuation.

Economic valuation examples:

1. Meta-analysis of willingness-to-pay for green spaces in the built zone
2. Hedonic pricing of green infrastructure in the built zone of Oslo
3. Time use value of Marka peri-urban forest outside the built zone of Oslo
4. Urban trees in the built zone

Non-economic valuation examples:

5. Blue green factor scoring of property in the built zone of Oslo
6. Health impacts of green infrastructure in Oslo

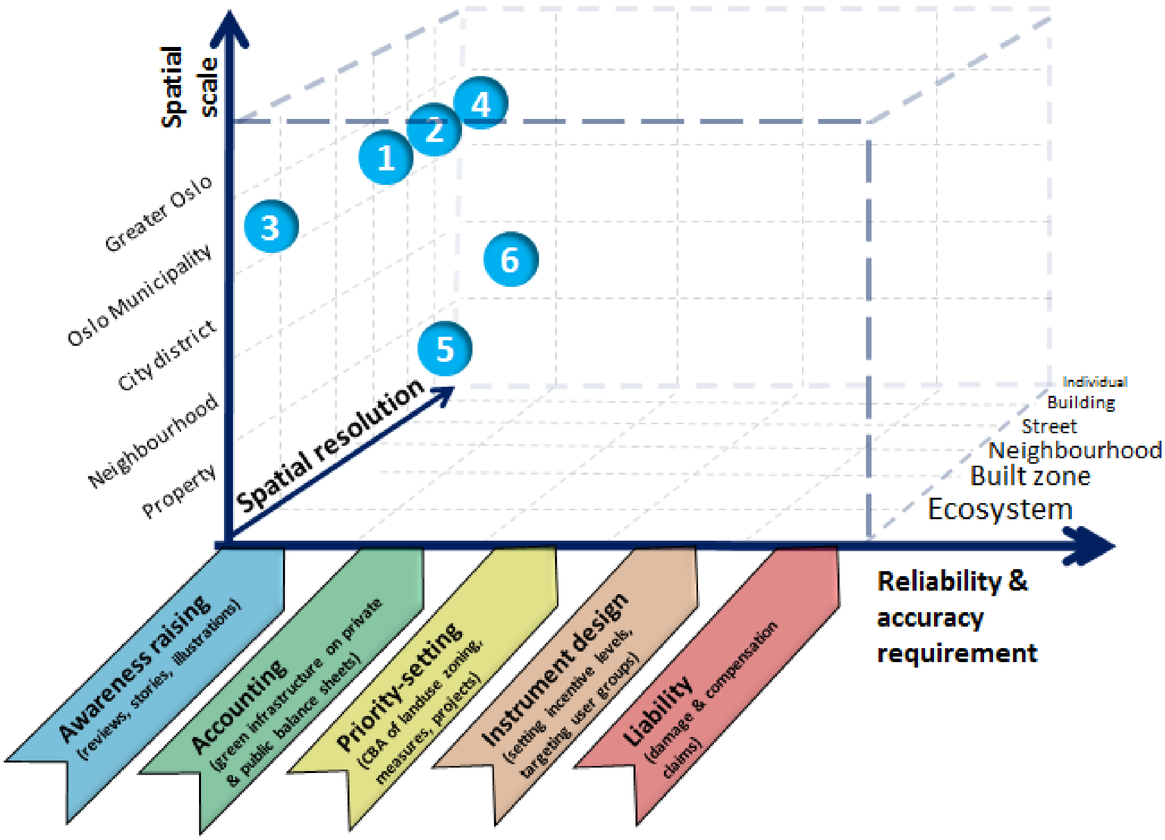


__Figure 5.1__ Spatial and decision contexts of the valuation examples

The economic valuation examples (1-4) are all at the scale of aggregate values for population of Oslo Muncipality, while the spatial resolution of the data varies from data on individual trees (4) and properties (2), through population densities per km^2 around neighbourhood parks (1), to the whole Marka forest ecosystem(3). Regarding the non-economic valuation; the blue green-factor is an accounting system at property scale with a building structure resolution (5). The health studies document the effect of green infrastructure at neighbourhood scale on individual perception of own health (6). The valuation examples in this report are all for awareness raising purposes with a level of reporting that should be able to satisfy relatively low requirements for documenting accuracy and reliability.

The choice of ecosystem service valuation examples in chapter 5 was made based on the following criteria:

- Convenience – availability of data
- Triangulation - comparison across different valuation methods addressing the same ecosystem service
- A review of valuation studies from other cities showed that cultural services were expected to be among the most important within the built area (Barton et al., 2015a).
- Demonstrating valuation focused on a bundles of services from a particular type of green structure (city trees) versus focusing on a particular type of ecosystem service (recreational services)

In chapter 6 we provide some suggestions for further studies of ecosystem services in Oslo based on our subjective opinion as researchers. We emphasise that future policy- applied valuation of ecosystem services for Oslo should be based on consultation with policy makers at different spatial administrative levels. Consideration could then be given to such criteria as:

- What ecosystem services are currently considered unpriced in national level guidance documents (see chapter 3)
- What ecosystem services have not been addressed by municipal policy documents (see chapter 4)
- What urban ecosystem services have been identified by Oslo Municipality as important for «awareness raising» regarding the importance of green infrastructure,
- What land use planning and investment decisions are a public concern as indicated by their prominence in political debate and in the media.
- What the research literature has found to be high value urban ecosystem services
- Costs of investment alternatives
- Cost of obtaining new data

In this pilot study we have not conducted a consultation across administrative levels of these issues. The discussion of potential policy contexts that follows each valuation example is therefore hypothetical.

5.1 Willingness to pay for recreation urban parks in Oslo

5.1.1 Ecosystem services

Valuation results in brief

Total open green space in Oslo's built area is approximately 2837 ha distributed across 548 distinct locations. Oslo's total open green space could be worth approximately 1 billion NOK/year in terms of willingness-to-pay to conserve them. This is equivalent to an average 1985 NOK/year per inhabitant>15 years old. This is based on a value transfer method which assumes that Oslo's population would be willing-to-pay what other populations have said they would be willing to pay for open space in a number of different countries.

For the first example of monetary valuation of ecosystem services from green infrastructure we start with urban open space. The term 'urban open space' is defined by Brander and Koetse (2011) and includes urban parks, forests, green spaces such as sporting facilities, undeveloped land, and agricultural land.

As urban open space represents a range of landuses it also provides the full range of ecosystem services identified in the introduction of the report (Reinvang et al., 2014). Only the value of recreation services of parks is valued in this example. Value transfer may include some other aspects of experiential and knowledge based services, although this is not well documented. They are partial because value estimates do not account for structural qualities of open spaces (only area).

Category	Ecosystem services of urban parks	Potential	Valued here
Cultural services	Recreation, physical and mental health	X	X
	Aesthetics	X	(X)
	Education, cognitive development	X	(X)
	Sense of place and cultural heritage	X	(X)
	Tourism	X	
	Art/toys	X	
Regulating services	Storm water mangement	X	
	Erosion control	X	
	Local climate regulation	X	
	cleaning soil, water or air	X	
	CO2 sequestration	X	
	Noise reduction	X	
Provisioning services	Food production		
	Fiber production		
	Water provision		
Habitat services	Habitat for biodiversity	X	
	Pollination and seed dispersal	X	

5.1.2 Valuation for awareness-raising

Contingent valuation is a method that asks people directly about their willingness to pay (WTP) to finance measures that protect or improve ecosystems. Strand and Wahl (1997) have conducted the only willingness-to-pay study in Oslo. They show that maximum willingness-to-pay can exceed the price of undeveloped land. They call for further studies to differentiate willingness to pay between city districts.

In this chapter we wanted to demonstrate the use value transfer with meta-analysis which adjusts values by amongst others size of green space and local population density. The meta-analysis by Brander and Koetse (2011) uses 20 different studies of willingness-to-pay for parks and green space, agricultural and undeveloped land and forests. Meta-analysis looks across a number of study sites and as such can only adjust for ecosystem characteristics that can be classified at all sites. The description of ecosystem services in the meta-analysis is limited to broad categories of recreation, preservation, aesthetics and environmental/agricultural services. All supporting and regulating services are grouped as a single category.

Meta-analysis produces a weighted average of WTP from the original studies, where the weights used are the coefficients in the meta-analysis function, and the input values are the characteristics of the study site. The approach adjusts original willingness-to-pay estimates in countries with different income levels to Norway's GDP/capita. We tried several approaches to adjusting population density around the green space(s), and the size(s) of green space(s) in Oslo. Furthermore, we predict the willingness-to-pay specifically for the ecosystem service *recreation* and the type of open space *parks* . This means that the meta-analysis 'borrows statistical power' from the studies that have these characteristics.

The original studies for parks and recreation in cities were from the US, Australia and China, which are culturally different from Oslo. On the other hand, the meta-analysis also borrows power for the effects of income, population density and open space area on willingness-to-pay from the whole sample (including several European countries). Our value transfer assumes that Oslo's population would actually be willing to pay what the populations said they were willing to pay for protecting parks for recreation in the countries where the original studies were carried out.

The accuracy and reliability of meta-analysis transfer depends on the original studies from which it is calculating. We use it in Oslo for purposes of demonstrating the value transfer technique. An alternative approach would have been to select a single 'best' study from a European city more like Oslo, or update the values in Strand and Wahl (1997) to 2014 values.

Table 5.1 shows the sensitivity of the meta analysis function to park size and population density.

Table 5.1 *Marginal willingness-to-pay (US$/ha yr) for recreation in parks of different sizes and surrounding population densities*

	Area (hectare)							
Population density (per km)	0.2	2	10	100	1000	5000	10000	50000
20	54,782,249	8,682,401	2,395,873	379,720	60,182	16,607	9,538	2,632
200	169,293,334	26,831,185	7,403,956	1,173,448	185,979	51,320	29,476	8,134
500	265,234,773	42,036,879	11,599,906	1,838,461	291,376	80,404	46,180	12,743
1500	454,380,699	72,014,488	19,872,105	3,149,516	499,165	137,742	79,112	21,831
2500	583,614,083	92,496,599	25,524,060	4,045,291	641,135	176,919	101,613	28,040
6500	932,100,420	147,727,961	40,764,930	6,460,806	1,023,969	282,560	162,288	44,783
		Values in table: WTP (NOK/ha yr.)						

Source: meta-analysis values based own elaboration based on Brander and Koetse (2011)

The dotted black line in ***Table 5.1*** represents the minimum area and maximum population density in the original meta-analysis data used by Brander and Koetse (2011). The dotted rectangle represents the approximate mean predicted value for the meta-analysis data – the area of the model that is most reliable. Most of Oslo's parks and green spaces are smaller than the minimum values and most population densities in Oslo are greater than the maximum.

We therefore used the total area of green spaces within Oslo's built area of 2837 hectares distributed across more than 500 different locations within the city. Plugging a total area of 2837 hectares and a population density of 2600 persons/km^2 into the meta-analysis function we obtain an estimate of US$ 43 178 per year per hectare (2003 dollars). Using Oslo's average population density of 2600 pers/km2 for the outer city is expected to underestimate value of green space in the inner city.

Adjusting to 2013 values and using a purchasing power parity adjusted exchange rate, then multiplying by 2837 hectares, we obtain a total value transfer estimate for parks in Oslo. We estimate that willingness-to-pay could be about 1 billion NOK/year for conserving this total area of 2837. This is equivalent to an average NOK 1 985 per Oslo citizen older than 15 years. The value estimate is conservative because we have applied the meta-analysis assuming that the 2837 hectares are a single green space. If we applied the meta-analysis to each green space individually, with site specific population densities, and summed over all the more than 500 green spaces the aggregate value would be much higher[7]. However, the Brander and Koetse meta-analysis does not have observations of small urban parks, and the studies they draw on are also from areas with lower population density than Oslo. For this reason the model has little explanatory power for the individual green spaces in Oslo and could overpredict marginal WTP.

The meta-analysis value transfer estimate above is equivalent to a capital value of 4,3 million NOK/ha[8]. For a rough comparison we come back to Strand and Wahl (1997)[9] study of maximum willingness to pay of Oslo residents to preserve green space in the face of property development in three of the city's districts. They found a maximum willingness to pay of 60 million NOK/ha[10] which at the time of the study exceeded average land prices of 13,5 million NOK/ha (all values in 1997-NOK). This confirms that our value transfer approach is indeed a lower bound estimate which would likely be considerably higher where a new study to be carried out in Oslo.

5.1.3 Valuation for further policy support

Throughout this chapter we have also assumed that willingness-to-pay is accepted as a valid method for awareness-raising (***Figure 5.2.***). Despite the numerous assumptions required to carry out value transfer using meta-analysis, we argue that the values may generate awareness of recreational values of urban green space that are typically taken for granted.

Are the values reliable enough even for the least demanding context of awareness raising at an aggregate regional level (with no spatial resolution)? While aggregate values initially seem very large, breaking them down to per person per year, and per person per weekend estimates helps reflection about whether they seem reasonable.

What is reasonable is determined relative to points of comparison or benchmarks. So far we have no such benchmarks in this report, but with other chapters we will be able to compare the values generated with meta-analysis with other methods. Compared to the estimates of the recreational

[7] This and other assumptions of the meta-analysis are discussed further in Barton, D.N., Vågnes Traaholt, N., Blumentrath, S., 2015a. Materials and methods appendix for valuation of ecosystem services of green infrastructure in Oslo. NINA Report 1115.,
[8] 2003 NOK, 3,5% interest over 20 years.
[9] Reported in Lindhjem and Sørheim 2012
[10] 1997 NOK, 3,5% interest, we don't have information about the number of years over which present value was calculated.

value of Oslo's Marka forest –using a different value transfer method – which is discussed in a later section, the estimates here do not seem unreasonable.

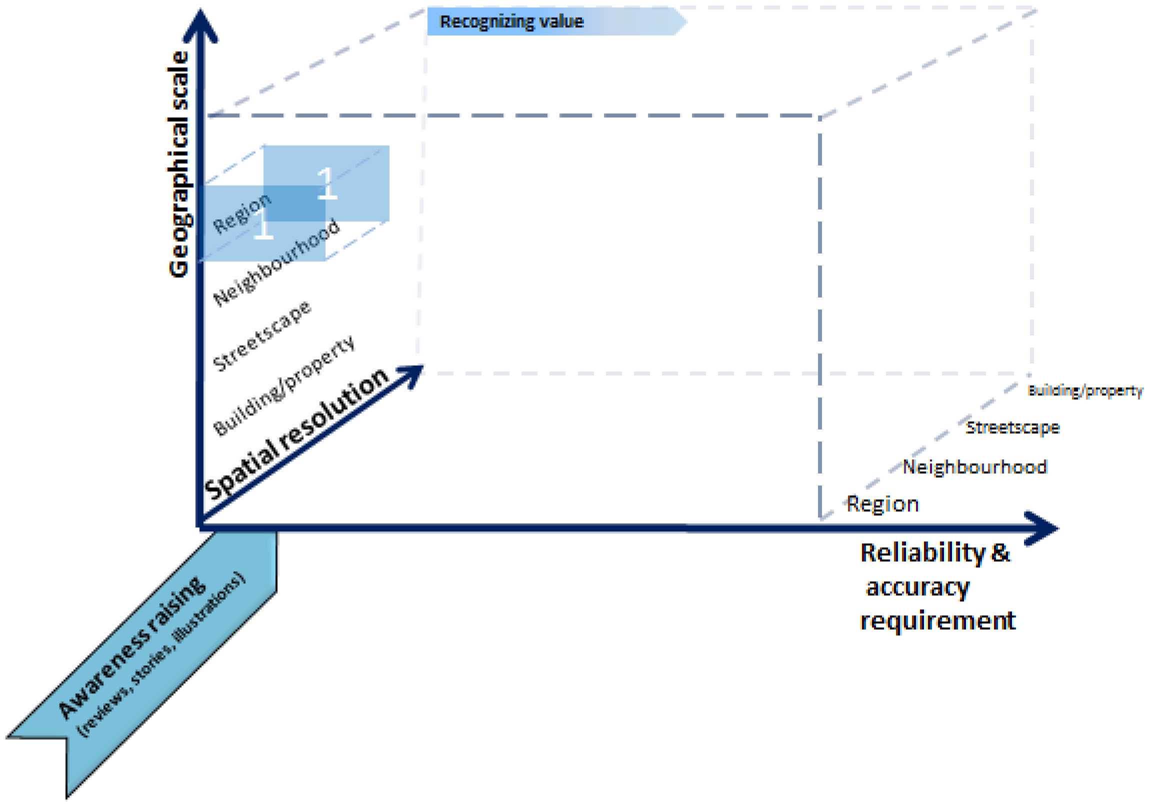


Figure 5.2 *Willingness-to-pay for recreation in urban parks and green spaces for the purpose of awareness raising*

Could meta-analysis valuation estimates be used for any policy purposes other than awareness raising and at a lower spatial scale and finer spatial resolution? Barton et al. (2015a) discuss in detail why the meta-analysis function does not have the spatial resolution required to use it for valuation at the level of the majority (if not all) of Oslo's parks and green spaces.

As we shall see in the valuation example of recreational time use in Marka in this report (section 5.4), it is feasible with internet survey methods to periodically collect estimates of recreational time use in green spaces which can be used for aggregate valuation estimates. It may also be possible to assess recreational trip destination, purpose and travel time using representative surveys of the population. Online surveys – while relatively cheap to carry out relative to the ecosystem service values identified – do not adequately represent children and the elderly and some immigrant groups (which is also the case with other survey modes, except personal interviews). There is also a problem of re-call regarding how recreational trips depend on seasonal and weather conditions.

Currently there is no monitoring of the use of public parks and green spaces ("friområder") in Oslo which hampers the assessment of investments in providing better public access ("tilretteleggingstiltak") (Reinvang et al., 2014). Reinvang et al. (2014) demonstrated that relevant data for valuation can be collected with low cost rapid survey techniques. Season specific on-site surveys of visitor recreation purpose, time use and access time across (a sample) of Oslo's public green spaces would provide spatially disaggregated data that could be used in planning investments. On-site surveys would also address the problem in online surveys of lacking representation of children, elderly and immigrants, seasonal and weather conditional visitation.

