DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS
STATISTICS DIVISION
UNITED NATIONS

System of Environmental Economic Accounting

SEEA EEA Revision

Expert Consultation

Working group 1: Spatial units

<u>Discussion paper 1.2:</u>
Treatment of ecosystems assets in urban areas

Version date: 30 April 2019

Recommended citation:
Wang J., Soulard, F., Henry, M., Grenier, M., Schenau, S., Barton, D., Harris, R., Chan, J.Y., Keith, D., Obst, C. (2019) Discussion paper 1.2: Treatment of ecosystems assets in urban areas. Paper submitted to the SEEA EEA Technical Committee as input to the revision of the technical recommendations in support of the System on Environmental-Economic Accounting. Version of 30 April 2019.

Research area #1: Spatial units

Discussion paper 1.2: Treatment of ecosystems assets in urban areas

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1. Introduction

Most people worldwide live in urban areas and the trend towards urbanization is continuing. Urban areas are therefore the main setting in which people experience the environment around them.

Urban areas provide a different mix of ecosystem services than natural and semi-natural areas. For example, various studies have identified local food production, air quality, climate and noise regulation, as well as cultural and recreational services, as ecosystem services that are most likely to be provided by urban ecosystems (e.g., Gómez-Baggethun and Barton, 2013). Diverse vegetation introduced in urban and peri-urban areas can also be a repository for genetic resources (Kinzig et al., 2007 as cited in Bordt and Saner, 2019) and support pollination services in neighbouring cropland areas. Natural hazard risk reduction is another potential important service that may While many ecosystem functions may be degraded in urban areas, the value of the services provided may be higher than the value of similar services provided elsewhere as result of the close proximity to the people who benefit from them.

While ecosystem accounts were conceived as a framework for application at a national level, they are by their nature spatially explicit, and applying the framework at sub-national scales could increase their usefulness to a broader group of policy makers. For example, monitoring condition indicators for urban areas is highly relevant since urban ecosystem condition affects living conditions for the majority of people, and could help speak to policy issues in urban planning. Detailed ecosystem accounts for urban areas could, for example, support reporting of Sustainable Development target 11.7 –By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities. It could also help support numerous other global initiatives such as the development of a post 2020 agenda for the Convention on Biological Diversity.

The link between ecosystem assets and services and human activities in urban areas can be better understood through the application of a more detailed spatial scale than is required for accounting at a national level. For example, a small urban park or row of street trees might be considered important at an urban scale in the delivery of ecosystem services. This paper therefore raises various issues and discusses potential options relevant to the production of ecosystem accounts focused on urban areas. The principle aim is to provide guidelines on the compilation of ecosystem accounts for urban areas as input for the SEEA EEA revision process.

This paper is organized as follows:

1. Introduction
2. Background and definitions
3. Summary description of issues relevant to urban ecosystem accounting
4. Discussion of options and implications
5. An option for an urban ecosystem type hierarchy, condition indicators and other account tables
6. Appendix: Published urban accounts table examples
7. Appendix: Urban ecosystems in SEEA EEA and MEA
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2. Background and definitions

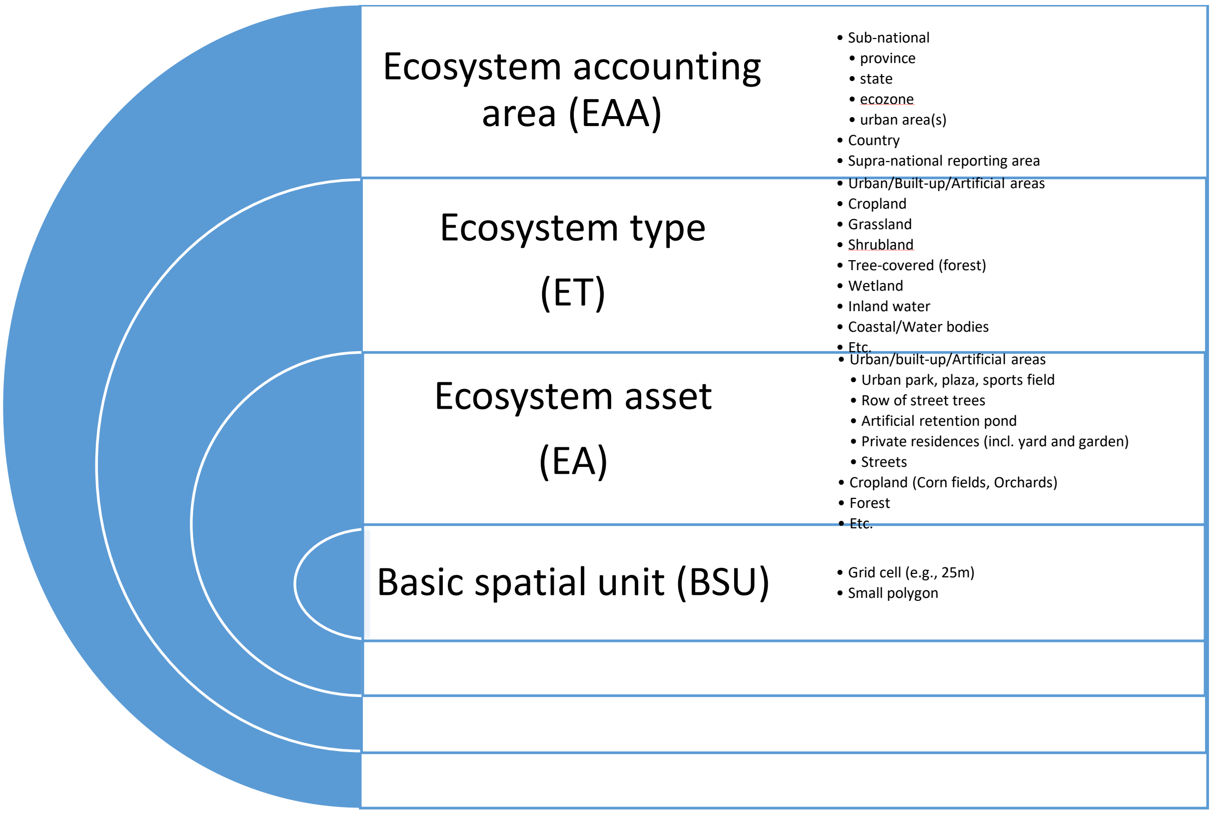
The delineation of areas into a complete set of mutually exclusive and contiguous spatial units is at the foundation of ecosystem accounting. For reference purposes, the *Technical Recommendations in support of the SEEA-EEA* (TR, 2017) defines three spatial units relevant to the delineation of ecosystems and accounting. These units are summarized here (TR, chapter 3):

1. Ecosystem assets (EA) represent a specific spatially-bounded and contiguous ecosystem of a specific ecosystem type, comprising all the relevant biotic and abiotic components required for it to function and supply ecosystem services.
2. Ecosystem assets of a similar type can be grouped into an ecosystem type (ET) class. A hierarchical, nested ET classification structure is under development but is not yet finalized.
3. The geographical aggregation of EA and ETs for which accounts are produced, e.g., for large administrative areas such as provinces or countries; ecological areas such as biomes or other environmental areas, such as watersheds; or for a specific ecosystem type such as forests or artificial/urban areas, is termed the ecosystem accounting area (EAA).

According to the above definitions, a given EA of a specific type might therefore be classified to multiple EAA reporting areas, but should be conceptually distinct from other ecosystem assets and types. While accounts for an EAA may be reported by EA, they will more typically be aggregated by ET and all areas within an EAA should be delineated without any gaps or overlaps.

In addition to the above units, the basic spatial unit (BSU) is a spatial measurement unit based on a grid (e.g., 25 m) or small polygons and underlies the EA.

Figure 1. Spatial units



Thus, from the above definitions and descriptions, it follows that urban areas will be included in the core national ecosystem accounts, but could also be the subject of a distinct urban EAA compilation of ecosystem accounts should there be specific policy interest or need for this topic. This latter approach might also be extended to the compilation of satellite accounts for urban areas using more detailed delineation and typology that may not be present in the core accounts.

This paper presents options and recommendations that could support aspects of either or both approaches to accounting for urban areas.

3. Summary description of issues relevant to urban ecosystem accounting

This discussion paper is written in response to the SEEA EEA 2020 Revision note, which states that:

"[a]n emerging interest concerns ecosystem accounting for urban areas considering the large proportion of the work population living in cities. <u>These should be distinguished from areas defined in terms of land cover or use as built-up areas and instead considered as combinations of multiple ecosystem types. In this sense, urban areas may be considered a specific form of ecosystem accounting area</u>, <u>but one requiring specific definition to support policy and decision making</u>" [underline added].

This instruction appears explicit that ecosystem accounts for urban areas should compile information on the multiple component ecosystem types within an urban ecosystem accounting area and that the specific urban definition that requires recommendations is the EAA.

