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Project identification

1. Defra Project code: NR0109
2. Project title: CASE STUDY TO DEVELOP TOOLS AND METHODOLOGIES TO DELIVER AND ECOSYSTEM-BASED APPROACH –THAMES GATEWAY GREEN GRIDS
3. Contractor organisation(s): Collingwood Environmental Planning
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4. Total Defra project costs (agreed fixed price): £ 127,098
5. Project: start date .... 02 October 2006
   end date .... 01 April 2008

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Executive Summary

7. The executive summary must not exceed 2 sides in total of A4 and should be understandable to the intelligent non-scientist. It should cover the main objectives, methods and findings of the research, together with any other significant events and options for new work.

This case study research project, supported by the Defra Natural Environment Policy Research Programme Phase II, ran from October 2006 to April 2008. **The purpose of this project was to assess the types of ecosystem services provided within a particular case study area undergoing extensive urban regeneration and how best they could be evaluated within current land use planning and decision-making frameworks.** The case study area selected was Kent Thameside, a key development area of the Thames Gateway Growth Area within the Government's Sustainable Communities Plan. The area is one already under some considerable constraints, e.g. in terms of water resource availability, flood risk, air quality, transport and biodiversity. However, there are extensive areas of brownfield (previously developed) land available in North Kent for new development, particularly resulting from historical quarry and cement works activity in the area. The Channel Tunnel Rail Link (CTRL) passes through Kent Thameside and the new CTRL station at Ebbsfleet is also located within the area. Within Kent Thameside the project focused on the Green Grid initiative – an important planning concept designed to improve the environmental perception of the Gateway, enhance environmental assets with a network of green spaces and corridors, recognise the importance of multi-functional green spaces for community life and help ensure that green spaces can also provide important adaptation tools, for example, in relation to helping with flood relief and in improving the quality of life.

The project focused on three main geographical areas within Kent Thameside:-
i) a pilot study on Dartford Marsh
ii) a strategic study on Kent Thameside Green Grid as a whole;
iii) a local study focused around Ebbsfleet, Gravesham.

The overall aim of the research was *to evaluate the value and appropriateness of using an ecosystem services approach within existing land use planning frameworks, particularly its application through a range of decision support tools, using Kent Thameside as a case study.*

Through the locations above three main decision support tools were explored for their applicability to integrating ecosystem services into planning frameworks, especially the green grid: network analysis, geographical information systems (GIS) and STELLA modelling. Only the first two of these tools were explored in depth. Network analysis is based on tracing the links and interaction pathways between individual components of the environment (in this case land use/land cover categories and ecosystem services) resulting in a series of chains (network) or webs (systems diagrams) between the factors.

Network analysis proved to be useful technique to engage with stakeholders and to understand the relationships between land use/land cover[1] categories and ecosystem services provided by those land use/land cover types.

GIS was used to represent land use/land cover types – and therefore ecosystem services - spatially, by combining a range of existing datasets. This geographical representation was not without difficulties, including the problems posed by combining different types of datasets of different quality and scale. Any errors or assumptions contained in data sets can be compounded if combined with other data sets, similarly, by combining good quality data with poor quality data it could result in data of unknown quality and unknown limitations. However, **it did prove possible to use existing datasets to represent ecosystem services spatially.** This transpired to be most useful at the strategic level; at the local level the existing datasets are rarely of a resolution sufficiently fine to distinguish the heterogeneity of the local environment, although even here the GIS could be useful in identifying areas with potential for multifunctionality. At the local level a combination of 'ground-truthing' using aerial photography and site visits, and local public consultation, proved to be successful in getting to a better understanding of the sorts of ecosystem services delivered by local green space. Information gathered in this way could be readily translated using network analysis into **a typology of ecosystem services at the local level** by tracing the interaction pathways back to the associated land cover types. Network analysis proved a useful tool to represent the complexity of an ecosystem and the interactions between its various components. What GIS and network analysis could not do, in the course of this research at least, was quantify the amount of an ecosystem service that was present or desirable, or how that might change over time. These shortfalls are not insurmountable, and point to the need for more research to develop the tools further.

The research used a **different approach** from other projects within the Defra ecosystem services research programme that have explored ecosystems services. It used **land use/land cover classification as ecosystem units whereas other studies have used habitats**. The use of land use classification units has **practical application to planners**, who are familiar with this type of classification.

Green Grid Planning

The added dimension that the ecosystems approach provides can offer real benefits to spatial planning, particularly **in promoting multifunctionality by ensuring that green grids help proactively to *shape* development, planning around what exists and its potential, rather than their delivery simply occurring reactively *through* development.** Ecosystem services also provide a different focus for discussion with stakeholders, with the potential to help reduce the common problem of trade-off between different interests through seeking to deliver multiple services and multiple benefits.

Sustainability appraisal/SEA

Ecosystem services could help make baseline data in SA/SEA much more relevant to the assessment process by combining datasets in a useful way for planners and decision-making. **The use of network analysis around ecosystem services provides a means to identify key issues, and could be used as part of scoping and also alongside/supplementary to SA/SEA objectives.** Ecosystem services can provide important information on the potential for multifunctionality when considering alternatives options for plans and programmes. **Potentially, ecosystem services could be used as an alternative to SA/SEA objectives in the assessment methodology;** in other words, an SA/SEA objective "To protect and enhance biodiversity" might be re-cast in ecosystem service terms "What will be the effect on biodiversity provisioning services?" But this is likely to take time to take hold, given that the use of SA objectives is now well embedded in SA/SEA practice, and in any case could be quite data dependent. However, ***'ecosystem services thinking'* could provide an important perspective in SA/SEA in the same way that life cycle thinking provides wider benefits to sustainable product and service provision beyond heavily data dependent life cycle analysis/assessment.**

Recommendations

The findings from the development and application of the tools used in this research lead to a number of recommendations to help take forward the advances made and contribute to Defra's Action Plan (2007): *Securing a healthy natural environment: An action plan for embedding an ecosystems approach.*

[1] **Land use/land cover types** were the units of analysis used to classify and analyse the study area. They are based on existing open space categories commonly used by planners, relating to the type of vegetation, topographical features and use of an area.
GIS categories refer to the land use /land cover units prescribed to parcels of land in the study area.

Further research

R1 **Further research should be undertaken by Defra on using network analysis, combining GIS datasets, introducing new datasets and modelling ecosystem services at different scales.** Some ecosystem services lend themselves to more strategic scales and others to more local scales, while others can be modelled at a variety of scales. Identifying these different scales for different services will aid planners in understanding which services can be most effectively protected and enhanced at their spatial level. In doing so it will be important to ensure the full engagement of stakeholders (expert and public) in exploring the use of scoring and weighting when combining datasets and the extent that this is feasible and desirable.

R1a Further research on the use of **specific datasets**, e.g. more specific land *use* datasets such as breaking down food production into different types of farming; higher resolution datasets, e.g. for greenness/NDVI such as CASI; higher quality terrain information such as the Environment Agency's LiDAR data (useful for terrain/flood regulation and aesthetic mapping)

R1b Further research on **accessibility barriers to movement** (e.g. busy roads, railways, quarry faces, rivers), which are likely to be particularly important in people's ability to be able to access open space, even if it is provided within a particular location.

R1c Further research on **individual versus combined ecosystem services maps**. This was an issue raised at the final project seminar on which there was a range of views. The combining of ecosystem services maps was tested for only one local situation using only three ecosystem services in this research and there is clearly considerable scope for exploring the merits or otherwise of this further, at different scales and for multiple ecosystem services.

R2 **Ecosystem services could be used to help define environmental limits and thresholds/define environmental capacity.** Our work has not sought specifically to address this – it has focused more on maximising multifunctionality, but this should be the next step – i.e. how much service should be provided/is needed within an area? **Further research should be undertaken to define limits and thresholds to ecosystem service provision, using existing environmental standards as the starting point, e.g. air quality, water quality, BAP targets.** This research would have to be tailored to the appropriate scale(s) for the service in question and the associated limit defined accordingly. With limits defined sustainability appraisal (SA) and strategic environmental assessment (SEA) could utilise this information in assessments of local development documents, regional spatial strategies and other sectoral plans and programmes.

R3 An English Ecosystem Assessment could provide a robust basis for use in strategic spatial planning – and particularly in relation to regional/sub-regional level spatial mapping and analysis of ecosystem services potential. **The initial mapping undertaken here for Kent Thameside should be extended to the Thames Gateway as a whole, to facilitate the strategic planning of green infrastructure in the context of developing sustainable communities.** The development and refinement of the approach for more specific local mapping will also be essential to test the applicability of more definitive mapping. **Opportunities for this exist** - and interest expressed, subject to funding - **in Kent Thameside** to help the local authorities in considering the effects of future developments and master plans on local ecosystem services, and **in London** with respect to the consequence for ecosystem services of the increasing loss of front and back gardens.

R4 **Further research would be useful to investigate which services accrue on either a strategic or local scale, and how this division might be used to integrate an ecosystems approach into the planning system. One approach would be to focus on a few key services and their delivery across the Thames Gateway, investigate how they are provided and how they might be enhanced.** Future research could seek to derive limits and standards for minimum levels of ecosystem service levels, e.g. the minimum amount of flood storage required in the Thames Gateway.

R5 **The research councils and academic community should seek to further explore and promote the integration of ecosystem services into planning frameworks.** This will necessitate the active support of interdisciplinary and transdisciplinary applied research in this area. Ecosystem services epitomises the need to cross research boundaries and disciplines, especially across the natural and social sciences, and to address real practical challenges. Both of these areas have been poorly addressed in the past by research councils, and although this is improving many of the driving forces in academia still militate against such research. **A specific area that could be investigated is how, if at all, network analysis and GIS mapping might relate to monetary valuation of ecosystem services.**

Government and authority action

R6 **An ecosystem services approach should be integrated into the future planning and delivery of green grids/green infrastructure throughout the Thames Gateway and elsewhere.** Green grid planning needs to be underpinned by the potential to deliver ecosystem services in order to support the multifunctional objectives of green grids and provide a more robust means of directing the delivery of green grid space. This may require more formal guidance in the form of a planning policy statement (PPS) **to ensure that green grids help proactively to *shape* development, planning around what exists and its potential, rather than their delivery simply occurring reactively *through* development.**

R7 **Local authorities should be encouraged, e.g. through government guidance, to use an ecosystem services approach in planning green and open space in order to promote greater multifunctionality.** This might be encouraged through integrating the approach into development plan preparation, open space strategies, and community engagement, for example. **The development and use of ecosystem service typologies, perhaps linked with state of the environment reports, could facilitate this.**

R8 **Network analysis provides a useful tool that can be used by planners to engage with stakeholders in creative and interactive ways in developing multifunctional green grids** (that deliver multiple ecosystem services) and should become a regular tool used in future strategic and local green grid planning. This should include discussions about the use and enhancement of local green space.

R9 **Communities and Local Government (DCLG) should include ecosystem services in their ongoing revision of guidance on sustainability appraisal**, to encourage its appropriate incorporation into SA application at various strategic levels. **A flexible approach to using ecosystem services in SA should be encouraged – in line with the 'living draft' nature of the SA guidance, so that *'ecosystem services thinking'* is encouraged and trialled in a range of different contexts.**

R10 **Government agencies and regional observatories should seek to provide appropriate datasets for incorporation into ecosystem services approaches.** A consistent approach to the nature, range and scale of datasets that can be used in mapping ecosystem services needs to be established, which may need specific research to undertake a gap analysis, i.e. identify which datasets are currently being accumulated in regional observatories and which would be a priority to be developed.

Project Report to Defra

8. As a guide this report should be no longer than 20 sides of A4. This report is to provide Defra with details of the outputs of the research project for internal purposes; to meet the terms of the contract; and to allow Defra to publish details of the outputs to meet Environmental Information Regulation or Freedom of Information obligations. This short report to Defra does not preclude contractors from also seeking to publish a full, formal scientific report/paper in an appropriate scientific or other journal/publication. Indeed, Defra actively encourages such publications as part of the contract terms. The report to Defra should include:
   - the scientific objectives as set out in the contract;
   - the extent to which the objectives set out in the contract have been met;
   - details of methods used and the results obtained, including statistical analysis (if appropriate);
   - a discussion of the results and their reliability;
   - the main implications of the findings;
   - possible future work; and
   - any action resulting from the research (e.g. IP, Knowledge Transfer).

Case study to develop tools and methodologies to deliver an ecosystem-based approach: *Thames Gateway Ecosystem Services Assessment Using Green Grids and Decision Support Tools for Sustainability* (*THESAURUS*)

Authors:

William Sheate, Ric Eales, Eoghan Daly (Collingwood Environmental Planning), and
Andrew Murdoch, Chris Hill (Geodata Institute)

CONTENTS

GLOSSARY of key terms used in this report

Ecosystem services are the benefits that humans obtain from ecosystems, and they are produced by interactions within the ecosystem…These include provisioning, regulating, and cultural services that directly affect people. They also include supporting services needed to maintain all other services…Ecosystem services affect human well-being and all its components, including basic material needs such as food and shelter….” (MEA, 2005)
GIS categories refer to the land use /land cover units prescribed to parcels of land in the study area.
Land use/land cover types were the units of analysis used to classify and analyse the study area. They are based on existing open space categories commonly used by planners, relating to the type of vegetation, topographical features and use of an area.
Network analysis is the *process* of tracing the links and interaction pathways between individual components of the environment (in this case land use/land cover categories and ecosystem services) resulting in a series of chains (network) or webs (systems diagrams) between the factors. The *output* is a network model (or diagram).
NDVI – The **Normalised Difference Vegetation Index** (NDVI) gives a measure of the vegetative cover on the land surface over wide areas.
Ordnance Survey MasterMap (OSMM) contains more than 450 million uniquely identified geographic features, representing real world information down to individual address and street and building level (see http://www.ordnancesurvey.co.uk/oswebsite/products/osmastermap/).
STELLA modelling is a graphical interface model using inputs and outputs to simulate relationships between factors under consideration, in this case ecosystem services.

1. Introduction

Ecosystems are natural resources that provide people with many essential goods and services, including for example, air, food, drinking water, landscape, and recreation space. The concept of ecosystem services has been developed internationally by the Millennium Ecosystem Assessment, supported by the Global Environment Facility and the United Nations Environment Programme, among others. Defra's Natural Environment Policy research programme has already undertaken considerable work in this area, for example on developing inventories of ecosystem services, understanding environmental limits and valuation of ecosystem services. The purpose of this project, however, was to assess the types of ecosystem services provided within a particular case study area undergoing extensive urban regeneration and how best they could be evaluated within current land use planning and decision-making frameworks.

The case study area selected was Kent Thameside, a key development area of the Thames Gateway Growth Area within the Government's Sustainable Communities Plan. The area is already under some considerable constraints, e.g. in terms of water resource availability, flood risk, air quality, transport and biodiversity. However, there are extensive areas of brownfield (previously developed) land available in North Kent for new development, particularly resulting from historical quarry and cement works activity in the area. The Channel Tunnel Rail Link (CTRL) passes through Kent Thameside and the new CTRL station at Ebbsfleet is also located within the area. Within Kent Thameside the project focused on the Green Grid initiative – an important planning concept designed to improve the environmental perception of the Gateway, enhance environmental assets with a network of green spaces and corridors, recognise the importance of multi-functional green spaces for community life and help ensure that green spaces can also provide important adaptation tools, for example, in relation to helping with flood relief and in improving the quality of life.

The ***Aim*** of the research was:

To evaluate the value and appropriateness of using an ecosystem services approach within existing land use planning frameworks, particularly its application through a range of decision support tools - network analysis, STELLA modelling and Geographical Information Systems (GIS) - using Kent Thameside as a case study.

The modelling approaches considered involve the use of graphical and/or computer-based tools that seek to represent the key relationships and functions of ecosystem services in a given area.

The ***objectives*** of the research were:

1. An extensive literature review on ecosystem services, sustainability assessment, green grids and environmental and landscape mitigation measures, to identify links and synergies, and develop a conceptual understanding of how ecosystem services can be used within existing planning frameworks such as Local Development Frameworks (LDFs), Regional Spatial Strategies (RSSs) and sustainability appraisal (SA). *Milestone M1 – Literature review report.*

2. Using Kent Thameside as the case study (part of the Thames Gateway), and the Green Grid approach in particular, identify through stakeholder engagement the potential ecosystem services provided by Green Grid. *Milestone M2– Typology of ecosystem services provided by Green Grid in Kent Thameside.*

3. Develop an initial *generic* network analysis and STELLA model of the Green Grid initiative in Kent Thameside, along with the necessary GIS data requirements and availability. *Milestone 3 - Generic network analysis and STELLA models, with relevant GIS data requirements and availability.*

4. Hold a workshop (Workshop 1) with key stakeholders (e.g. local authority officers, statutory agencies, NGOs, recreation interests, local businesses) to report on the typology of ecosystem services and introduce the proposed modelling approaches to be used in the research and explore options/sub-cases to which the modelling will be applied. *Milestone M4 – Delivery of Workshop 1*

5. Finalise options for network analysis and STELLA/GIS modelling, including referral back to the stakeholder panel*. Milestone M5 – Agreed options/sub-cases for modelling.*

6. Within the case study area identify *up to* four different aspects or geographical levels through which to explore ecosystem service functions of Green Grid and to adapt, apply and test the applicability of modelling approaches to different levels and services (*sub-cases*) – specifically network analysis, STELLA and GIS. The first of these shall be undertaken as a pilot study. *Milestone 6 – Completed pilot models.*

7. Adapt, apply and test the applicability of the modelling approaches to the remaining agreed sub-cases. *Milestone 7 - Completed sub-case models.*

8. Hold a workshop/seminar (Workshop 2) for reporting results and disseminating the findings from the modelling to stakeholders, including the usefulness of the models and in terms of ecosystem services of Green Grids. *Milestone 8 – Delivery of Workshop 2.*

9. Draw conclusions on the applicability of the ecosystem services approach to existing planning frameworks, and the appropriateness of network analysis, STELLA and GIS as tools to be used within this approach. *Milestone 9 – Final Report.*

An extensive literature review was undertaken in order to place the study in its wider context. This literature review covered issues around ecosystem services, GIS and other decision-support tools, spatial planning frameworks, sustainable communities, the Thames Gateway and regional and local planning policy. Following the literature review stakeholder interviews were undertaken within the Thames Gateway in order to facilitate the development of a typology of ecosystem services within the whole of the Kent Thameside Green Grid area. A diagram of the approach taken is contained in Figure 1.