There is a wider question of how to consider childrens' preferences and demand for recreation in green spaces in economic analysis. Standard practice is not to account for childrens' preferences directly, but estimate by assessing guardians' willingness-to-pay. There are several rationales for this. Children do not vote nor have disposable income. Economic analysis assumes that guardians are fully able to internalise childrens' welfare in their own welfare when responding to willingness-to-pay questions. A question for further research is whether guardians' WTP for recreation is significantly different for single persons versus household heads with children.

The question of whether and how to account for childrens' use of green spaces is raised again in section 5.3 on time use and section 5.6 on health impacts.

5.2 The capital value of green infrastructure in property prices

5.2.1 Ecosystem services

What are the ecosystem services from urban green space that could be reflected in hedonic valuation using property prices? What environmental amenities are home buyers and sellers aware of when negotiating a property price? While a review of this question remains to be done we assume that accessibility to cultural ecosystem services are the potentially most important neighbourhood characteristics of city housing:
:

- Recreation, physical and mental health
- Aesthetics
- Sense of place and cultural heritage

Valuation results in brief

For every meter an apartment is closer to a city park its value is expected to increase by between NOK 162-368. There are 160 722 apartments within 500 meters of public parks in Oslo. The combined additional value of park proximity for these apartments is NOK 8.3 – 18.9 billion. If the park has a water feature it is even more valuable – the additional value across apartments close to water features in Oslo is estimated at NOK 2,8 - 6,6 billion. The effects are uncertain and require further research.

The following ecosystem services could be reflected in property prices in Oslo, but are likely to be specific to certain locations and kinds of buildings.

- Water management. Repeated flooding may be cause water damage to properties with basements.
- Local climate regulation. Tree cover provides shading in the summer, but also restriction of view. The effect is person and location specific.
- Noise reduction. Noise is a significant determinant of housing prices. Vegetation and open space has an effect on noise attenuation in some cases.

Category	Ecosystem service	Poten-tial	Valued
Cultural services	Recreation, physical and mental health	X	X
	Aesthetics	X	X
	Education, cognitive development		
	Sense of place and cultural heritage	X	X
	Tourism		
	Art/toys		
Regulating services	Storm water mangement	X	
	Erosion control		
	Local climate regulation	X	
	cleaning soil, water or air		
	CO2 sequestration		
	Noise reduction	X	
Provisioning services	Food production		
	Fiber production		
	Water provision		
Habitat services	Habitat for biodiversity		
	Pollination and seed dispersal		

If a policy-maker were to put this method to use could she tie individual ecosystem services to the hedonic results? Hedonic pricing is not able to distinguish between individual ecosystem services unless structural characteristics of properties are observable and can be linked to individual services. An example might be noise reduction where noise maps are available and noise is a significant determinant of property price. Soundproofing vegetation could in principle be characterised for each property and included as a variable in a hedonic price function. The inability of hedonic pricing to identify individual ecosystem services for green infrastructure is not necessarily a problem for policy applications of valuation. Investment decisions that involve changing the overall accessibility for green infrastructure in the neighbourhood can use hedonic pricing results.

5.2.2 Valuation for awareness raising

Hedonic pricing is the study of multi-correlation between environmental characteristics of a property and sales price. Vågnes Traaholt (2014) used different spatial statistical models to identify the connection between sales prices of more than 9000 apartments sold in Oslo between 2003-2013 and characteristics of blue-green structures (***Figure 5.3***). The analysis was limited to apartments.

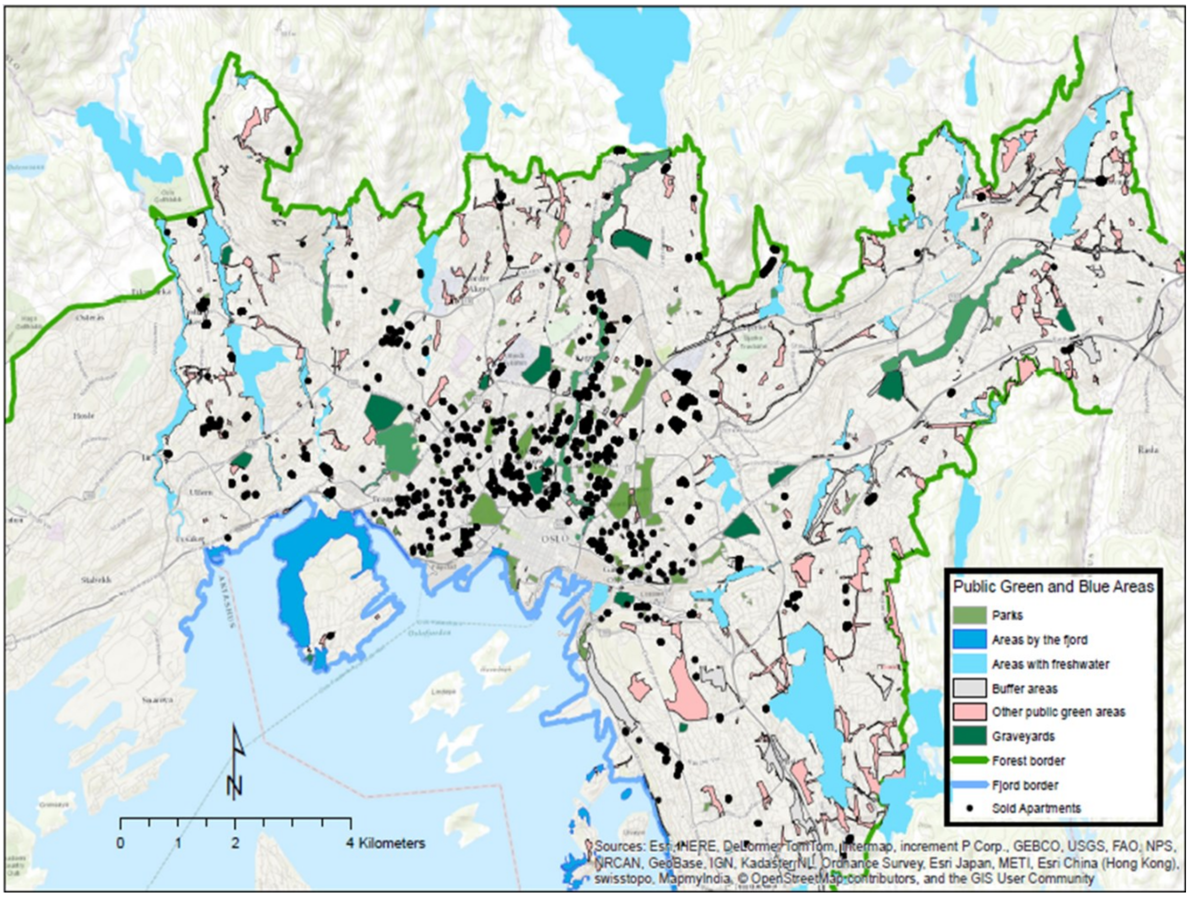


Figure 5.3. *Location of apartments sold 2004-2013 and green infrastructure considered in the hedonic pricing study. Source: Vågnes Traaholt (2014). GIS data: BYM, Oslo Kommune. and Norges Eiendom*

Vågnes Traaholt tested a number of different econometric models, changing the assumptions about the spatial correlation between blue and green structures and other neighbourhood characteristics. The simplest linear regression model showed a number of significant blue green structure variables. However, the variables were not statistically significant across all model specifications that were tested. In the following we base our value estimates on the simple linear model. The data, different model specifications and assumptions are discussed in more detail in (Barton et al., 2015a).

Results of the hedonic pricing aggregated across apartments in Oslo are summarised in ***Table 5.2***.

Table 5.2 *The aggregate marginal values of blue green infrastructures across all apartments in Oslo*

Variable	Effect area	Number of apartments in effect area	Sum over all apartments of.. ..expected marginal effects (MNOK)	..lower bound marginal effect (2,5%) (NOK)	..upper bound marginal effect (97,5%) (NOK)
Forest border	within 500m of Marka forest	36310	2467	845	4110
Fjord shoreline	within 1000m of fjord	34965	5875	4717	7048
Fjord open space	within 100m of open space by fjord	414	170	22	335
Park	within 500m of parks	160722	13595	8325	18935
Large park	when closest park > 100,000 m2	31147	1293	304	2304
Cementary	within 500m of cementary	45356	3535	2081	5010
Freshwater	within 200m of park with freshwater element	53089	4610	2672	6594
Green area	green area within 500m	224204	-317	-369	-265

Although this is a study using actual sales data from Oslo we could call the hedonic property pricing function a type of value transfer (with relatively high accuracy and reliability relative to study conducted in a different city). However, we do conduct value transfer in extrapolating the results from more than 9000 apartments to all apartments in Oslo. The 95% confidence estimate on aggregate values is a reflection of the reliability of this extrapolation.

For every meter an apartment is closer to a public park the expected value increases between kr./m. 162-36 per apartment. This effect is the mean marginal prices effects out to a radius of 500 meters. There are 160 722 apartments within 500 meters of public parks in Oslo. The aggregate value added across all these apartments of park proximity is estimated at 8.3-18.9 billion NOK. This is a capital value (i.e. not per annum). The range of values has been calculated based on the 95% confidence interval of the model parameter values.

If the public park has a water element such as a pond, lake, stream or river the aggregate value added is estimated at 2,8-6,6 billion NOK for a total 53 083 apartments within 500 meters of parks with blue structures. If the closest park is also a large parks this has a value added of 0,3-2,3 billion NOK for the 31 147 apartments within 500 meters.

Apartment owners also value the silence of cemeteries, as it were. The 45 356 apartments within 500 meters of cementaries have an estimated value added of NOK 2.1 – 5 billion.

If an apartments lies within 1000 meters of the fjord coastline the value added is between NOK 4,7 – 7 billion (34 965 apartments). The value of Oslo's peri-urban forest is also reflected in property prices. The value added of a total 36 310 apartments within 500 meters of the Marka forest is estimated to be between NOK 0,8 – 4,1 billion.

The negative value for green area within 500m indicates that property value is lower the more green area there is in the neighbourhood. This effect is independent of pure proximity effect to the closest and may be an indirect indicator of prices decreasing with distance to the city centre.

There is also uncertainty as to which model specification is most correct. Model testing shows large spatial autocorrelation. Spatial autocrrelation can be problematic for valuation of green spaces when other neighbourhood characteristics co-vary with availability of green space. This could mean that blue-green structures are proxies for other unobserved factors that are driving property prices. When corrected for this may reduce or eliminate the significance of a number of model parameters. This will require further model testing, but we put results forward here as indicative of potential values of green infrastructure in combination with other unobserved neighbourhood characteristics.This and other modelling issues are discussed further in Barton et al. (2015a).

Finally, we have not transferred our results to individual or semi-detached housing. They constitute separate housing markets which should be the subject of separate studies. As such the aggregate values presented here can be interpreted as conservative.

5.2.3 Valuation for further policy support

The total value-added estimates for apartments were generated for awareness-raising purposes. Are they relevant for private or public policy decisions?

Vågnes Traaholt (2014) points out that the hedonic price function that was estimated is valid for assessing marginal (small) changes in availability of green infrastructure. This raises the difficult question of "how small is marginal"? A new medium sized park may add only a fraction of a percent to the overall park area of the city (small), but if located in neighbourhood with below average park access may have a non-marginal effect on property prices in that neighbourhood. As a rule of thumb the value-added estimates are more uncertain the larger the change in green space area, but we don't know by how much.

For this reason, we suggest that the current hedonic pricing model should not be used for cost-benefit analysis of establishment (or loss) of green spaces *at particular locations*. Nor should the current estimates be used for ranking different park development alternatives, because the model does not distinguish between park characteristics, nor park locations. However, we do argue below that documentation of the added value of green spaces on property prices in aggregate could be used as one – of several – arguments for property taxation.

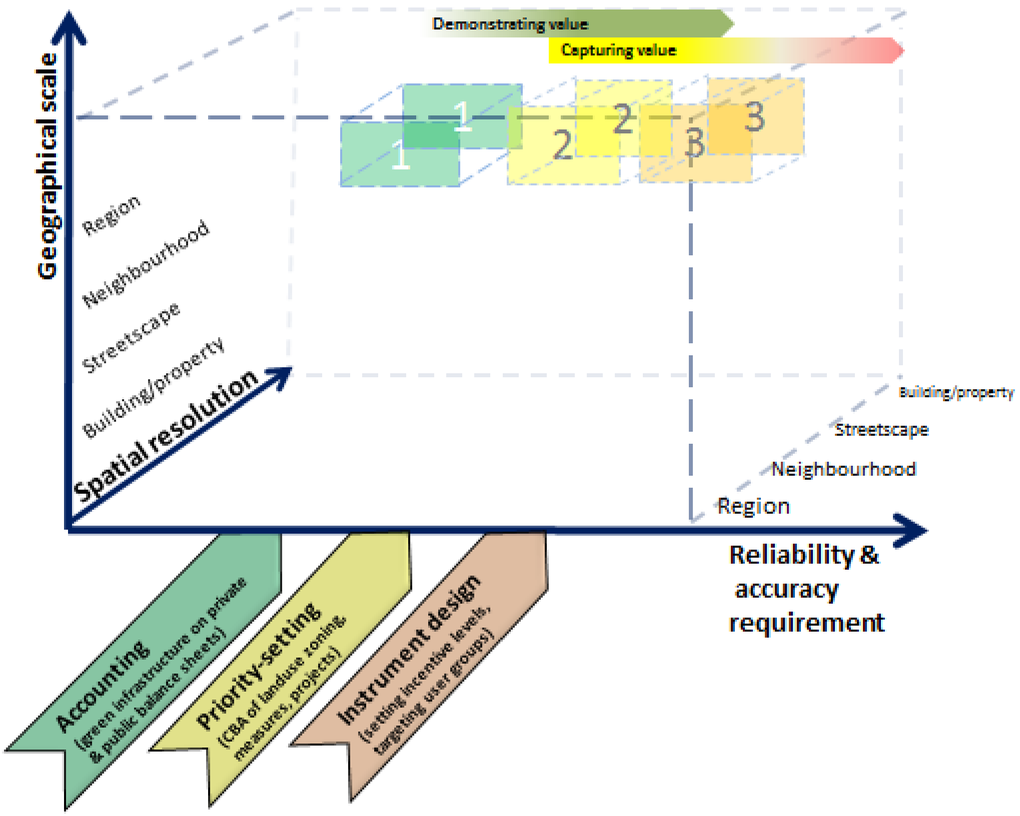


Figure 5.4 *Potential policy contexts for use of hedonic pricing could be in national accounting or instrument design*

We look in further detail at some additional data requirements should hedonic pricing be used for national accounting (at regional scale and resolution) or for instrument design in terms of adjusting property taxes for utility from green-blue space (at regional scale and property resolution) (***Figure 5.4***).

1. **National accounting of capital value of ecosystem services from blue green infrastructure ?**

Mapping of ecosystem services is under discussion as part of experimental ecosystem accounting (UN, 2013). Thus far accounting has not focused on urban ecosystems. However, despite their limited spatial extent, their large demand may make them relevant also at national level. National accounting does not require spatial resolution below regional level. Valuation methodologies are preferably based on market prices. A challenge with accounting studies is converting flows to capital values, because assumptions about the discount rate must be made. The hedonic pricing method assesses capital values so no such assumptions need be made. In all these regards then, the city-level hedonic pricing study such as Vågnes Traaholt (2014) should provide the required accuracy and reliability for national accounting.

2. **Priority-setting – justifying earmarking of a property tax ?**

Fjord, forest and parks are maintained through public financing. From the point of view of the municipality of Oslo the hedonic pricing results may be an additional justification for private-public cost sharing in maintenance of public green infrastructure. For example, the hedonic pricing results could provide additional justification for introducing private property taxes, or increasing existing rates where these are currently too low to finance public green infrastructure.

We have shown how the hedonic pricing data we have for apartments can be sufficient – under certain modelling assumptions - to compute expected (average) price effects across the whole of Oslo. We have also argued that it is not sufficient to compute the added value of *specific* parks in specific neighbourhoods (there are not enough sales data per neighbourhood). However, think the method could provide support at an aggregate level. The *aggregate* value-added of green infrastructure relative to total property market value could give some indication as to the portion of the tax that could be justified based on financial needs to maintain public green infrastructure.

As stated the results shown here do not include detached and semi-detached housing. Hedonic property pricing in these markets could be expected to reveal different value added from green infrastructure. That would raise the question of whether hedonic pricing results could be used as justification for differentiating property tax levels according to property type. Distributional effects and taxation are a political question. From a technical point of view there would not be statistical support for such tax differentiation unless there were significant differences between housing types in value added by green infrastructure (at e.g. 95% confidence levels) and these differences were consistent across several modelling approaches (reliability requirement).

The hedonic pricing study shows that the welfare contribution to the home owner of proximity to green infrastructure is at least to some extent ‘priced in’. If property taxes were made proportional to property market value there would be no need to use hedonic pricing results to differentiate property tax levels. Hedonic pricing would nevertheless be an additional argument for municipal government to earmark part of property taxes to green infrastructure maintenance and investment.

3. Instrument design – capturing value-added at property level through utility fees ?

Could the findings on value-added of green infrastructure be applied in instrument design, even though the hedonic pricing provides only expected (average) value added estimates across the whole city?

For private property developers the findings that properties close to green infrastructure have – on average - higher value is not a surprise to the extent that they can observe buyers willingness-to-pay every day. Views of the fjord, forest and parks are regularly featured in property advertisement and priced in by developers and real estate agents. We do not have data on blue-green structural features of properties themselves, but future research could focus on documenting willingness-to-pay for structures promoted in the blue-green factor (see section 5.5).

Private property developers may be interested in the findings of hedonic pricing of green infrastructure to the extent that they co-finance maintenance of public spaces and need arguments to recover their costs from home owners. However, hedonic pricing results do not identify particular ecosystem services of green infrastructure – particular public utilities - to home owners (or only very indirectly). So it may be difficult to use them *at the level of specific projects or neighbourhoods* to justify per household public utility fees for maintaining specific public green infrastructure.

5.3 The recreational value of the Marka forest

5.3.1 Ecosystem services

An estimated 86% of Oslo's population aged 15 or older uses the 'Marka' peri-urban forest for recreation in the course of a year (Synnovate, 2011). A large majority use it for multiple purposes including trekking, physical recreation, skiing and experiencing nature.