From this perspective, key issues in developing guidelines for ecosystem accounts for urban areas might include the size threshold (e.g., a minimum population or area of built-up) for inclusion in these urban accounts and approaches for defining the urban EAA boundary, as well as the amount, if any, of the peri-urban area to be included. Existing efforts to account for urban areas have so far taken different approaches to identifying this urban area boundary (Statistics Canada, 2016; UK EFTEK, 2017; MAES, 2016)—see Appendix 6 for examples. Issues related to the application of inconsistent definitions of urban areas have previously been identified, for example in the reporting of urban populations to the United Nations (UN) or the Organisation for Economic Cooperation and Development (OECD) (UN, 2018; OECD, 2013; Dijkstra, L. et al., 2018).

However, a second issue relates to the question of what urban ecosystem accounts should track—at what scale and for what purpose should specific asset types be delineated and classified within this urban ecosystem accounting area. This relates essentially to the types of policy questions that urban ecosystem accounting will address and the scale needed to identify ecosystem services provided by built, semi-natural and natural green and blue features in urban areas.

Urban areas—cities—whether defined according to administrative boundaries, built-up extent, functional area or other delineations, are composed of areas with different types of land covers and uses and may have significant differences in structure within specific types. City form and structure is not homogeneous—cities often follow a gradient from less developed and even rural peripheral areas, characterized by larger lots and single detached dwellings with more green space, into a more developed urban core with high rise office and apartment buildings and more impervious surfaces.

For example, on their peripheries, cities may have significant amounts of natural and semi-natural land covers including treed or forested areas, farmland or large parks, in addition to more developed or built areas with residential, commercial and other uses. At a national level, these areas would be captured according to their ecosystem type and changes in their extents and condition would be useful for measuring urban expansion or sprawl around cities; however, not captured at this scale would be the yards and green spaces within the continuously settled or built-up area.

At a detailed scale, even areas with a higher degree of built-up area may contain significant areas of green covers, such as yards, parks, cemeteries, even street trees or green roofs, which may provide ecosystem services by providing the setting for recreation and helping filter air pollutants and reduce stormwater runoff and urban heat. This urban green infrastructure therefore has significant policy usefulness and is a distinguishing factor of urban ecosystem accounting.

It may, however, be difficult to delineate and classify urban ecosystem assets according to the standard definitions described in section 2—Background and definitions, as also covered in Discussion paper #10 (Barton D. N. and C. Obst, 2018). Urban ecosystems can occur in most terrestrial settings—whether highland or lowland, in forest, grassland, desert, tropical or tundra regions. They are defined chiefly by the presence of people and by their alteration of the underlying environment. Areas within cities may be structurally and functionally different from other urban areas, yet not contain all the relevant biotic and abiotic components needed to supply ecosystem services. For example, a heavily urbanized commercial district will rely on other areas to supply its water, to filter its air, to process its wastes, but will be morphologically different from adjacent urban areas.

As well, the question of scale may create conceptual problems for the requirement for mutual exclusivity of ecosystem assets when applying a top-down classification approach. Specifically, it may be difficult to classify some natural and semi-natural areas within an urban ecosystem accounting area into a mutually exclusive natural or semi-natural ecosystem type. At a broad top-down driven scale, a given 'green area' might be viewed as urban, but at a detailed scale it may be treed, wetland, lake, cropland or other type of ecosystem (note again the classification structure for ET is not yet finalized.) While this may be less a problem for a sports field or residential yards which are more clearly urban or urban green areas that have been built and modified by and for humans, it may be a more significant challenge in classifying the larger parks, rivers, lakes or other natural features that are embedded in urban areas.

4. Discussion of options and implications

Some of the main questions and issues relevant to spatial units in urban ecosystem accounting that are identified in the section above and that are explored further in this section are:

1. What size of urban area should be included in ecosystem accounts for urban areas; how to delineate the urban ecosystem accounting area, how much of the urban periphery/hinterland should be included?
2. What urban ecosystem asset categories are relevant for an urban/built-up ecosystem type class breakdown? What are the physical (and other) characteristics of a green/blue area that lead it to be considered urban/built-up and differentiate it from non-urban ecosystem types, particularly when this area is within or adjacent to an urbanized region? To what extent do these characteristics reflect the ecosystem type or the ecosystem condition?
3. What is the scale at which ecosystem assets in urban areas should be delineated to provide useful information to policy makers, i.e., what is the size threshold for urban ecosystem assets?

These questions are used to identify preliminary options for urban ecosystem type sub-classes and model urban accounts tables including preliminary extent, condition and service tables (section 5).

4.1 Scope and delineation of the urban ecosystem accounting area

Options, discussion and implications: The desired scope of urban ecosystem accounting is not yet clear. Artificial surfaces are a feature of cities, but also smaller settlements such as towns and villages, and also industrial sites. A question therefore is whether some threshold should be set to determine a given area's inclusion in urban ecosystem accounts—should the scope of urban ecosystem accounts be limited to large metropolitan areas and cities? Or should it include towns and villages? Should it include all identifiable human settlements and industrial sites? And should such a threshold be based on population or population density characteristics, buildings, or a minimum delineated area or percentage of artificial surfaces/built-up?

Once this conceptual scope is determined the urban EAA can be delineated. There are many potential ways to define the outer limit of an urban EAA. For example, depending on the purpose, urban areas may be defined based on administrative boundaries, population, population density or functional characteristics defined for example by commuting flows or a specific ecosystem function, morphological criteria such as built-up extent and others. The main relevance of setting the EAA boundary is its role in optimizing the usefulness of urban accounts.

The use of different definitions limits comparisons between countries. However, what works well in one area may not easily apply well in others. The population threshold to be termed a city might be very different in India or China compared to Europe or North America. For this reason, the United Nations relies on data provided by countries—according to each nation's definitions and criteria—to produce estimates of urban and rural populations (UN, 2018). Similarly, the form and structure of a city in a developed country may look different from one in a developing country, and the amount of built-up area per person can vary significantly.

Developing appropriate recommendations on the delineation of an outer boundary for urban ecosystem accounting depends on the intent of urban ecosystem accounts and consideration of what aspects of ecosystem accounting are better reported specifically for urban areas rather than at a larger scale. There may be interest not only in distinguishing urban from rural and including the more heavily urbanized or densely urbanized areas, but also less densely urbanized, adjacent suburban areas and peri-urban areas. While urban accounts are likely not the best place to account for agriculture or forestry-related ecosystems, these associated land covers and uses will occur in and adjacent to cities, and as such will be peripherally included. Urban ecosystem accounting areas will also contain wetlands, shorelines, estuaries, rivers—some potentially in good condition, others degraded.

However, more important for capturing the condition of urban areas and their associated services will be capturing the detail of the urban structure and gradient—areas of impervious cover, urban 'green (and blue) infrastructure' including both natural and artificial areas etc. The urban ecosystem area boundary selected should be adequate to capture these areas.

Countries that have begun experimenting with urban ecosystem accounts have used different approaches in defining these boundaries. The urban pilot case studies completed for the Mapping and assessment of Ecosystems and their Services (MAES): Urban ecosystems, used three boundaries for delineating urban ecosystems—the regional scale based on Eurostat's NUTS2 and NUTS3 boundaries), the metropolitan scale based on the functional urban area (FUA) core and commuting zone and the urban scale based on the FUA core (MAES, 2016).The UK has developed urban natural capital accounts using built-up area with the addition of a variable sized buffer as the boundary of urban areas (EFTEK, 2018). Norway has tested the use of urban ecosystem boundaries based the UK EFTEK built-up area with buffers and a zone of influence approach. Canada has produced basic accounts for its metropolitan areas using standard census geographies—census metropolitan area (CMA) and census agglomerations (CA)—which amalgamate adjacent municipalities if they meet specific population thresholds and functional economic integration thresholds based on commuting flows (Statistics Canada, 2016).

The above functional urban area (FUA) geography was developed by the OECD and the EU to create a more comparable spatial unit for urban areas and has been applied to 29 OECD countries and 1,179 urban areas of different size. It considers urban areas as functional economic units and aggregates these areas based on national commuting data (OECD, 2013). Despite the usefulness of functional urban areas (FUA) for some purposes, some of the resulting areas do not always well represent what most people would consider an 'urban area,' likely due to the use of different sized building blocks and varying applicability of commuting rules in some countries.

For example, in Canada, the core and commuting zone of the FUA for Thunder Bay (CAN14)—a small urban area with a population of 145,918 in 2014 (OECD, 2016a)—has a total area of 119,000 km^2 (close to 0% of which is urban land cover), which is roughly equivalent in size to the sum of all FUA in Spain (122,000 km^2) (OECD, 2016b). Some of Canada's census geographies—also functional areas aggregated based on population and commuting data—have similar issues. For example the CA of Wood Buffalo is 62,000 km^2, with a population of 73,000 in 2016, is largely forest apart from Fort McMurray (Statistics Canada, 2017). While these types of boundaries can easily be used as the EAA boundary for urban accounts, there may be significant over-bounding of the 'core' urban area, which may not always make sense.