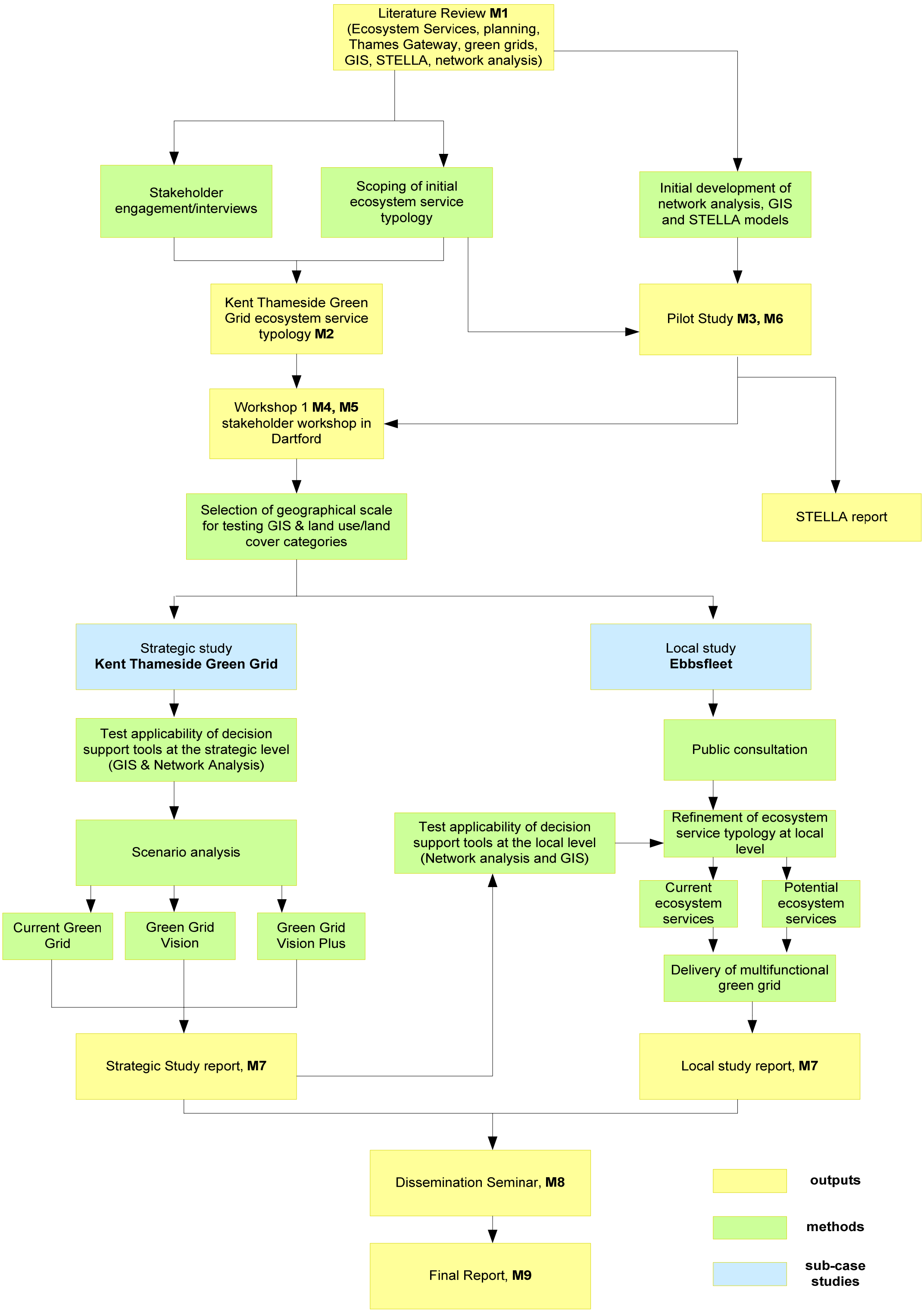

Figure 1: The research approach

2. Typology of ecosystem services

The Millennium Ecosystem Assessment (MEA, 2005) categorises ecosystem services as supporting, regulating, provision and cultural services. Within each of these categories numerous 'ecosystem services' exist and these depend on the specific location concerned. A 'typology' of ecosystem services can be developed for any location (and at any scale) which describes and categorises the ecosystem services provided. While many services can be identified from an understanding of the literature and the environmental characteristics of an area the typology can only be completed effectively by involving stakeholders to understand how the area (and therefore the ecosystem) is used, i.e. identifying the services actually derived by people in the area.

The overall approach to the involvement of stakeholders in developing the typology comprised the following steps:

i) Generic typology development
ii) Stakeholder mapping
iii) Method of engagement
iv) Question design and development
v) Piloting and undertaking interviews
vi) Analysis of interviews
vii) Obtaining feedback on the draft typology

The initial list of stakeholders ranged from environmental NGOs (e.g. Sustrans, CPRE, English Heritage, Groundwork, RSPB), local bodies (e.g. Kent County Council, SEEDA, Thames Estuary Partnership, Kent Thameside Delivery Board), Government agencies (e.g. Environment Agency, Forestry Commission) and private development companies and their representatives (e.g. Land Securities, Jacobs Babtie). Stakeholders were initially identified through consultation with the Kent Thameside Green Grid Manager and via internet search engines, some stakeholders were identified later on in the process through recommendations from other stakeholders. In order to include a representative range of stakeholders' interest in the Green Grid, the stakeholders were appraised against the generic typology of ecosystem services to identify which they were likely to be primarily and more generally concerned with. Representatives of stakeholder interests were then selected by the research team to be interviewed on the basis that they could provide a unique perspective to help further the typology development, and to verify and increase the specific of the generic typology developed.

In summary, respondents readily identified with cultural benefits of the Kent Thameside Green Grid (KTGG) (100% of respondents), with recreation being the service that was most frequently mentioned. Supporting services, on the other hand, were rarely identified, as were socially unacceptable uses of the KTGG, with only 23% of respondents naming such uses (for example, vandalism, fly-tipping and graffiti).The interviews also revealed which areas of the KTGG were perceived as good examples of multi-functional green space. The most frequently cited examples were Shorne Wood Country Park and Dartford Marshes (30% and 23% of respondents respectively). Other areas that were mentioned quite frequently were riverside areas in general and sites within Swanscombe, namely Swanscombe Heritage Park and Swanscombe Peninsula). Areas of the KTGG that were considered unique to Kent Thameside or that provided rare ecosystem services were also sought through the interviews. Those which were most frequently mentioned were Swanscombe Heritage Park and North Kent Marshes (23% and 12% respectively). Other parts of the KTGG that were frequently used as examples were marsh areas in general and the River Thames / riverfront areas. When asked which of the ecosystem services each interviewee identified was the most important service / the service that would be missed the most if it was no longer provided, very mixed responses were obtained. In general, it was felt that they were all as important as each other and that the range of services provided was a key benefit of the KTGG. Some respondents did specify which services they felt were most important, but acknowledged that this reflected their organisation's priorities.

The final typology developed for the KTGG is shown in Figure 2 below, showing the wide range of services potentially provided by the green grid network, identified through network analysis and stakeholder engagement. Further details and examples can be seen in the Typology Report.

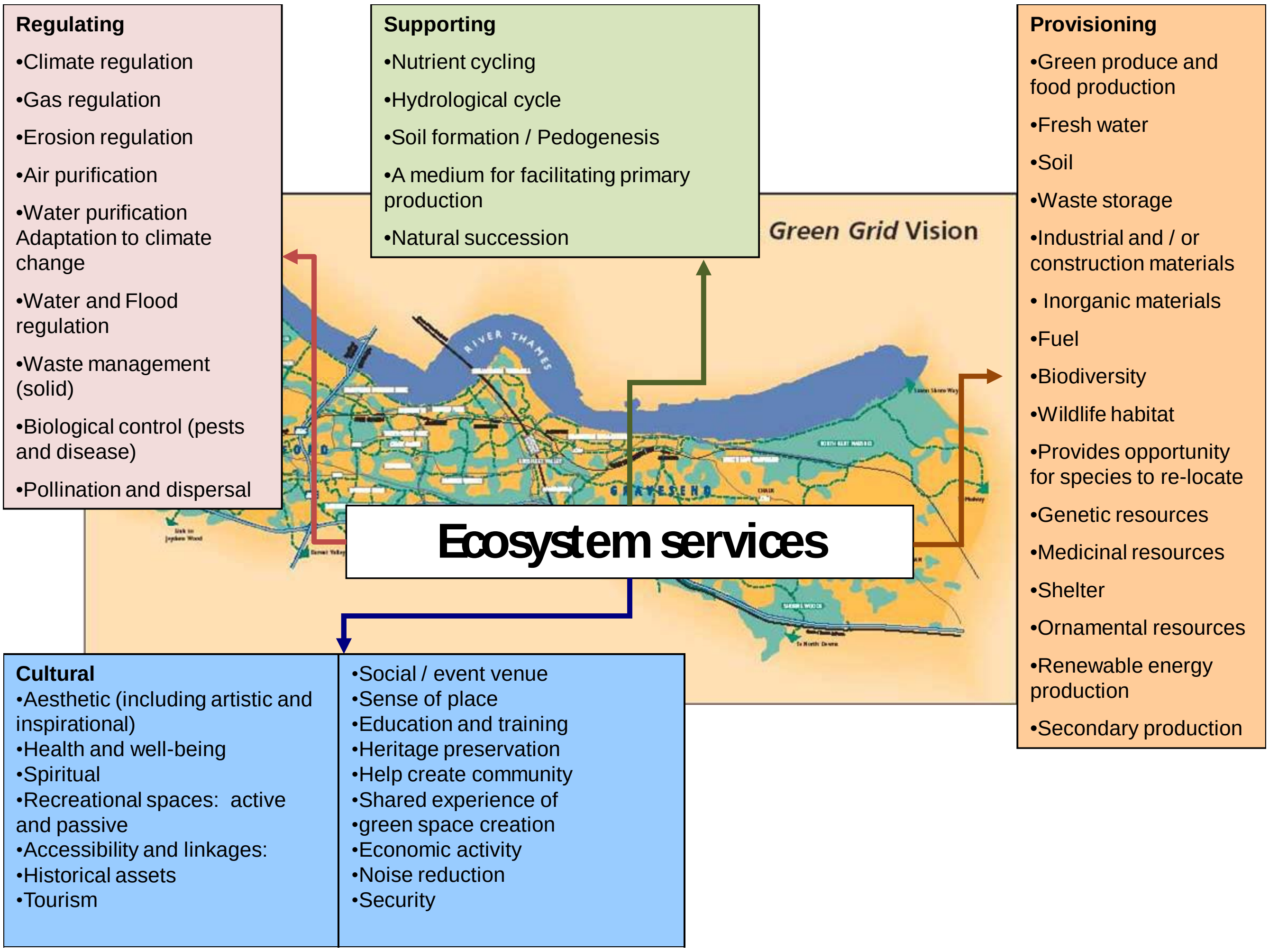

Figure 2: Ecosystem services of Kent Thameside Green Grid

3. Pilot study - Dartford Marshes

The original intention had been to develop generic GIS and network analysis models and test those with a pilot study. In practice it was found that the generic models (especially for the workshop) needed to be more spatially specific to engage with the stakeholders and so the generic and pilot modelling was combined, using Dartford Marshes as the example.

For the pilot study the first step was to develop network analysis models of ecosystem services, using the typology developed earlier, for the following situations and management options:

- Ecosystem services currently provided by Dartford Marshes
- Ecosystem services affected by 'The Bridge' housing development
- Ecosystem services affected by maximising flood risk management
- Ecosystem services affected by maximising biodiversity
- Ecosystem services affected by maximising access and recreation

Potential ecosystem services currently provided by Dartford Marshes were identified based on current land uses and land cover. In constructing the diagrams, open space categories based on Planning Policy Guidance Note (PPG) 17 were used to classify spaces. From the use of these spaces, potential ecosystem services were identified. The Green Grid Report (2006) produced by Kent Thameside also provides a listing of green spaces and green infrastructure, but the categories used in PPG 17 are more widely used in planning.

Another category that could have been used in preparing the diagrams is habitat types, for which there is some available data. It was felt, however, that a land use and land cover categorisation would be better for identifying ecosystem services because the ecosystem services approach being evaluated in this research relates to land use planning frameworks, which use land use categories. Also, habitat and land cover data may not include certain urban land uses, such as brownfield sites, which were a major feature in the pilot study area.

The impacts on ecosystem services due to 'The Bridge' housing development were based on potential impacts during construction and operation. The network analysis model for maximising flood risk management explored the impacts on the provision of ecosystem services as a result of periodic inundation, limited maintenance of defences and using water bodies for flood storage. The network model for maximising biodiversity showed potential impacts of creating, restoring and managing habitats on ecosystem services provided. Similarly, the network model on maximising access and recreation traced potential impacts on ecosystem services provided and identified where increasing access might conflict with another service, such as biodiversity. In all the diagrams, direct, indirect and cumulative impacts (whether positive or negative), the ecosystem service affected by the policy options and the impact of one ecosystem service on another ecosystem service were indicated.

In identifying potential impacts (e.g. increased tidal flood storage capacity may impact on freshwater biodiversity, or increased woodland may result in increased predation of ground nesting marsh birds by raptors (hawks)), research on previous studies was undertaken to find out what impacts resulted from particular actions. For example, in determining the likely impacts of periodic inundation, studies on the effects of inundation in the Essex saltmarshes were examined. To complement the diagrams, GIS maps were prepared to indicate a spatial representation of the current situation, the effects of housing development, and the impacts of the management options.

The network analysis models were based on *land use and land cover* categories. However, the available mapping datasets were based on land cover types. It was necessary therefore to refine the categories in the GIS maps to reflect both land use and land cover categories. The GIS mapping brought together initial datasets that were available for the various topic areas. While by no means a complete list of the datasets potentially available for each topic, the maps contained the major datasets required in order to identify the ecosystem services offered and also to help explore the different management options outlined above. This issue of combining datasets in order to represent ecosystem service provision spatially provides a significant challenge which had to be addressed in the subsequent geographical studies (below).

A Stakeholder Workshop was conducted on the 2nd July 2007. The aim of the workshop was to help focus the research on relevant policy and priority issues and areas within Kent Thameside's Green Grid. The specific objectives of the workshop were:

- to raise awareness amongst stakeholders of the ecosystem services approach generally, and the research project in particular;
- to explore the ecosystem services currently provided by the Kent Thameside Green Grid and the aspirations for the services it could provide in the future;
- to develop a shared understanding about the challenges and issues facing Kent Thameside and the delivery of the Green Grid in particular;
- to explore the potential value within existing planning frameworks of the range of decision support tools being used as part of the research (i.e. network analysis, STELLA modelling and GIS);
- to share ideas on the options for scenarios and case studies to focus on as part of the research; and
- to establish an ongoing stakeholder forum for engaging with the research.

The findings from the workshop are set out in the Report on the Stakeholder Workshop.

The agenda for the workshop included introductory presentations to the Kent Thameside area, the research project and Dartford Marshes, which was to be used as the illustrative example throughout the afternoon. The rest of the workshop was divided into two main sessions:

Session 1: Analysis of future options using Dartford Marshes as an illustrative case study
Session 2: Identification of wider issues across the whole of Kent Thameside.

The objective of Session 1 was to:

- investigate and prioritise the possible effects of different hypothetical management options on the provision of ecosystem services at Dartford Marsh.

The current situation and ongoing housing development at The Bridge adjacent to the Dartford Marshes were initially considered followed by three management options:

- maximising flood management capacity
- maximising biodiversity
- maximising access and recreation.

Initially participants, drawn from previous stakeholder interviews and also from the Kent Thameside region more widely, were introduced to the decision support tools, specifically network diagrams and GIS maps. Examples already prepared were used to illustrate how they can be used to investigate ecosystem services affected by development at Dartford Marsh. Participants were asked:

- *what are the ecosystem services currently provided by Dartford Marshes?*

- *how could these change following housing development?*

The participants were then asked to annotate the network diagrams to reflect their discussions. The second part of Session 1 sought participants' views on how ecosystem services provided may change under the three management options. Participants were provided with GIS maps and network diagrams illustrating the changes each management system would have on the marshes and were asked:

- *what changes in ecosystem service provisioning would occur under the hypothetical management option?*

In the light of the above, participants were asked to annotate the network diagrams to reflect their discussions, an example of which is provided in Figure 3. The comments/amendments indicate the additions or changes stakeholders suggested to the understanding of the relationship between ecosystem services described by the diagrams under the option considered. Sessions 2 sought their views on wider influences across Kent Thameside.