Valuation results in brief

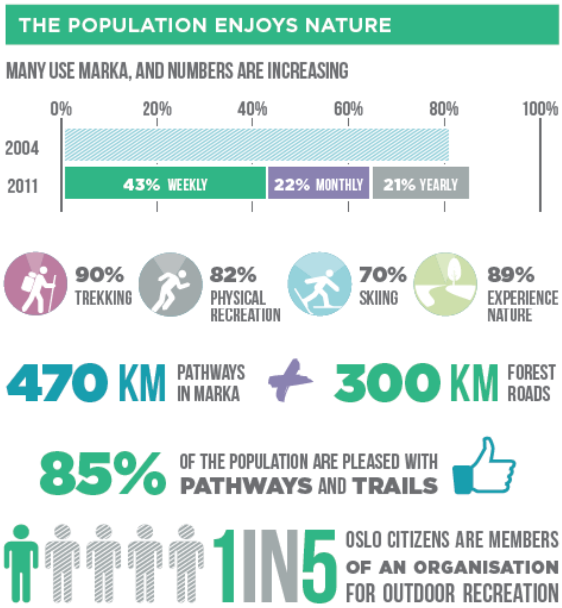
The recreational value of Oslo's Marka forest for the adult population (>15 years) was estimated at between 2.3 - 13.3 billion NOK/year, based on estimates of total annual visitation and average time use.

Oslo's peri-urban forests provide all the ecosystem services identified by Oslo Municipality policy documents as important for city's population (see ***Table 4.1***). In this valuation example we focus on the economic valuation of recreation time in the forest.

Category	Ecosystem service	Potential	Valued
Cultural services	Recreation, physical and mental health	X	X
	Aesthetics	X	
	Education, cognitive development	X	
	Sense of place and cultural heritage	X	
	Tourism	X	
	Art/toys	X	
Regulating services	Storm water mangement	X	
	Erosion control	X	
	Local climate regulation	X	
	cleaning soil, water or air	X	
	CO2 sequestration	X	
	Noise reduction	X	
Provisioning services	Food production	X	
	Fiber production	X	
	Water provision	X	
Habitat services	Habitat for biodiversity	X	
	Pollination and seed dispersal	X	

5.3.2 Valuation for awareness raising

The hedonic property pricing study observed value of proximity to the "Marka" forest in apartment prices. We have also estimated the value of the forest in terms of number of recreational visits and time spent by Oslo's population over a whole year. From a recent survey of Oslo's population by Synnovate (2011) we have an estimate of the number of visits made to Marka by the population older than 15. The study asked residents to state their visitation frequency in different seasons. We use this information to calculate that Oslo's adult population makes 23,4 million trips per year to Oslo's peri-urban forest. Based on an independent study (Gundersen et al., submitted) we also know that the average time for each trip was roughly 3 hours. Simple multiplication suggests that Oslo's population spends 73 million hours per year in the Marka forest. These figures do not account for children 15 or younger.



Figur 5.5 Characteristics of recreational use of Oslo's Marka forest
Source: OsloKommune (2013c)

Armed with estimates for total number of annual visits and time use, what is the value of each visit and each hour of recreation time? We used several independent approaches which are further documented in Barton et al. (2015a).

The largest estimates are obtained by valuing recreation time. If we assume that the alternative use of recreation time is paid employment we can use an average wage rate after tax as a reflection of the opportunity cost of recreation time. This is a conservative estimate of the value of time spent in recreation. The average wage after tax of NOK 187/hour for Oslo's adult population is used as our marginal estimate of the value of time. The aggregate economic value of recreation time spent is then 13.2 billion NOK *per year* (***Table 5.3***).

Table 5.3 *Total value of visits to Marka forest by Oslo's adult population*

Valuation methods	Per month	Per hour	Per trip	Totalvalue of visits to Marka (NOK/år)	Assumptions and sources
Value of recreation time					
Opportunity cost of time; wage after tax (100%)		187		**13,297,333,559**	based on interviews in Svartdalen Park (August 2014)
Opportunity cost of time; wage after tax (33%)		62.271		**4,428,012,075**	assumptions in Sælen and Ericson(2013) & Svartdalen sample
Cost of training studio	453	37.75		**2,684,354,769**	Din Side (assume 12 hours/week)
Willingness to pay (WTP)					
Choice experiment (spring-summer-autumn)			124.8	1,957,550,484	based on Sælen and Erikcson (2013)
Choice experiment (winter)			209.3	1,612,318,420	based on Sælen and Erikcson (2013)
Choice experiment (whole year)				**3,569,868,904**	based on Sælen and Erikcson (2013)
Consumer surplus (=WTP - travel cost)					
Choice experiment (spring-summer-autumn)			71.09	1,115,313,264	Sælen and Erikcson (2013) ; 50% car, 50% public transport
Choice experiment (winter)			155.64	1,198,923,192	Sælen og Erikcson (2013) ; 50% bil, 50% offentlig transport
Choice experiment (whole year)				**2,314,236,456**	Sælen og Erikcson (2013) ; 50% bil, 50% offentlig transport
Travel cost method (meta-analysis)			143.6	**3,358,718,206**	Zandersen and Tol(2009)

A rule of thumb in travel cost studies has been to use 1/3 of the wage rate after tax to value travel time. Using this assumption the time value of visits to Marka is 4,4 billion NOK. Recent studies travel time valuation studies (Fezzi et al., 2014; Ovaskainen et al., 2012) show that travel time is valued at around 75% of the after tax wage rate. Judging by these results the opportunity cost of time spent in Marka probably lies closer to about 10 billion NOK/year.

Alternatively, we could assume that people used Marka only for physical exercise and the cost of alternative physical exercise in a training studio could be taken as a replacement cost. Assuming a monthly subscription and a 12 hour training week in a health studio we estimated a 'training replacement cost' of 38 NOK per hour. This is also a conservative estimate of the value of physical recreation. Using this replacement cost we estimate an aggregate value for physical recreation only of 2,7 billion NOK/year.

Sælen and Ericson (2013) interviewed skiers at several entry points to Marka, asking their willingness to travel different distances to alternate Marka sites under different snow cover conditions. They use a choice experiment format to explore a number of alternative distances and conditions. Based on their results transferred to the whole of Oslo's adult population we estimate a willingness-to-pay of 3,6 billion NOK per year.   Each trip incurs travel expenses as well as time costs in travel. Subtracting time costs of travel and expenses we estimate a consumer surplus to forest recreation of approximately NOK 2,3 billion per year (***Table 5.3***).

Finally, we looked at values we would obtain from a meta-analysis of travel cost studies for forest recreation (Zandersen and Tol, 2009). An average trip had a consumer surplus of NOK 149 – resulting in an aggregate consumer surplus of 3,4 billion NOK per year.

In summary, we used four different valuation methods for the marginal value of visits or visit time. The methods seen together place the aggregate recreational value of Marka in the range from 2,3 – 10 billion NOK per year.

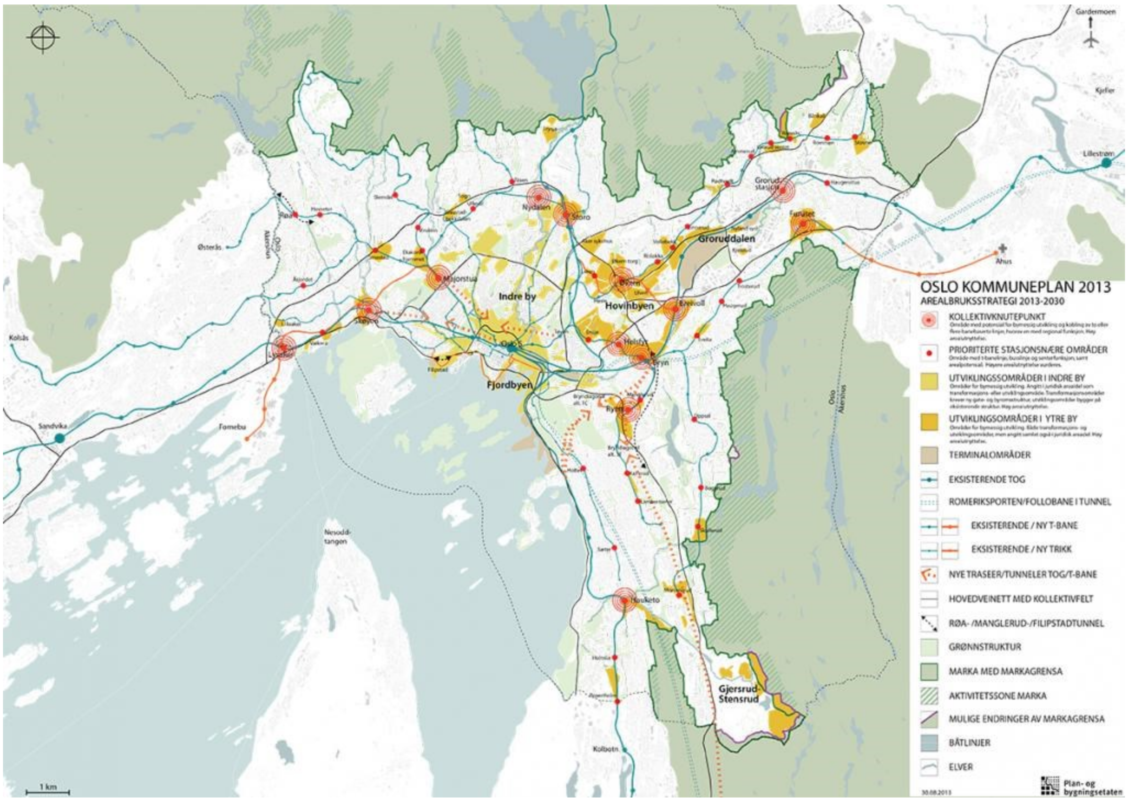


Figure 5.6 *Proposed "Activity zones" within the Marka forest border in the Oslo Municipal Plan 2030. Activity areas indicated in grey on green background within Marka border.*

Source: (OsloKommune, 2013b).

5.3.3 Valuation for further policy support

A hypothetical policy context for valuation estimates would be conducting a benefit-costs analysis of land use regulation proposals for the Marka forest in the new Municipal Plan for 2030. For example, what are the potential costs and benefit of the proposed «activity zones» versus «current forest» in Marka forest bordering the built area? What kind of reliability and accuracy requirements would be required of monetary valuation of forest recreation in such a context? The policy context is at city level as the proposed "activity zones" (***Figure 5.6*** previous page) run along almost the entire length of the border identified in the Marka Act. The analysis would need to have a spatial resolution at least at neighbourhood level to distinguish between different sections of the forest as different city neighbourhoods have different accessibility to the forest.

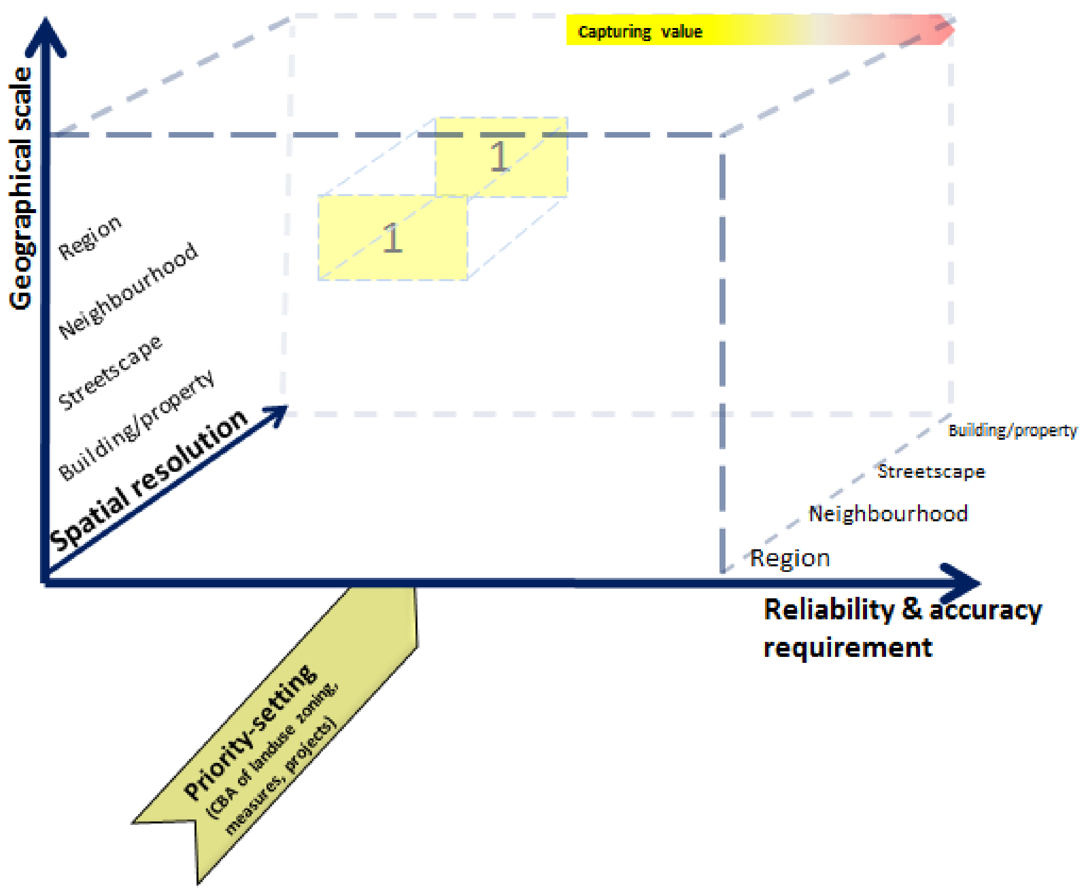


Figure 5.7. *Potential policy contexts for further valuation of recreational use of forests - benefit cost analysis of landuse zoning within Marka.*

Priority-setting studies have large information requirements (***Figure 5.7*** below). Valuation for priority-setting would have to differentiate forest qualities; access to forest from different neighbourhoods, distance decay of willingness-to-pay from the Marka border, from access points. It would also have to assess proposals for alternative uses of forest area for e.g. sports facilities. Willingness-to-pay for additional sports facilities in activity zones could be seen as opportunity costs of conserving the forest in its present state. Other policy contexts for valuation would be relevant if time use in Marka could be spatially disaggregated for different forest activities, for example time use on forest roads, and marked trails (winter, rest of year) versus hiking off-trail. With regular surveys, spatial patterns in recreation in clear-cut forests might be observed, and could be used in cost-benefit analysis of forestry permits. As with any increase in data resolution one would have to consider at what point increased data collection costs outweighed the incremental benefits of better distribution of forestry concessions.

5.4 The liability value of city trees

5.4.1 Ecosystem services

Valuation results in brief

Oslo's city trees have a total environmental liability value of between 28 billion NOK (700 000 trees) and 42 billion (1 200 000 trees).

City trees constitute perhaps the single most important green structure in addition to open green space in cities. City trees potentially provide a bundle of ecosystem services. As we shall see the liability valuation methodology used in this example explicitly assesses aesthetics and visibility (recreation), but bundles other ecosystem services under a variable called "environmental factors". We are therefore not able to identify individual regulating ecosystem services from habitat services for example.

Category	Ecosystem service	Potential	Valued
Cultural services	Recreation, physical and mental health	X	X
	Aesthetics	X	X
	Education, cognitive development	X	
	Sense of place and cultural heritage	X	(X)
	Tourism		
	Art/toys	X	
Regulating services	Storm water management	X	(X)
	Erosion control	X	(X)
	Local climate regulation	X	(X)
	cleaning soil, water or air	X	(X)
	CO2 sequestration	X	(X)
	Noise reduction	X	(X)
Provisioning services	Food production		
	Fiber production		
	Water provision		
Habitat services	Habitat for biodiversity	X	(X)
	Pollination and seed dispersal		

5.4.2 Valuation for awareness raising

Based on a LiDAR laser scanning Oslo has between 0.7 and 1.2 million trees taller than 5 meters in the built zone (Bymiljøetaten, 2015). In other words every citizen of Oslo shares the city environment with 1-2 large trees. This is a conservative estimate as we have not included forest patches within the built zone where individual tree crowns could not be identified.

Oslo Municipality has a strategy to replace every tree that is felled within the built zone with at least one new one. Damage to trees on Municipal land is subject to a fine and an environmental damage claim. Environmental liability for city trees is calculated using the VAT03 assessment model developed by Randrup (2005). The VAT03 assessment model is based on the replacement cost of a city tree, including purchase and planting costs. This base value is then adjusted for the tree's structural health and for its qualities in a neighbourhood context, including adaptation and contribution to its local environmental. Environmental qualities include aesthetics, noise and pollution reduction, in other words several regulating ecosystem services. An overview of the VAT03 model structure is provided in ***Figure 5.8***.