Municipal or administrative boundaries are well understood and would likely meet some users' demands for local/city data; however, they too may not align with the extent of urban ecosystems, either under- or over-bounding the urban ecosystem. Under-bounding is likely a greater concern if the intent is to capture all urban types. However, significant over-bounding, as in the case above, may result in less than coherent and consistent urban accounts.

For this reason, the use of built-up extent with a buffer could be useful to define the outer boundary of the EAA. However, this type of EAA might be less usable for policy makers who might want data that is more directly relevant for cities according to administrative/municipal boundaries.

Given that accounts can be created for multiple EAA and to meet different policy needs, countries are likely best placed to determine the most appropriate EAA boundary for their uses. It may be helpful, however, to consider how the different EAA cross-walk with others. For example, in producing urban natural capital accounts, the UK DEFRA used a reconciliation step, subtracting these areas from their national accounts to avoid double counting (2017). This step may not always be possible. For example, Statistics Canada currently only publishes accounts for CMAs and CAs where the spatial data are of sufficient quality and can therefore not account for all built-up area in the country at the same level of detail.

4.2 Definition of the urban ecosystem asset and type

Options, discussion and implications: The main characteristics that define urban/built-up areas are human presence, built structures, impervious cover and introduced vegetation. These or similar physical characteristics can be used to differentiate between different subtypes of urban areas. Doing so may require delineation of urban ecosystem asset types to a level that goes beyond the definition provided for EAs (see above – section 2).

The ecosystem functions and services of some highly developed urban areas may be compromised while at the same time these areas differ significantly in form and structure from adjacent less intensively developed urban areas. For example, a central business district may be characterized by a very high degree of impervious cover including pavement and buildings, engineered water flows, and limited biota consisting of people, rodents, insects and street trees. In order to function properly, this area will depend on ecosystem services provided outside the region. Roads or buildings may be spatially bounded and contiguous but they may not contain all the abiotic and biotic components required for them to function and supply ecosystem services and in fact likely produce few ecosystem services at all. Still, more detailed urban/built-up sub-type(s) are relevant in developing ecosystem accounts for urban areas, though a more limited set of sub-types may be needed for national-level accounts.

Urban/built-up sub-types could be defined based on use (e.g., industrial, residential, commercial, mixed use), land cover (e.g., buildings, road/pavement, urban green/blue cover—lawns, trees, other vegetation), intensity of use or density (e.g., % of soil cover, floor space ratio of buildings), property ownership (public, private) or a mix of these and other criteria (examples provided in Section 5 Option 1). It may be desirable to distinguish greenspace and water based on accessibility (e.g., private yards, gardens, recreational facilities vs. public parks) or other more detailed characteristics. However, the characteristics included may depend on data availability but also potential policy uses.

Delineating private yards or public gardens, for example, as green space distinguishable from the adjacent homes would require a very fine resolution. However, where data is available to do so, these areas could be reported as a green/blue sub-class within an urban/built-up type given their relevance to human well-being and ecosystem services. This also permits reporting on the condition of these green/blue assets in the associated condition tables.

In some cities, features such as tree canopy, green roofs and walls are also managed, often at significant cost. Some of these physical characteristics may also be considered to be defining features of ecosystem condition. While these features might be reported in extent tables where a sub-type exists, some could alternatively be reported as condition variables for the overall urban area or sub-area (e.g., green roofs (ha), tree canopy cover (ha/%) or impervious surface (ha/%) (See section 5 for potential ET hierarchies and condition indicators).

The UK ONS and DEFRA's approach identifies grey space as built-up area and suburban including areas of greenspace and bluespace smaller than 0.0025 ha, natural land cover as "any land cover being classified as natural in type, for example, grassland, heath, scrub, orchards, coniferous trees" and blue "all inland water bodies for example, rivers, lakes, ponds, canals and so on." It also identifies the extent of functional green space "any green space that has a function in its use for example, public parks or gardens, playing fields, golf courses, allotments" including areas with natural land covers and blue spaces, publicly-accessible green space "a subset of functional green space" and the extent of residential gardens (see UK ONS and DEFRA (2018) and examples in Appendix 6.2).

The MAES Urban Ecosystems report does not propose a typology of urban green spaces, but does discuss different classification approaches including structural (land cover, vegetation) and functional (e.g., land use, purpose) (2016). It also presents the urban green space typology of the European Commission's Green Surge project, which includes categories for private, industrial, commercial and institutional urban green space (UGS) and UGS connected to grey infrastructure (e.g. street greens, house gardens), parks and recreation (e.g., large urban park, pocket park, botanical garden, cemetery), building greens (e.g., green wall, green roof), and allotments and community gardens, in addition to agricultural land, natural, semi-natural types and blue spaces (see Appendix 6.4).

Alternatively, if the urban/built-up ecosystem type is not broken down to a level of detail that permits reporting these urban green space extents, information on the urban blue/green ratio and select other characteristics could be included in the condition accounts as a landscape-level characteristic of the urban area (see Section 5 Option 2 as an example). One benefit to this approach is that it may simplify the urban/built-up typologies. This approach may be applicable where urban areas are viewed at a relatively macro scale and the smaller embedded green areas within the urban/built-up are not separately delineated (see Statistics Canada (2016) and examples in Appendix 6.1). One downside is the reduced capacity to report on the local urban blue/green extents (gardens, parks) and their condition, which could be seen as defining features of ecosystem accounts for urban areas. Reporting the urban blue/green areas as a condition of the EAA may also be suitable where the EAA is limited to the extent of the built-up area, with little peri-urban and few natural-semi natural ecosystem assets included.

Identifying natural and semi-natural ecosystem assets types such as grasslands, croplands, forests etc. on the periphery of a continuously built-up region within an EAA should be relatively straightforward if they are of sufficient size. However, it may be difficult to identify such natural assets within the continuously built-up zone. A recreational sports field, playground or residential outdoor yard space is more evidently artificial and might be considered urban green space. A large botanic garden, carefully managed and planted with native and non-native species might also be urban green. But how would one classify a large relatively natural park wholly surrounded by an urban zone? Is it forest or grassland? Or is it urban park/urban green space? What about a large relatively natural lake within an urban zone? Or a small pond, reservoir or engineered bioretention pond? Are they lakes/inland water or urban lakes? What about a beach? Is it shoreline or urban shoreline? What about engineered green spaces such as remediated landfills, mines or quarry sites?

Figure 2. Urban green asset or natural asset?

Imagery ©2018 CNES / Airbus Digital Globe, IMTCAN, Landsat / Copernicus, Province of British Columbia, Map data © 2018 Google Canada

Having numerous 'natural' categories under an urban class poses some difficulty as it may not be clear where a given 'urban forest' or 'lake' or 'shoreline' should appear. In principle, urban green sub-classes should not duplicate natural and semi-natural class types. It may suffice to consider 'urban green' to be green infrastructure that is embedded within or adjacent to a built-area and that has been significantly altered or managed (e.g., residential yards, urban parks), while natural and semi-natural ecosystem assets in urban areas would generally be larger, retain more natural features and/or clearly fit within an alternate ET (e.g., cropland). However, this may be difficult to distinguish using remote sensing and other data sources and may end up being a subjective decision.

One potential downside of allocating larger urban green/blue spaces to natural and semi-natural classes may exist if they share few characteristics with the natural and semi-natural type to which they have been assigned. For example, assigning a large urban park to either forestland or grassland may be questionable as presumably the services resulting from these areas differ. This issue might be minimized in the case of a satellite urban account where the natural and semi-natural categories are not directly comparable to natural and semi-natural categories in the core accounts.