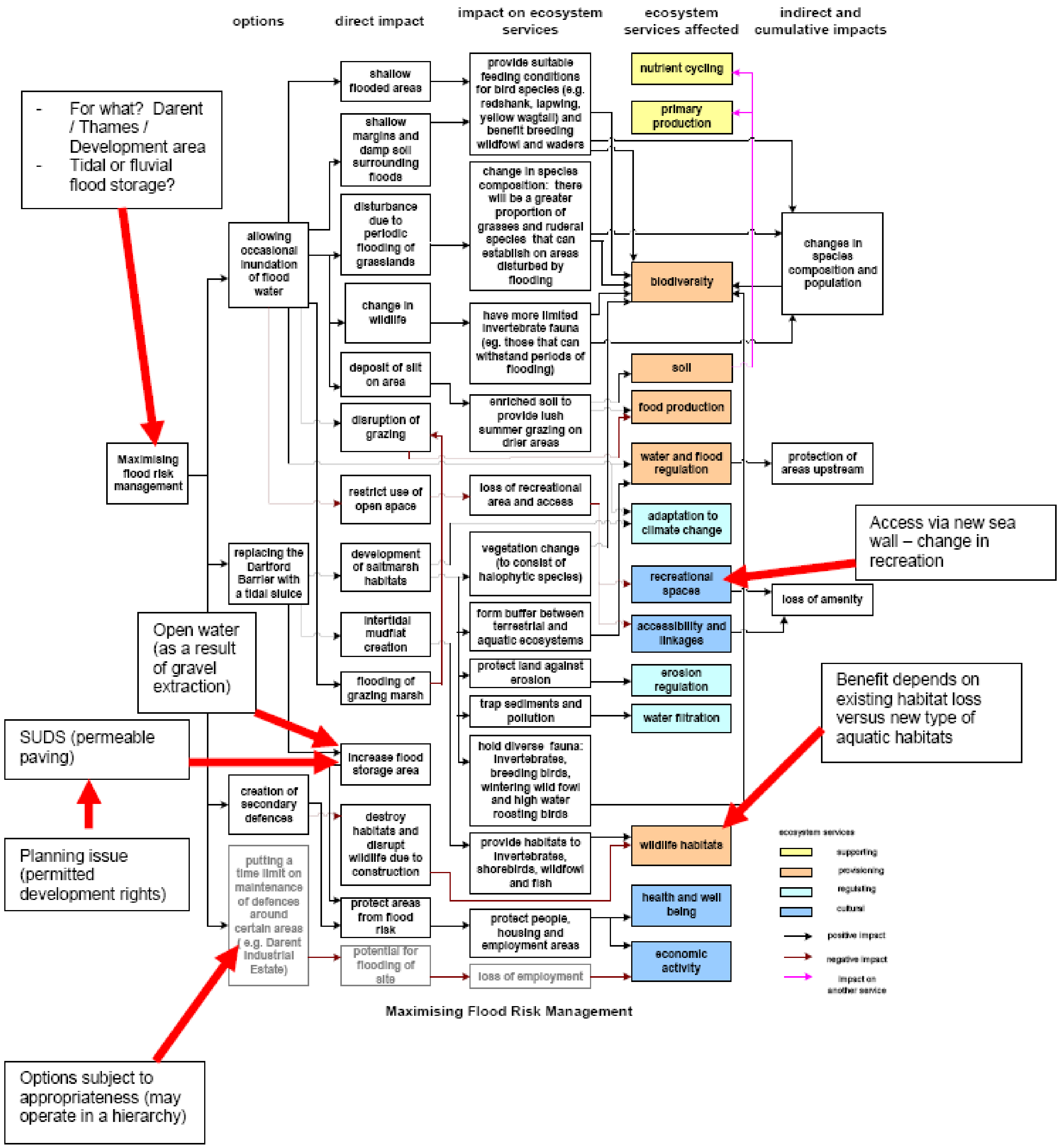

Figure 3: Stakeholder comments on flood risk management network analysis model

Some important conclusions were drawn from the pilot study that informed the selection of further study areas:

i) There was a mismatch between existing GIS data and the land use / land cover categories used in the network diagrams; for the purposes of the pilot the map categories were matched as close as possible to the diagram categories. In the later study areas, this issue would need to be addressed by use of additional spatial data and data analysis to get the best fit to the land use / land cover categories;
ii) The ecosystem services typology developed earlier in this research (Typology Report) proved helpful in the preparation of the network diagrams;
iii) The combined use of network analysis and GIS proved effective in communicating the concept of ecosystem services at the workshop, where participants were able to provide feedback and ideas. The network diagrams were also useful in exploring ecosystem services in Dartford Marshes and tracing potential impacts (direct, indirect and cumulative) as well as impact relationships under different management scenarios. GIS provided the spatial representation and some quantification which provided an additional dimension in putting across the concept of ecosystem services;
iv) Dartford Marshes proved to be an appropriate choice for a pilot study because it was of manageable scale, there were existing data that were useful and development/management proposals that could be explored in terms of their effects on ecosystem services provision; and
v) The pilot study allowed the investigation of a variety of ecosystem services and key issues particularly relevant to the Thames Gateway – such as flood risk and development pressure.

3.1 Selection of geographical studies

Following the workshop, the feedback from the stakeholders was used to inform the selection of further study areas. These sub-case studies, considering different aspects/geographical levels, were used to explore the ecosystem service functions of green grid and to adapt, apply and test the applicability of the modelling approaches to different levels and services. STELLA modelling - a graphical interface model using inputs and outputs to simulate relationships between ecosystem services - was explored, along with network analysis and GIS, during the pilot study, but found to be of limited use in the context of ecosystem services, largely because it required data which often was not available, and appeared more suitable to specific local situations where data might be available (e.g. through monitoring of a specific nature reserve or Site of Special Scientific Interest (SSSI)) (see separate STELLA report). The following criteria were used to select potential case studies:

- Data availability;
- Case studies at different scales (ideally one case study at the Kent Thameside level and one at the local level);
- Case studies including a range of different ecosystem services;
- Case studies incorporating some of the key issues facing the area, such as flood risk, development pressure and delivering a multifunctional Green Grid;
- Opportunities to explore the fears and aspirations raised during the workshop;
- Opportunities to apply different tools, including GIS, network analysis and STELLA modelling; and
- Opportunities to consider existing planning frameworks, such as Sustainability Appraisal and developing a strategy for the future of the Green Grid.

Two geographical scales were then selected to provide a combination of locations that best met these criteria:

- Kent Thameside Green Grid as a whole - a strategic study - and delivering/operationalising the multifunctional vision;
- A local study area (to be negotiated), such as Dartford Marsh, Darenth Wood, or Swanscombe Peninsular and the options for future use/management within the Green Grid network. This local area proved quite difficult to negotiate; eventually an area close to the Ebbsfleet International Station was selected. Swanscombe Peninsula was not possible due to its current sensitivity during the development of a new masterplan.

3.2 Key findings from the pilot study

1. **Land use classifications from PPG 17 can be used as the starting point for categorising land use/land cover types in the area. The ecosystem services typology developed through stakeholder engagement (interviews/workshop) can then be matched to those land use/land cover types using network analysis.**

2. **Using a land use/land cover classification is useful because data is already available in this form and is more useful than habitat types as has wider resonance with planners.**

3. **Network Analysis and GIS are useful tools as part of an ecosystems approach, enabling the definition and spatial mapping of ecosystem services.**

4. **Stakeholder consultation is an essential component in identifying the ecosystem services that are provided by an area and helps to highlight key issues that might otherwise be overlooked.**

5. **A wide range of stakeholders, drawn from various organisations, including NGOs, government agencies and local authorities, either already had or were able to develop a good understanding of the ecosystem services concept and the associated terminology and recognised its usefulness in identifying priority issues.**

6. **Network analysis, combined with GIS mapping, provides a practical way to engage with such stakeholders about the type and nature of ecosystem services in the area.**

4. Strategic Study – Kent Thameside Green Grid

The aim of the strategic study was to explore how ecosystem services may help support the development of the strategy for the Kent Thameside Green Grid and other planning frameworks.
The objectives of the study were:
- To evaluate the use of network analysis and GIS modelling in understanding the ecosystem services provided by the Green Grid and the relationships between them;
- To test the ability of the environmental datasets to categorise the land use / land cover types identified and describe the appropriate level of 'ecosystem service' (see Annex 1 for the list of those datasets used);
- To evaluate the relationships, or in-combination elements, evident within the network analysis diagrams, and illustrate these within the GIS environment.

To achieve the above objectives, the overall approach adopted for the Kent Thameside study consisted of the following steps (note some steps were undertaken sequentially and others in parallel):
- Establish current baseline conditions, environmental and policy context for Kent Thameside and the Green Grid;
- Define units of analysis for identifying ecosystem services;
- Identify various scenarios for analysis;
- Construct network analysis models;
- Undertake mapping and analysis of land use / land cover types and ecosystem services of KTGG; and
- Identify and develop recommendations for Green Grid strategy development and other planning frameworks.

The first two steps were carried out simultaneously. A study of baseline conditions was undertaken at the same time as the GIS data identification and collation.

In order to identify potential ecosystem services that the KTGG provides, the units of analysis for this exercise were defined. The ecosystems approach is a way in which the overall health or integrity of ecosystems can be assessed and the multiple benefits derived from them - i.e. the goods and services - described and managed. To operationalise this concept, it is necessary to understand the spatial context or ecosystems that are providing goods or services. Haines-Young et al (2006) proposed two approaches or perspectives in defining ecosystems[2]:
- Habitats focus
- Ecosystem services focus

In the habitats focus, habitats are used as distinct ecological units that provide goods and services. The Defra project on the Status and Trends in England's Ecosystem Services considered the use of habitats (Biodiversity Action Plan (BAP) Broad and Priority Habitats) as service providing units and explored the association between habitats and services in a matrix format[3]. English Nature also used a habitat approach in carrying out a preliminary assessment of ecosystem services provided by three habitat types: broad-leaved woodland, inter-tidal zone and freshwater wetland[4]. In the ecosystem services focus, the attention shifts to the particular goods and services. The focus in this approach is to identify the functional units that are needed to understand the processes from which these services are provided. These units, however, are likely to vary for each service and may be at varying geographical scales. Also, by concentrating on particular services, the relationships or linkages between services may not be fully appreciated. In terms of the ecosystem services focus, this research uses the Kent Thameside Green Grid as the spatial context and it would be more useful to understand the ecosystem services provided by the Green Grid elements rather than focusing on the services themselves.

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[2] Haines-Young, R., Potschin, M. and Somper, C. (2006). *The Ecosystem Concept and the Identification of Ecosystem Goods and Services in the English Policy Context*. Draft Review Paper to Defra, Project Code NR0107.
[3] Haines-Young, R. and Potschin, M. (2007). *Status and trends in England's ecosystem services*. Paper presented at the Defra Workshop on Evidence needs for an ecosystems approach on 7 September 2007.
[4] English Nature (2006). *England's Ecosystem Services. A preliminary assessment of three habitat types; broad-leaved woodland, the inter-tidal zone and fresh-water wetlands*. English Nature Research Report No. 701.

Thus, in defining the units of analysis, the following were considered:

- How the units of analysis can help understand how an ecosystems approach can be relevant to land use planning;
- Units of analysis selected should reflect ecosystems or elements found in the KTGG; and
- These units can be applied in open spaces strategy and land use planning.

The aim was to investigate units that would be useful in land use planning, classification systems, that are familiar to planners and which are currently employed in planning open spaces. Two ways of categorising open spaces are shown in Table 1 which are a mix of land use and land cover categories. Planning and Policy Guidance Note (PPG) 17 provides categories which cover the broad range of open spaces that might be of value. The Green Grid Report (2006)[5] produced by Kent Thameside provides a list of green spaces or green infrastructure. This closely follows the green infrastructure classification produced by the Greening the Gateway Partnership[6]. Green infrastructure[7] is defined as a functional network of green spaces, green links and riverside spaces that can provide many benefits to the communities.

Based on the categories in Table 1 and the Green Grid elements in Kent Thameside, a land use/land cover classification system was developed and potential services provided by these units were identified. A network analysis model showing the category of open spaces/green infrastructure is presented in Figure 4 below. This broad classification covers a combination of habitat types which provide particular services and the relationships between services were explored in the network analysis.

The categories in Table 1 were easily adapted to the Kent Thameside Green Grid classification and the construction of the network diagrams illustrating the ecosystem services provided by the Green Grid. However, in applying the classification in GIS, adjustments had to be made because of the types of data available in GIS format – see Figure 5 and 6 below. These issues will be discussed in a later section on the application of GIS, but first, the various Green Grid scenarios are discussed in the following section.

Table 1: Open space categories used for network analysis and GIS

<table>
<tr><th colspan="2">Open Space Categories</th></tr>
<tr><th>PPG 17[8]</th><th>Green Grid/Green Infrastructure</th></tr>
<tr><td>
• parks and gardens – including urban parks, country parks and formal gardens
• natural and semi-natural urban greenspaces – including woodlands, urban forest, scrub, grassland, wetlands, open and running water, wastelands, derelict open land and rock areas (cliffs, quarries and pits)
• green corridors – including river and canal banks, cycleways and rights of way
• outdoor facilities – tennis courts, bowling greens, sports pitches, golf courses, athletic tracts, school and other institutional playing fields and other outdoor sports areas
• amenity green space – informal recreation space, greenspaces in and around housing, domestic gardens and village greens
• provision for children and teenagers – play areas, skateboard parks, outdoor basketball hoops and other more informal areas
• allotments, community gardens and city (urban farms)
• cemeteries and churchyards
• accessible countryside in urban fringe areas
• civic spaces, including civic and market squares and other hard surfaced areas designed for pedestrians
</td><td>
• wide range of public and private green space including parks
• nature reserves – including marshlands, grasslands, intertidal mudflats and heathlands
• woodlands
• coasts and rivers and river frontages
• landscape planting
• amenity areas - including small neighbourhood green spaces
• sports grounds and play areas
• cemeteries and churchyards
• road verges
• allotments
• private gardens
• brownfield sites
</td></tr>
</table>

[5] Kent Thameside (2006). *The Green Grid: Conserving and enhancing our natural heritage.*
[6] Greening the Gateway Partnership (2005). *A summary of the Valuing the Gateway's Greenspace Seminar held at the Thames Gateway Forum*, 23rd November 2005.
[7] ODPM (2003) *Greening the Gateway Strategy*.
[8] Planning Policy Guidance (PPG) 17: *Planning for Open Space and Recreation*.