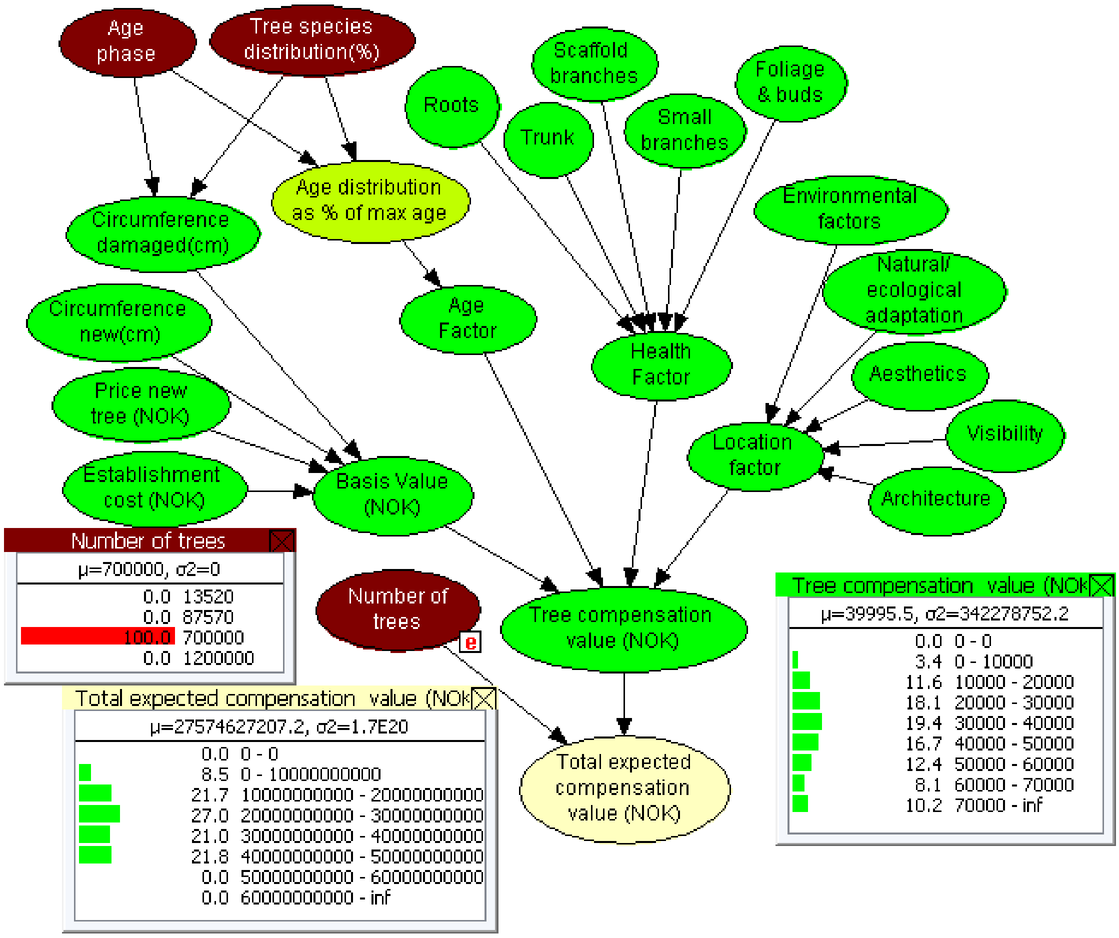


Figure 5.8 *Liability value distribution using the VAT03 model*

Value per tree and total assuming a conservative estimate of 700 000 city trees. The variance (σ2) around the expected value (μ) is very large as also illustrated by the probability distributions in green in the panels called "tree compensation value (NOK/tree)" and "Total expected compensation value (NOK)".

Based on the VAT03 method which is presently being used for Oslo Municipality's city trees we conducted a value transfer to all trees on both private and public land. There is currently no environmental liability on trees on private land from a legal point of view. However, there is no reason to believe that trees have less regulating functions just because they are located on private land. Private land might be correlated with other spatial factors that differentiate demand for a tree's regulating services. Considering the projected growth of Oslo City, trees that are currently in less population dense locations, may within their lifetime provide increasing ecosystem services. As a precautionary principle one could argue that also trees on private land should have environmental liability because a number of the regulating and cultural ecosystem services are public goods.

With this in mind we asked, 'what would be the total liability value of all city trees in the built zone if assessed according to VAT03?' This hypothetical liability value is based on a regulatory definition of value, rather than a willingness-to-pay-based estimate. Some trees on private property represent a disservice for property owners in terms of shade, blocking of views, leaves and allergies. In this sense, our aggregate liability value represents an overvaluation. Again, our estimates are made for awareness raising purposes with the aim of encouraging further discussion about the value of green infrastructure. With this upward bias in mind, our application of the VAT03 assessment model tells us that the aggregate economic value of the liability amounts to between 28 – 42 billion NOK. The aggregate value also depends on the assumption about how many large city trees there are registered (***Figure 5.8***).

While the liability valuation may be biased upward for trees on private land, our aggregate estimates is conservative approach in the sense that it does not value any trees – public or private - lower than 5 meters (nor other vegetation for that matter). The calculation was made assuming that Oslo's trees have a similar age and species distribution as those managed by Oslo Municipality. Furthermore we have assumed an expected health and location factor is that of an average tree with a wide distribution. This uncertainty is reflected in the large variance of the 'total expected compensation value' (***Figure 5.8***).

5.4.3 Valuation transfer results for awareness raising

Given our assumptions the expected compensation value for a randomly chosen city tree in Oslo is roughly kr. 40 000. This is kr. 20 000 less than the (unscaled) replacement cost per tree in an actual liability case we know from Akerselva and Kåresvei in 2014 (VaktmesterKompaniet, 2014). The average tree in Oslo is inferior to the trees that were damaged in these concrete cases. Oslo Municipality imposes a fine on entrepreneurs or property owners for illegal damage of trees equivalent to the VAT03 compensation value. This is the per tree environmental liability of city trees proscribed by a public body, and as such an expression of social value. We saw from the model structure that this is also a surrogate value for a number of ecosystem services associated with trees.

Based on this assumption of the liability value of trees what would be the total expected social value of trees in Oslo? The expectation is 27.6 billion NOK if we conservatively assume 700 000 trees or 43.3 billion NOK if we assume the upper range of 1 200 000 trees. Given the uncertainty about the location, health and age characteristics of the population[11] of trees the uncertainty around this estimate is very large (see the probability distribution and explanation under ***Figure 5.8***.

We are using the best available data of trees on site and a valuation model that has been adopted by the city authorities. Why is this a case of value transfer for ecosystem service? (1) It is value transfer in the sense that we are extrapolating tree values and characteristics from a (very) small sample to the total population, even though this is within the same study site. (2) we are assuming that the marginal environmental liability value also scales spatially to all city trees.

Can we confidently assume that the marginal environmental liability value can be interpreted as an average value across the whole population of trees? Two reasons why this may not be so come to mind:(1) the marginal social value of trees should be increasing with increasing scarcity, which would indicate that current marginal liability value is lower than average value; (2) from a economic welfare theory point of view there could be reasons to question whether value's can be aggregated across green structures or whether we first need to determine individual WTP per tree and then aggregate across them.(3) the liability value method used here is based on the

[11] We use the population concept because these are individual city trees, versus a forest stand.

interpretation of a regulation as an expression of social value of trees. It is a different valuation method from individual welfare based methods[12].

5.4.4 Valuation for further policy support - information gaps

The value transfer conducted in this chapter was carried out in the context of “awareness raising”, with low requirements for reliability and accuracy of valuation estimates.

Can we envisage policy-support contexts that would require greater reliability and accuracy of the ecosystem service valuation of city trees, either using the VAT03 methodology or another valuation method? ***Figure 5.9*** suggests two hypothetical policy-support contexts in which the ecosystem service valuation of trees could help to internalise.

Potential policy contexts for further valuation

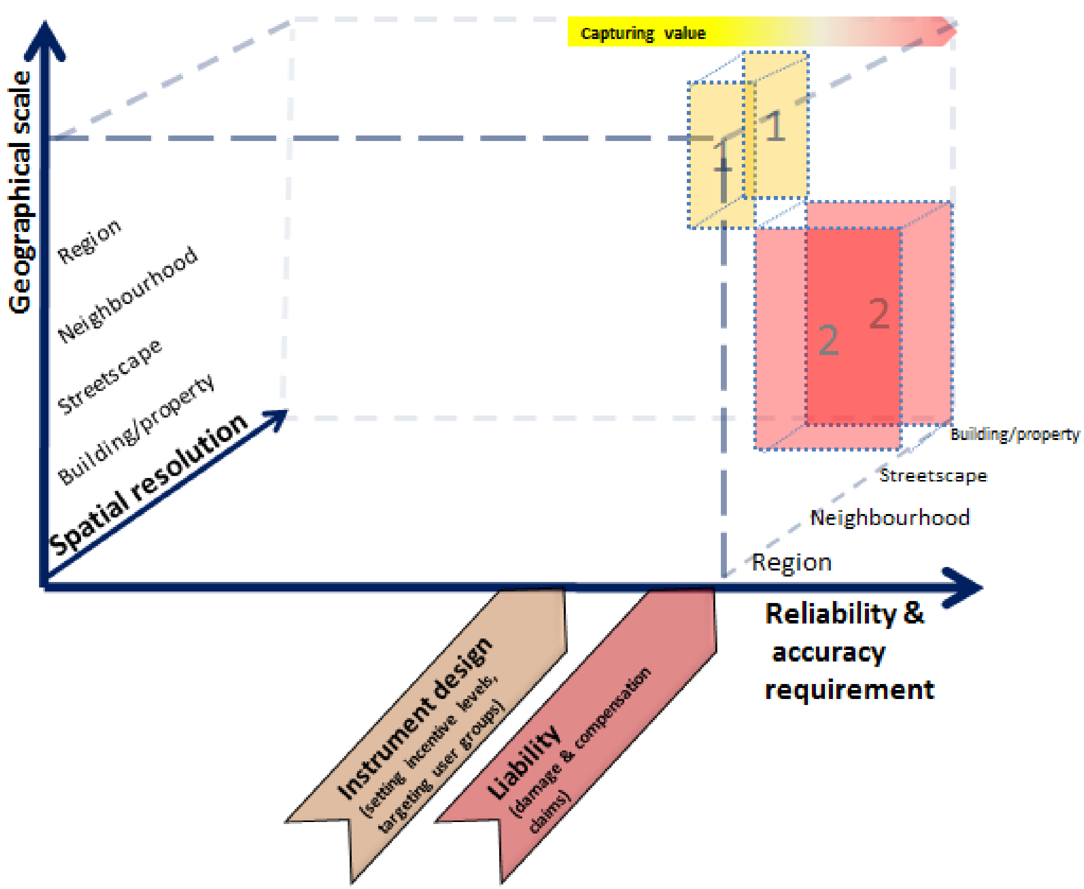


Figure 5.9. *Two hypothetical contexts for policy-relevant ecosystem services valuation of trees (1) a city-wide ecosystem service utility fee for city trees and (2) environmental liability for city trees at neighbourhood, street or property level.*

[12] Further discussion of different market and non-market valuation methods can be found in Barton, D.N., Vågnes Traaholt, N., Blumentrath, S., 2015a. Materials and methods appendix for valuation of ecosystem services of green infrastructure in Oslo. NINA Report 1115.

Two hypothetical policy-support contexts in which the ecosystem service valuation of trees could help to internalise, are:

(1) A city-wide **ecosystem service utility fee for city trees**. If an average ecosystem service value for city trees could be documented, there would be an economic rationale for charging citizens a utility fee in a similar way to a water and sewage utility fee. In fact, public utilities such as water&sewage and waste disposal are charged on a cost recovery basis. rather than willingness-to-pay. The requirements for economic valuation in support of implementing an ecosystem service utility fee for trees could conceivably require the following steps (i) cost accounting of city tree conservation, renewal and management (ii) valuation of aggregate ecosystem services value of trees (iii) a benefit-cost comparison to justify that aggregate benefits exceed aggregate costs (iv) calculation of an average utility fee per household based on average cost recovery. Note that similar to a water and sewage utility fee no attempt is made to differentiate the utility fee based marginal cost or willingness-to-pay per user. The utility fee is determined based on an equal cost-sharing principle per per citizen.

(2) **environmental liability for city trees** at neighbourhood, street or property level. In fact the VAT03 method is already in use by the Environment Agency is a working example of an instrument for environmental liability. However, we noted above that the importance of regulating ecosystem services is limited to a single 'environmental factor' while three different factors adjust for cultural ecosystem services. Further work may be justified on determining the relative importance of cultural versus regulating services at different locations in the city.

5.5 Non-economic valuation of green infrastructure in property development

The property level is likely to be the finest level of spatial resolution relevant for ecosystem service assessment in an urban context. The framework for policy-relevant valuation in ***Figure 2.4*** reflected this. At high resolution it is conceptually problematic to use the ecosystem service terminology because ecosystems are larger spatial units. It has been common to use the "environmental amenities" concept for benefits accruing to the home owner. Notwithstanding this conceptual question there are some practical limitations to economic valuation of individual blue green structures at property level.

Valuation results in brief

The blue-green factor (BGF) is a non-economic approach to assessing the importance of blue and green structures for a selection of ecosystem services in new property developments. BGF gives high priority to water and drainage surfaces regulating run-off, as well as to trees. Structures providing biodiversity habitat, aesthetics and recreation are seen as 'additional' ecosystem services. The assessment approach recognises that ecosystem services of green infrastructure are 'bundled', and difficult to disentangle. Nevertheless, the BGF has deliberate focus on regulating hydrological services in order to be simple to implement.

Assessing the costs of including blue-green structures in property development is the simplest approach, and is carried out by default as part of assessing financial feasibility of blue-green structures. But this does not answer the question of the off-property 'externality' contribution of blue-green property structures to ecosystem services.

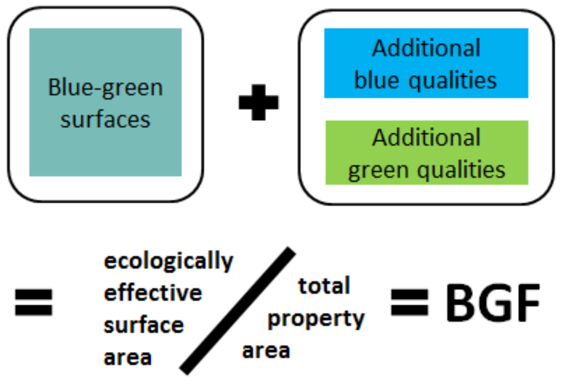


Figure 5.10 *Blue-green factor calculation*
Source: translated from Framtidens Byer (2014)

Economic valuation methods at this level will mostly capture environmental amenity effects on property owners themselves. As discussed above economic valuation methods such as hedonic pricing can value bundles of environmental amenities of a property, but need multi-annual data on a large number of sales across homes to have sufficient statistical power. Data on structural proxies for environmental amenities must also be available for all homes sold. Stated preference such as choice experiments could be used, but the number of property characteristics that respondents can meaningfully assess in a survey situation is in practice limited to perhaps 4-6 choice attributes and price. A choice experiment can only assess a limited number of generic property types within which the levels of blue-green attributes are varied. Stated preference methods are an alternative when wanting to focus on home purchasers' willingness-to-pay for specific blue-green property attributes, but such a focus comes at the expense of observing how multiple property features determine a single amenity. This is useful information for property developers in assessing financial feasibility, but does not address all of the public planners concerns regarding the public goods – contribution to urban ecosystem services off-property - created by the structure.

The location specific contribution to urban ecosystem function of individual blue-green structures cannot be assessed on every property, so a system of standardised ecosystem service scoring is needed. The blue-green factor approach addresses this information gap.

5.5.1 Ecosystem services

Blue-green structures at property level contribute to all the priority urban ecosystem services that were listed in ***Table 4.1***. In this example, we focus on the ecosystem services addressed in the Blue-Green Factor (BGF):
- Storm water management
- Recreation and mental health
- Aesthetics
- Pollination
- Habitat for biodiversity

Category	Ecosystem service	Potential	Valued by BGF
Cultural services	Recreation, physical and mental health	X	X
	Aesthetics	X	X
	Education, cognitive development	X	
	Sense of place and cultural heritage	X	
	Tourism	X	
	Art/toys	X	
Regulating services	Storm water management	X	X
	Erosion control	X	
	Local climate regulation	X	
	Cleaning soil, water or air	X	
	CO2 sequestration	X	
	Noise reduction	X	
Provisioning services	Food production	(X)	
	Fiber production	(X)	
	Water provision	(X)	
Habitat ser-vices	Habitat for biodiversity	X	X
	Pollination and seed dispersal	X	X

Green space factors and points systems have been used in several European cities as a policy instrument to attain desired levels of green and blue surfaces in new property developments. Different green and blue 'elements' are scored based on their importance, and a weighted sum score is calculated for proposed property developments. Green space factors can be regarded as policy instruments in several ways. They may be used for certifying new building development in relation to achieving a minimum total score. At the same time property developers are given the flexibility in designing how to incorporate blue-green structures into building plans.

Through the Cities of the Future program Oslo Municipality Planning and Building Agency, Bærum Municipality, Dronninga Landskap AS, Cowi AS, and C. F. Møller collaborated in developing a 'blue-green factor' scoring system to guide new urban development towards the overall goals of the Green Plan for Oslo (FramtidensByer, 2014). The BGF proposal has been developed and tested on a number of case studies. However, the final proposal has as yet not been incorporated into municipal building codes or regulation.

Value	Symbol	Factor
		Plot Area (including the built area) Fill out the area
		1.BLUE-GREEN SURFACES
1		Open permanent water surface that can receive rainwater
0.3		Partially permeable surface like gravel, crushed stone, and reinforced grass surface
0.2		Impermeable surfaces with drainage to vegetated areas or an open drainage magazine
0.1		Impermeable surfaces with drainage to a local closed storm water drainage
1		Surfaces with vegetation associated with soil or bedrock
0.8		Surfaces with vegetation, not associated with soil > 80 cm
0.6		Surfaces with vegetation, not associated with soil 40 – 80 cm
0.4		Surfaces with vegetation, not associated with soil 20 – 40 cm
0.2		Surfaces with vegetation, not associated with soil 5 –20 cm
		2. Additional qualities = Blue and Green additional qualities that give extra points. The same area can therefore be counted a number of times below
		Blue additional qualities
0.3		Natural edges to water srufaces
0.3		Rain bed or equivalent
		Green additional qualities, Points below (trees) should be filled in as a number
1		Existing large trees > 10 m
0.8		Existing trees that can be expected to grow to over > 10 m
0.6		Existing trees that can be expected to grow to be small to medium, 5 – 10 m
0.7		Newly planted trees that are expected to be > 10 m
0.5		Newly planted trees that are expected to be 5 – 10 m
		Points below should be filled in as m2
0.6		Native vegetaion
0.4		Hedges, bushes and multi-stemmed trees
0.4		Green walls
0.3		Perinnials and other ground cover
0.1	75m2	Contiguous green areas over 75 m2
		Points below are filled in with the number 0,05
0.05		Connection to existing blue-green structures.
		TOTAL BLUEGREEN FACTOR (BGF)

Figure 5.11. *Blue-green factor scores Source: translated from Framtidens Byer (2014)*

The Blue-green factor (BGF) scores the 'importance' of each structure based on performance criteria mainly in relation to water infilstration and storage capacity Scores are given for different kinds of blue-green surfaces in relation to their hydrological regulating effect. Additional points are then given for water and vegetation features that enhance run-off control in conjunction with aesthetic qualities and biodiversity habitat (***Figure 5.11***).