4.3 Scale

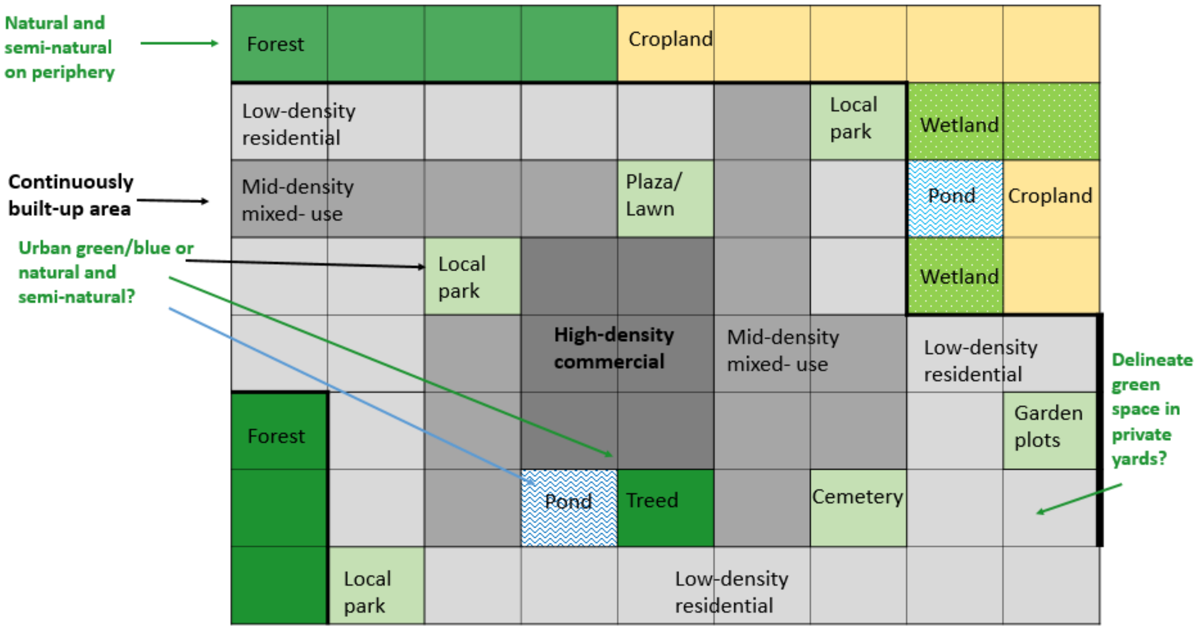
Options, discussion and implications: Because both natural and built ecosystem assets are likely to be relatively small in size within urban areas, the size threshold for urban assets and the scale or resolution at which urban ecosystems should be delineated and tracked is therefore a fundamental question for urban ecosystem accounting. According to the TR, the scale should be sufficiently detailed to be able to reflect a composition of ecosystems across the EAA that is appropriate for analysis and decision making (TR 3.10). However, this scale may be limited by the availability of appropriate data, e.g., through differences in the availability of detailed remote sensing data, land use maps, cadastral information and building registers.

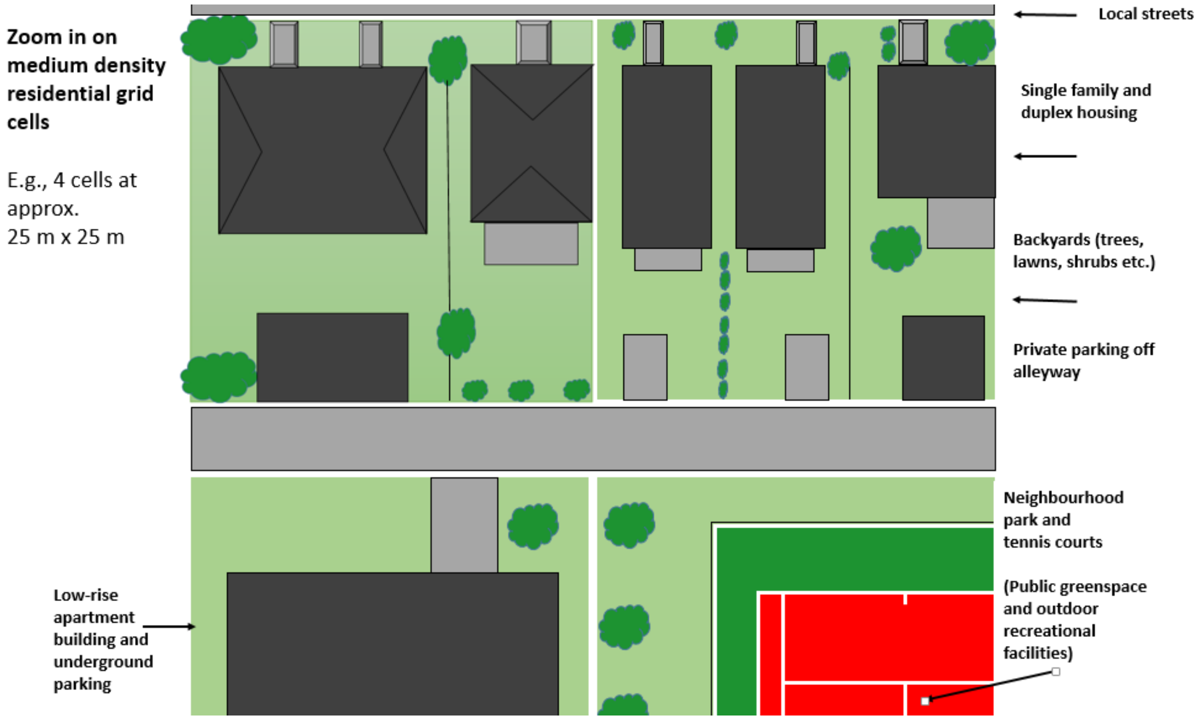
Applying a top-down approach relies on the concept of dominance in determining the ecosystem type. The EA and ET spatial unit definitions require mutual exclusivity—a given area should not be both an urban ecosystem asset type and for example a cropland or a forest land asset type. While built structures and roads clearly belong to an urban/built-up ecosystem type, this determination may be more difficult for green and blue infrastructure around and particularly in urban areas.

Correctly identifying natural and semi-natural ecosystem types from artificial green ecosystem types within urban areas will require a level of precision that may not always be available from existing datasets. However, use of a less fine-grained grid will result in less accuracy in identifying green features.

The problems and questions of scale are not unique to urban areas—the same issues occur in other ecosystem types. For example, top down typing of a large area as forest ignores the interspersed open grassland patches, underlying wetlands and lakes and it may be difficult to set boundaries in the ecotone or transition zone between these ecosystem types. Similarly, it may be difficult to delineate the various natural, semi-natural and built areas within rural areas and mosaic landscapes with a lot of agriculture. The separate delineation of these areas is also a matter of scale and requires the same subjective allocation of an area to a given type, preferably giving weight to the policy and analytical trade-offs.

Figure 3. Does it depend on scale?


Natural and semi-natural on periphery
Continuously built-up area
Urban green/blue or natural and semi-natural?
Forest
Cropland
Low-density residential
Local park
Wetland
Mid-density mixed- use
Plaza/ Lawn
Pond
Cropland
Local park
Wetland
High-density commercial
Mid-density mixed- use
Low-density residential
Delineate green space in private yards?
Forest
Garden plots
Pond
Treed
Cemetery
Local park
Low-density residential


Zoom in on medium density residential grid cells
E.g., 4 cells at approx. 25 m x 25 m
Local streets
Single family and duplex housing
Backyards (trees, lawns, shrubs etc.)
Private parking off alleyway
Neighbourhood park and tennis courts
(Public greenspace and outdoor recreational facilities)
Low-rise apartment building and underground parking

5. Options for an urban ecosystem type hierarchy, condition indicators and other account tables

The following draft hierarchy and tables are provided as examples only, covering some of the concepts and options covered above in section 4.2, to facilitate discussion.

Note that some discussion has centered on whether blue/green assets embedded within the urban/built-up ecosystem types should be delineated as part of the extent account or whether these sub-classes should exist solely within the ecosystem condition table (see section 4.2).

The former is consistent with a view of urban areas as cities composed of various constituting ecosystem types and is the main approach considered in Option 1 tables. However, an alternate approach—where the extent table is limited to the full size of the urban area and the extent of the green/blue components is considered a condition of this area—is shown in Option 2 tables. This latter approach is more consistent with a view of urban systems as ecosystems (Bai et al., 2005). However, a downside of this second approach relates to the inability to report on the condition of these urban green/blue features.

There has also been some discussion of whether certain physical characteristics that might be measured in distances (e.g., of hedge rows) or areas (e.g., of artificial green roofs or walls) should be included as ecosystem extent or condition.

Reporting some extents as condition is compatible with Discussion paper 2.3 produced by Working group 2—which states that “the extent of ‘minor’ ecosystem types can be registered in the ECI [ecosystem condition indicators] class V [Landscape pattern], if necessary” (Czúcz, B. et al., 2019).

The preferred approach may depend on the scale at which data are tracked and mappable. Where data are available to track small urban green/blue assets and report on their condition, option 1 may be preferable, while correspondingly, option 2 might better suit where urban area data are not highly detailed. However, there may be other considerations that require further exploration.

It could also be that a hybrid option that delineates and tracks the larger urban green and blue (e.g., large parks, cemeteries) and natural and semi-natural ecosystem types within an urban EAA, but that reports on the smaller embedded urban green and blue features (small parks, private yards, gardens e.g., as a % green area), in the condition table would work well. The scale or size of urban ecosystem assets that should be separately identified in a set of ecosystem accounts for urban areas is therefore also an issue that requires resolution.

While this paper includes an example ecosystem service table, it does not discuss monetary valuation of these assets and services in detail, even though this is the ultimate outcome of building ecosystem accounts for urban areas.