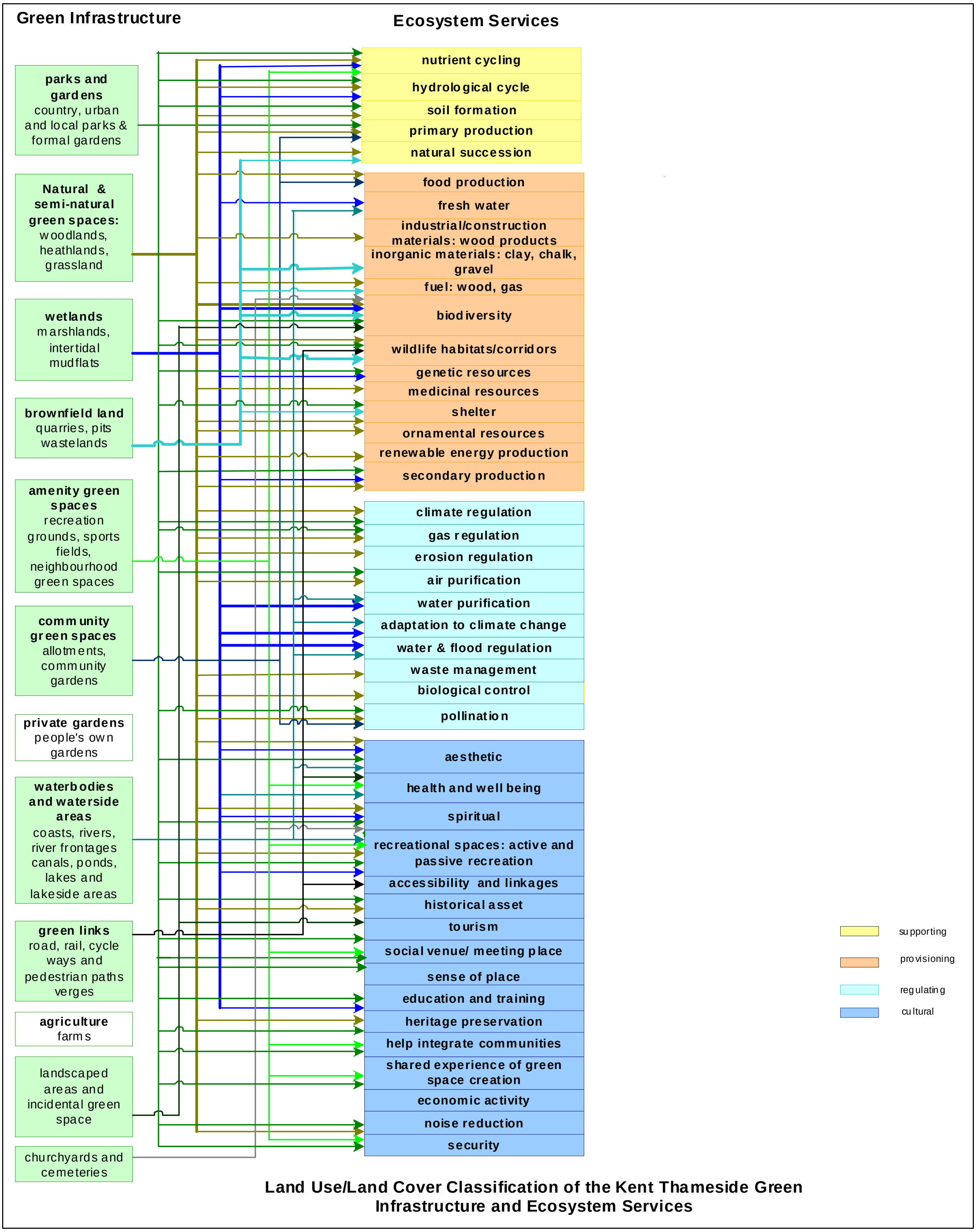


Figure 4: Kent Thameside green infrastructure and ecosystem services provision

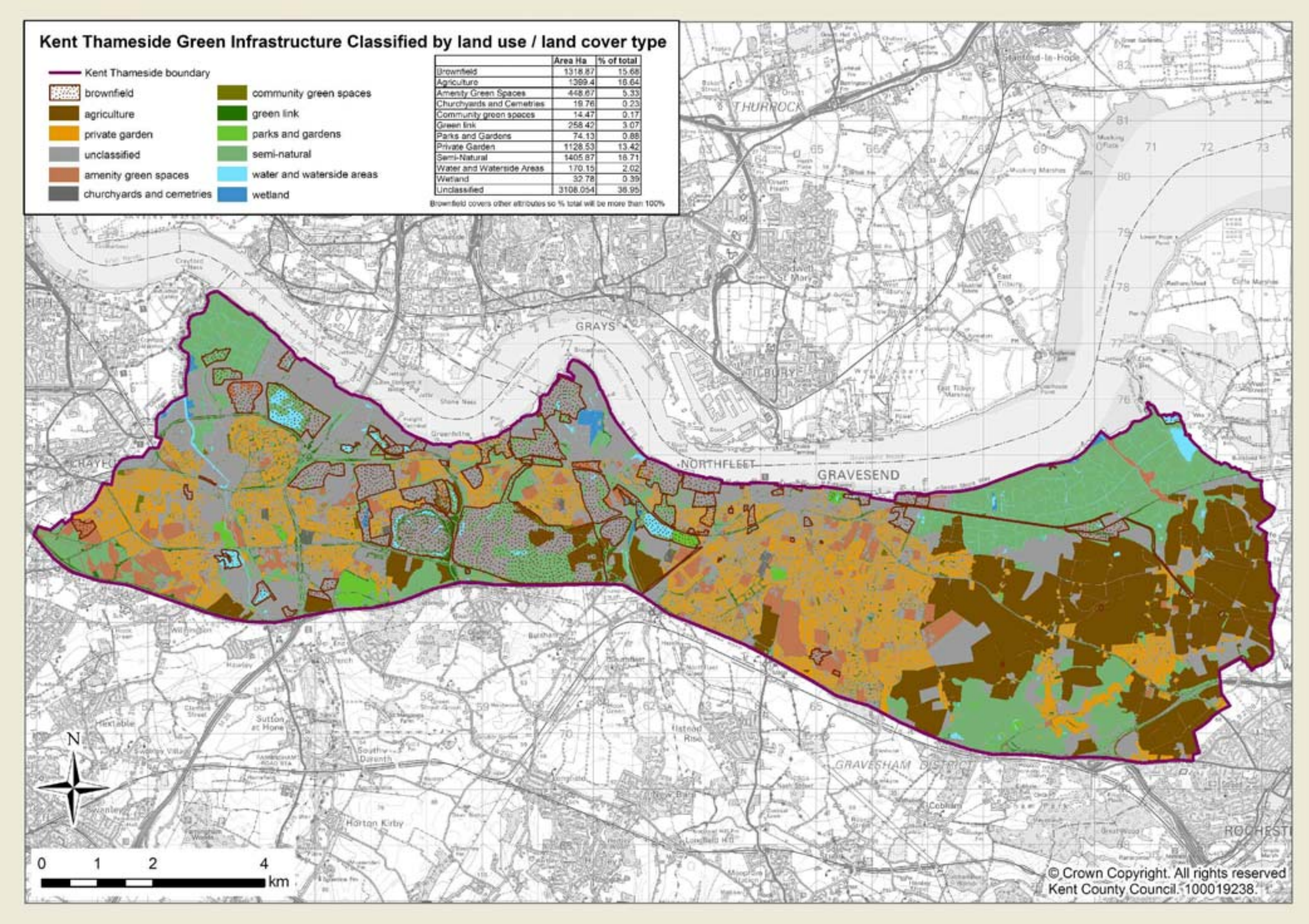


Figure 5: Land use/land cover (green infrastructure) classes

4.1 Identifying Green Grid scenarios

The aim of this study was to explore how ecosystem services may help the development of the strategy for the Kent Thameside Green Grid, as well as other planning frameworks. To fulfil this aim, the project team looked at how the Green Grid strategy was developed and how the ecosystems approach can fit into this process. One way is to use scenario analysis. Scenario analysis is a research tool that has been used widely in planning, environmental and social research.

Three Green Grid scenarios were therefore selected in which to explore ecosystem services. These scenarios represented the current situation of the Green Grid, the Green Grid as described by the "Vision" proposed by Kent Thameside and finally, what a vision of the Green Grid might look like if it sought to maximise ecosystem service provision (as envisioned by the research team).

4.1.1 Current Green Grid

Currently the Green Grid of the Kent Thameside area consists largely of pockets of generally disconnected green spaces that provide a relatively limited range of ecosystem services (see Figure 6 below). The ODPM (2004)[9] provides a loose definition of what green grids are for:

> *"to connect communities to a comprehensive network of existing and new green spaces and to link these to the river frontage. In addition, Green Grid pays particular attention to the practical environmental, economic and social benefits which both urban and rural greenspace can deliver, and it serves to champion the need for increased landscape integrity to all its supporting partners".*

This definition lacks robustness and is open to interpretation, resulting in a lack of detailed strategy and prescriptive policies that has given developers flexibility to provide green spaces that do not necessarily form a coherent system of linked spaces and do not provide the range of multifunctional activities (or ecosystem services) that are possible. What has been provided is often not utilised to its full potential, and thus may be undervalued by the local people as well as policy makers and other interested groups. In some instances what currently exist as green spaces do not link up, undermining a number of "use" based services. In other instances, the Green Grid links may be roads through housing developments with limited "green" credentials.

[9] ODPM (2004) Creating Sustainable Communities: Greening the Gateway

No single GIS layer existed for the current Green grid, until now. Figure 6 and Figure 7 provide composite maps based on a number of published versions by Kent Thameside and information obtained from the Green Grid Programme Manager at Kent Thameside. Figure 6 was constructed using a GIS map provided by the Programme Manager, which had the most up to date information about areas of green grid already existing in Kent Thameside. This information was combined with a map taken from a promotional document published in 2007 called Explore the Green Grid[10]. There were some disparities between the two maps, which is represented on Figure 6 below (and see Kent Thameside report, Appendix 3 for high resolution version) by the different coloured hatching.

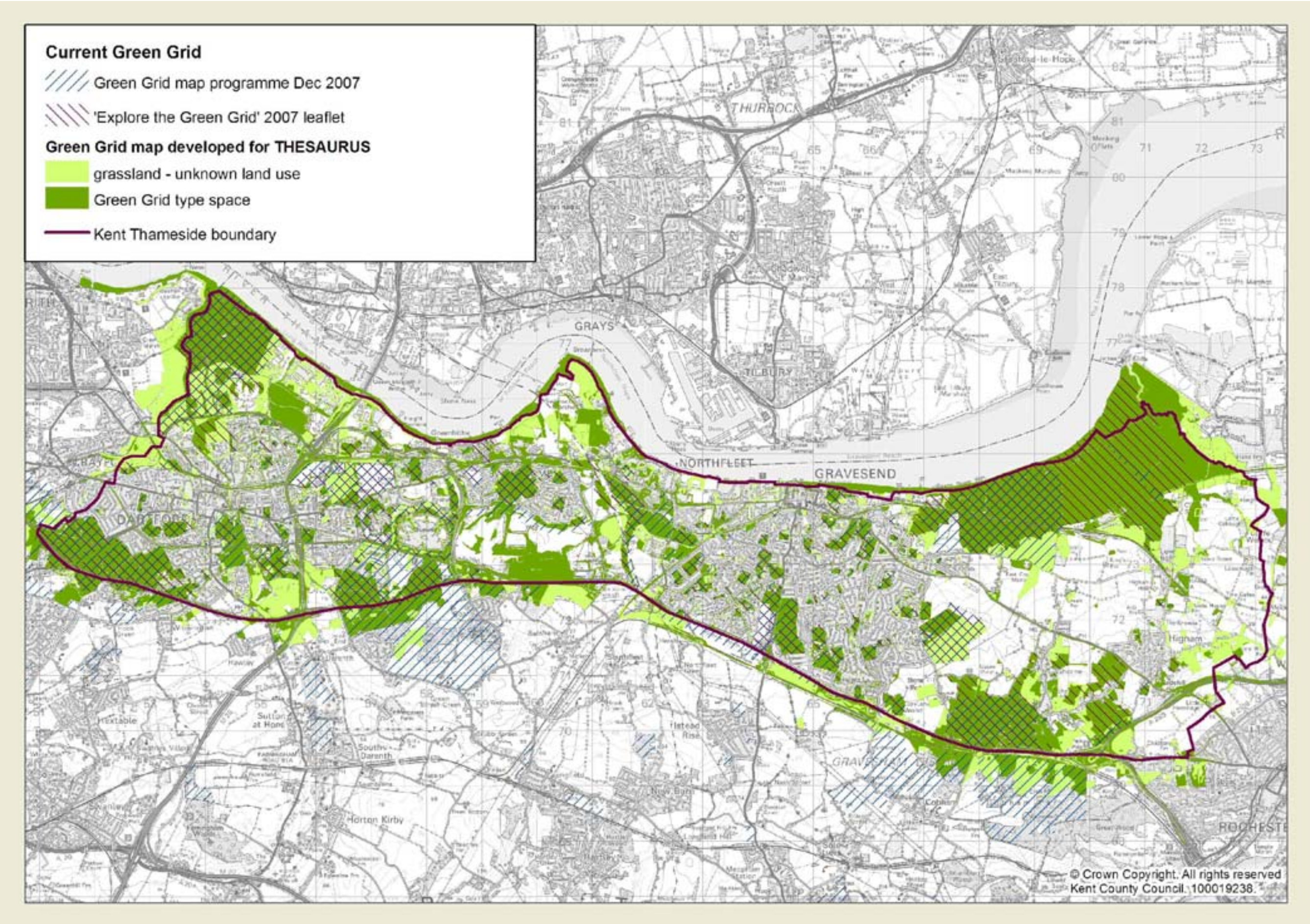


Figure 6: Current Green Grid

4.1.2 Green Grid "Vision"

The Green Grid "Vision" is described in the Kent Thameside document, "The Green Grid – Conserving and Enhancing Our Natural Heritage"[11] (see Figure 7 below). Figure 7 was constructed by overlaying the improved strategic links (based on existing landscape features) of the "Vision" on top of the map of the current green grid. The major strategic links demonstrate what Green Grid should exist and delineate where new development of the Grid can occur. The range and scale of the Green Grid contained in the vision is impressive, but unfortunately does not fit well with the reality of what exists on the ground or at the moment seems likely to exist in the future. Within the current green grid programme defining the green grid vision is still under discussion with local authorities. A data layer called 'Proposed local parks in deficient areas' represents part of the design scheme (Design Strategy Framework Plan, 2004). When comparing this data layer with other GIS data layers, it appears this vision is out of date in places as green spaces exist at or very near to some of the proposed park locations. Within large brownfield sites destined for development, there are several proposed local parks, the location of which is more likely to be guided by the developers than the KTGG recommendations. Other proposed parks are in dense housing areas, where there is likely to be a need for more green space. Recent site developments and site allocations have not been restricted by the Green Grid vision, and have actually prevented the realisation of a number of strategic links. Where links have been provided as set out in the vision, they are often of a poor quality with limited green characteristics. For example, the major strategic link "Eastern Quarry Central" is apparent in the Ebbsfleet Valley Masterplan as prepared by Land Securities. This major strategic link is a paved road lined with trees, which satisfies the loose definition of Green Grid, but does little to meet the multifunctional aspirations

[10] Kent Thameside (2007) *Explore the Green Grid* http://www.greengrid.org.uk/images/Publications/Explor%20the%20Green%20grid%20map%20FINAL%20high%20res.pdf
[11] Kent Thameside (2006) *The Green Grid – Conserving and Enhancing Our Natural Heritage* http://www.greengrid.org.uk/images/Publications/green_grid_%20Framework%20document.pdf

behind the concept. It also appears that the spatial representation of this "Vision" seems to have been developed principally based on recreation and access, and landscape, rather than to maximise the multifunctionality of the Green Grid. For the purposes of the research project, to operationalise this concept of maximising multifunctionality, an alternative vision for the Green Grid has been explored, a vision that allies itself with the definition of Green Infrastructure as provided by the TCPA[12]:

> *"a sub-regional network of protected sites, nature reserves, green spaces and, and greenway linkages. The linkages include river corridors and flood plains, migration routes and features of the landscape (which are important as wildlife corridors)".*

The TCPA also state that green infrastructure should provide for multifunctional uses and delivering ecological services, operating at all spatial scales from urban centres through to open countryside.

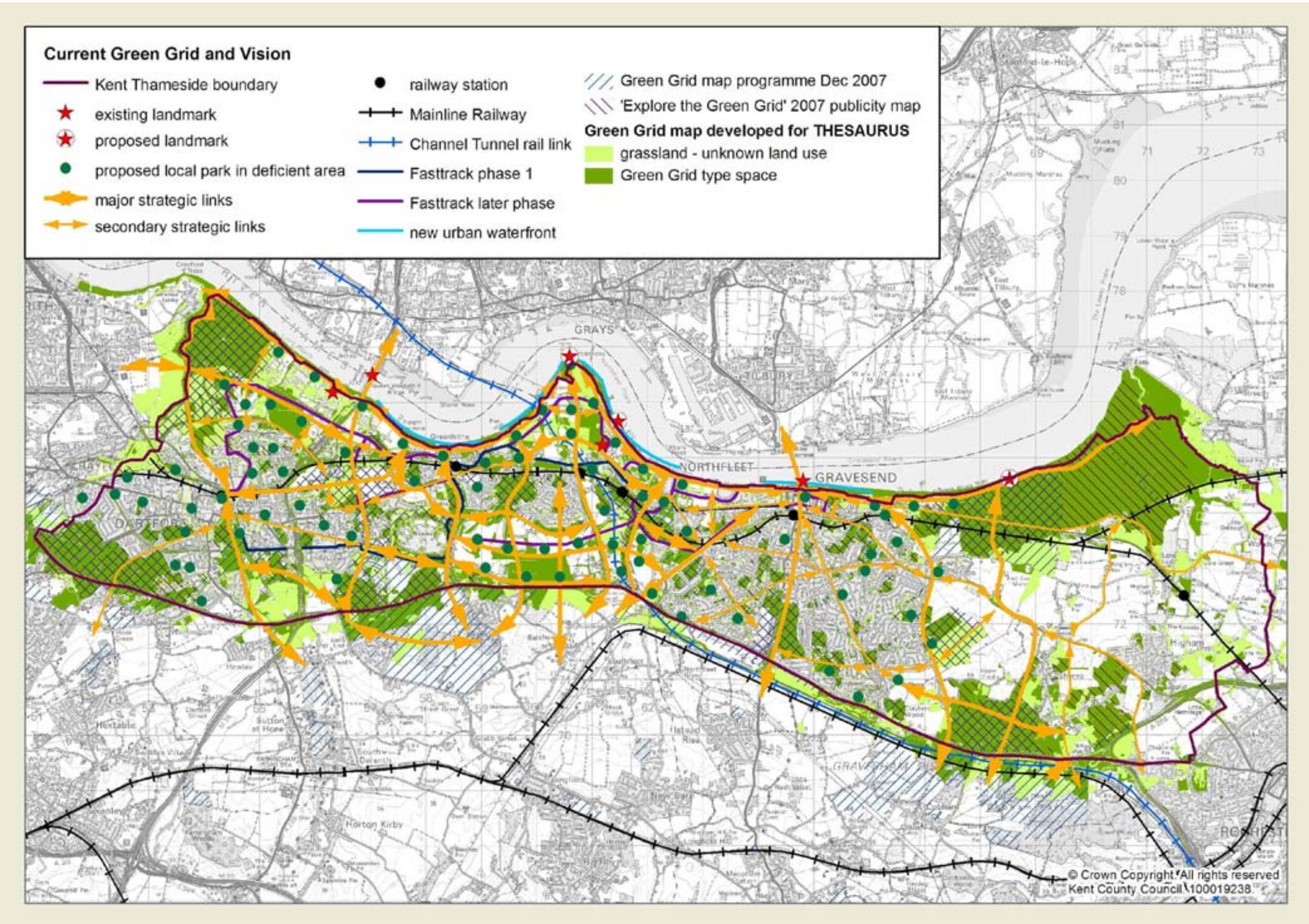


Figure 7: Green Grid Vision from Conserving and Enhancing Our Natural Heritage

4.1.3 Multifunctional Green Grid based on maximising ecosystem services

A multifunctional Green Grid is a hypothetical scenario developed for the purposes of the research project to explore how the existing vision could be built upon to maximise the ecosystem services it provides. By acknowledging the characteristics and topographical features of the area and mapping the land use/land cover classifications and ecosystem services associated with them, the aim would be to both maximise the area included within the Green Grid as well as to provide the greatest range and quantity of appropriate services for each area of Green Grid by exploring synergies between services, although it is acknowledged that some services may be mutually exclusive / potentially in conflict. For example, private gardens could not provide public access opportunities, often so central to much of the Green Grid provision. However, gardens can still provide multiple ecosystem services, e.g. biodiversity, flood storage, air quality and landscape services. A multifunctional approach to the Green Grid is therefore likely to prioritise areas able to deliver more services.

Instead of designing the Green Grid at a strategic level and then trying to accommodate the local environment to fulfil the obligations of the broad strategy, a multifunctional Green Grid would seek to design it by mapping the green infrastructure and associated ecosystem services that already exist in an area and planning the future built development around a multifunctional Green Grid (see Figure 8 below). Instead of a disjointed series

"A multifunctional Green Grid would seek to design it by mapping the green infrastructure and associated ecosystem services that already exist in an area and planning the future built development around a multifunctional Green Grid."

[12] http://www.tcpa.org.uk/biodiversitybydesign/1-1-g2.htm

of isolated green spaces which provide a limited range of ecosystem services, a coherent network of green spaces strengthened by the inter-linkages could be created.