The sum of scores is divided by the total property area, so that each property has a normalised BGF score/m2 which can be compared across properties (***Figure 5.10***).

5.5.2 Ecosystem function assumptions

Scoring of each structure is based on the judgement of technical experts in architecture,urban planning, hydraulics and hydrology[13]. Judgements were tested and adjusted through a number of case studies in Oslo (FramtidensByer, 2014).

Blue-green surfaces

- Open permanent water surfaces are relatively more important than potentially permeable or impermeable surfaces with regard to their run-off storage capacity.

- Vegetation surfaces with direct drainage to soil or bedrock are more important than surfaces with no drainage with regard to their infiltration potential. The deeper the soil for non-connected surfaces the higher the water storage capacity.

Blue additional qualities

- Natural edges and rain beds provide aesthetic and habitat qualities to water surfaces.

Green additional qualities

- Trees are scored individually relative to size and growth potential, determining their importance for rainfall interception and evapotranspiration, and for their functions as habitat and for aesthetics. Trees may constitute a large share of the total BGF score for a property.

- Native vegetation, perennials and other ground cover provide additional scores for their importance for biodiversity habitat, including pollinators, and aesthetics.

- Hedges, bushes and green walls, give additional scores for their aesthetics value.

- Contiguous green areas and connection give additional score for their importance as recreation areas and connectivity with other urban green infrastructure structure.

5.5.3 Value transfer assumptions and results

While the BGF has yet to be implemented in policy it constitutes a practical example of 'non-economic' valuation of ecosystem services. The BGF scores represent qualitative assessments of the relative importance of different ecosystem functions. Scores are compared across different types of green infrastructure providing different ecosystem services. In this sense BGF scoring is hybrid of ecosystem service supply/potential and social 'importance' or demand.

The assessment approach recognises that ecosystem services of green infrastructure are 'bundled', and difficult to disentangle. The BGF therefore has deliberate focus on regulating hydrological services in order to be simple to implement. For this reason structures providing biodiversity habitat, aesthetics and recreation are seen as 'additional' ecosystem services. Their relative importance in the overall BGF score is also smaller than for the hydrological regulating services.

The BGF focus on simplicity means that each structure is scored the same no matter where the assessment takes place. The assumption is that the marginal value of each structure in terms of surface area or number of individual trees is the same whether upstream or downstream in an urban catchment.

5.5.4 Valuation for further policy support

BGF identifies relevant blue-green elements at a building permit level. It is a multi-criteria, non-economic valuation method, balancing the objectives of comprehensiveness and simplicity. At this resolution multi-criteria non-economic methods fill an information gap because they offer the flexibility needed to assess across large local variation across properties with poor data quality. However, as currently conceived it applies only to new property developments in the built area. It is currently not a spatially representative classification system for both existing and new green infrastructure in and around Oslo's built area.

The blue-green factor methodology is currently not part of municipal regulation of private landuse due to concern that it may be too complicated for property developers to implement. However, the BGF may still be used by the municipality itself in evaluating its own building practices, and in so doing provided inspiration to private developers [14]. Standardised scoring also allows authorities to develop minimum standards that property developments should attain in different parts of the city. Here scoring supports a regulatory approach. Standardised ecosystem service scoring can be combined with structure cost data to evaluate cost-effectiveness of alternative property development plans towards providing 'off-property' ecosystem services.
How could BGF approach be extended also to existing green infrastructure and currently unbuilt areas in the city?

[14] Pers.com. Tove Dyblie, BYM.

Two hypothetical extensions of the blue-green factor (BGF) to city-wide policy assessments of green infrastructure include (***Figure 5.12***):

(1) Assessment of the flood mitigation benefits and costs blue-green structures versus traditional drainage systems,
(2) Using structural diversity scoring of urban green spaces for recreational gap analysis and targeting of further municipal investments in accessibility

Potential policy contexts for further valuation

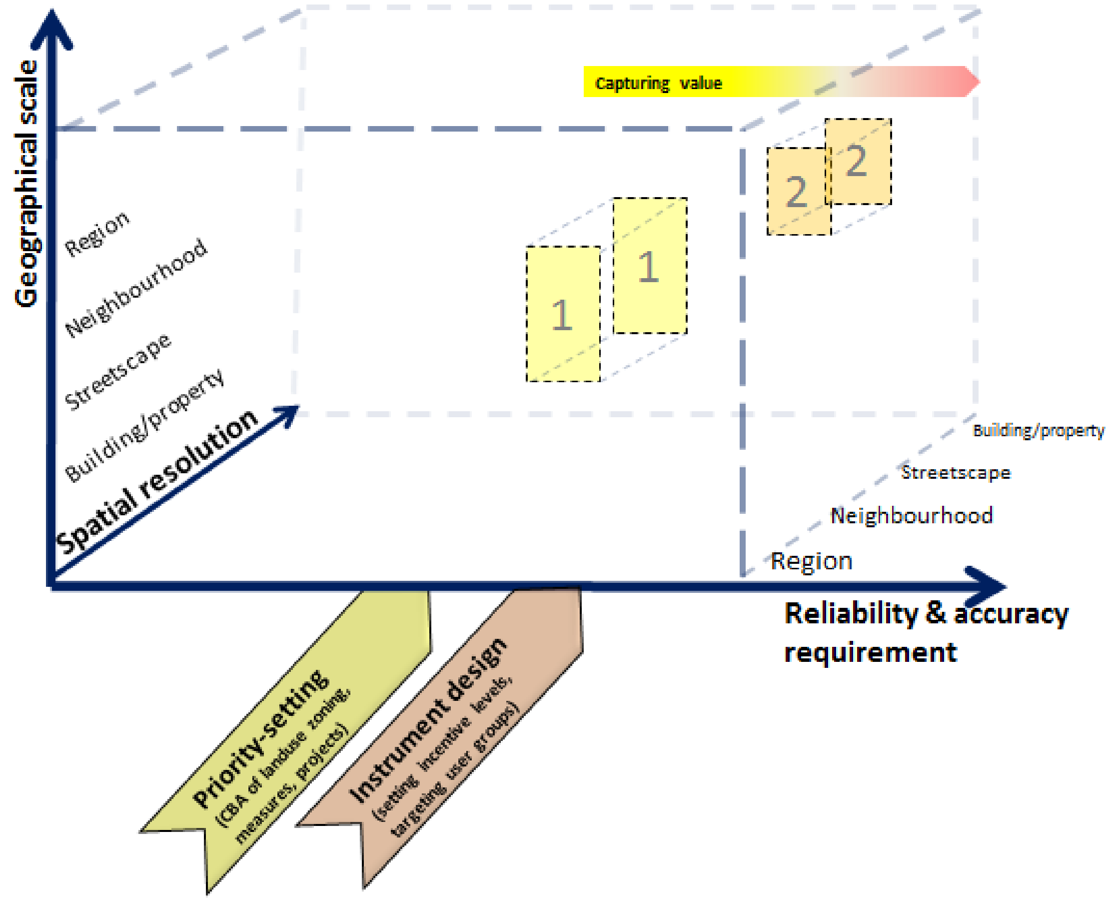


Figure 5.12. *Two hypothetical extensions of the blue-green factor (BGF) to policy assessments of green infrastructure (1) Assessment of the flood mitigation benefits and costs blue-green structures versus traditional drainage systems, (2) using structural diversity scoring of urban green spaces for citywide gap analysis and targeting of further municipal investments in accessibility*

5.5.5 Information gaps - challenges in assessing flood mitigation and recreation function of urban green structures

1. Assessing flood mitigation benefits and costs blue-green structures versus traditional drainage systems

One of Oslo Municipality's priority areas for action in relation to environmental management is urban flood control. Green infrastructure obviously fulfils ecological functions required for flood risk mitigation, principally infiltration of run-off and flood control. However, the examples thus far in the report have not addressed how we would proceed in quantifying and valuing flood risk mitigation in monetary terms. What are the information requirements in moving from (i) a qualitative method such as BGF which does not differentiate properties in terms of hydrological context to (ii) a quantification of flood risk that accounts for urban hydrology?

Preliminary work done by Reinvang et al. (2014) suggest that urban hydrological modelling that accounts for specific local drainage conditions and specific property at risk is required to provide results that can be used – beyond awareness raising - for decision-support. Such site-specific modeling work is information intensive and costly and should be weighed against the marginal property values at risk. These methodological issues of ecosystem services valuation could be addressed by the National Commission on Surface Water ("Overvannsutvalget").

2. **Recreational gap analysis using structural diversity of urban green space**

The blue-green factor methodology could be combined with data on other ecosystem service functions of green infrastructure and scaled up from property level to green infrastructure in general. In particular Voigt et al. (2014) suggests a rapid assessment approach to characterising the presence/absence of biotic, abiotic and built structures in urban green spaces. The methodology would combine most of the biotic and abiotic structures in the blue-green factor, with other built structures of importance for recreation. The aim would be to generate a scoring system which was more weighted towards cultural ecosystem services than the BGF. Oslo Municipality has previously conducted gap analysis based on the accessibility to different sizes of parks across the city (OsloKommune, 2006). This structural diversity index would provide more resolution by looking at the correlation of park size with structural diversity and diversity of recreational uses. The structural diversity index could be used to identify areas of the city with low multi-functional coverage of green spaces (***Figure 5.13***)(Soy-Massoni et al., in progress).

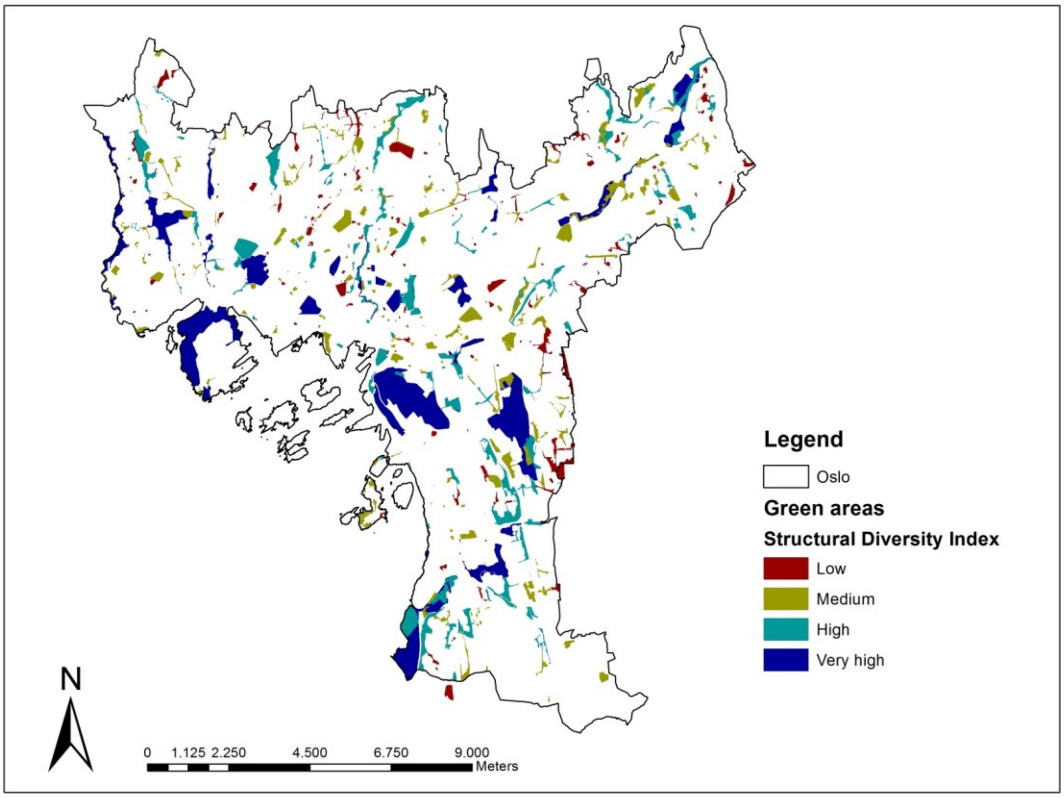


Figure 5.13. *Relative value of green infrastructure in Oslo based on a structural diversity indicator. A higher total normalized value indicates higher structural diversity.*

Source: Soy-Massoni et al. (in progress). GIS data: PBE and Bymiljøetaten, Oslo Kommune.

5.6 Non-economic valuation of supporting services of green infrastructure for human health

5.6.1 Ecosystem services and health – a complex web of interactions

Valuation results in brief

While hard to quantify the supporting services of urban green infrastructure for human health are likely to be large. Human health is perhaps the most important mediator for how important we consider provisioning, regulating and cultural ecosystem services also provided by green infrastructure.

None of the examples of economic valuation in this report quantify the benefits of urban green infrastructure to health of citizens.

As this is a scoping study we have not conducted an in depth review of the literature, but we have not found economic valuations of health effects associated with ecosystem functions of vegetation and water. While there is economic valuation of health impacts in terms of loss of income due to loss of quality adjusted life years and estimates of medical treatment costs, these are usually linked to noise, air and water pollution. Vegetation mitigates noise and air pollution, wetlands abate water pollution, but these effects must be disentangled from a number of other factors in an urban environment. In ***Figure 5.14*** we suggest that the 'missing link' between economic valuation of health benefits and use of green infrastructure is the epidemiological study of physical and psychological health impacts.

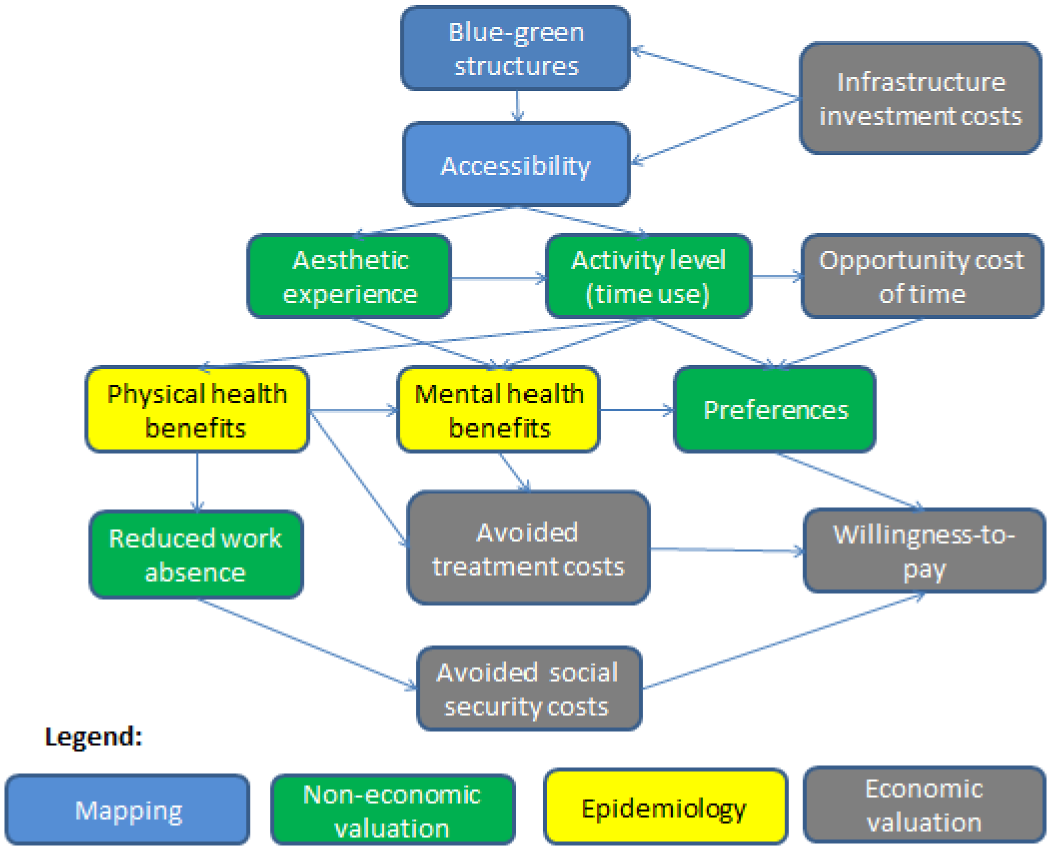


Figure 5.14 *Potential relationships between blue-green structures non-economic measures of ecosystem service benefits and economic valuation methods.*

5.6.2 Ecosystem supporting services of green infrastructure - human health and urban habitat

Establishing a causal relationship between green space and urban health are complicated because incidence rates are low and time spans for benefits to materialise long (Lee and Mahaswaran, 2010). Even after controlling for socio-economic factors other unidentified confounding factors abound, and the role of green spaces in health while potential, may be unrealised due to other context factors. For example, in a study of 10-14 year old boy scouts in Houston Texas no environmental factors were found to be correlated to physical activity (Jago et al., 2006; Jago et al., 2005). The only significant factor to positively influence physical activity was the availability of sidewalks. While we do not know the particular configuration of green space and transport habits in the study area, this finding would be consistent with lacking accessibility on foot due to scarcity of sidewalks and predominance of car use. This is just one example of built infrastructure and transportation habits around green spaces confounding the understanding of what at first looks like a simple spatial proximity to green space.

With such site specific confounding effects it is an even greater challenge to associate the specific characteristics of green spaces to health effects. Gardsjord et al. (2014) found that studies investigating the importance of specific park components and characteristics on use are scarce. Studies identifying the link between urban park use and health are if anything even scarcer.

The ecosystem service framework has a problem dealing with the causal links of such a complex phenomenon. In this chapter we cite studies which provide epidemiological evidence for the importance of green spaces for physical and mental health. In the ecosystem services cascade terminology epidemiological studies document how the urban habitat structure functions as 'habitat for humans'. This can simply be seen as the study of ecosystem function (in much the same way we would study reproduction, morbidity and mortality dynamics of a species conditional on changes in its natural habitat, but without making subjective considerations of importance).

Recreation is commonly classified as a 'cultural ecosystem service'. However, green infrastructure plays a more fundamental role than as just a cultural benefit. In our largely technology supported urban lives many of us may forget the original meaning of "re-creation". Despite its limited spatial extent, urban green infrastructure is still important for mental and physical re-generation and hence life-support. If we view re-creation as a "liveability" requirement of city habitat, epidemiological studies are also non-economic valuation of "supporting services".