Option 1. Example urban/built-up ecosystem type classification hierarchy and tables

Depending on policy needs, the following or similar ecosystem type classification for urban/built-up/artificial surfaces types might be developed:

UEZ1 – continuously built-up area

UEZ1.1 – use characteristic (e.g., industrial, commercial, residential)

UEZ1.1a – intensity or density characteristic (e.g., high density, medium, low)

UEZ1.1ax – asset type (e.g., building, road/artificial surface, green/blue (e.g., sports field, residential yard, green roof)

Additional levels as needed to be considered e.g., accessibility/ownership or other.

Figure 4 Object-based ecosystem classification

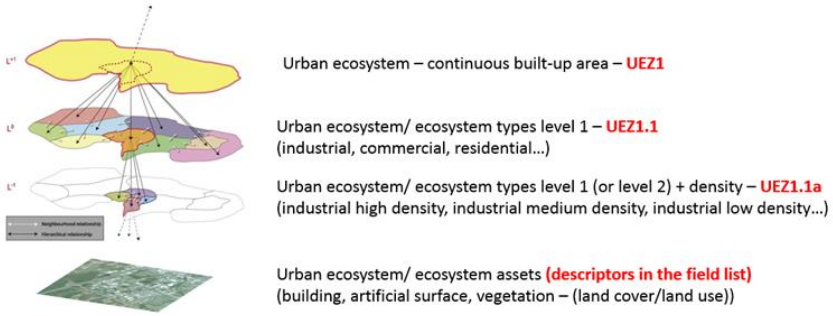


Image adapted from Blaschke, T. et al., 2014

In the following Option 1 tables, the EAA is assumed to include urban/built-up ecosystem types as well as natural and semi-natural types. Within the urban/built-up type, sub-classes might be distinguished based on use, intensity (e.g., population or building density), asset type (e.g., built-up, road and urban green and blue), and more detailed type sub-classes as needed.

These sub-types are nested; however, the ideal hierarchy is not identified here. The level of detail or progression through the hierarchy might differ based on policy needs and data availability;in the interest of space, not all levels are included below.

Significant areas of ecosystem assets within the EAA that are not defined under urban/built-up sub-types might be delineated according to the natural or semi-natural type to which they belong (e.g., cropland, forest etc.). In principle, these natural and semi-natural areas differ conceptually from urban green and blue, but in practice there may be some difficulty in distinguishing between the two, particularly when such assets are embedded within the fabric of the larger urban area (section 4.2).

Option 1 examples.

Urban EAA - Urban ecosystem extent account including some high-level sub-types (format based on p. 42 SEEA TR)

	Ecosystem types in urban areas											
	Urban/built-up type and sub-classes				**Natural and semi-natural types**							**Total area**
	Residential	Commercial	Industrial	Total	Cropland	Grassland	Shrubland	Forest	Barren	Wetland	Inland water	
Opening extent (km2)												
Additions to extent												
Reductions in extent												
Net change in extent												
Closing extent (km2)												

	Ecosystem types in urban areas											
	Urban/built-up type and sub-classes				**Natural and semi-natural types**							**Total area**
	High-density	Mid-density	Low density and periurban	Total	Cropland	Grassland	Shrubland	Forest	Barren	Wetland	Inland water	
Opening extent (km2)												
Additions to extent												
Reductions in extent												
Net change in extent												
Closing extent (km2)												

Option 1 examples.

Urban EAA - Urban ecosystem extent account including sub-types broken with urban green/blue sub-type as extent (format based on p. 42 SEEA TR)

	Ecosystem types in urban areas																			
	Urban/built-up type and sub-classes												**Natural and semi-natural types**							**Total area**
	Residential			Commercial			Industrial			Total			Cropland	Grassland	Shrubland	Forest	Barren	Wetland	Inland water	
	Built-up	Road	Green/Blue	Built-up	Road	Green/Blue	Built-up	Road	Green/Blue	Built-up	Road	Green/Blue								
Opening extent (km2)																				
Additions to extent																				
Reductions in extent																				
Net change in extent																				
Closing extent (km2)																				

	Ecosystem types in urban areas																			
	Urban/built-up type and sub-classes												**Natural and semi-natural types**							**Total area**
	High-density			Mid-density			Low density and periurban			Total			Cropland	Grassland	Shrubland	Forest	Barren	Wetland	Inland water	
	Built-up	Road	Green/Blue	Built-up	Road	Green/Blue	Built-up	Road	Green/Blue	Built-up	Road	Green/Blue								
Opening extent (km2)																				
Additions to extent																				
Reductions in extent																				
Net change in extent																				
Closing extent (km2)																				

Option 1 examples.

Urban EAA - Urban ecosystem condition account (e.g., based on page 57 SEEA TR) including sub-types broken with urban green/blue

		Ecosystem types in urban areas																			
		Urban/built-up type and sub-classes												Natural and semi-natural types							
Example indicators of condition		High-density			Mid-density			Low density and periurban			Total urban/built-up			Cropland	Grassland	Shrubland	Forest	Barren	Wetland	Inland water	**Total area**
		BU	R	G	BU	R	G	BU	R	G	BU	R	G								
Species (e.g. population and other)	Opening condition																				
	Closing condition																				
Vegetation (e.g., % canopy cover, green roof ha, street tree or hedgerow length)	Opening condition																				
	Closing condition																				
Water quality (e.g., stormwater discharge, turbidity, etc.)	Opening condition																				
	Closing condition																				
Air pollutant concentrations	Opening condition																				
	Closing condition																				
Soil (e.g., pH, metals, etc.)	Opening condition																				
	Closing condition																				
Soil sealing (% impervious cover)	Opening condition																				
	Closing condition																				
Infrastructure density (e.g., site coverage, floor space ratio)	Opening condition																				
	Closing condition																				
Access (e.g., Average distance to green space, walkability)	Opening condition																				
	Closing condition																				

Option 1 examples.

Urban ecosystem service (e.g., based on page 71 SEEA TR) including sub-types broken with urban green/blue

	Ecosystem types in urban areas																			
	Urban/built-up type and sub-classes												**Natural and semi-natural types**							**Total area**
Example ecosystem services	High-density			Mid-density			Low density and periurban			Total urban/built-up			Cropland	Grassland	Shrubland	Forest	Barren	Wetland	Inland water	
	BU	R	G	BU	R	G	BU	R	G	BU	R	G								
Provisioning services																				
Crops																				
Regulating services																				
Water regulation																				
Climate regulation																				
Air filtration																				
Noise regulation																				
Cultural services																				
Recreation																				

Option 2 examples.

In the following Option 2 examples, the basic extent table covers the urban area, with potential for high-level sub-classes such as industrial, residential and commercial or according to a density gradient of intensity or density as shown in option 1. However, the differentiating factor is that urban green/blue features are considered a condition of the urban area and are reported in the condition table.

Urban EAA - Urban ecosystem extent account with no green/blue sub-types (format based on p. 42 SEEA TR)

	Urban EAA		
	Commercial	Industrial	Residential
Opening extent (km2)			
Additions to extent			
Reductions in extent			
Net change in extent			
Closing extent (km2)			

Urban EAA - Urban ecosystem condition account (e.g., based on page 57 SEEA TR) with green areas reported as conditions

Example indicators of condition		Urban EAA		
		Commercial	Industrial	Residential
Species (e.g. population and other)	Opening condition			
	Closing condition			
Vegetation (e.g., % canopy cover, green roof ha, street tree or hedgerow length)	Opening condition			
	Closing condition			
Water quality (e.g., stormwater discharge, turbidity, etc.)	Opening condition			
	Closing condition			
Air pollutant concentrations	Opening condition			
	Closing condition			
Soil (e.g., pH, metals, etc.)	Opening condition			
	Closing condition			
Soil sealing (% impervious cover)	Opening condition			
	Closing condition			
Infrastructure density (e.g., site coverage, floor space ratio)	Opening condition			
	Closing condition			

Access (e.g., Average distance to green space, walkability)	Opening condition			
	Closing condition			
Forest	Opening condition			
	Closing condition			
Cropland	Opening condition			
	Closing condition			
Shrubland	Opening condition			
	Closing condition			
Wetland	Opening condition			
	Closing condition			
Other natural land	Opening condition			
	Closing condition			
Urban green space	Opening condition			
	Closing condition			
Water	Opening condition			
	Closing condition			

Urban ecosystem service (e.g., based on page 71 SEEA TR) with no green/blue sub-types

Example ecosystem services	Urban EAA		
	Industrial	Commercial	Institutional
Provisioning services			
Crops			
Regulating services			
Water regulation			
Climate regulation			
Air filtration			
Noise regulation			
Cultural services			
Recreation			

6. Appendix: Published urban accounts table examples

6.1 Statistics Canada

Statistics Canada has published a basic ecosystem extent account for 33 census metropolitan areas. The following excerpted tables provide data for the 3 largest CMAs: Toronto, Montreal and Vancouver. Other tables are available from the publication (Statistics Canada, 2016).