The Green Grid strategy should:
- **i) be based on the existing characteristics and land uses of the area;**
- **ii) take account of the ecosystem services already provided;**
- **iii) maximise ecosystems services provision by extending the concept of the Green Grid to include open space areas not previously regarded as part of the Green Grid and identify additional services that could be provided by linking these spaces; and**
- **iv) manage the existing Green grid to maximise the ecosystem services already provided.**

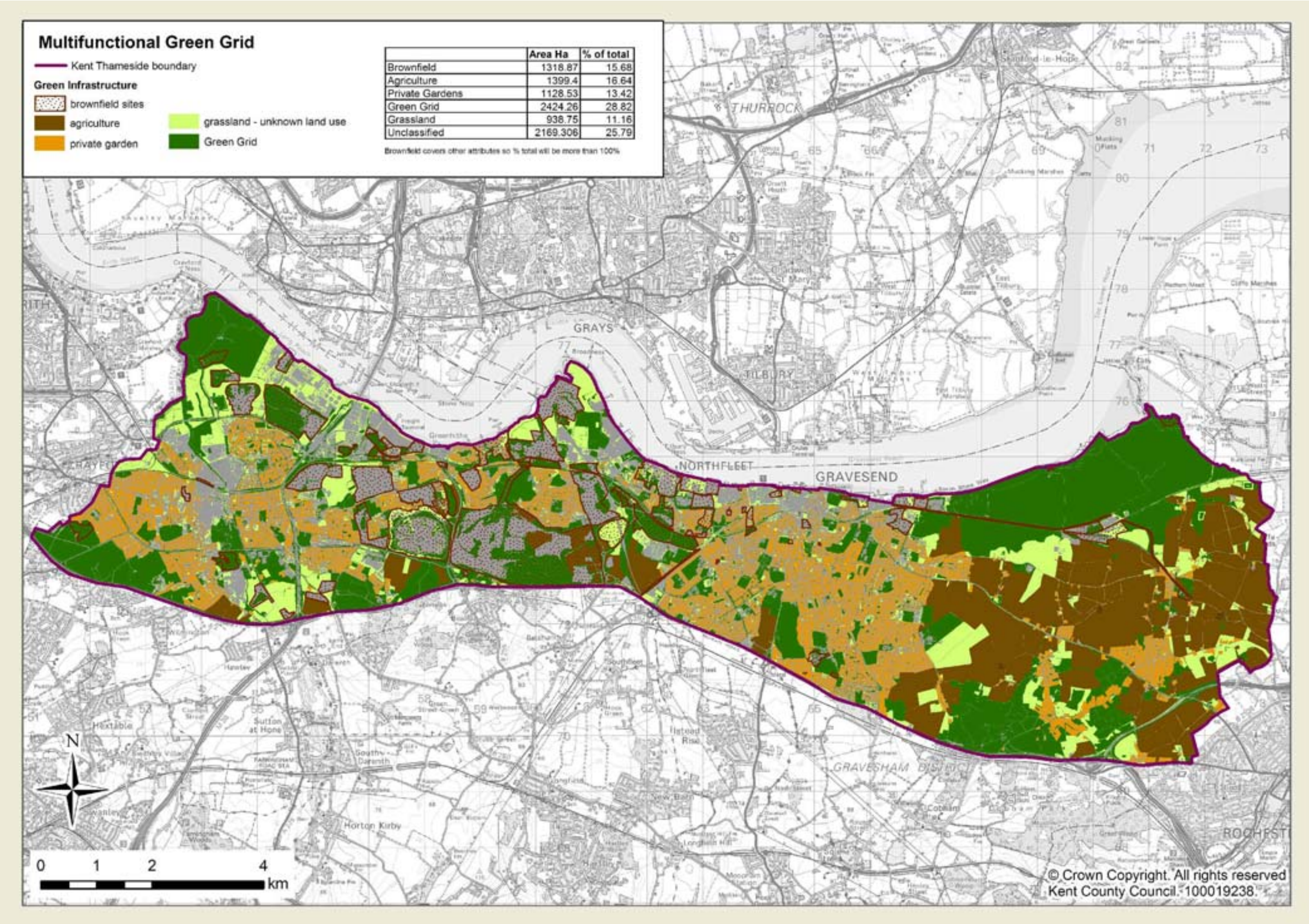


Figure 8: Existing land cover/land use as a basis for a Multifunction Green Grid

4.2 Constructing network analysis models

Based on these three scenarios, network analysis models of ecosystem services provided by the Kent Thameside Green Grid were constructed. These models used the typology of ecosystem services developed earlier in this research, which were found to be useful when tested in the pilot study. The ecosystem units employed were land use/land cover categories selected earlier to identify the ecosystem services provided by the KTGG. In identifying these services, the land use/land cover units were characterised based on the study of baseline conditions.
Network analysis models were developed for the following scenarios:
- Current Green Grid
- Green Grid Vision
- Multifunctional Green Grid based on maximising ecosystem services

For the "Current Green Grid", land use/land cover categories were based on the information provided by the Kent Thameside Green Grid Design Strategy and Guidelines (2004)[13] and the Green Grid Green Links Project, Draft Final Report (2004)[14]. In addition, site visits of Kent Thameside were undertaken. Figure 9 below (and in Appendix 1 of the Kent Thameside report) illustrates the potential ecosystem services provided by each of the

[13] Landscape Design Associates (2004). *Kent Thameside Green Grid Strategy and Guidelines*. Report prepared for Kent County Council.
[14] Land Use Consultants (2004). *Green Grid Green Links Project, Final Report*. Prepared for Kent County Council.

land use/land cover categories or green infrastructure, the effects of providing certain services on the environment and society and the benefits to people or society.

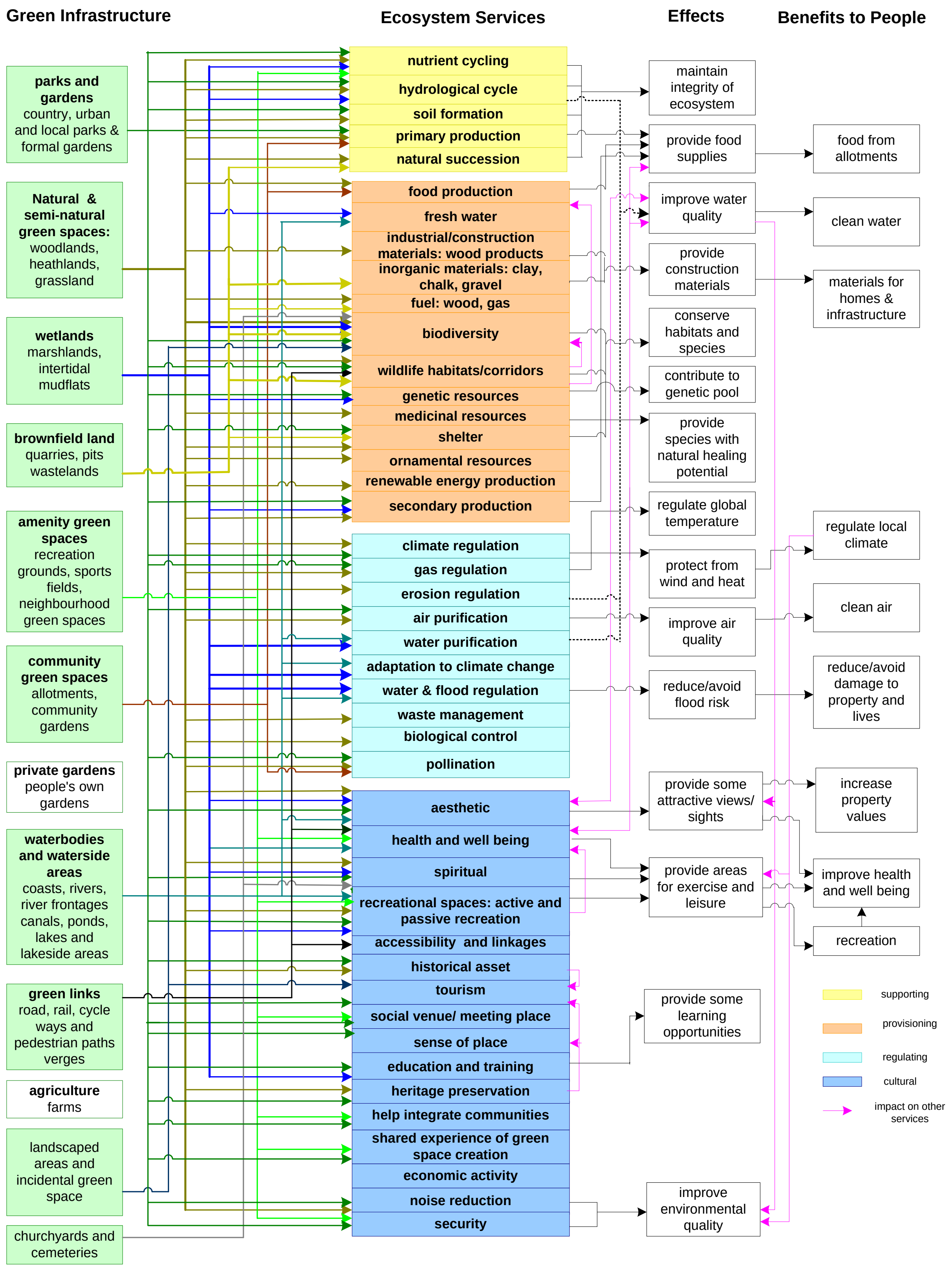


Figure 9: Ecosystem Services currently provided by the Kent Thameside Green Grid

4.3 Constructing GIS maps of ecosystem services

The network analysis models facilitated the correlation of ecosystem services with associated green infrastructure (or land use/land cover) classifications. The next step was to construct GIS maps representing the green infrastructure associated with specific ecosystem services. In order to apply such a land use /land cover classification, attribute information associated with the Ordnance Survey Master Map (OSMM)[15] were used to identify the network of green infrastructure that existed in the Kent Thameside. Data selected from OSMM were collated and relevant land use/land cover classifications applied. Additional land use information was also required to classify the MasterMap data to make it relevant to the ecosystems approach. This additional information is stored within OS MasterMap (typically the *'descriptive group'* and *'descriptive term'* attributes) and these allow one to see additional details that describe a habitat, outside the generic classification provided by Ordnance Survey. For example, an area might come under the following classification:

OSMM Theme	**= Land**
Descriptive Group	**= Natural Environment; Road**
Descriptive Term	**= Non-coniferous Trees; Scrub**

The selected and collated MasterMap data is the 'Green Infrastructure'.

4.3.1 Further processing of 'Green Infrastructure' dataset to identify Ecosystem Service provision

The next stage in determining how green infrastructure is providing ecosystem services was to:

- determine which green infrastructure features provide which ecosystem services; and
- analyse how the service provision varied between different types of green infrastructure.

The network diagram in Figure 9 shows which green infrastructure classes potentially provide each ecosystem service. These classes of green infrastructure can be selected from the main Green Infrastructure dataset as described above. There are variations in the types and amount of ecosystem service that each green area contributes, which will depend on a number of factors relevant to each ecosystem service. Examples include, distance from a river, soil type and proximity to populated areas. A table detailing the digital data that could be useful for analysing each ecosystem service is included in Appendix 2 of the Strategic Report.

This study examined a number of ecosystem services individually, including; food production; climate regulation; flood regulation; aesthetic; recreational spaces: active and passive recreation; help integrate communities; and biodiversity. However for the purpose of this report only the "recreational spaces: active and passive recreation" service are considered in detail, more information on the other services is available in the Strategic Report.

This study took the approach of using existing datasets to try to map ecosystem services and ensure that the process and use of the tools could be replicated by planners and other planning practitioners. When collating data from several different sources there was often considerable variation in the context, accuracy, scale, currency and completeness of the data sets (the metadata) in order even to be able to assess this in the first place. To overcome these issues, the OSMM maps were used as they contain all geographic features at a resolution high enough to map all green infrastructure features. 'Attribute' information associated with the OSMM spatial data were used to identify the network of green infrastructure (attribute information identifies whether features are part of the natural environment or manmade, and can give some indication of land cover). The next step of GIS processing involved applying a land use/land cover classification to selected 'attribute' data. Each land use provides a different set of ecosystem services, i.e. playing fields have a higher recreational value than agricultural land, while agricultural land has higher food production value than a verge of brownfield land. In order to add land use information and also add a further classification of broad semi-natural land cover types, the OSMM selection was combined with:

i) Open space data, to deduce further land use information
ii) Brownfield data for land use information, and
iii) Kent Landscape Information Systems (K-LIS) semi-natural 2003 data to deduce broad semi-natural land cover types, e.g. heathland, woodland and wetland.

Effectively, the method adds to the descriptive terms associated with the OSMM data. There were issues related to combining data sets of different ages with different spatial accuracy, some conflicts became apparent. These conflicts demanded that a decision on which data set takes precedence and in this study it was decided that, due to the high level of detail and the level of accuracy in identifying small green areas in an urban environment, that the OSMM data would take precedence.

[15] Ordnance Survey's OS MasterMap contains more than 450 million uniquely identified geographic features, representing real world information down to individual address and street and building level (see http://www.ordnancesurvey.co.uk/oswebsite/products/osmastermap/).

4.4 Understanding ecosystem services at the Kent Thameside level

Using the whole of the Kent Thameside as a strategic study provided an opportunity to explore a wide range of ecosystem services, which can inform strategy development of the Green Grid and other planning frameworks. Indeed, the approach presented in this study has a wider application in the context of planning the Thames Gateway Parklands and other Green Grids. This potential for wider application is due to the methods and units used in identifying ecosystem services. The methods used - network analysis and GIS - complemented each other. The network analysis method is not difficult to apply once the relationships between land uses and services they provide are understood. There is data available in GIS format which can be used in defining ecosystem services. However the quality, currency and resolution of data can limit the accuracy of the definition. The complexity of ecosystem services also provides challenges in accurately mapping ecosystem service provision. In total eight ecosystem services were mapped at this scale, in addition to combined maps and green grid scenarios (links below relate to the large file maps in the Strategic Study report available at http://www.cep.co.uk/Thesaurus.htm):-

- 1a. Food production (1) - Map_6_FoodProduction70_30_2
- 1b. Food production (2) - Map_7_FoodProduction3070
- 2. Greenness/NDVI - Map_8_NDVI_2
- 3. Greenness + Climate regulation - Map_9_NDVI+ClimateRegulation2
- 4. Flood Regulation - Map_10_FloodRegulation
- 5. Aesthetic/visual - Map_11_aesthetic2
- 6. Recreation - Map_12_Recreational_spaces2
- 7. Integration of communities - Map_13_IntegrateCommunities2
- 8a. Biodiversity (1) Map_14_biodiversity_1v2
- 8b. Biodiversity (2) Map_15_biodiversity_2v2

An example of how one ecosystem service (recreational spaces: active and passive recreation) was mapped for this study is provided below.

4.4.1 Recreational spaces: active and passive recreation

The evaluation of recreational spaces conducted in the study was based on two assumptions: firstly, that recreational spaces near centres of population will be used by more people and, therefore, have a higher value and secondly, that people can spend longer using larger recreational spaces and a wider variety of recreation options are available in larger spaces, and therefore larger areas have a higher value. Adjacent sites with a similar green infrastructure description were merged (dissolved by Green Infrastructure class) to calculate a more realistic site size. Sites over the threshold sizes of 2ha, 20ha and 100ha were scored according to the size of the population within the defined distance zone. Using area as a separate factor differentiated between sites of varying sizes, e.g. 20ha and 99ha, giving larger sizes a higher score (see Table 4.1). The 3 ANGSt standards and the area factor were given equal weighting in the analysis. For the resulting map and scoring details see Figure 10 below (and in Appendix 3 of the Strategic Report).

Table 4.1: Recreation data and processing steps

Factors affecting ES provision	Datasets to illustrate factors	GIS processing to weight green infrastructure for ES provision
adjacency to population	census data: postcode look up table (Office of National Statistics)	Using ONS census data (postcode, output area, rural/urban classification), create a population density surface (kernel density algorithm) that spreads the population out more *realistically* from the postcode centroids and which is constrained within the relevant output areas in urban locations and to a raster model of built land cover types in rural areas. Following the ANGSt requirements for greenspace provision, buffer spaces over a particular area threshold by the specified distance e.g. buffer sites over 2ha in size by 300m. Use the buffer zones to perform zonal statistics on the population cluster raster. The 'sum' statistic indicates the likely population within the specified distance band for the greenspaces. Assign score based on the population size the Green Infrastructure is in proximity to.
Area of Green Infrastructure	NA	Calculate area of Green Infrastructure. Assign scores based on Green Infrastructure size.

4.4.2 Assumptions

An issue with the first assumption (adjacency to population) is that building more housing near existing recreation spaces will, according to this assumption, increase the value of these recreation spaces. An issue with the second assumption (area of Green Infrastructure) is that recreational use of linear routes such as cycle routes and footpaths is likely to be underestimated because they have a small area. Recreational use level data would be a useful additional dataset. This method evaluates the number of people who can easily access a recreational space based on the distance they live from the space, but this analysis does not take into account ***barriers*** which might prevent or deter people from accessing a space. Railways, busy roads, rivers and water bodies are examples of potential barriers to access. As well as illustrating the potential value of a recreational space, analysing the adjacency of the population illustrates the potential pressures on recreational spaces in urban areas.