Without conducting economic valuation, the epidemiological examples below make the case that human health support is the most important of ecosystem services of urban green infrastructure. Because supporting services underpin provisioning, regulating and cultural services they are hard to identify separately.

Human health is perhaps the most important mediator for how important we consider provisioning, regulating and cultural ecosystem services also provided by green infrastructure. Hence, human health returns in different guises in every one of the economic valuation chapters to follow.

Health thresholds for green space availability

In a study from the Netherlands, Jonker et al. (2014) found that the quantity and quality of urban green spaces is positively correlated with small-area life expectancy and healthy life expectancy. Their study concurs with a growing body of evidence that urban green space provides supporting services in the sense of healthy habitat for city dwellers, reducing stress, stimulating physical activity, improving micro-climate and reducing ambient air pollution.

In a study from four UK cities, Mitchell et al. (2011) found a significant association between the amount of green space in an area and mortality rates, and self-reported morbidity rates (***Figure 5.15***). Their study shows very clearly that increased green space area does not lead to proportional gains in health. For mortality rates, we see no significant effect of increasing green space area in the range from 20-59%. Only when green space surpasses a threshold of 60-79% do we see a significant drop in mortality rates (across all three spatial measures used by researchers).

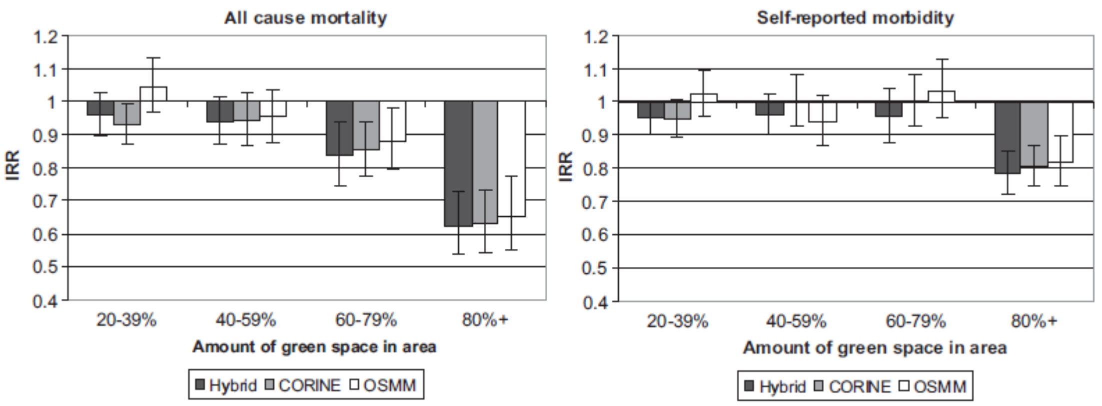


Figure 5.15 *The association of green space with mortality and with morbidity in populations of four cities in the UK.*

Source: Mitchell et al. (2011), Figure 4, p.857
Note: IRR. Incidence rate ratios. All cause mortality does not include external causes. Morbidity incidence is measured using self-reported illness. The study used three different indidcators of green space as seen by the triple bars in the diagrams.

For self-reported morbidity the threshold lies even higher at >80% green space area. This study suggests that there are important threshold effects – once residents' access to green space falls below 60-80% there may be significant health costs. The study also helps us understand that what we define as health 'benefits' or 'costs' depends on the benchmark or reference level for citizens' access to green space.

In a national level study from Denmark Stigsdotter et al. (2010) recorded 36 indicators of self-reported health (***Figure 5.16***). For all indicators there was little or no significant effect of green space proximity within 1 km. However, when distance to green space increased beyond 1 km significant effects on health were observed across all indicators.

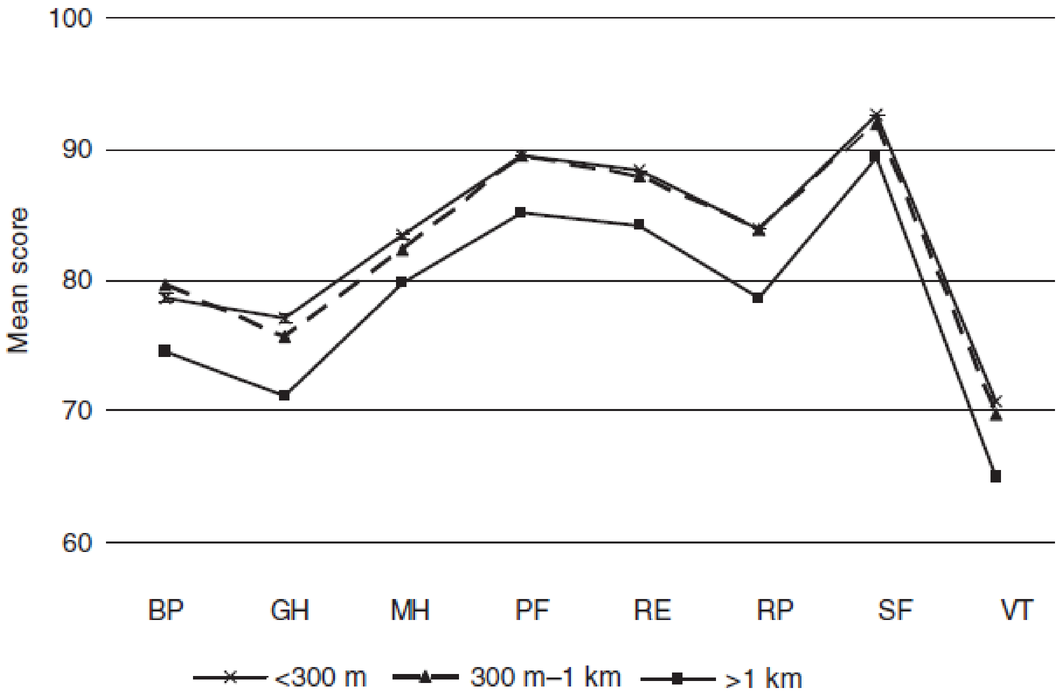


Figure 5.16 *Gender and age-adjusted health scores as a function of distance to nearest green space as rated in a population-wide study from Denmark*

Source: Stigsdotter et al. (2010), Figure 1, p. 413
Note: The SF-36 health score is composed of 36 measures divided into 8 subscales: BP, bodily pain; GH, general health; MH, mental health; PF, physical functioning; RE, role emotional; RP, role physical; SF, social functioning; VT, vitality.

Children's health

Economic valuation of ecosystem services frequently under-estimates benefits to children because economic theory takes as the accounting unit the household, only records preferences of the household head (although they will incorporate consideration for family children), or estimates benefits based on national statistics related to employment and income. We are conscious of this omission in all of the valuation examples in the rest of this scoping report.

In their review, Gardsjord et al. (2014) found that youth is an understudied age group when investigating the importance of specific park components and characteristics. They found access to green spaces as the most frequently reported predictor of park use among youth.

Having recreation facilities in the neighbourhood leads to higher physical activity among youth in a study from Canada (Tucker et al., 2009). A study of US adolescents found that outdoor spaces can particularly benefit female adolescents who tend to have lower physical activity (Boone-Heinonen et al., 2010).

In Minneapolis and San Diego, US, the odds of higher physical activity are higher in places with parks, schools and high population density during weekdays, and lower in places with more roads and food outlets (Rodriguez et al., 2012).

In a longitudinal study following children from age 9-10 to 18 in Southern California Wolch et al. (2011) found significantly lower body mass index (BMI) at age 18 for individuals who had lived with more green area within 500m of their homes. Effects were larger for boys than girls.

The documentation of health effects in children due to specific green structures is sparse. However, Faber Taylor and Kuo (2011) found in the US that green space as open grass and big trees & grass significantly reduce parent-reported severity of Attention Deficit/Hyperactivity Disorder (ADHD) in their children (***Figure 5.17***). The benchmark was play “deep indoors” in “built indoor” environments.

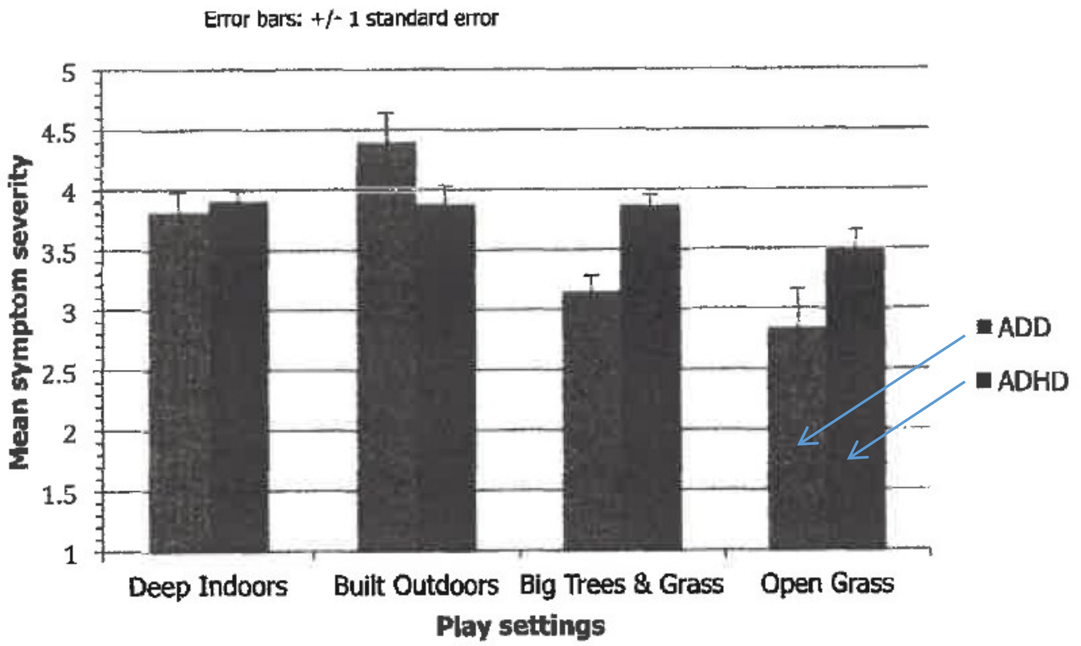


Figure 5.17 *Interaction of play setting and symptom diagnosis determine ADD and ADHD symptom severity. ADHD: Attention Deficit/Hyperactivity Disorder ADD: Attention Deficit Disorder (no hyperactivity)*

Source:Faber Taylor and Kuo (2011)

The researchers also show that the type of green space characteristics matter for symptoms. Green space with big trees or just open grass made no significant difference on children who did not have hyperactivity symptoms (ADD). However, for children with hyperactivity symptoms (ADHD) play in open grass meant a significant reduction in symptoms relative to an area with big trees & grass. The authors do not discuss a mechanism that would explain this finding. A possible explanation is that “open space” represents more opportunities for high physical activity than areas with “big trees and grass” (assuming that grass is not as open). The study shows that green space characteristics can be symptom specific, as well as age group specific. In very well designed studies such context specific effects are measurable.

5.6.3 Preferences for green and blue structures

A number of methods for measuring relative preferences for specific green space characteristics (Nordh, 2012) and mapping and measuring accessibility are available (Koppen et al., 2014).

Of particular relevance for Oslo is the large amount of research conducted at NMBU by Helena Nordh and colleagues for small city parks.

In a study of 72 parks in Stockholm Nordh et al. (2009) show that the size of parks is correlated with the number of park components (***Figure 5.18***). Interviewing university students they found that the self-reported likelihood of restoration (re-creation) is correlated with the number of park components (park structural diversity). Particular structural components elicit particular emotional reactions with "fascination" associated with water and size, and "being away" associated with grass, bushes, trees and size.

In a conjoint study of Oslo residents' preferences for characteristics of small parks, Nordh et al. (2011) find similar preferences across age groups for trees, bushes, presence of people (***Figure 5.19***). Water and flowers were relatively more preferred by those older than 60, while grass was relatively more preferred by those younger than 29. Preferences were broadly similar across men and women.

In another study of small urban parks - "pocket parks" - Nordh and Østby (2013) interviewed university students in Oslo for their relative preference for natural and designed characteristics, management and park surroundings (***Figure 5.20***, next page). natural characteristics were most frequently associated with restoration likelihood, while enclosure, calm and lack of traffic and seating possibilities were also quite important. The study emphasises the importance of conserving natural features of also the smallest urban parks.

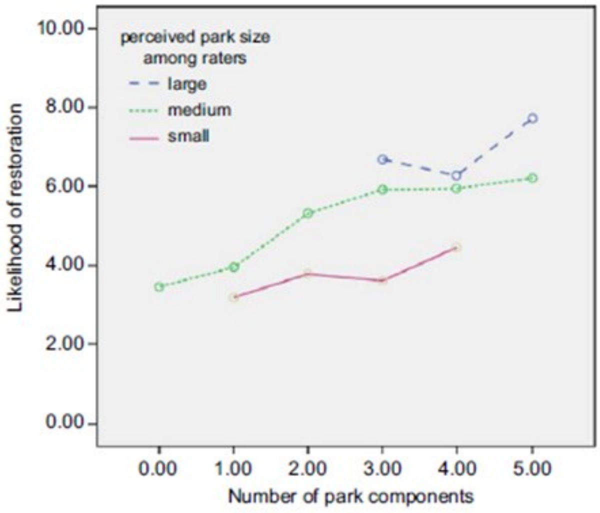


Figure 5.18 *Number of small urban park components with above-median values as a function of park size, as rated by a sample of students in Stockholm*

Source: Nordh et al. (2009), Figure 5. p. 232

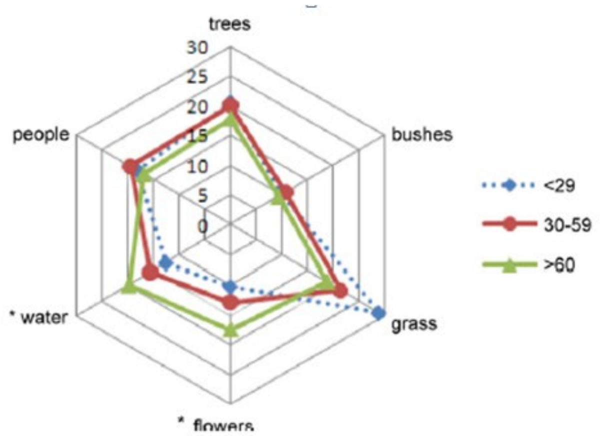


Figure 5.19 *Average importance of different small urban park components by age group, as rated by a sample of Oslo residents*

Source: Nordh et al. (2011), Fig. 7, p.100

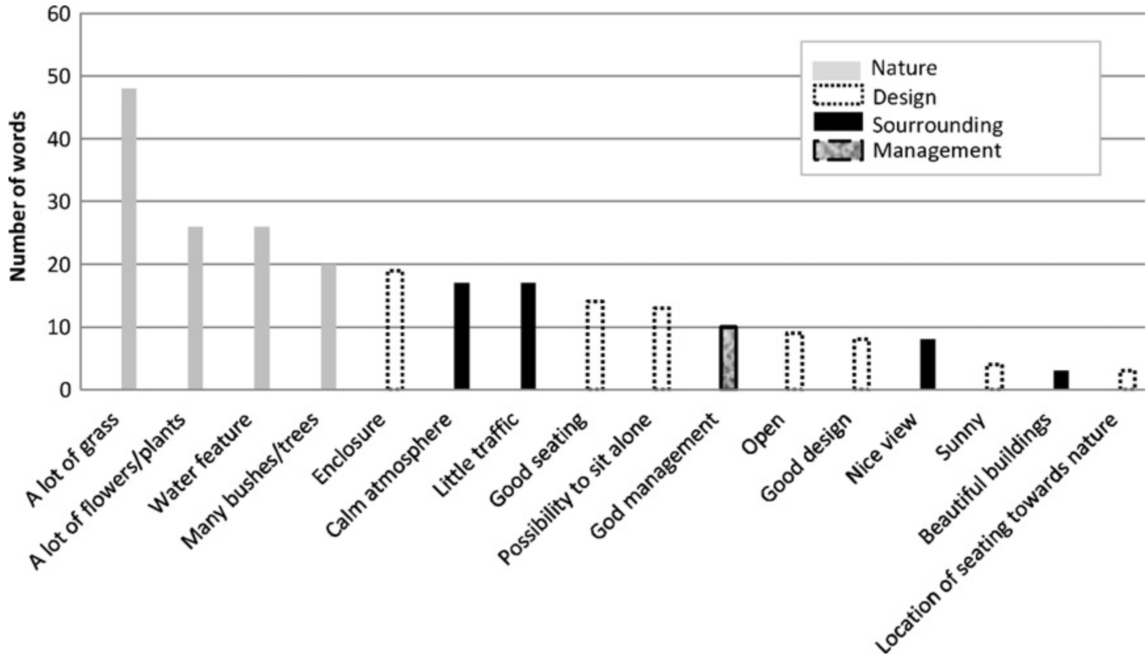


Figure 5.20 *Structures of small urban parks with highest likelihood of having a restorative effect on visitors, as rated by a sample of students in Oslo*

Source: Nordh and Østby (2013), Table 1, p.14

5.6.4 Valuation for further policy support

This chapter has provided a number of examples of epidemiological studies and preferences studies indicating the importance of green infrastructure. Common to epidemiological studies that have observed significant effects is a regional scale data set controlling for variation at different resolutions (park, neighbourhood and home characteristics). The studies were all non-monetary assessments of impacts and preferences. Future economic valuation studies for awareness raising purposes regarding health benefits could try to transfer epidemiological findings to Oslo to make rough estimates of changing incidence of mortality and morbidity with different proximity to and total available green space. Proximity and availability thresholds would have to be controlled for. Incidence likelihoods per capita could be valued using assumptions about the value of Quality Adjusted Life Years (QUALYs) transferred from the air pollution valuation literature. The resulting estimates would be associated with very high uncertainty, but might still provide orders- of-magnitude that spur further policy and research interest.