Ecosystem asset account, Toronto census metropolitan area-ecosystem (CMA-E), 1971 to 2011

	Total built-up area [1]		Arable [2]	Natural and semi-natural [3]
	Settled	Roads		
	square kilometres			
Opening stock 1971	850	418	4,930	6,615
Land lost to settled area	...	...	-961	-448
Balance of change [4]	1,409	403	-102	-300
Closing stock 2011	2,260	821	3,867	5,866

... not applicable

[1] Built-up area data are taken from multiple sources. The 1971 built-up area is based on *Canada Land Inventory: Land Use* (CLI: LU) and *Canada Land Use Monitoring Program* (CLUMP). CLI: LU and CLUMP built-up areas that were not built-up in the AAFC *Land Use, 1990* dataset were removed from the 1971 built-up data and reclassified according to their 1990 cover. To improve comparability with the other years, roads included in the 1971 core built-up area were identified and removed to produce the 1971 settled area. As the 1971 dataset did not include roads outside the core built-up area, roads were modeled by applying the ratio of roads to settled area from 1990 to the 1971 settled area. Built-up area estimates for 2011 are based on *Land Use, 1990, 2000 and 2010,* codes 21 (Settlement–Built-up and urban) and 25 (Roads–primary, secondary and tertiary).

[2] Arable land lost to settled area is calculated by overlaying the growth in settled areas from 1971 to 2011 on the CLI: LU base layer and, for areas where the 1971 settled area was trimmed, on the area reclassified using AAFC *Land Use, 1990*. The following CLI: LU classes were included: cropland, improved pasture and forage crops, orchards and vineyards and horticulture.

[3] Natural and semi-natural land lost to settled area is calculated by overlaying the growth in settled area from 1971 to 2011 on the CLI: LU base layer and, for areas where the 1971 settled area was trimmed, on the area reclassified using AAFC *Land Use, 1990*. The following CLI: LU classes were included: forest, natural pasture and rangeland, outdoor recreation areas, rock and unvegetated surfaces, open wetland and unmapped areas.

Ecosystem asset account, Montréal census metropolitan area-ecosystem (CMA-E), 1971 to 2011

	Total built-up area [1]		Arable [2]	Natural and semi-natural [3]
	Settled	Roads		
	square kilometres			
Opening stock 1971	581	294	4,201	5,110
Land lost to settled area	...	...	-448	-462
Balance of change [4]	911	349	328	-677
Closing stock 2011	1,491	643	4,081	3,970

Ecosystem asset account, Vancouver census metropolitan area-ecosystem (CMA-E), 1971 to 2011

	Total built-up area [1]		Arable [2]	Natural and semi-natural [3]
	Settled	Roads		
	square kilometres			
Opening stock 1971	348	159	387	5,148
Land lost to settled area	...	...	-166	-296
Balance of change [4]	462	116	127	-244
Closing stock 2011	810	275	348	4,609

6.2 UK ONS and DEFRA

UK ONS and DEFRA have published initial ecosystem accounts for urban areas in Great Britain, including the following excerpted tables (2018):

Table 1: Extent of urban area and broad habitats contained within it, Great Britain, 2007 to 2011

Extent		Extent (hectares)	Source
Total Urban Area		1,768,000	Enhanced ONS BUA (2011)
Area of 'broad' habitats contained within the urban area	Coastal Margins	4,000	Land Cover Map 2007
	Enclosed farmland	403,400	
	Freshwater	9,100	
	Marine	4,100	
	Mountains, moorlands and heaths	11,200	
	Semi-natural grassland	34,200	
	Woodland	87,900	
	Grey space[1]	1,212,000	

Source: Eftec (2017) A study to scope and develop urban natural capital accounts for the UK

Notes:

1. As defined by LCM definitions 'Built-up Areas' and 'Suburban'. This will include areas of greenspace and bluespace smaller than 0.0025 ha, as these areas were too small to detect by methods used to develop the Land Cover Map
2. These figures may not sum due to rounding.

Table 3: Extent of urban green spaces in 2017, Great Britain

	England	Scotland	Wales	Great Britain
Extent (hectares)				
Urban area	1,502,000	176,000	91,000	1,768,000
Natural land cover	456,700	64,700	27,600	549,000
Blue space	17,900	2,500	1,000	21,400
Functional green space	107,600	12,700	4,500	124,800
Publicly accessible green space	73,600	7,710	3,300	84,610
Proportion of urban area (%)				
Natural land cover	30%	37%	30%	31%
Blue space	1%	1%	1%	1%
Functional green space	7%	7%	5%	7%
Publicly accessible green space	5%	4%	4%	5%
Number of sites				
Functional green space	53,085	5,500	3,700	62,300
Publicly accessible green space	35,900	3,300	2,400	41,600

Source: Ordnance Survey

Notes:

1. These figures may not sum due to rounding.

Table 4: Extent of urban residential gardens and proportion of total urban area, Great Britain, 2017

	England	Scotland	Wales	Great Britain
Built-Up Area (Hectares)	1,502,000	176,000	91,000	1,768,000
Residential Garden (Hectares)	459,500	44,100	25,700	529,300
Proportion of urban area comprised of residential gardens (%)	31%	25%	28%	30%

Source: Ordnance Survey

Extent of functional green space and number of sites by country

	Great Britain		England		Scotland		Wales	
	Hectares	Number of sites	Hectares	Number of sites	Hectares	Number of sites	Hectares	Number of sites
Bowling Green	910	3,380	630	2,518	250	721	40	141
Religious Grounds	5,670	14,434	4,910	12,273	470	1,253	300	909
Open Access Land	6,870	N/A	6,350	N/A	0	N/A	510	N/A
Cemetery	7,440	3,959	6,260	3,197	890	415	290	347
Allotments or Community growing spaces	7,860	9,974	7,440	9,228	140	219	280	527
Other Sports Facility	14,520	7,255	12,460	6,167	1,390	702	670	386
Golf Course	16,900	1,707	13,460	1,321	3,190	291	240	96
Playing Field	27,130	14,862	23,420	12,625	2,460	1,237	1,250	1,000
Public Park/ Garden	37,500	6,754	32,660	5,756	3,890	686	950	313
Publicly accessible green space	84,610	40,009	73,600	33,851	7,710	3,591	3,300	2,569
Functional green space	124,800	62,325	107,590	53,085	12,680	5,524	4,530	3,719

Extent of natural land cover in 50 largest built up areas in Great Britain, hectares

	Natural land cover	Blue Space
Liverpool BUA	5,991	316
Tyneside BUA	6,619	630
Greater London BUA	72,316	5,473
Edinburgh	4,846	194
Ipswich BUA	1,296	56
Leicester BUA	3,005	60
Brighton and Hove BUA	1,911	122
West Midlands BUA	20,880	697
Bristol BUA	4,522	226
Derby BUA	1,687	41
Bournemouth/Poole BUA	3,348	104
Aberdeen	2,198	164
Dundee	1,644	31
Cardiff BUA	3,290	239

Greater Glasgow	9,382	528
Birkenhead BUA	2,426	127
Northampton BUA	1,764	39
Oxford BUA	1,052	31
Coventry BUA	2,844	46
Luton BUA	1,169	7
Teesside BUA	3,768	74
Kingston upon Hull BUA	2,280	147
Reading BUA	2,379	72
Sheffield BUA	5,845	126
Cambridge BUA	1,414	53
Nottingham BUA	6,724	159
Blackpool BUA	1,724	42
Greater Manchester BUA	29,060	1,053
Mansfield BUA	1,406	12
Medway Towns BUA	1,417	50
Barnsley/Dearne Valley BUA	2,207	24
York BUA	831	41
Doncaster BUA	1,136	19
South Hampshire BUA	6,609	1,918
Preston BUA	3,339	112
Peterborough BUA	1,294	25
Stoke-on-Trent BUA	4,824	95
Norwich BUA	1,829	35
Warrington BUA	1,361	77
Sunderland BUA	3,188	111
Wigan BUA	1,442	32
Farnborough/Aldershot BUA	2,454	106
Swindon BUA	1,471	22
Southend-on-Sea BUA	3,039	38
Swansea BUA	3,165	140
Newport (Newport) BUA	3,159	174
Plymouth BUA	2,008	90
West Yorkshire BUA	29,126	493
Milton Keynes BUA	2,790	78
Crawley BUA	2,032	43

Table 5: Breakdown by country of urban sites of specific scientific interest condition and extent as known at May 2018, United Kingdom

Country	Extent (hectares)	Condition[5]	Favourable	Unfavourable	Destroyed/ Partially destroyed	NA
England [1]	9,590	Units	1,317	1,592	20	3
		%	45%	54%	1%	0%
Scotland [2]	1,170	Units	335	134	3	18
		%	68%	27%	1%	4%
Wales [3]	580	Units	1,090	1,344		20

		%	44%	55%		1%
Northern Ireland [4]	220	Units	NA	NA	NA	NA
United Kingdom	11,560	Units	NA	NA	NA	NA

Source: Natural England, Natural Resources Wales, Natural Scottish Heritage, Opendata Northern Ireland

Notes:

1. Unfavourable includes sites recorded as ‘unfavourable recovering’, ‘unfavourable no change’ and ‘unfavourable declining’.
2. Favourable includes sites recorded as ‘favourable maintained’, favourable recovered, ‘favourable declining’. Unfavourable includes sites recorded as ‘unfavourable recovering’, ‘unfavourable no change’ and ‘unfavourable declining’.
3. Favourable includes sites recorded as ‘appropriate conservation management’. ‘Unfavourable sites include those recorded as ‘needs action’.
4. No data containing condition of ASSI sites is included.
5. The ‘Latest Assessed Condition” is used for the condition indicator for Scottish SSSI’s.