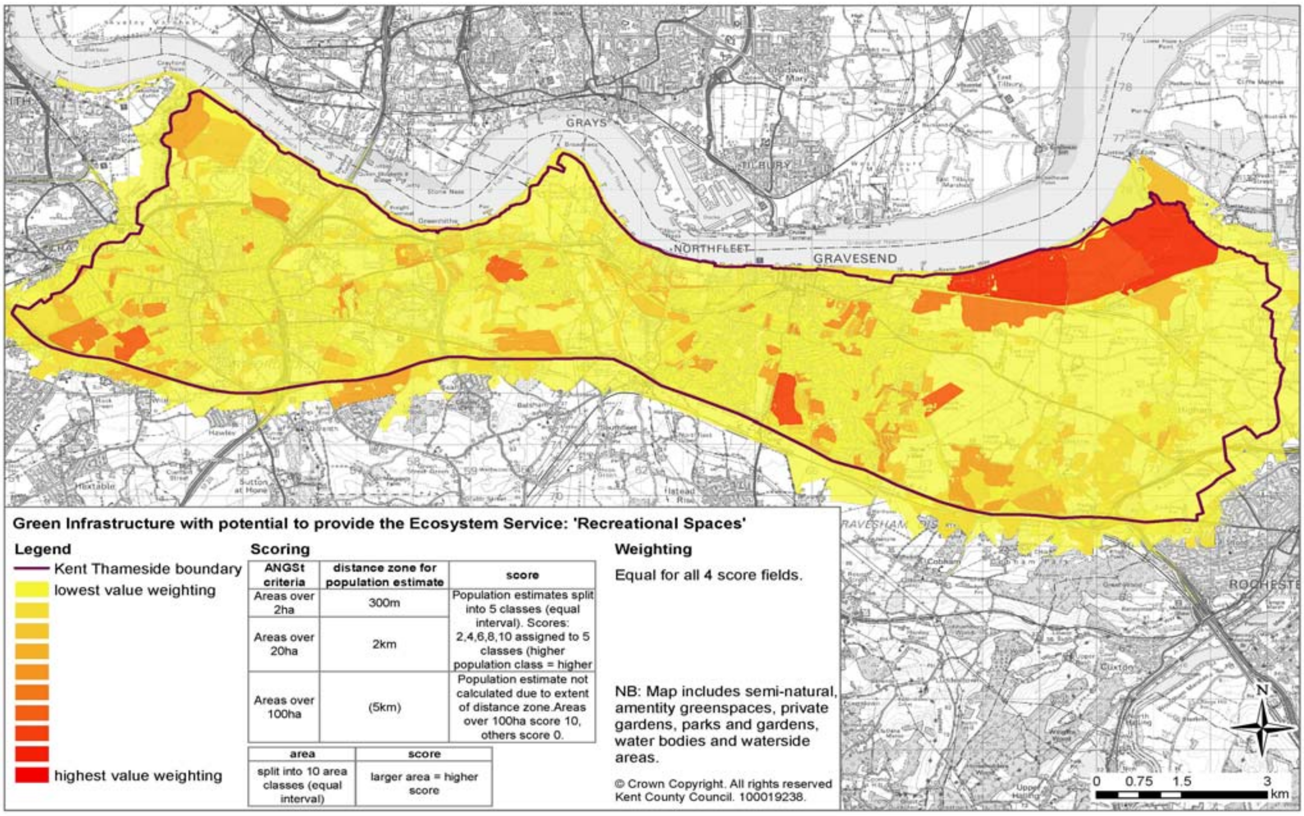


Figure 10: Recreational spaces potential in Kent Thameside

4.4.3 Combining ecosystem service maps

From the strategic study an attempt was made to combine a selection of land use/land cover data sets to produce a combined ecosystem services map for biodiversity, recreation and flood regulation. Given the complexities involved, and constraints in terms of time and resources available, this was only undertaken for a small area (Ebbsfleet) to coincide with the local study area (Figure 11). There are interesting issues involved in combining such maps since it can be argued that the assumptions used in weighting in the construction of individual maps are incommensurate with each other. Some attendees at the final project seminar felt that it was unnecessary since a combined effect could be seen simply by viewing the maps indivudally.

There were some aspects in this strategic study that could be further explored in the local study (below). For example, particular services or relationships between services and their contribution to the improvement of environmental quality could be studied in more detail. The network analysis technique could be developed further by varying the width of lines, putting in colour, annotations and animating the diagrams to highlight certain aspects. With a smaller scale local study, it would be easier to include a public involvement component. The public could help further define the nature and quality of ecosystem services provided through consultation. Scale issues in relation to data can be explored more effectively at the local level. For example by ‘ground-truthing’ datasets against aerial photography and local public engagement the real nature of a broad category such as ‘urban parkland’ can be ascertained, e.g. it may be open grassland or it may be brownfield, or combinations of many land use/land cover categories.

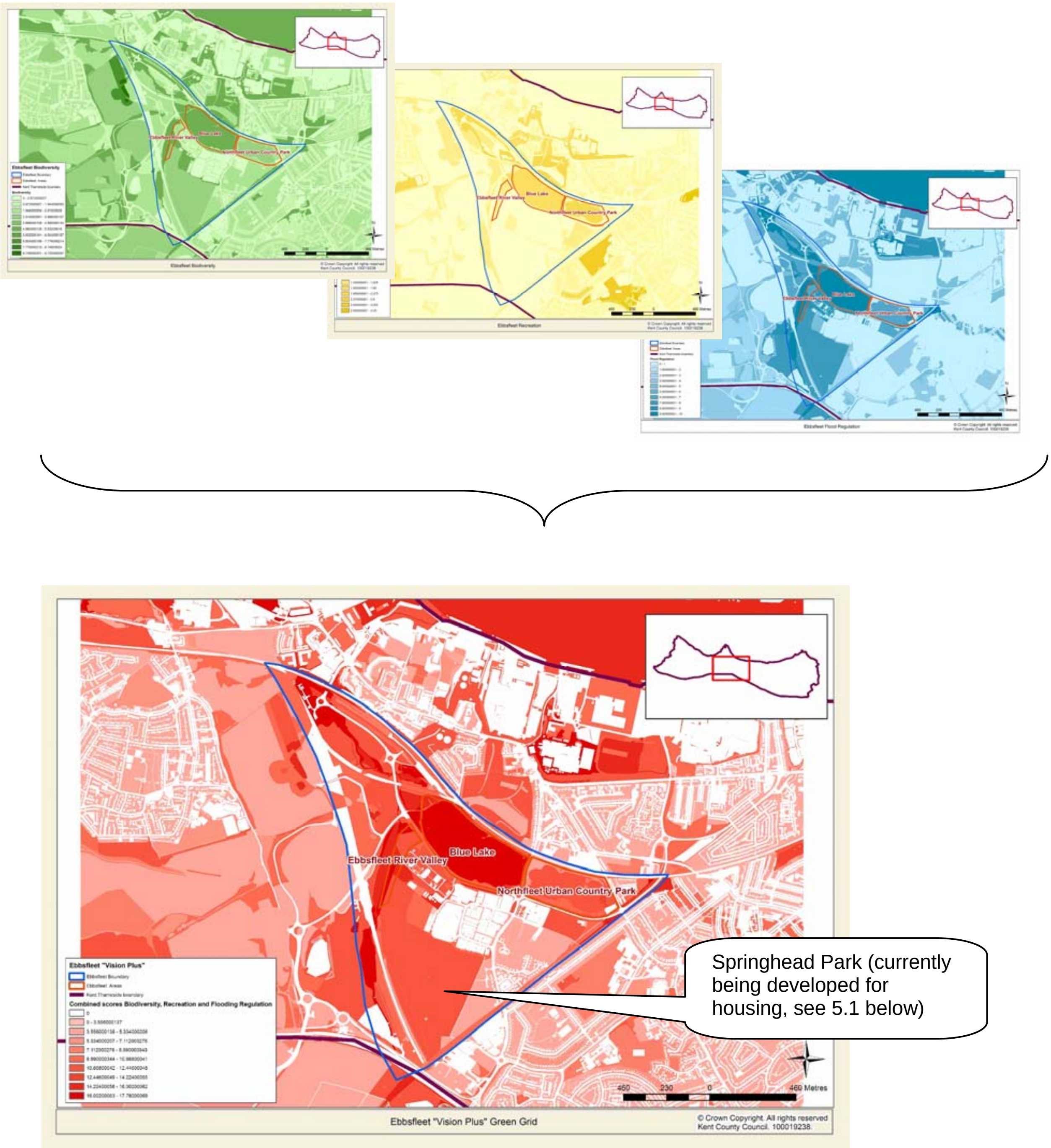


Figure 11: Combined ecosystem services map (for biodiversity, recreation and flood regulation)

4.5 Key findings from the strategic study

1. **Land use/land cover classifications, based on PPG 17, were used to construct network diagrams and help understand the type and nature of the ecosystem services provided by the Kent Thameside Green Grid.**

2. **Network Analysis and GIS are useful and practical tools to understand the ecosystem services provided in an area and the relationship between these services.**

3. **There are issues of availability and applicability of data, which may be overcome by combining available data sets.**

4. **The scale of available data can limit its usefulness at the local level, often being too coarse to capture the heterogeneous nature of an area. The network analysis technique, combined with**

public consultation, provides a way of understanding local heterogeneity which can be used to refine data sets or identify gaps to be filled.

5. **Combining of *datasets* necessitates the use of weightings in generating a particular ecosystem service map using land use/land cover categories. These weightings can be problematic and should be derived from stakeholder engagement to ensure a degree of consensus on what the resulting maps actually represent.**

6. **Combining *ecosystem services* in combined maps is problematic, though feasible using a decision-support tool as used in the example shown in Figure 11. However, some stakeholders attending the final project seminar consider it unnecessary as this can compound the problems of adding incommensurate weights together. They also felt that a combined effect could be seen clearly enough by looking at the separate maps individually.**

7. **Some ecosystem services are better viewed at a more strategic scale, e.g. flood risk, landscape; others at a more local scale, e.g. informal recreation, noise. It may be that flood risk would be better viewed at an even more strategic scale than Kent Thameside, e.g. the whole Thames estuary, as currently being undertaken by the Environment Agency in the Thames Estuary 2100 study. Some services can, however, be sensibly viewed at a range of scales, e.g. biodiversity, though with a different focus (e.g. from landscape to habitat to species scale in the case of biodiversity). The ecosystem typology is the important tool here, since that is the way to indentify which ecosystem services are most appropriate at which levels.**

8. **There is scope for using a wider range of datasets than those utilised in this study, e.g. air quality, water quality, and biodiversity action plan data. The focus in this study was on testing the applicability of the tools, rather than trying to produce definitive maps. Having found that the tools can be useful in exploring ecosystem services and their relationships in spatial planning the next step would be to generate more definitive maps using a wider range of, and in some case more up-to-date, datasets for specific areas, including Kent Thameside.**

5. Local study - Ebbsfleet

The Ebbsfleet Valley was chosen as the local study area as it contains three areas of green space (Northfleet Urban Country Park, Blue Lake – NUCP - and Ebbsfleet River Valley). The current green grid in the area is show in Figure 12. The aim of the local study was to explore ecosystem services provided by the NUCP and to adapt, apply and test the applicability of GIS and network modelling. The objectives of the local study were:

i) to calibrate the environmental data sets to the local specific/conditions;
ii) to evaluate the use of local green grid (and its associated ecosystem services) through public consultation;
iii) to use scenario analysis to explore the utility of an ecosystem services approach to provide multifunctional green space.

To achieve the above objectives, the overall approach adopted for the Ebbsfleet Valley local study consisted of the following steps (note some steps were undertaken sequentially and others in parallel);

a) Establish current baseline conditions, environmental and policy context for Gravesham Borough Council and the Green Grid; Assess the appropriateness of using the units of analysis from the strategic level of Kent Thameside at the local level of Ebbsfleet Valley.
b) Consult with local stakeholders to ascertain how the green spaces are currently used and what would improve this experience
c) Construct network analysis models and establish linkages between ecosystem services of case study area.

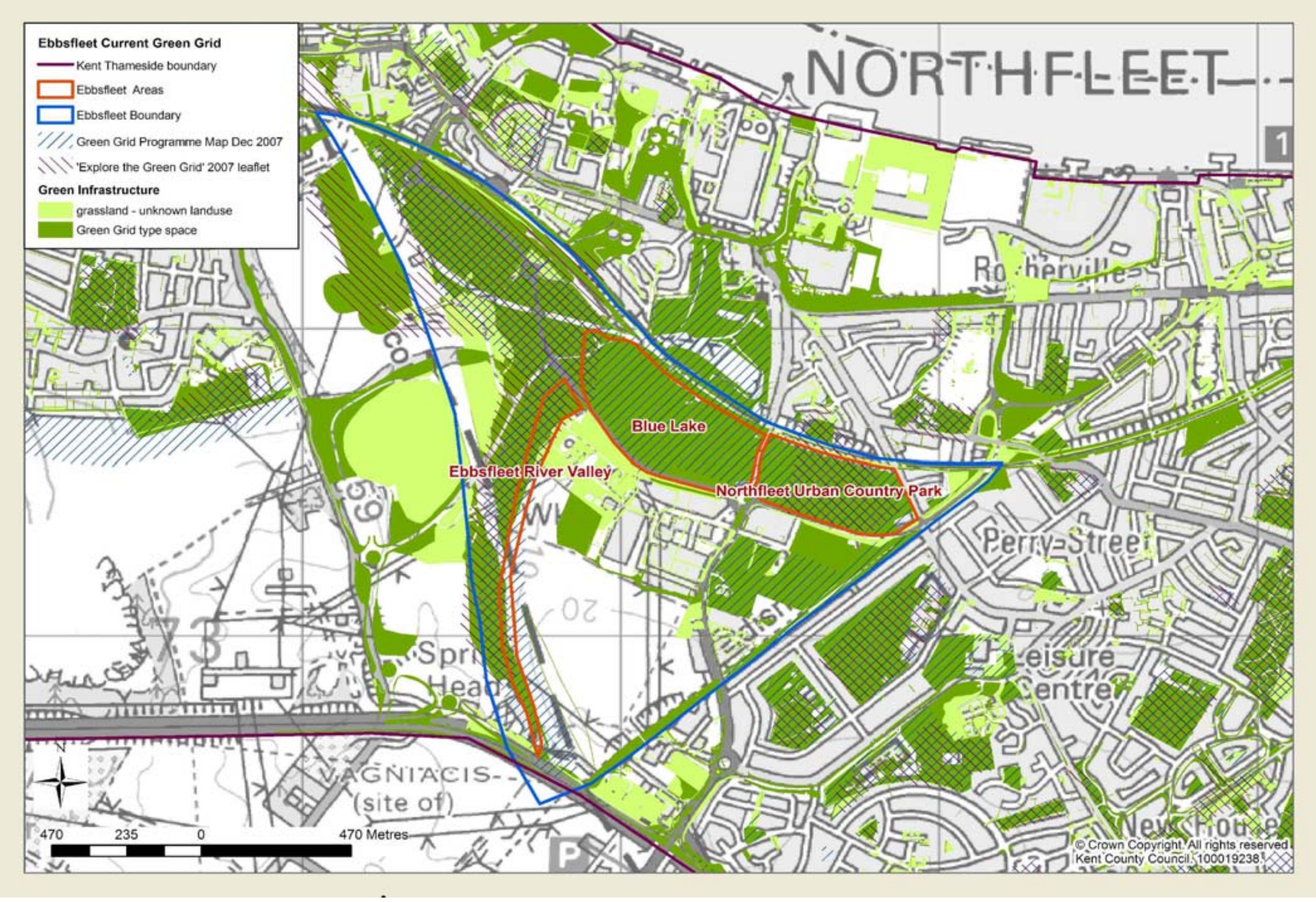


Figure 12: Current Green Grid of Ebbsfleet Study Area

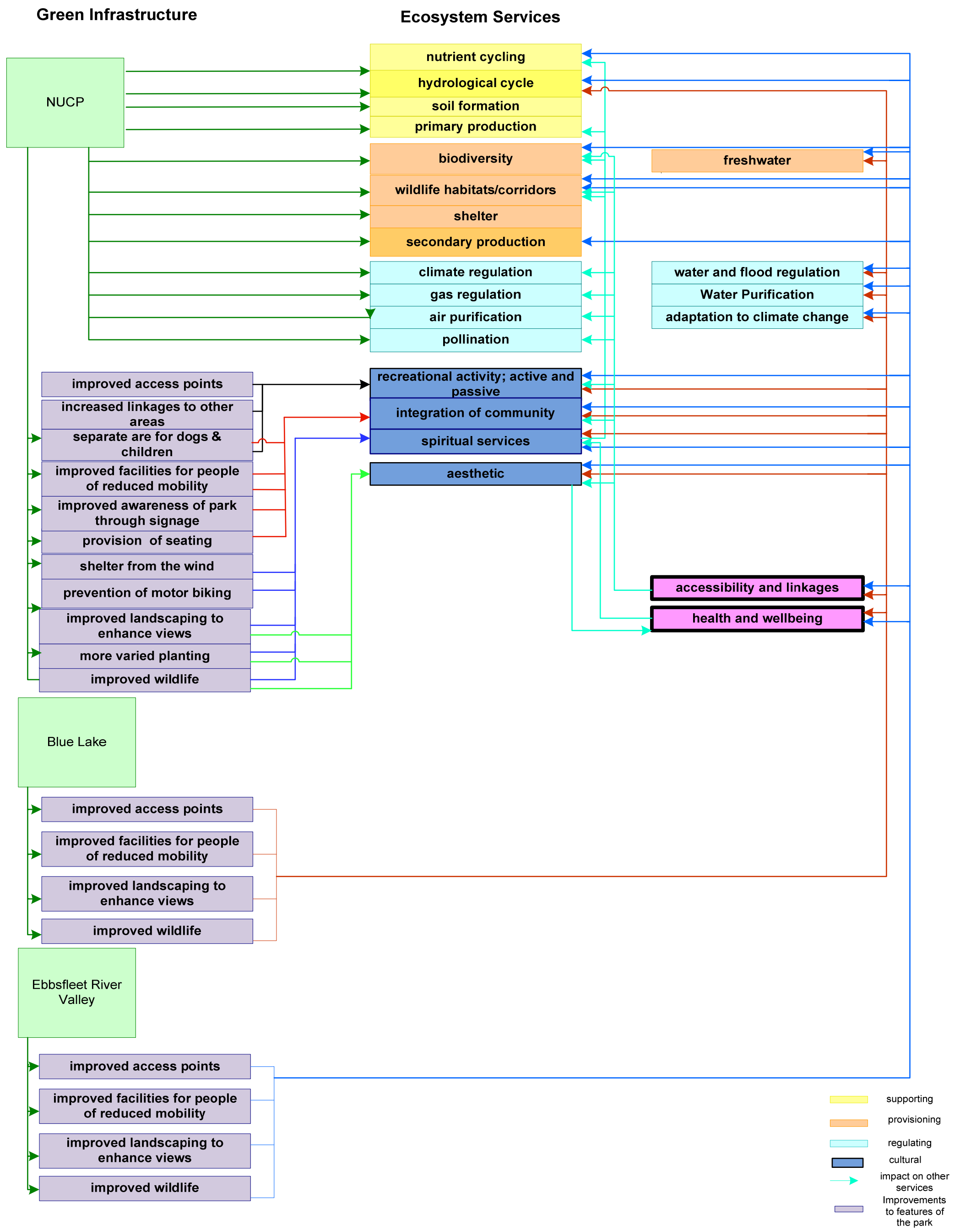
While the wider typology used for earlier parts of the research was refined to make relevant to the local area, it was important that this refinement was informed by understanding what services were utilised by local people. A public consultation event was held in Gravesend with 29 local people attending. The objectives of the consultation were:-

- To consult local people on how they currently use NUCP;
- To find out what people like and don't like about the park;
- To find out what features of the park facilitate current recreational use of the park by local people;
- To consult local people on how changes to the park might change the way they use it;
- To find out what features of the park could be added or improved to support this future use.