If epidemiological does-response studies were available on green infrastructure impacts on health, and awareness raising valuation studies had been conducted, what would be the next steps in the policy-relevant valuation hierarchy? Given the current state of knowledge this is highly speculative. Nevertheless, we can use the example of the Handbook 140 on impact assessment of transport projects (see chapter 3). Since the first version appeared in 1988 several decades of research have succeeded in internalising valuation of health effects from accidents, air pollution and noise in the social economic analysis of transport projects. This has been made possible by a concerted research agenda on estimating dose-response functions and then developing simplified look-up tables for guidance documents and operationalisation in Impact Assessments. Given the dose-response examples cited in this chapter we know that the methodology is available. What is needed is sufficiently large samples and longitudinal studies that can capture cumulative and chronic health effects. Such relationships could be transferred from other cities, but would ideally be commissioned for Norwegian cities specifically. Once green infrastructure does-response functions are mapped to morbidity and mortality end-points, available economic estimates of e.g. QUALYs could be 'plugged in' in the same way they are done for the currently 'priced' health effects in Handbook 140. 'Priced' health effects of green infrastructure could then be evaluated as part of economic analysis of public infrastructure investments.

In summary, there is still some way to go before health impacts could be considered 'priced impacts' in impact assessment of green infrastructure. For the near future studies are needed for awareness raising at an aggregate level using different kinds of methods with different data resolutions (***Figure 5.21***).

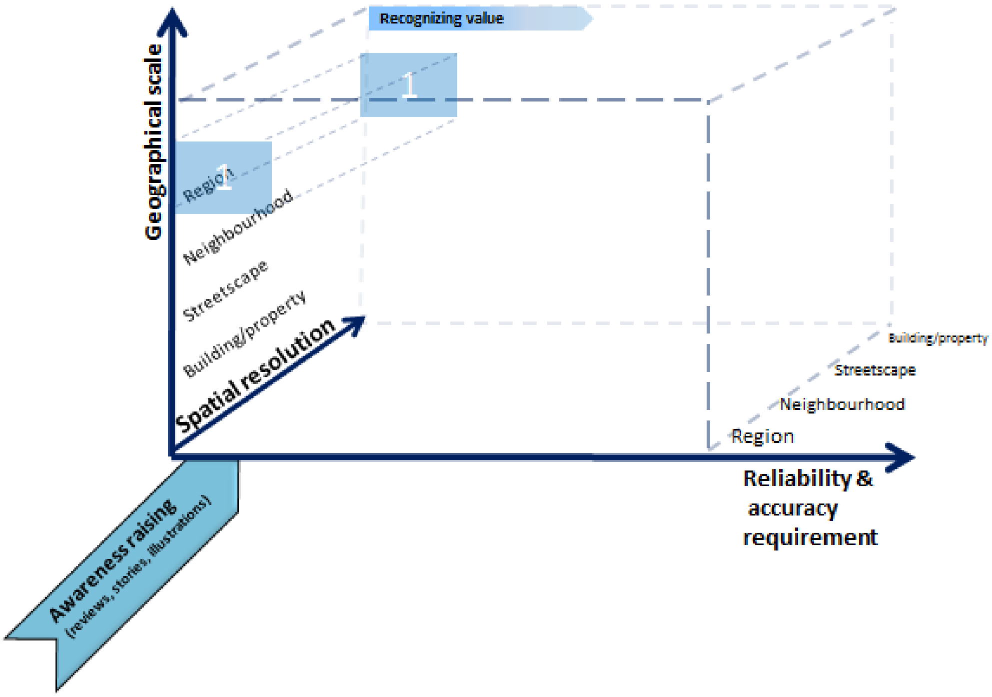


Figure 5.21 *Awareness-raising of potential health benefits of green infrastructure – multi-level resolution studies needed.*

6 Recommendations regarding information gaps and research needs

6.1 Pilot study valuation results

In this report we have discussed valuation for awareness-raising through 6 different examples, four of them using economic valuation methods:

Economic valuation examples:

1. Meta-analysis of willingness-to-pay for green spaces in the built zone
2. Hedonic pricing of green infrastructure in the built zone of Oslo
3. Time use value of Marka peri-urban forest outside the built zone of Oslo
4. Urban trees in the built zone

Non-economic valuation examples:

5. Blue green factor scoring of property in the built zone of Oslo
6. Health impacts of green infrastructure in Oslo as a whole

The two methods looking at recreation in green spaces (1) and the peri-urban forest (3) found annual values of 1 to more than ten billion Norwegian kroner. The value of green spaces in property prices (2) and the liability value of trees (4) revealed capital values in the range of tens of billions of Nowegian kroner. These values partially overlap and should not be added arithmetically. Recreational value of parks and green spaces overlap with property values and value of city trees in parks. The recreation time value of the peri-urbn forest overlaps with property value of proximity to the edge of Marka.

Nevertheless, for awareness raising purposes we can with great certainty say that ***nature in Oslo has a total annual value of several billion kroner*** *(Barton et al., 2015b).* We know that this value represents mainly cultural ecosystem services. Regulating services remain largely unvalued.

In moving on from a pilot study consideration should be given to the uses of further economic valuation. Depending on the use context there will be different requirements for accuracy and reliability, involving different information requirements and study cost. We see three main directions that could be taken. They are not mutually exclusive, but each involve further studies and in most cases new studies on ecosystem function and ecosystem service valuation.

Increasing resolution for decision-support: in some cases valuation methods are available and data could be collected to increase the resolution of valuation studies to a point where they would be relevant in decision-support.

Widening scope for awareness raising: awareness could be raised about the economic value of a number of ecosystem services and some green infrastructure that were not addressed in the pilot study. This could in some cases be done without new primary economic valuation studies.

Increasing scale for awareness raising across jurisdictions: the scale of a valuation study could address neighbouring municipalities of Greater Oslo to address whether there were ecosystem service benefit or cost spill-overs across municipalities that could be relevant for regional planning policy.

Methodology development: based on our review of Norwegian guidance documents we see a gap in impact assessment and economic analysis in relation to ecosystem services.

6.2 Increasing resolution: from awareness raising to decision-support

What are the additional information requirements of moving further along in the 'decision-context hierarchy' ? What are the demands on further ecosystem service mapping in terms of requirements on accuracy and reliability? Are new primary valuation studies needed? What valuation methods are relevant in those cases? Here we synthesise the discussion on "valuation for further policy support" from each of the 6 examples.

We emphasise that the decision-contexts suggested here do not necessarily reflect actual policy issues.

6.2.1 Natural capital accounting

National economic and environmental accounting (NEEA) is evaluating standards for ecosystem accounting (UN, 2013). To the best of our knowledge ecosystem service accounting studies have not focused on urban ecosystem services (Schröter et al., 2014). While urban ecosystem services are relatively small in surface area in a national context, they represent the habitat for the majority of the world's population and ecosystem service values per unit of area are expected to be high (Gómez-Baggethun and Barton, 2013). In our pilot study we also find large cultural ecosystem service values. These values represent methodological challenges for NEEA standards which only admit market-price and revealed preference valuation methods, and not methods based on consumer surplus. Cultural services such as recreation have to a large extent been valued using stated preference methods which estimate consumer surplus.

In our pilot study NEEA standards would reject the findings of the meta-analysis of contingent valuation of park recreation, but accept the revealed preference values of hedonic property pricing. In this sense further ecosystem services valuation work in Greater Oslo represents a rich testing ground for operationalizing NEEA in Norway, and even at municipal level.

For example, the hedonic property pricing results could be used to evaluate the extent to which the capital values uncovered could be integrated into 'municipal experimental ecosystem accounts', downscaling NEEA methodology.

6.2.2 Priority setting – benefit-cost analysis and cost-effectiveness analysis

Hedonic pricing of urban green space could be used in assessing the economic benefits of creating new public parks in low coverage areas in Oslo. Mapping of low coverage areas has already been carried out (OsloKommune, 2006). Once a green space is regulated as a recreation area, economic valuation could at best be used as one more *ex post hoc* justification for the decision. For open spaces that are still legally 'unprotected' it would be interesting to test benefit-cost analysis as decision support ex ante, using the results of the hedonic pricing study. Does the aggregate hedonic value-added to existing housing in the neighbourhood outweigh the foregone property development value? How do we avoid double counting when aggregate partially overlapping hedonic property values with values from stated preference willingness-to-pay studies and time value studies? In order to use hedonic pricing to evaluate specific parks spatially representative data is needed on property values and characteristics. The local relevance of the method is limited by the actual number and location of property sales.

Regarding the time use values uncovered for recreation in the Marka forest, next steps involve disaggregating time use to particular locations and recreational activities. One important hypothesis that could be tested is the extent to which urban parks and peri-urban forest are complements and substitutes for different types of recreational activity. This would be relevant for the assessment of proposals to create public parks within the built zone close to the marka border versus built sports facilities in the proposed activity zones within the Marka forest.

For this question in particular a bespoke stated preference study could evaluate the willingness to pay for a limited set of alternative investments in sports and recreation facilities.

6.2.3 Instrument design

The Blue-green factor (BGF) has been proposed as a method for **scoring** and providing **incentive**s for ecosystem service performance in building design, and as a tool for **screening** building plans (FramtidensByer, 2014). Weighting of individual blue and green structures is based on expert knowledge, and focuses on importance for surface water regulation. Stated preference /market research methods such as choice experiments could be used to evaluate the extent to which property buyers' preferences for green structures diverge from the weighting in the BGF.

Property development within the Marka border has been proposed in several places in recent years, with proposals for extending the Marka border in other locations to offset the development. Recreation use mapping and stated preference methods such as choice experiments could be used to assess whether the proposed **development offsets** were equivalent from a consumer surplus point of view.

6.2.4 Natural damage assessment and litigation

Oslo Municipality currently uses the VAT03 methodology (Randrup et al., 2003) for assessing economic liability of city trees. The methodology goes quite far in adjusting the liability value for neighbourhood characteristics in terms of aesthetics and recreation. However, it does not differentiate between trees with regards to their neighbourhood effects on regulating services. Because VAT03 is currently being used to calculate compensation claims that could be challenged in court, we think the method could be strengthened by further calibrating the model for trees in different contexts. This could be done by applying the model to a randomly selected sample of trees across different neighbourhoods on both public and private land.

Further work could also be done, in collaboration with legal specialists, on the scope for extending the VAT03 model to assess the compensation value of trees on private property, e.g. in disputes between neighbours.

In summary, there are a number of opportunities for exploring the relevance of valuation methods by commissioning new studies that have higher spatial resolution.

6.3 Widening scope: valuation for awareness raising on other urban ecosystem services

In the pilot study we were not able to address a number of ecosystem services which have been identified as important in the urban ecosystem services literature (Gómez-Baggethun et al., 2013) because there was no easily available mapping data, use data, dose-response modeling and/or valuation studies. In some cases there were available meta-analyses, but the spatial resolution was too rough for the urban context of our study. For example, this was the case for willingness-to-pay urban wetlands using a meta-analysis on wetland valuation by Brander et al. (2010).

Here we summarise ecosystem services we were unable to address in this report, but which are potentially important based on the following criteria:

(i) blue-green structures – landscapes and respective ecosystem services which are relatively under-represented in municipal policy documents would be more likely to achieve and awareness raising effect from applying economic valuation
(ii) ecosystem services with high values from other cities
(iii) contested ecosystem services, where there is disagreement on their importance
(iv) availability and cost of valuation methods

We suggest what types of *spatial and biophysical mapping* and *valuation* data might be relevant to consider for awareness-raising valuation in each case. The following ideas are intended as a starting point for further brainstorming on study design, aided by a substantial international case study literature[15].

6.3.1 Integrating across ecosystem services – urban habitat and human health

Justification: quantifying ecosystem services ultimately aims at quantifying ecosystems importance for human health and well-being. Recent epidemiological studies have succeeded in establishing the significance of urban green structures for human health. In effect, they document supporting services of urban blue green habitat for humans. Lifestyle illnesses place a large economic burden on public health systems, as well as private costs.

Spatial and biophysical data: epidemiological studies controlling for individual physical activity, access to green infrastructure, and quality of green infrastructure. See section 5.6.

Valuation method: Costs of morbidity and mortality (quality adjusted life years).

6.3.2 Experiential and cognitive services - fjord and island recreation

Justification: the pilot study only valued the hedonic property value of proximity to the Oslofjjord coastline. It did not address coastal and marine recreation on the Oslofjord nor on its islands.

Spatial and biophysical data: map destination and time use for coastal and marine recreational activities such as picnicking, bathing, and boating.

Valuation method: value of time use

6.3.3 Experiential and cognitive services – tourism in natural areas in Oslo

Justification Non-residents' recreational values from using the islands, fjord, coastline, parks and Marka forest were not addressed in the recreational valuation of the pilot study. Oslo has around 300 000 cruise boat visitors (InnovationNorway, 2013) and 3 million guests nights per year[16]. Oslo aims at profiling itself as a green capital (OsloKommune, 2013c). What is the economic importance of green infrastructure for Oslo's tourism sector?

Spatial and biophysical data: survey trip purposes, time spent by location and expenses of foreign and domestic visitors to Oslo.

Valuation method: value of recreation time and expenses on different dedicated outdoor activities

[15] It was not within the scope of this pilot study to conduct a review of this literature, and there are many available sources such as TEEB and UK NEA.
[16] www.visitoslo.com

6.3.4 Experiential and cognitive services – environmental education

Justification: Oslo's schools use neighbourhood forests, lakes, streams and the coastline in outdoor exercises in the environmental science curriculum. What is the value of having natural areas within walking distance of a school?

Spatial and biophysical data: survey schools for the number of pupil outdoor teaching days across Oslo

Valuation method: value outdoor teaching time per pupil directly; or value replacement cost assuming outdoor teaching is replaced by indoor teaching; or value additional travel time to alternative natural areas

6.3.5 Regulating service – storm water management

Justification: urban stormwater management entails large investments and there is interest in evaluating the extent to which green and blue structures within the built zone can reduce design requirements for urban drainage and/or reduce costs of flood damage(Reinvang et al., 2014). The restoration of urban streams and rivers has been taking place in Oslo over the last decades. Only recently have restoration measures been subject to benefit-cost analysis focusing mainly on recreational benefits (Magnussen et al., 2014). In both cases the assessment of benefit from stormwater management have been constrained by the lack of urban hydrological modelling.

Spatial and biophysical data: flood risk mitigation of urban green infrastructure depends mainly on three hydrological processes (i) evapotranspiration from vegetation (ii) soil infiltration and (iii) delay runoff through temporary storage. Of these three delaying run-off through temporary storage is perhaps the most important for mitigating extreme rainfall events in small urban catchments[17]. Understanding the latter so-called hydrological routing effect requires spatially explicit modelling. Further studies should characterise urban green spaces in terms of vegetation cover and soil types and hydrological network in terms of storage capacity, and routing times using hydrological simulation models.

Valuation method: assess property value at risk at flooding locations predicted by the urban hydrological model.

6.3.6 Regulating services - waste water treatment

Justification: until the 1970's the Oslo fjord was used as a sewage waste treatment basin for the city. Since regular sewage started being treated water quality has improved, although sewage still reaches the fjord during high intensity rainfall. Investments in sewage treatment have been large and are ongoing. Costs of sewage treatment represent the revealed willingness to pay for minimum standards of water quality in the Oslo fjord.

Spatial and biophysical data: What is the sewage treatment capacity of the Oslofjord in terms of population equivalents that would still keep water quality within minimum regulatory requirements? This question could be answered using a marine water quality simulation model.

Valuation method: the replacement cost approach could be used to evaluate what the sustainable population-equivalent sewage load to the Oslo fjord represents in terms of costs of equivalent sewage plant treatment

[17] Pers.com. Nils Roar Sælthun, hydrologist

6.3.7 Regulating service – noise and air pollution mitigation

Justification: noise is a significant predictor of the price of apartments in the built zone according to the hedonic pricing study. Vegetation mitigates the perception of noise both in terms of reducing the energy of sound waves and through visual impression of screening. The economic value of vegetation in mitigating the disamenities of traffic is potentially large, but spatially distributed and undocumented in Oslo.

Spatial and biophysical data: air pollution and noise have been mapped in detail in Oslo. Mapping of city trees and overlay with pollution maps would map potential mitigation. Data on actual mitigating effect of individual structures could be transferred from studies in the literature, or ideally studied for representative vegetation in Oslo. Seasonal differences would need to be accounted for.

Valuation method: hedonic pricing estimates in this study can be ascribed to changes in noise level. Hedonic pricing of air pollution might also produce significant results.

6.3.8 Regulating and provisioning service – drinking water treatment and supply

Justification: The economic role of wetlands and lakes in the supply and pre-treatment of Oslo's drinking water from Maridalsvannet could raise awareness about another ecosystem service of Oslo's Marka greenbelt. Economic analysis is not required to justify policy as watershed protected around Maridalsvannet is a century old and drinking water safety is fully regulated. However, peri-urban watershed protection for drinking water purposes is an 'iconic' ecosystem service internationally and one that is easy to communicate.

Spatial and biophysical data: determine added water treatment steps required by regulation in the hypothetical situation that Maridalsvannet catchment was impermeable or built area. The assessment of the effectiveness of water treatment functions depends on assumptions about pollution loading.

Valuation method: replacement cost in terms of investment in and maintenance of additional treatment processes

6.3.9 Supporting, experiential and cognitive service – urban pollinators

Justification: Bees require intact green space and floral diversity to be sustainable. As such they are an indicator of how well the urban landscape mosaic provides supporting services as biodiversity habitat. Urban beekeeping is rapidly gaining popularity in Oslo. Bees are easily identifiable, and perform pollinating services in gardens and orchards. While pollinating services are not commercially important in Oslo, bees are iconic in communicating knowledge about and concern for ecosystem function and services.

Spatial and biophysical data: survey the presence of pollinators across a rural-urban gradient in which green structures and foraging resources are also mapped. Map actual and potential demand for beekeeping (in collaboration with ByBi). Map Oslo's apple orchards.

Valuation method: only very partial economic valuation is possible. Commercial value of Oslo's apple orchards. Costs of maintaining floral diversity throughout Oslo's public parks and private gardens. Willingness-to-pay for beekeeping.

6.4 Increasing scale: assessing ecosystem services across jurisdictions

This study has focused on valuation of ecosystem services within the administrative boundaries of Oslo Municipality. Future ecosystem service mapping and valuation studies could have *other systems boundaries depending on the policy purpose* of the analysis as discussed in chapter 4. Here we suggest some alternative system boundaries related to hypothetical policy questions.