Table 7: Total number of access points for functional green space per hectare, Great Britain, 2017

Urban Access Points	England	Scotland	Wales
Total access points per hectare of functional greenspace	1.32	1.38	2.02
Total access points	142,340	17,522	9,068
Functional Greenspace (hectares)	107,600	12,700	4,500

Table 8: Proximity to green space, Great Britain, 2018

	Average distance to functional green space	Average distance to blue space site	Average area of natural land cover within 200m
Great Britain	259m	365m	4.6 hectares

Table 10: Annual value of air quality regulation from urban green and blue space (£'000), United Kingdom, 2015

		2015 £'000 per yr
$PM^{2.5}$	Respiratory hospital admission	£800
	Cardiovascular hospital admissions	£700
	Life years lost	£193,800
SO^2	Respiratory hospital admission	£300
NO^2	Respiratory hospital admission	£200
	Cardiovascular hospital admissions	£100
	Life years lost	£12,600
O^3	Respiratory hospital admission	£2,200
	Cardiovascular hospital admissions	£300
	Deaths	£600
Total		£211,600

Source: Eftec (2017) "A study to scope and develop urban natural capital accounts"

Table 12: Total annual value of cooling from green space and blue space in each of Great Britain's city regions (£'000), 2012 to 2016 average

	Annual value from avoided labour productivity loss	Annual value from air conditioning savings	Total annual value
Total	£159,396	£6,245	£165,641
Cardiff city Region	£1,304	£149	£1,453
Edinburgh city region	£110	£26	£135
Glasgow city region	£116	£26	£141

Greater Manchester city region	£3,909	£241	£4,150
Liverpool city region	£1,499	£241	£1,740
London city region	£135,560	£4,304	£139,863
North East city region	£161	£26	£187
Sheffield city region	£2,115	£159	£2,274
West Midlands city region	£8,804	£483	£9,286
West of England city region	£2,931	£432	£3,363
West Yorkshire city region	£2,890	£159	£3,049

Source: Eftec (2018) "Scoping UK urban natural capital account - local climate regulation extension"
Notes:
1. Figures may not sum due to rounding.

Table 13: Summary physical and monetary flow accounts for the noise mitigation benefits of urban natural capita, United Kingdom, 2017

Noise band [1]	Number of buildings benefiting from noise mitigation by urban vegetation [2] ('000s)				
	England	Scotland	Wales	Northern Ireland	UK
more than=80	Less than 1	-	-	-	
75.0-79.9	Less than 1	-	Less than 1	Less than 1	
70.0-74.9	8	Less than 1	Less than 1	Less than 1	
65.0-69.9	36	1	3	1	
60.0-64.9	98	6	8	4	
Total	142	7 [3]	12	6	167

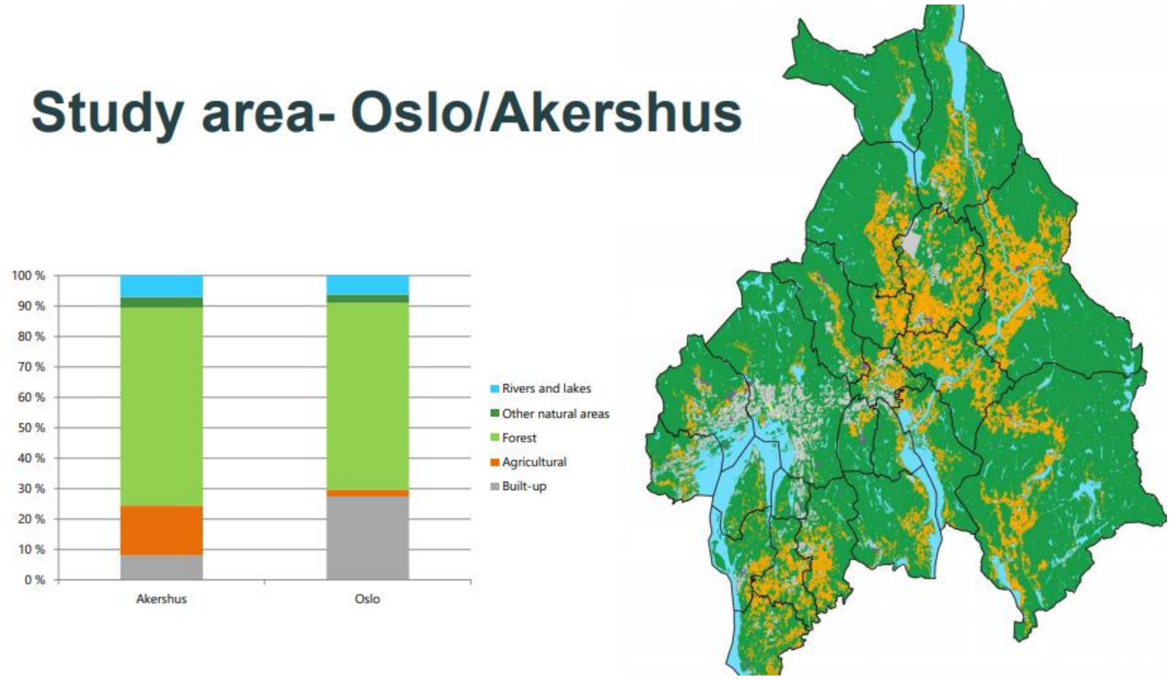
Noise band [1]	Annual value of noise mitigation (£'000/yr)				
	England	Scotland	Wales	Northern Ireland	UK
more than=80	1	-	-	-	
75.0-79.9	139	-	11	2	
70.0-74.9	1,041	7	100	53	
65.0-69.9	3,799	117	295	133	
60.0-64.9	7,339	454	634	305	
Total	12,320	578	1,040	493	14,431

Source: Eftec (2018) "Scoping UK urban natural capital account - local climate regulation extension"
Notes:
1. 5 dB bands applied along with guidance in Defra (2014a).
2. Urban vegetation includes large woodlands (>3,000m2) and smaller woodlands (<3,000m2), but not very small woodlands (<200m2).
3. Number of dwellings receiving mitigation in Scotland is likely to be lower than the estimates for the other countries because we used the Lden noise metric rather than the LA1018 metric which was not available for Scotland.

6.3 Norwegian Institute for Nature Research

The urban EEA project conducts research on ecosystem services from urban ecosystems in the Oslo region, including green spaces in the built-area and the peri-urban nature areas. It tests mapping and valuation methods to identify tradeoffs and synergies in ecosystem services from green infrastructure and urban development. Excerpts from various publications associated with the Urban EEA project are included here:

From Steine, 2018:



From Lauwers, L. et al., 2017:

Table 1. *An overview of the mean compensation value and the total compensation value for the trees ofeach street, based on the random sample of trees in Oslo's greenest streets (excluding public parks).*

City district	Street	Total Compensation Value (NOK)	Mean Compensation Value (NOK)
Grorud	Vestbyveien	20 499 984	83 570
St. Hanshaugen	Bjørnstjerne Bjørnsons plass	12 516 471	99 639
Stovner	Stovnerbakken	21 314 935	114 031
Vestre Aker	Ris skolevei	20 499 998	102 334
Søndre Nordstrand	Nordåsveien	21 527 408	97 871
Ullern	Noreveien	20 500 000	116 241
Alna	Edvard Munchs vei	20 607 096	87 623
Frogner	Bygdøynesveien	20 504 792	94 167
Nordre Aker	Sognsveien	846 981 613	109 682
Nordstrand	Gladvollveien	20 569 540	69 682
Sentrum	Prinsensgate	2 289 767	134 692
Østensjø	Byggveien	2 050 000	99 817
Bjerke	Refstadsvingen	20 499 650	103 254
Gamle Oslo	Konows gate	20 499 985	76 023
Grünerløkka	Fjordgløttveien	2 049 843	111 909
Sagene	Hans Nielsen Hauges gate	20 500 000	110 089

Table A1 The 16 streets with their tree density derived from the LIDAR data, the amount of trees defined by LIDAR 2011 and the actual amount of trees present today (2016) within a 10-m buffer zone. Only trees higher than 5 meter were included.