Invitations had been sent to members of the local consultation panel, and distributed widely through local schools and groups. People who attended ranged from those who used the park on a daily basis, sometimes several times a day, to those who were previously unaware of the parks existence. The consultation explored how people currently use the park, and how they would hypothetically like to use it in the future, and what changes they would like to see to support this use. The consultation results were used to construct four network analysis models:-

i) current services provided by NUCP;
ii) potential services if enhancements made to NUCP;
iii) potential services with enhancements including links with Blue Lake;
iv) potential services with enhancement including links with Blue Lake and Ebbsfleet River Valley.

The last of these is shown in Figure 13 below. The result shows that enhancement to the green spaces and to the links between green spaces could deliver both new ecosystem services and more of the existing ecosystem services.



Ecosystem Services Potentially Provided by NUCP, Blue Lake & ERV

Figure 13: Ecosystem Services potentially provided by NUCP linked to Blue Lake linked to Ebbsfleet River Valley

5.1 Use of decision support tools at the local level

The usefulness of the decision support tools to planners depends on the accuracy of the data that supports them. If the data is not of the correct scale there is the danger that either misinformed decisions will be taken or that the tools will not be used at all. Planners are faced with decisions that cut across numerous scales, so the tools that they use have to be capable of adapting to the changing requirements.

GIS is a useful tool to map ecosystem services present at the strategic level, capable of identifying areas which are providing, or have the potential to provide, a range of ecosystem services. However, the strategic study revealed that due to the scale of the data used to inform the GIS mapping, there are numerous challenges to representing the services present at the local level which may limit its applicability to local level planning decisions. In particular, the resolution of much of the widely available data is too coarse for picking up local level detail, which needs to be ground-truthed with aerial photography and local surveys or observations and public engagement. For example, there is a national tranquillity map which shows the tranquillity score for the area in 1km squares; such a resolution is clearly of little use when looking at the Ebbsfleet area at the local level. However, even at a coarse resolution the GIS can help to identify areas with potential for multifunctionality. The case of Springhead Park is a case in point (see Figure 11 above), providing a good illustration of how the strategic identification of potential ecosystem services, such as flood regulation potential, might have been used as a way of directing where new development is located, and how important areas that could be integrated into a multifunctional green grid could be used strategically to help direct development, rather than relying on development to deliver fragments of green grid that might have limited multifunctional potential. For Springhead Park it is too late – it is already under new housing development.

Some services require the combining of datasets which raises questions of how those datasets are combined, e.g. what weightings are applied and how are those weights derived. The local case study, however, pointed to network analysis as a way of helping understanding ecosystem services at the local level following public consultation. For example, with regard to aesthetic quality, a green space in an urban area could be assumed to be aesthetically pleasing, but may in fact have compromised sight lines and be poorly managed, thus reducing the aesthetic services present. This is difficult to capture using GIS, as the data required to map such nuances might not exist, or if it does exist, be incorrect or out of date. Network analysis allows one to diagrammatically represent the components that provide a high level of aesthetic services, identifying the most pertinent connections, and exploring how more aesthetic services could be provided. Network analysis, therefore, can be used, with stakeholder and/or public consultation, to generate and refine data sets that can then be represented spatially through GIS.

"Network analysis can be used, with stakeholder and/or public consultation, to generate and refine data sets that can then be represented spatially through GIS."

Network analysis was found to complement GIS at the local level, and identify the range of ecosystem services which may exist in an area. Network analysis can be used to model hypothetical scenarios of ecosystem services provision and is useful in identifying linkages between services. This would be advantages to planners seeking the delivery of multifunctional green spaces that provide recreational/cultural services in addition to provisioning/support services. The linkages between services offer an effective way of delivering ecosystem services to a local area by focusing on the services that people are aware of and see as important to them and their quality of life, using the delivery of these services to provide other (less obvious) services by proxy. Network analysis models are also useful for engaging stakeholders in dialogue about ecosystem services, providing a visual means of presenting and commenting on the potential interactions between services.

5.2 Public consultation

Public consultation should be invaluable to the eventual delivery of multifunctional green spaces, revealing how a space is likely to be used, what is likely to work in an area and what is important about the space to local people. It is important for any plans to change a local green space to be based on what is required in a local area, which necessitates that local people be consulted and involved in the design and any development or enhancement of the facilities. During a consultation exercise it is not necessary or appropriate to use ecosystem services jargon as many people – as seen in this local study - have quite an intrinsic understanding of the basic issues underpinning the concept of ecosystem services provided by a green space. Uses of the park, and the pleasure/benefits derived, can be translated subsequently into an ecosystem services typology and then to network analysis to explore the full range of services potentially provided by a space.

"During a consultation exercise it is not necessary or appropriate to use ecosystem services jargon as many people – as seen in this local study - have quite an intrinsic understanding of the basic issues underpinning the concept of ecosystem services provided by a green space."

5.3 Ecosystem services in Ebbsfleet

The area of the local case study is currently poorly served by its green spaces. The paucity of the services provided is detrimental to the lives of local people and to the character of the area. The Ebbsfleet Study Area has the potential to provide a wide range of ecosystem services, which could be achieved through a number of key improvements identified during the consultation;

- Establishing well signposted and better physical linkages between NUCP, Blue Lake and ERV would provide synergistic benefits, re-establishing lost routes around the local study area, routes that have been cut-off by previous developments. These re-established routes would allow local people to enjoy a wider range of services than if they were to visit the green spaces in isolation, and would also provide considerable recreational benefits to the area,

- Improved planting could improve the quality of services provided by each green area, at relatively low cost and maintenance and with considerable benefits for ecosystem services. The right planting, complementing the landscape and the requirements of the local area, has the potential to transform a relatively underutilized green space providing a limited range of ecosystem services into a multifunctional green space appealing to a broader range of people. While planting is not a panacea for poor quality green space, it can provide a host of services that (as revealed by the consultation) are integral to the use of green space, while simultaneously providing a host of other (less obvious) ecosystem services benefits,

- The consultation also raised the prospect of using Blue Lake for more formal services such as boating, swimming, or even the presence of a cafe. The provision of such services could facilitate wider ecosystem services improvements and diversify the range of ecosystem services available.

- The use of an ecosystems approach in planning the development of the Ebbsfleet Study Area, combined with the decision support tools, has the potential to facilitate the local Green Grid decision making process by enabling planners to identify areas which, due to their natural characteristics, have the potential to provide certain ecosystem services. In addition, the tools aid the consultation with, and help communicate the concept of ecosystem services to, local people so that the most relevant services are identified. For example, the local study revealed that the study area was the only place locally that dogs could be let off the lead for a run, and for this reason was values by local dog-owners. Conversely, parents with young children felt threatened by these dogs and thus curtailed their use of the park. This insight suggests that any changes to the park should seek to accommodate the concerns and wishes of both groups, reducing the need for trade-offs and potentially increasing the multifunctionality and use of the area. This also ensures that the outcomes remain relevant to the local situation and increases the likelihood of their effectiveness and success over the long term.

5.4 Key findings from the local study

1. **Due to the resolution of the data used to inform GIS mapping, it is often unable to pick up local nuances, limiting its applicability to local level planning decisions. It can, however, be useful for identifying areas that have potential for mulitfunctionality and where there needs to be further 'ground-truthing' e.g. by using aerial photography and local observation and engagement.**

2. **Consultation can be used to reveal how a space is used, how it could be used and what is important about the space to local people, all essential in delivering multifunctional green spaces and developing a complete typology of ecosystem services for the area.**

3. **During a consultation exercise it is not necessary to use ecosystem services jargon as people have an intrinsic understanding of the basic issues underpinning the concept of ecosystem services provided by a green space, i.e. their uses of the area.**

4. **Network analysis can then be used to relate the uses of local green space to ecosystem services provided by that space (to complete the typology), and potential ecosystem services that could be delivered or affected if suggestions for improving that space were acted upon.**

5. **The ecosystem services typology is a useful tool in its own right to facilitate *'ecosystem services thinking'* and to help integrate an ecosystems approach into the planning and management of local green space and spatial planning more widely.**

6. Conclusions

6.1 Decision support tools

6.1.1 Network analysis

Network analysis provides a systematic way of organising thoughts and variables and defining relationships. **In particular the approach is useful to understand the relationship between spatial units (categorised as part of this project as using land use/land cover) and the ecosystem services** these provide. Network analysis could be used by planners during the early stage of the planning process when developing strategies or plans to provide an overall picture of relationships and effects. Network models (the diagrams/outputs) could be used during the option selection process by exploring potential effects of various options. Network analysis (the process of generating the models) can also be used during stakeholder workshops or the consultations stage, e.g. using groups of people, it can be used as an interactive tool where participants can comment on and amend paper copies of the diagrams.

6.1.2 Use of GIS

GIS is an integrative tool allowing the combination of many, often disparate, datasets. However, it is only as good as the data it processes. The use of up-to-date datasets of a resolution equal to OS Master Map, if available, are necessary. If combining datasets of differing currency or quality, it is necessary to decide which dataset information should take priority when applying the land use/land cover classification. As **the scoring and (particularly) the weighting of ecosystem service provision factors involve subjectivity, stakeholders should be used to guide the *weighting* of factors. Expert stakeholders** can offer their experience based on past research to *score* some ecosystem services, such as biodiversity, while **local community stakeholders** will also have important perspectives on the how they utilise local ecosystem services, such as informal recreation or aesthetic/cultural services. This was not within the scope of this research, but should be undertaken in further research.

Sensitivity analysis was explored briefly with the food and biodiversity ecosystem service analysis. Sensitivity analysis involves taking the individual components of the model and iteratively adjusting their values in order to determine the impact on the resulting outputs. Here, this relates to whether changing the values means that different areas become more important in terms of their ecosystem services than they did previously. This then provides pointers as to whether the model is heavily reliant on certain datasets and whether this might be problematic if the datasets are old, or of coarse resolution, or whether the weightings are inappropriate. Particular factors will have a greater influence on analysis outputs than others and by adjusting the weightings one can explore this to determine the most important factors in the model. **Sensitivity analysis is therefore an important and recommended step in investigating the factors that affect ecosystem service provision**, as well as the necessity to include stakeholder dialogue, which we were not able to within the constraints of this project.

A final test of the ecosystem service maps would be make site visits to, for example, compare the aesthetic value found on the ground with the relative value indicated on the map. This 'ground truthing' may lead to identification of further factors affecting ecosystem services and fine tuning of analyses. Further research will be needed to provide more comprehensive, up-to-date and consistent datasets to enable better combining of datasets into practical land use/land cover classes. This project has sought to make a first attempt at this, but the actual resulting GIS maps for the study area itself need to be treated with some caution. **The study has shown, however, that such combining is possible and that it is also possible to map potential ecosystem services using existing GIS datasets. However, the existing GIS data generally is more appropriate for use at strategic levels than local levels, where its resolution is too course to reflect the often heterogeneous nature of the local environment. This is where appropriate ground-truthing and local public engagement is necessary to understand more fully the potential range of land cover and land uses actually present.** Even using such coarse data at local level, however, allows potential areas of multifunctionality to be indentified for more detailed investigation.

6.1.3 STELLA modelling

STELLA modelling is a graphical interface model using inputs and outputs to simulate relationships between factors under consideration, in this case ecosystem services. It was found to be far less useful than initially anticipated, largely because of its need for appropriate data. It certainly has potential for exploring in some detail the nature of the relationships between ecosystem services at a very local level, e.g. a local nature reserve or country park, providing sufficient and appropriate data is available. As a practical tool for use in planning frameworks such as green grids or sustainability appraisal, however, it was felt that its use would be very limited. It could provide academic value to detailed study of key service relationships, but would be unlikely to be used on a day to day planning basis. Consequently STELLA modelling was not taken beyond a number of pilots attempts (see STELLA report for further details).

6.2 Using ecosystem services in planning frameworks

The strategic study used a **different approach** from other projects within the Defra ecosystem services research programme that have explored ecosystems services. It used **land use / land cover classification as ecosystem units whereas other studies have used habitats**[16]. The use of land use classification units has **practical application to planners**, who are familiar with this type of classification. Since the context of the study is that of strategy development of Green Grids, this classification can fit more easily into planning processes. The land cover element is also useful for sub-classifying semi-natural areas, separating wetlands and water bodies which have different ecosystem service provision from other semi-natural land classes such as woodlands. The study used the characterisation of land uses and land cover to provide the link to ecosystem services and construct network analysis models for different scenarios, which differs from usual valuation approaches used in other ecosystems services research. **Network models and scenario analysis, however, can be easily understood by planners and stakeholders, providing a platform for further discussion and debate.** Through network models, interactions and relationships of services were traced and displayed, which are

[16] Haines-Young et al (,2006). *The Ecosystems Concept and the Identification of Ecosystem Goods and Services in the English Policy Context*. Draft review paper to Defra. Project Code NR0107.

important in assessing what these services provide in combination. This complexity of interactions or relationships cannot be easily explored in valuation techniques.

This study, due to time limitations, did not seek to quantify the level of ecosystem services present, although the findings of the research point to the benefits that this would offer. Quantification would be useful to enhance the utility of an ecosystems approach to planners, allowing them to judge the merits of proposed plans on the levels (and range) of services provided or potential services. It would also facilitate scenario analysis of future options by providing a clearer basis against which to compare options. **One approach to quantifying services would be by using environmental quality standards – how much a particular ecosystem service is needed to help deliver a particular environmental quality standard? An example might be the standard for open space provision set locally by local authorities (following guidance in PPG 17 Planning for open space, sport and recreation (2002).** This will require more research to relate services to indicators, but the rationale and logic of doing so is clear.

Additionally, the ability of the decision support tools to explore and model *potential* services would allow planners to identify how and where multifunctionality could be provided, and what steps could be taken to improve existing levels of service provision. This concept of *potential* services is also useful when consulting stakeholders on 'local' services as it can aid the communication of rather abstract concepts, and stimulate discussion through a visual representation (using network models and GIS) of future scenarios.

6.2.1 Green Grid planning

The strategic study explored three Green Grid scenarios, current, Green Grid 'Vision' and 'Vision Plus'. The proposed Vision Plus extends the concept and coverage of the Green Grid and so identifies a wider range of ecosystem services provision. **As a planning tool, the ecosystem services approach provides a comprehensive and systematic perspective to the future planning of Green Grids.** Typically, while Green Grids have always had multifunctionality at the heart of their objectives, they have often been planned and delivered with a focus on landscape and recreation. This, perhaps, has been partly because developers' support for green grids is based on these aspects as being the most relevant to the success of their developments. And while some of the wider functions and benefits of green infrastructure have been recognised in previous studies[17] and plans[18], **the ecosystems approach looks at services that have not been previously considered in this context.** For example, supporting services (such as hydrological cycling and soil formation) provide important benefits, but these have not always been taken into account when planning Green Grids or open space strategies. **The added dimension that the ecosystems approach provides can therefore offer real benefits to planning, particularly in providing a proactive way to identify potential multifunctionality and plan around what exists and its potential (in terms of service provision), rather than what developers are prepared to offer. Ecosystem services also provide a different focus for discussion with stakeholders, with the potential to reduce the common problem of trade-off between different interests.**

The idea that trade-offs between service provision can be reduced was strengthened over the course of the research. **Inherent to the ecosystem approach is a recognition that society and the economy depend upon ecosystem services and therefore the environment as a whole. This provides a more holistic view of sustainability than the traditional balancing of environmental, social and economic factors,** which inevitably sets various factors against each other, demanding trade-offs. An ecosystem approach to Green Grid planning would start with identifying the areas best suited to delivering multifunctionality and designing development around those. Under the current approach the Green Grid is unable to deliver the most multifunctional space because that may already have been allocated to development. In such a case the environmental benefits have already been traded-off against the economic benefits of private developers. However, **high quality, multifunctional green space is likely to bring economic benefits to the wider community and to developers,** since the area is likely to be more attractive as a consequence, supporting higher property prices. And the management costs of managing a green space for biodiversity services, flood risk alleviation, recreational services and community integration, may not necessarily be significantly greater than if managed for only service.

6.2.2 Ecosystem services in sustainability appraisal

Drawing on the findings from the research, and particularly from the strategic and local studies, it is possible to see real opportunities for incorporating ecosystem services into sustainability appraisal, and specifically providing input to a number of key stages of Sustainability Appraisal (SA):

- ***Baseline*** - **ecosystem services could help make baseline data much more relevant to the assessment process by combining datasets in a useful way for planners and decision-making.** All too often baseline data represents a significant input of effort and resources within the SA, but it is not

[17]For example, CABE Space (2004). *The Value of Public Space: how high quality parks and public spaces create economic, social and environmental value.* Greening the Gateway Partnership (2006*) Thames Gateway Green Infrastructure Guidance*.
[18]See Green Grid plans: Kent Thameside (2006). The Green Grid: *Conserving and enhancing our natural heritage*. LDA Design (2005*), East London Green Grid: Framework Report*., and LDA Design (2004) Thames gateway South Essex Green Grid Strategy.

always clear how it is best used in informing the assessment process. Presenting the baseline in ecosystem service terms, through land use/land cover, could provide an alternative or supplementary way that is more relevant to the assessment and decision-making process.