6.4.1 Watershed boundaries

Awareness raising. The role of the Marka greenbelt in providing regulating services that benefit Oslo's population living in the built zone may be taken for granted by the wider population. Oslo's own catchments lie largely with municipal boundaries. Oslo's water supply comes from the Maridalsvann catchment. The role of peri-urban forests in regulating drinking water quality is an iconic ecosystem service that has received attention in a number of international studies. Hydrological modelling discussed under 6.3.5 could be extended to assess the role played by Marka's forest vegetation cover, wetlands and lakes– outside the built zone - in regulating run-off and to Oslo's streams and rivers. Assessment of the flood mitigation and drinking water supply services may serve to raise awareness about the multi-functionality of Oslo's watersheds.

6.4.2 Marka forest ecosystem boundaries

Natural capital accounting. The Marka forest to the north, west and east of Oslo extends to other municipalities. The relative importance of cultural, provisioning, regulating and supporting ecosystem services is likely to vary between neighbouring municipalities, depending i.a. on proximity and density of the population. In the peri-urban landscape around Oslo we argue that ecosystem services are multiple, partially overlapping and conflicting to a greater extent than in rural landscapes. The Marka forest provides a good testing ground for how to implement natural capital accounting within relatively clear ecosystem boundaries that span several local government jurisdictions.

6.4.3 Neighbouring municipalities

Instrument design of ecological fiscal transfers. Study of ecosystem services provided by neighbouring municipalities to Oslo and vice versa. To what extent does Oslo's land use regulations benefit or impose costs on neighbouring municipalities? Are there arguments for making ecosystem service adjustments to the current state-to-municipal fiscal transfers (through adjustments to the so-called "kommunenøkkel")?

6.4.4 Commuter and housing market boundaries

Instrument design of property taxes. Municipalities around Oslo provide residential space for commuters who work largely in Oslo itself. Peri-urban municipalities are likely to have a smaller commercial tax base than Oslo, while providing natural amenities to residents. Such an argument may be the basis for assessing differential municipal property taxes, justified in part by differential access to ecosystem services. A hedonic property pricing study of the Greater Oslo region could evaluate residential choice and prices based on access to municipal utilities, transport services and ecosystem services.

6.4.5 Importing virtual ecosystem services - the ecological footprint of Oslo

Awareness raising. What ecological equivalent land area outside Oslo, within Norway, does Oslo depend on for provisioning services? What ecological equivalent land area outside Norway does Oslo depend on for provisioning services? The study would be aimed at awareness raising about urban sustainability in Norway.

6.5 Methodology development - pricing ecosystem services in impact assessment

In chapter 3 we discussed the extent to which ecosystem services are priced in economic analysis at the concept design and impact evaluation stages of infrastructure projects in Norway. Further research could evaluate how ecosystem service concepts could improve the assessment of unpriced impacts in Norwegian impact assessment methodology of Handbook 140 (StatensVegvesen, 2006).

For example, the identification of ecosystem functional linkages between "unpriced" and "priced" impacts (***Figure 6.1***) could help avoid double counting. National efforts to map nature types could take into consideration the spatial resolution that would be required to assess impacts on ecosystem services from infrastructure projects.

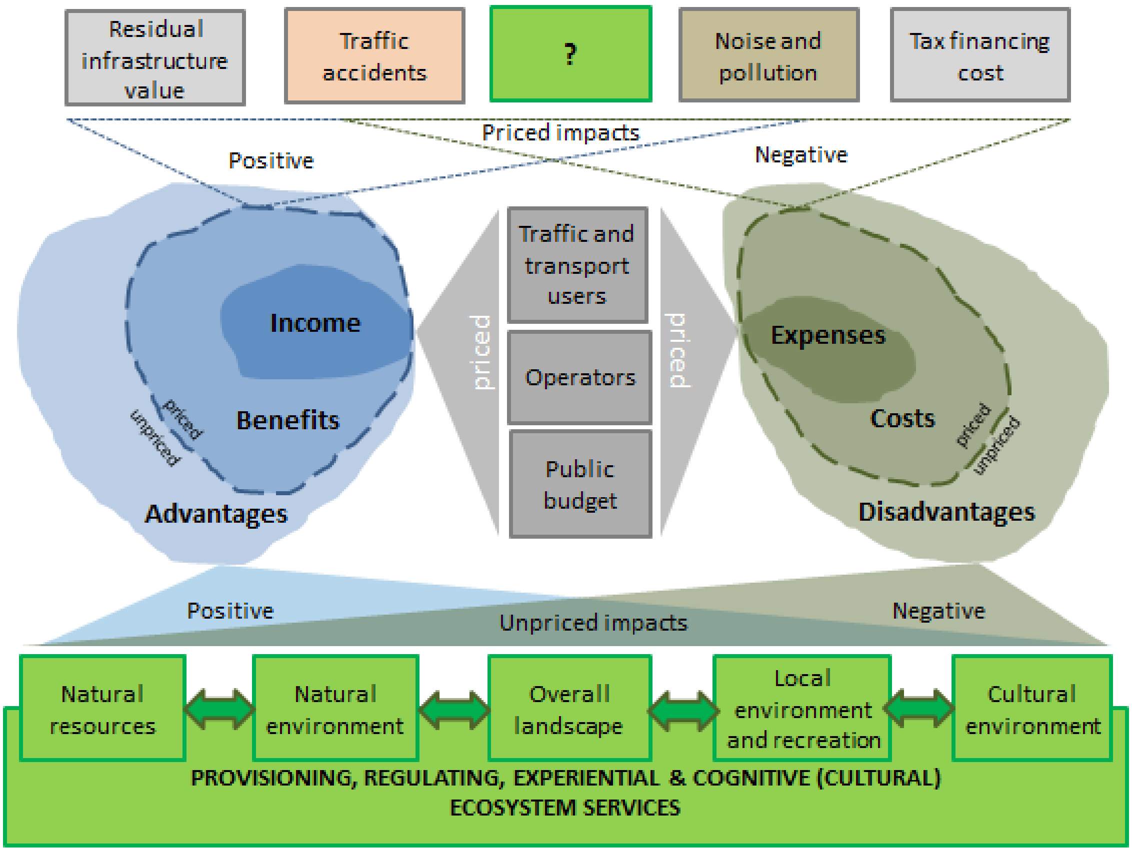


Figure 6.1 *Relationship between Norwegian impact assessment methodology and ecosystem services.*

Ecosystem services science may improve understanding of interlinkages between "unpriced" and "priced" impacts. The question mark at the top of the figure asks whether any of the "unpriced" ecosystem services at the bottom of the figure may in future be "priced" as part of national Impact Assessment guidelines.

Some ecosystem services valuation methods make “pricing” possible, but lack implementation due to high information investment costs. This may provide justification for starting a longterm research programme to include ecosystem service impacts as priced impacts in Norwegian impact assessment methodology (***Figure 6.1***). Such a research programme could focus on ecosystem services were statistical modelling methods exists, but lack implementation in Norway due to high costs of obtaining large enough cross-section and longitudinal data to document effects.

7 Conclusions

Chapter 1. Towards 2020 EU member states are carrying out ecosystem service mapping and valuation. This effort runs the risk of expending considerable resources collecting spatial data which is not targeted at specific decision-problems. While the aim of the report is to look beyond the awareness raising role of economic valuation, there are considerable practical challenges to be faced in applying economic valuation of ecosystem services to policy. Despite the difficulties, if economic valuation of ecosystem services succeeds in raising awareness, it gains legitimacy and there will be a demand for applying the methods more specifically. Conducting economic valuation of ecosystem services for awareness raising does not endorse "pricing" of ecosystem services as a policy instrument.

Chapter 2. Valuation of ecosystem services is decision-context specific because values are an expression of preferences for alternative courses of action at particular times and places. Awareness of sources of uncertainty is important in knowing the appropriate decision-support contexts for economic valuation. A framework for identifying sources of uncertainty in economic valuation of ecosystem services can aid decision-makers with the interpretation of whether value transfer errors meet their requirements for accuracy and reliability in specific decision-contexts. A conceptual framework for the decision-contexts of the economic valuation of ecosystem services can help policy-makers define their expectations when commissioning new economic valuation studies.

Chapter 3. Despite several decades of environmental economic research in Norway, economic valuation of ecosystem services is only practiced to a very limited extent as part of Norwegian project concept assessment and impact evaluation. The definition of ecosystem services as "unpriced impacts" by definition has limited development of economic valuation methods as decision-support. Ecosystem services are not an integrated concept in green infrastructure planning.

Chapter 4. Oslo Municipalities planning documents have an extensive coverage of cultural ecosystem services and supporting services related to biodiversity conservation. Regulating ecosystem services are extensively addressed in the built area, although less so for the peri-urban area. Regulating services that are relatively poorly documented in municipal policy documents include carbon sequestration and storage, pollination and seed dispersal and noise reduction of green infrastructure.

Chapter 5. The valuation examples from Oslo constitute the main body of the report, with four economic and two non-economic valuation examples. The examples demonstrate economic valuation of ecosystem services for awareness-raising purposes. The examples illustrate the framework in chapter 2 where the awareness-raising context has relatively low requirements for accuracy and reliability.

Recreational values of parks and green spaces. Green spaces in Oslo's built zone constitute roughly 28 km^2 across more than 500 different areas. Oslo's total green space is conservatively estimated to be worth 1 billion kroner per year. The estimate is based on willingness-to-pay studies transferred from a number of studies of urban populations in other countries. This value is equivalent to about kr. 1985 per inhabitant older than 15 years. The value transfer has been adjusted for a number of factors including differences in income level, size of green space and population density.

Capital value of green infrastructure in property prices. We carried out a statistical analysis of the relationship between the price of apartments in Oslo and proximity to green infrastructure. The study used sales data from 2004-2013. Within 500 meters from city parks the expected value of an apartment rises by NOK 162-368 for every metre closer to the closest park. There are 160 722 apartments within 500 meters of public parks in Oslo. The aggregate value of proximity to parks for all these apartments is NOK 8,3-18,9 billion. If the park has a water structure it is even more valuable. The added value of blue structures in parks is between NOK 2,8-6,6 billion. Large parks have an added value of NOK 0,3-2,3 billion.

Proximity to the Oslo fjord, Marka forest and cementaries has a further added value of several billion Norwegian kroner, according to property price statistics. All values are capital values (not annual) and as such appropriate for urban natural capital accounting. Aggregating the lower bound of all the hedonic price values gives a conservative estimate of NOK 19 billion for the capital value of green infrastructure in Oslo's built zone as reflected in apartment prices.
The estimate does not include other types of housing.

Value of recreation time in Marka peri-urban forest. Based on a survey of recreational activities of Oslo's adult population, approximately 73 million hours per year are spent in the peri-urban forest called Marka. The value of this recreational time can be estimated using a number of different methods, such as travel costs, costs of physical training alternatives and opportunity costs of work time. The different methods produce a range for the value of recreational time in Marka of between NOK 2,3-13,3 billion per year. The value is uncertain because of the uncertainty about the correct way to value recreational visits and time. While uncertainty is quite large we are confident that the value is at least several billion per year.

Value of economic liability for city trees. There are 0,7-1,2 million city trees taller than 5 metres in Oslo's built zone. Every citizens shared the built zone with 1-2 large trees. Oslo Municipalilty has a policy of replacing every tree that dies with a new one. Damage or destruction of trees on municipal land carried an economic liability. Liability is calculated according to an assessment models that accounts for the species, age and health of the tree, as well as characteristics of the location, including ecosystem services. The assessment model predicts that the expected liability value of an average city tree on municipal land is about NOK 40 000.
We used the assessment model on all city trees – both on private and public land – within the built zone to determine an aggregate (hypothetical) liability value for all city trees. Total liability of large trees in the built zone is between NOK 28-42 billion depending on the number of trees that are assessed. Liability value does not consider that trees may be perceived as a nuicance – ecosystem disservices - on private land. The method does not account trees smaller than 5 metres tall.

The valuation examples in this report cover only a fraction of urban ecosystem serices. Nevertheless these scoping examples collectively convey the awareness-raising messages that "**nature in Oslo is worth billions"** (Barton et al., 2015b)**.** Further discussion of assumptions underlying the four economic valuation examples can be found in Barton et al. (2015a).

Two further non-economic valuation examples are provided in chapter 5. The **blue-green factor (BGF)** is a system for scoring the relative importance of blue and green structures at the property level. The BGF was developed by Oslo and Bærum Municipality in collaboration with landscape architects, entrepreneurs and consultants. The BGF is also a scoring tool that can be used to set minimum building standards for blue green structures. As such it demonstrates how valuation methods can also be used to design policy instruments. The final section in the chapter reviews a number of international epidemiological studies that find significant **health** benefits of urba green infrastructure. While a handful of studies document Oslo citizens preferences for blue and green structrures in parks, there is to our knowledge currently no epidemiological study documenting the health benefits of green infrastructure in Oslo. Based on the review, we expect potential health benefits to be large, although their documentation requires a substantial new research.

Chapter 6. The last chapter in the report provides recommendations for further economic valuation of ecosystem services in and around Oslo.

Increasing resolution for decision-support: in some cases valuation methods are available and data could be collected to increase the resolution of valuation studies to a point where it would be relevant in decision-support. Some examples of applications include;,hedonic property pricing could be disaggregated at city district level and used to justify differential municipal fees to maintain and improve green infrastructure; recreational time use studies in Oslo's parks could be used to better target further upgrades in access to and quality of green infrastructure; further spatial studies of recreational opportunities, current and projected use would inform plans to re-regulate parts of Oslo's peri-urban forest to recreational "activity zones"; further valuation studies of ecosystem services of city trees could justify economic liability for and regulation of trees on private land within the built zone.

Widening scope for awareness raising: awareness could be raised about the economic value of a number of other ecosystem services and some green infrastructure that were not addressed in the pilot study

Increasing scale for awareness raising across jurisdictions: the scale of a valuation study could address neighbouring municipalities of Greater Oslo to address whether there were ecosystem service benefit or cost spill-overs across municipalities that could be relevant for regional planning policy.

Methodology development for ecosystem services in Impact Assessment Handbook 140 (HB140) of the Norwegian Roads Authorities. Based on our review of Norwegian guidance documents we also see a gap in impact assessment and economic analysis in relation to ecosystem services. A sustained programme of research on impacts of infrastructure on urban ecosystem services – such as has been conducted for noise and air pollution since the 1980s - holds out the promise of internalising economically important, but currently 'unpriced impacts' on particularly recreation and health.

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9 Appendix 1 – Norwegian ecosystem service terminology in green infrastructure guidance

The following table maps the ecosystem terminology adapted from the Norwegian Official Report on ecosystem services (NOU, 2013:10) to and urban context (Reinvang et al., 2014) to the Environment Agency Guidance Document M100 on "Planning of green infrastructure in cities and urban areas" (Miljødirektoratet, 2014).

***Table A1.1** Mapping of Norwegian green infrastructure guidance terminology to ecosystem services terminology*

Økosystemtjeneste		Nevnt i veileder	Alternativ formulering
Regulerende	Pollinering og frøspredning	2.2[3]	
	Vannhåndtering	2.2[3], 2.3	Overvannshåndtering og flomdemping, forvaltning av nedbør og overflatevann, lokal overvanndisponering, infiltrasjon og fordøye avrenning, redusere intense avrenningssituasjoner,
	Motvirke erosjon	2.2[3], 2.3	erosjonsbeskyttelse
	Lokal klimaregulering	2.3	Temperaturregulering, vinddemping, ventilasjonskanaler, frisklufttilførsel
	Rensing av vann	2.2[3], 2.3	Vannrensing, rense overflatevann
	Rensing av jord		
	Rensing av luft	2.2[3], 2.3	Luftkvalitetsregulering, filtrering av luft, forbedring av luftkvalitet, avleding av lokal luftforurensing, redusere lokal luftforurensing
	CO2 opptak og lagring		
	Støyreduksjon	2.1	Stille soner, miljøvennlig transport, skjerming mot støy[2]
Forsynende[4]	Matproduksjon		
	Kunst/leketøy		
	Friskt vann		
Opplevelse og kognitive	Rekreasjon, mental og fysisk helse	2.1, 2.2, 2.3	Friluftsliv og fysisk aktivitet, Naturopplevelser, turgåing, *Naturens stressreduserende og*, *Rekreativ effekt,* velvære, lek
	Estetikk	2.1, 2.2	Opplevelseskvalitet, grønt preg, naturpreg
	Turisme		
	Utdanning og kognitiv utvikling	2.2	Pedagogisk verdi, læringsarenaer
	Stedsidentitet og kulturarv	2.1, 2.2	Norsk naturarv, kulturminner og -miljøer, kulturmiljøverdier, naturområder knyttet til tradisjons- og historiske verdier
Støttende	Habitat for truede arter	2.1, 2.2	Naturgitte forhold, som … sjeldne eller sårbare naturtyper[1], intakte resteområder, naturrestarealer
	Biologisk mangfold	2.1, 2.2, 2.3	Bevart (urørt) naturpreg; Stedegen vegetasjon; Norsk naturarv; Verdifullt naturmangfold, variert dyre- og planteliv, hverdagsnatur, biotopmangfold, artsmangfold

[1]Navngitt i veilederen som en mulig begrensing for universal utforming av grønnstruktur for friluftsliv (s 19).

[2]Nevner at "den psykologiske effekten av grønnstruktur er ofte større enn den målbare ved at vegetasjonen bidrar til en generelt positiv opplevelse av omgivelsene" og at "Tre og busker kan brukes for å øke den opplevde effekten av anlagte støyavskjermingstiltak." Mer kunnskap kan finnes i M-128-2014 Klima og Miljødepartement
[3]Disse tjenestene er nevnt på side 35, men ikke utdypet eller forklart.
[4]Denne kategorien er nevnt på side 35, men uten noen spesifikke tjenester.

A review of M100 reveals that ecosystem services terminology is referred to briefly as a potential new concept to urban planning of green infrastructure in Norway. While ecosystem services terminology as such is not applied throughout the M100 guidance document consideration of regulating, experiential and cognitive (cultural) and supporting services is amply integrated into planning guidance using established terminology for ecosystem function and user interests (***Table A1.1***).

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