City district	Street	Tree density (trees/ 1000 m²)	Number of trees (LIDAR)	Number of trees (ground-truthed)	Deviation (%)
Grorud	Vestbyveien	23	91	82	10 %
St. Hanshaugen	Bjørnstjerne Bjørn-sons plass	22	22	11	50 %
Stovner	Stovnerbakken	22	226	224	1 %
Vestre Aker	Ris skolevei	22	77	53	31 %
Søndre Nordstrand	Nordåsveien	21	262	256	2 %
Ullern	Noreveien	19	108	92	15 %
Alna	Edvard Munchs vei	18	108	92	15 %
Frogner	Bygdøynesveien	18	201	193	4 %
Nordre Aker	Sognsveien	18	626	754	-20 %
Nordstrand	Gladvollveien	18	250	258	-3 %
Sentrum	Prinsensgate	18	12	17	-42 %
Østensjø	Byggveien	17	69	63	9 %
Bjerke	Refstadsvingen	15	59	63	-7 %
Gamle Oslo	Konows gate	14	181	179	1 %
Grünerløkka	Fjordgløttveien	14	41	34	17 %
Sagene	Hans Nielsen Hauges gate	10	66	59	11 %
Mean error (Lidar)					6%

6.4 MAES Urban ecosystems

The *Mapping and Assessment of Ecosystems and their Services (MAES): Urban Ecosystems* report (2016) acknowledges that the general framework for MAES “based on pilots work on forests, agro-ecosystems, freshwaters and marine systems cannot simply be adopted in an urban environment.” Its goals were, among others, to build an indicator framework for assessing urban ecosystems and providing a methodology for measuring ecosystem services delivered by green infrastructure (p.12).

- The report defined urban ecosystems as “cities, the socio-ecological systems where most people live.” These areas include two functional components: green infrastructure (network of urban green space within the boundary of urban ecosystems including trees, forests, green roofs, hedges, playgrounds, cemeteries, river banks) and built-infrastructure (e.g., houses, buildings, roads, bridges, commercial and industrial, brownfields, dumps) (p.12-13)
- The report also defines the boundary of the urban ecosystems at three levels—the regional scale, the metropolitan scale and the urban scale. The latter two boundaries correspond to the functional urban area (FUA), including the city core and its commuting zone, and the city core of the FUA.
- The report includes summaries of 10 case studies where European cities begun work on mapping and assessing urban ecosystems services.
- It provides examples of urban green space typologies (for example, the European Commission’s Green Surge typology – table 16 excerpted below) and an indicator framework for urban ecosystem condition (table 18 excerpted below).

Table 16. Table Typology proposed by Green Surge for Urban Green Spaces (UGS)

Category	Green space element
Building greens	Balcony green
	Ground based green wall
	Facade-bound green wall
	Extensive green roof
	Intensive green roof
	Atrium
Private, commercial, industrial, institutional UGS and UGS connected to grey infrastructure	Bioswale
	Tree alley and street tree, hedge
	Street green and green verge
	House garden
	Railroad bank
	Green playground, school ground
Riverbank green	Riverbank green
Parks and recreation	Large urban park
	Historical park/garden
	Pocket park
	Botanical garden/arboreta
	Zoological garden
	Neighbourhood green space
	Institutional green space
	Cemetery and churchyard
	Green sport facility
	Camping area
Allotments and community gardens	Allotment
	Community garden
Agricultural land	Arable land
	Grassland
	Tree meadow / orchard
	Biofuel production / agroforestry
	Horticulture
Natural, semi-natural and feral areas	Forest (remnant woodland, managed forests, mixed forms)
	Shrubland
	Abandoned, ruderal and derelict area
	Rocks
	Sand dunes
	Sand pit, quarry, open cast mine
	Wetland, bog, fen, marsh
Blue spaces	Lake, pond
	River, stream
	Dry riverbed, rambla
	Canal
	Estuary
	Delta
	Sea coast

Table 18. Indicator framework for measuring the condition of urban ecosystems

Pressures indicators of urban ecosystems

Class	Indicator	Scale R	Scale M	Scale U
Urban Sprawl	Percent of built-up area (%)	•	•	
	e.g., Weighted Urban Proliferation (Urban Permeation Units m^{-2}) (Jaeger and Schwick 2014)	•	•	
Air pollution	Concentration of NO_2, PM10, PM2.5, O_3 (µg m^{-3})	•	•	•
	Number of annual occurrences of maximum daily 8 hour mean of O_3 > 120 µg m^{-3}	•	•	•
	Number of annual occurrences of 24 hour mean of PM10 > 50 µg m^{-3}	•	•	•
	Number of annual occurrences of hourly mean of NO_2> 200 µg m^{-3}	•	•	•

State indicators of urban ecosystems

Built infrastructure

Class	Indicator	Scale R	Scale M	Scale U
Population density	Number of inhabitants per area (number ha^{-1})	•	•	•
Land use and land use intensity	Artificial area per inhabitant (m^2 person^{-1})	•	•	•
	Land annually taken for built-up areas per person (m^2 person^{-1})	•	•	•
Road density	Length of the road network per area (km ha^{-1})		•	•

Green infrastructure

Class	Indicator	Scale R	Scale M	Scale U
Urban forest pattern	Canopy coverage (ha)		•	•
	e.g., different indicators based on forest pattern and fragmentation including SEBI 13		•	•
Tree health and damage	e.g. foliage damage crown dieback; measurements based on visual inspection of trees		•	•
Connectivity of urban green infrastructure	Connectivity of GI (%)		•	•
	Fragmentation of GI (Mesh density per pixel)		•	•
	Fragmentation by artificial areas (Mesh density per pixel)		•	•

State indicators related to the ratio between green and built infrastructure

Class	Indicator	Scale R	Scale M	Scale U
Land use	Proportion of urban green space (%)	•	•	•
	Proportion of impervious surface (%)	•	•	•
	Proportion of natural area (%)	•	•	•
	Proportion of protected area (%)	•	•	•
	Proportion of agricultural area (%)	•	•	•
	Proportion of abandoned area (%)	•	•	•

Indicators of urban biodiversity

Class	Indicator	Scale R	Scale M	Scale U
Species diversity	Number and abundance (number ha^{-1}) of bird species	•	•	•
	e.g., number of lichen species	•	•	•
Conservation	Number and abundance (number ha^{-1}) of species of conservation interest	•	•	•
Introductions	Number of alien species	•	•	•

R: Regional scale; M: Metropolitan scale; U: Urban scale

7. Appendix: Urban ecosystems in SEEA EEA and MEA

Urban ecosystems are mentioned only briefly in the *Technical Recommendations in support of the SEEA EEA*. Specifically, urbanization and urban areas are discussed in the following sections [underline added]:

- 2.2.3. ….while the ecosystem extent account provides a clear base for development of other ecosystem accounts, it also provides important information in its own right…Extent accounts can also support the derivation of indicators of deforestation, desertification, urbanisation and other forms of land use driven change].
- 3.2. Ideally, in ecosystem accounting, all ecosystems within the area for which the accounts are developed should be included. Urban areas, including sealed surfaces, should also be identified, even though they may have very few plant and animal species and may provide relatively few ecosystem services. Where the accounts include entries for types of ecosystems, the different ecosystems need to be delineated such that there are no gaps or overlaps – i.e. the approach must be mutually exclusive and collectively exhaustive.
- 3.30. There have also been, as yet, relatively few projects focusing on accounts for urban ecosystems. Tentatively, it seems appropriate that in the case of urban ecosystems various ecosystem types can also be differentiated based on the combination of cover, use and the services they supply. This may include, for instance, urban parks within city boundaries, different types of parks nearby cities but outside residential zones, and perhaps even specific areas such as rivers flowing in urban areas, river beds, canals or cemeteries.
- Table 3.1 initial example of land cover classes and ecosystem types:

Description of land cover classes (SEEA Central Framework)	**Possible ecosystem types**
Artificial areas (including urban and associated areas)	Residential/housing Urban parks Industrial uses (e.g., factories) Road infrastructure Waste deposit sites

The *Millennium Ecosystem Assessment* covers urban systems in Chapter 27 (Bai et al, 2005) and uses both the country-specific definition of urban centres as reported to the United Nations and a preliminary urban-rural split developed as part of Balk et al.'s *The Distribution of People and the Dimension of Place: Methodologies to Improve the Global Estimation of Urban Extents* (2004). It specifies that it takes the view of urban ecosystems as systems that include people (p. 799).

In its main messages, the chapter indicates that urbanization is not inherently bad for ecosystems, that urban areas represent a small proportion of the total land area of the Earth, and that dense urban areas create fewer environmental problems compared to areas of suburban sprawl. However, it recognizes three priority problems with regards to urban systems and ecosystem services, at different spatial scales:

- the pressure that urban demographic and economic growth place on ecosystems globally
- the degradation of ecosystems adjoining urban areas due to urban expansion
- the disparity in access to ecosystem services within urban settlements creating unhealthy living environments.

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