- ***Scoping, and engagement with stakeholders*** - **network analysis around ecosystem services provides a means to identify key issues/areas, and could be used also alongside/supplementary to SA objectives.** Ecosystem services provide a view that is cross-cutting at whatever level might be most appropriate, e.g. using just the four main ecosystem service categories of supporting, provisioning, regulating and cultural, or at the typology level, tailored to the specific study area through stakeholder/public consultation.
- ***Assessment and consideration of alternatives*** **- ecosystem services can provide important information on the potential for multifunctionality when considering alternatives.** And for assessment they can be supplementary or an alternative to the typical sustainability appraisal objectives. The advantage of ecosystem services is that they do not inherently result in trade-offs, or at least help to minimise trade-offs between different dimensions of sustainable development. They can also be used proactively with regard to alternatives and mitigation, e.g. by seeking to make use of existing features/services and enhance what might be provided.

Potentially, **ecosystem services could be used as an alternative to SA/Strategic Environmental Assessment (SEA) objectives; in other words, an SA/SEA objective "To protect and enhance biodiversity" might be re-cast in ecosystem service terms "What will be the effect on biodiversity provisioning services?" But this is likely to take time to take hold,** given that the use of SA objectives is now well embedded in SA/SEA practice, and in any case could be quite data dependent. **However, *'ecosystem services thinking'* could provide an important perspective in the same way that life cycle thinking provides wider benefits to sustainable product and service provision beyond heavily data dependent life cycle analysis/assessment.**

Ecosystem services could, therefore, be used as additional criteria to the SA objectives (perhaps rather than as alternatives to SA objectives), even at a generic/strategic level: what will be the effects on i) supporting services; ii) provisioning services; iii) regulating services; and iv) cultural services? This would prompt a discussion and perspective that would be different to normal SA. **It could provide a valuable basis for scoping discussions amongst stakeholders and as a useful access point for consideration of cumulative effects.** Network analysis modelling has a strong pedigree in cumulative effects assessment within Environmental Impact Assessment (EIA) and SEA, and is increasingly being used in SEA/SA practice. **Using ecosystem services as the units of analysis rather than environmental receptors and environmental effects is quite a simple step, but could provide a different way of looking at the environment and sustainability** in the same way as the concept of biodiversity provides a different way of looking at wildlife and nature conservation.

An English Ecosystem Assessment, which had a clear spatial dimension mapping ecosystem services at a strategic level could provide a valuable basis for informing the baseline elements of SEA/SAs, as well as the basis for more sub-regional and local investigations using network analysis and GIS, supported by good ground-truthing. A key challenge within SA has been the time and effort spent on gathering the most appropriate baseline data for specific studies, given that datasets exist in a myriad of different, often incompatible, forms. Notwithstanding the challenges inherent in combining datasets to represent ecosystem services in GIS mapping, e.g. through using land use/land cover categories as has been used in this research, the result would be very worthwhile from a practical planning and appraisal point of view. Datasets that may be relevant individually for monitoring of individual environmental parameters could be made much more relevant for spatial planning purposes through an ecosystem services approach.

6.2.3 Ecosystem services and monetary valuation
While outside the immediate scope of this research, there is potentially a close relationship between applying a monetary value to ecosystem services and the concept of defining and mapping the services which exist in an area. **This study highlights in particular the complexity of the interactions between services and the land cover types that provide them. The network diagrams clearly illustrate the potential difficulty in isolating any single (or even suite) of services, as the services derived are linked to each other and also linked to various land cover types. This raises important questions for monetary valuation of ecosystem services at the local level**, particularly the extent to which such a valuation will be able to capture the complexity and variety of the inter-relationships between services. With recreation, for example canoeing on a tidal river, a range of other services will be derived from the user beyond mere recreation. These may include spiritual/cultural services (from being amongst nature), health and well-being services (from taking exercise), educational services (from learning new skills), and so on. And the nature and extent of these services will vary - as will the benefits derived - on each occasion the canoeist enters the water, depending on other factors, such as the weather, the tides, whether solo or in a group, etc. Valuing the *benefit* derived from such a service – rather than the service itself - does not fundamentally resolve the problem of complexity, since the focus is then only on those benefits that can be assigned a monetary value; the ecosystem services and their complex relationships (which lead to diverse benefits) become somewhat inconsequential.

At the local level monetary valuation of ecosystem services is unlikely to fit comfortably in spatial planning decision-making, which inevitably involves complex political – and essentially qualitative - decisions taking into account a whole host of factors, although it could provide one of the inputs. From the final project seminar some stakeholders could see the benefit of valuation and/or quantification, for example to support negotiations with developers over provision of green grid space and facilities. But to work within planning frameworks an ecosystems approach needs to be able to engage with existing planning processes; most participants in the final project seminar tended to agree that the use of quantitative measures (amounts) of ecosystem services (both existing and amounts added or taken away via a particular intervention) would perhaps be more informative to the planning process than monetary valuation, particularly if this quantification could be in put in the context of relevant limits/thresholds for particular services. This would facilitate the adoption of an ecosystems approach as it would then be possible to measure success or failure of interventions, e.g. green grid provision.

Neither sustainability appraisal nor SEA, as an evidence base for spatial plans, attempt to assign monetary values to environmental factors; given its strategic nature it is inevitable that such assessment has been seen primarily as a qualitative process informed by quantitative data where possible. A better understanding of ecosystem services provision within an area could therefore help inform both the quantitative evidence base and the qualitative process of decision-making. This does not mean that monetary valuation of ecosystem services does not have a role in an ecosystems approach, but that it may be limited in the context of local spatial planning.

7. Recommendations

7.1 Further research

R1 **Further research should be undertaken by Defra on using network analysis, combining GIS datasets, introducing new datasets and modelling ecosystem services at different scales.** Some ecosystem services lend themselves to more strategic scales and others to more local scales, while others can be modelled at a variety of scales. Identifying these different scales for different services will aid planners in understanding which services can be most effectively protected and enhanced at their spatial level. In doing so it will be important to ensure the full engagement of stakeholders (expert and public) in exploring the use of scoring and weighting when combining datasets and the extent that this is feasible and desirable.

R1a Further research on the use of **specific datasets**, e.g. more specific land *use* datasets such as breaking down food production into different types of farming; higher resolution datasets, e.g. for greenness/NDVI such as CASI; higher quality terrain information such as the Environment Agency's LiDAR data (useful for terrain/flood regulation and aesthetic mapping)

R1b Further research on **accessibility barriers to movement** (e.g. busy roads, railways, quarry faces, rivers), which are likely to be particularly important in people's ability to be able to access open space, even if it is provided within a particular location.

R1c Further research on **individual versus combined ecosystem services maps**. This was an issue raised at the final project seminar on which there was a range of views. The combining of ecosystem services maps was tested for only one local situation using only three ecosystem services in this research and there is clearly considerable scope for exploring the merits or otherwise of this further, at different scales and for multiple ecosystem services.

R2 **Ecosystem services could be used to help define environmental limits and thresholds/define environmental capacity.** Our work has not sought specifically to address this – it has focused more on maximising multifunctionality, but this should be the next step – i.e. how much service should be provided/is needed within an area? **Further research should be undertaken to define limits and thresholds to ecosystem service provision, using existing environmental standards as the starting point, e.g. air quality, water quality, BAP targets.** This research would have to be tailored to the appropriate scale(s) for the service in question and the associated limit defined accordingly. With limits defined sustainability appraisal (SA) and strategic environmental assessment (SEA) could utilise this information in assessments of local development documents, regional spatial strategies and other sectoral plans and programmes.

R3 An English Ecosystem Assessment could provide a robust basis for use in strategic spatial planning – and particularly in relation to regional/sub-regional level spatial mapping and analysis of ecosystem services potential. **The initial mapping undertaken here for Kent Thameside should be extended to the Thames Gateway as a whole, to facilitate the strategic planning of green infrastructure in the context of developing sustainable communities.** The development and refinement of the approach for more specific local mapping will also be essential to test the applicability of more definitive mapping.

Opportunities for this exist - and interest expressed, subject to funding - **in Kent Thameside** to help the local authorities in considering the effects of future developments and master plans on local ecosystem services, and **in London** with respect to the consequence for ecosystem services of the increasing loss of front and back gardens.

R4 **Further research would be useful to investigate which services accrue on either a strategic or local scale, and how this division might be used to integrate an ecosystems approach into the planning system. One approach would be to focus on a few key services and their delivery across the Thames Gateway, investigate how they are provided and how they might be enhanced.** Future research could seek to derive limits and standards for minimum levels of ecosystem service levels, e.g. the minimum amount of flood storage required in the Thames Gateway.

R5 **The research councils and academic community should seek to further explore and promote the integration of ecosystem services into planning frameworks.** This will necessitate the active support of interdisciplinary and transdisciplinary applied research in this area. Ecosystem services epitomises the need to cross research boundaries and disciplines, especially across the natural and social sciences, and to address real practical challenges. Both of these areas have been poorly addressed in the past by research councils, and although this is improving many of the driving forces in academia still militate against such research. **A specific area that could be investigated is how, if at all, network analysis and GIS mapping might relate to monetary evaluation of ecosystem services.**

7.2 Government and authority action

R6 **An ecosystem services approach should be integrated into the future planning and delivery of green grids/green infrastructure throughout the Thames Gateway and elsewhere.** Green grid planning needs to be underpinned by the potential to deliver ecosystem services in order to support the multifunctional objectives of green grids and provide a more robust means of directing the delivery of green grid space. This may require more formal guidance in the form of a planning policy statement (PPS) **to ensure that green grids help proactively to *shape* development, planning around what exists and its potential, rather than their delivery simply occurring reactively *through* development.**

R7 **Local authorities should be encouraged, e.g. through government guidance, to use an ecosystem services approach in planning green and open space in order to promote greater multifunctionality.** This might be encouraged through integrating the approach into development plan preparation, open space strategies, and community engagement, for example. **The development and use of ecosystem service typologies, perhaps linked with state of the environment reports, could facilitate this.**

R8 **Network analysis provides a useful tool that can be used by planners to engage with stakeholders in creative and interactive ways in developing multifunctional green grids** (that deliver multiple ecosystem services) and should become a regular tool used in future strategic and local green grid planning. This should include discussions about the use and enhancement of local green space.

R9 **Communities and Local Government (DCLG) should include ecosystem services in their ongoing revision of guidance on sustainability appraisal**, to encourage its appropriate incorporation into SA application at various strategic levels. **A flexible approach to using ecosystem services in SA should be encouraged – in line with the 'living draft' nature of the SA guidance, so that *'ecosystem services thinking'* is encouraged and trialled in a range of different contexts.**

R10 **Government agencies and regional observatories should seek to provide appropriate datasets for incorporation into ecosystem services approaches.** A consistent approach to the nature, range and scale of datasets that can be used in mapping ecosystem services needs to be established, which may need specific research to undertake a gap analysis, i.e. identify which datasets are currently being accumulated in regional observatories and which would be a priority to be developed.

References to published material

9. This section should be used to record links (hypertext links where possible) or references to other published material generated by, or relating to this project.

Milestone 1 – Report: Literature Review, March 2007

Milestone 2 – Report: Developing the Ecosystem Services Typology for the Kent Thameside Green Grid, July 2007

Milestone 4/5 – Report: Functions and Services of the Kent Thameside Green Grid Report on the Stakeholder Workshop - 2 July 2007, August 2007 [Appendix 5 – Maps]

Milestone 3/6 – Report: Ecosystem Services of Dartford Marshes **Pilot Study Report**, September 2007

Milestone 7a – Report: Supporting the Development of a Strategy for the Kent Thameside Green Grid Using Ecosystem Services **Strategic Study Report**, March 2008 [Appendix 3 – Maps]

Milestone 7b – Report: Supporting the Development of a Strategy for the Ebbsfleet Valley Green Grid Using Ecosystem Services **Local Study Report**, March 2008 [Appendix 1 – Consultation Report; Appendix 3 – Maps]

Milestone 8 – Workshop 2 Final Dissemination Workshop/seminar presentations and summary, April 2008.

Additional outputs:

STELLA modelling report

Academic and other papers are under preparation.

Annex 1: Datasets used in the analysis and map production

Base Data

All projects used base data including aerial photography, and Ordnance Survey 10k and 50k raster

Ordnance Survey MasterMap

OS MasterMap polygons were used to create the base analysis units which were then merged with other datasets as shown in the table below to create a ***Green Infrastructure*** layer. The process effectively added additional columns into the dataset to enhance the MasterMap polygons.

Green Infrastructure	Original Data Source
• Parks and gardens	• open space data (source: KCC)
• Natural & semi-natural	• semi-natural and MasterMap data
• Wetlands	• marsh areas are described in MasterMap
• Brownfield land	• Buglife data updated to remove any sites known to have been developed since 2004 (when original dataset was created)
• Amenity green spaces	• open space data
• Community green space	• open space data
• Private gardens	• MasterMap data (multisurface)
• Water bodies and waterside areas	• MasterMap data
• Green Links	• Paths and verges (roadside) are identified in MasterMap
• Agriculture	• arable land is identified in MasterMap, but grazing land could not be separated from other grassland areas with the available datasets
• Landscaped areas and incidental green space	• no available data clearly identified this green infrastructure
• Churchyards and cemeteries	• open space data

Subsequent analysis work further enhanced the MasterMap polygons by incorporating additional data relevant to particular themes. For example in the *biodiversity* theme, the OSMM Polygon was tested to see if it was part of a SSSI and if so what condition it was in.

The final stage of the analysis was to score and weight the OSMM polygons based on their matching of certain criteria desirable for Ecosystems services. In most maps the final output is a weighted version of the green infrastructure layer and is shown as graduated colour legend in 10 clases.

OS MasterMap was also used to extract features for specific data layers not available elsewhere (e.g. pylons).

Breakdown by Individual Map
The following tables show the GIS datasets used in each map.

Aesthetic

Dataset	Description
Kent Thameside boundary	Boundary of study area
GI_aesthetic_weighted	**Green Infrastructure layer weighted for aesthetic ecosystem service**
OSMM_Water	Water features from OS MasterMap
riverctrlines_clip (+ 200m buffer)	River centreline features
OSMM_pylons (+ 50m buffers)	Pylon features extracted from OSS MasterMap
ctrl	Channel Tunnel Rail Link
mainline_railways (+ 200m buffer)	Main line Railways
fastrack	Fast Track Bus Route
LUC_routes	Routes supplied by LUC
industrial_areas (+250m and 500m buffers)	Industrial Areas

Biodiversity

Dataset	Description
Kent Thameside boundary	Boundary of study area
GI_biodiversity_weighted2	**Green Infrastructure layer weighted for biodiversity ecosystem service**
SNCI_Gateway	Sites of nature Conservation importance
tqsssi	SSSIs
tqnnr	National Nature Reserves
tqspa	Special Protection Areas for Birds
tqramsar	RAMSAR sites
tqsiteunit	SSSI Condition
Land Cover	Land Cover Type

Current GreenGrid

Dataset	Description
Kent Thameside boundary	Boundary of study area
Laurence_GG_union	Kent Thameside (2006) *The Green Grid – Conserving and Enhancing Our Natural Heritage*
leafletgreengrid	Green Grid shown on Explore the Green Grid Leaflet
Green_Infrastructure_v2	Green infrastructure layer

Current Green Grid and Vision

Dataset	Description
Kent_Thameside_boundary	Boundary of study area
Existing / Proposed landmark	Existing and Proposed Landmarks in Kent Thameside according to LDA Report
prop_local_park_in_def_area	Design Strategy Framework Plan 2004
strategic_links	Strategic Links
Railway Station	Railways Stations
Mainline Railway	Mainline Railways
ctrl	Channel Tunnel Rail link
fasttrack_phase1	FastTrack bus service Phase 1
fasttrack_later_phase	FastTrack bus service Phase 2
new_urban_waterfront	Urban Waterfront
Laurence_GG_union	Kent Thameside (2006) *The Green Grid – Conserving and Enhancing Our Natural Heritage*
leafletgreengrid	Green Grid shown on Explore the Green Grid Leaflet
Green_Infrastructure_v2	Green Infrastructure layer
prow	Public Rights of Way (KCC)

Flood Regulation

Dataset	Description
Kent Thameside boundary	Boundary of study area
GI_FloodRegulation_weighted	**Green Infrastructure layer weighted for flood regulation ecosystem service**
Kent Thameside Defences_polyline	Flood defences from EA
Areas Benefitting from Defences_region	Areas benefitting from flood defences EA
Flood_Zone_2_TE2100_061106	Flood Zone 2 Thames 2100
Flood_Zone_3_TE2100_061106	Flood Zone 3 Thames 2100

Food Production

Dataset	Description
Kent Thameside boundary	Boundary of study area
GI_FoodProduction_weighted	**Green Infrastructure layer weighted for food production ecosystem service**
magalc_KT	Agricultural Land Classification

Green Infrastructure Classes

Dataset	Description
Kent Thameside boundary	Boundary of study area
brownfieldsite2008_KT	Buglife
Green_Infrastructure_v2	Green infrastructure layer

Integrate Communities

Dataset	Description
Kent Thameside boundary	Boundary of study area
GI_IntegrateCommunities_weighted	**Green Infrastructure layer weighted for potential to integrate communities ecosystem service**
InteComm_300mbuffer3	Buffer of accessible green spaces
pop_surface	Population surface derived from Census data

Multifunctional Green Grid

Dataset	Description
Kent_Thameside_boundary	Boundary of study area
prop_local_park_in_def_area	Design Strategy Framework Plan 2004
strategic_links	Strategic Links
Laurence_GG_union	Kent Thameside (2006) *The Green Grid – Conserving and Enhancing Our Natural Heritage*
leafletgreengrid	Green Grid shown on Explore the Green Grid Leaflet
Green_Infrastructure_v2	Green Infrsatruture layer
prow	Public Rights of Way (KCC)

Recreational Spaces

Dataset	Description
Kent_Thameside_boundary	Boundary of study area
GI_recreational_spaces_weighted	**Green Infrastructure layer weighted for potential to provide recreational space ecosystem service**
pop_surface	Population surface derived from Census data

NDVI / Greenness Map

Dataset	Description
Kent_Thameside_boundary	Boundary of study area
NDVI	Normalised Difference Vegetation index, derived from Landsat TM imagery 30m resolution – a combination of the red and nir infrared bands.