

SYSTEMATIC MAP PROTOCOL

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How are nature based solutions contributing to priority societal challenges surrounding human well-being in the United Kingdom: a systematic map protocol

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Abstract

Background: The concept of Nature-based Solutions (NBS) has evolved as an umbrella concept embracing concepts such as Green/Blue/Nature Infrastructure, Ecosystem Approach, Ecosystem Services, but at their core, they cluster into the general theme of learning from and using nature to create sustainable socio-ecological systems, which enhance human well-being (HWB). NBS address societal challenges across a broad range of spatial scales—local, regional and global—and temporal scales—medium to long-term. While there are many reviews and a clear evidence base linking certain NBS to various elements of HWB, particularly urban greenspace and human health, no comprehensive mapping exists of the links between NBS interventions and the associated multiple positive and negative HWB outcomes across a range of habitats. The initial research phase used a participatory co-design process to select four priority societal challenges facing the United Kingdom: three related to management issues i.e. NBS cost-efficacy, governance in planning, environmental justice, and the fourth threats to the acoustic environment. These challenges collectively address priority management issues which stakeholders requested be investigated widely i.e. across landscapes, cityscapes, seascapes and soundscapes. Results of the study are intended to identify and define potential future environmental evidence challenges for UK science.

Methods: This protocol describes the methodology for approaching the research question: What evidence is there for nature based solutions and their impacts on human wellbeing for societal challenges related to cost-efficacy, governance in planning, environmental justice, and the acoustic environment? Using systematic mapping, this study will search for and identify studies that seek to assess nature-based solutions on human well-being with regard to these four societal challenges. Systematic searches across a number of academic/online databases are tested against a number of test articles. Search results are refined using eligibility criteria through a three stage process: title, abstract, full text. Data from screened studies are extracted using a predefined coding strategy. Key trends in data will be synthesized according to a range of secondary questions and be presented in a graphical matrix illustrating the knowledge gaps and clusters for research into nature-based solutions and human well-being for each societal challenge.

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Background

Approaching the turn of the millennium, an increasing number of individuals and organisations started to promote an anthropocentric view of the management of natural resources [1]. The thinking led to the realisation that humans and nature cannot be treated separately and has continued to resonate (for example see [2, 3]). Research and policy began to focus on the benefits that nature may provide for humans [4–6] and many theoretical and practical approaches developed. The concept of nature-based solutions (NBS) evolved as an umbrella concept embracing concepts such as Green/Blue/Nature Infrastructure, Ecosystem Approach, Ecosystem Services, Natural Capital, Ecosystem-based Adaptation//Mitigation, Ecological Engineering and Catchment Systems Engineering (see [1, 3]).

There are various definitions of NBS but, at their core, they cluster into the general theme of learning from and using nature to create sustainable socio-ecological systems, which enhance human well-being (HWB) locally, regionally or globally. NBS interventions are multifaceted and highlight the fundamental influences that preservation and diversification of ecosystems can have on human wellbeing. These range from climate regulation (e.g. [7]) and limiting the impacts of natural disasters such as flooding (e.g. [8, 9]) and epidemic disease outbreaks, to promoting improved human physical health (food, water, shelter etc.) and mental health by reconnecting citizens with nature (e.g. [10, 11]). At the same time, NBS address and respond to the challenges of nature conservation in the face of ongoing environmental degradation. However there may be trade-offs between the co-benefits of NBS interventions and co-harms [12], e.g. where exposure to infectious diseases linked to wildlife or arthropod vectors is increased (Fig. 1). In summary, NBS interventions are place-based modifications of the biophysical environment inherently involving human management of landscapes, seascapes and cityscapes. Furthermore, they aim to encourage stakeholders and all societal actors to act sustainably. For the purposes of this mapping review we adopted the internationally recognised IUCN definition of NBS as it was the broadest, i.e. “actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits” [1].

It is claimed that solutions based on nature should be integrated into many policy sectors including transport, housing, energy and health policies, climate regulation strategies and territorial planning because of the interactions, trade-offs, synergies and conflicts resulting from NBS target actions [13]. As such policy makers need to understand the evidence for the effectiveness of

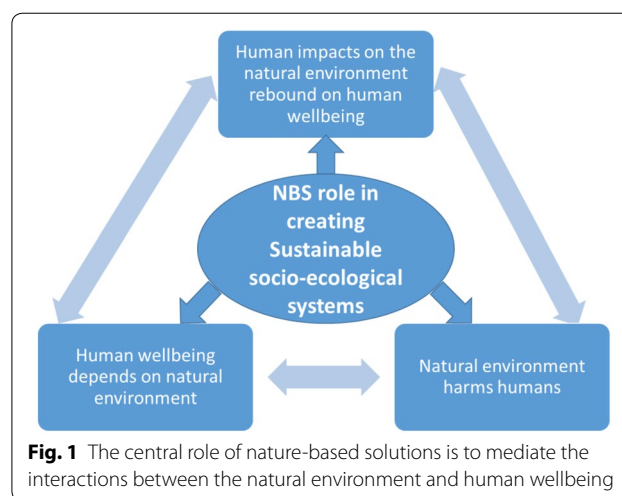


Fig. 1 The central role of nature-based solutions is to mediate the interactions between the natural environment and human wellbeing

NBS co-benefits and co-harms across policy domains. In this systematic evidence mapping we aim to ascertain the evidence for specific benefits and disadvantages of NBS interventions across societal challenges and policy domains. Only then can policy-makers and regulators make informed decisions to enact appropriate NBS actions which resonate with public values and lead to a more sustainable future.

There have been a number of reviews looking at evidence about associations between human health and natural environments. To date they have tended to focus on either physical health [10], or social perspectives [11] often centred on the urban environment [14]. McKinnon et al. [15] broadened the focus from nature-health relations to encompass 10 domains of human well-being when they conducted a systematic evidence review examining the link between nature conservation and human well-being. However, no comprehensive review exists of the links between NBS and the associated wider positive and negative HWB outcomes of NBS interventions enacted to address societal challenges across a range of habitats.

This evidence mapping review arose following the UKRI-NERC funded Environment Evidence for the Future (EEF) Initiative which consulted widely via a series of workshops held in Scotland, Wales, England and Northern Ireland. The consultation took place between 24 August and 20 September 2017 and included representation from the UK Overseas Territories (<https://nerc.ukri.org/research/partnerships/national/programmes/eef/summary/>). They employed a futures approach to identify and define potential future environmental evidence challenges. These challenges were further refined through consultation with the wider environmental science communities via an online tool. This initiative resulted in ten broad and cross-cutting themes where

environmental evidence is required to address the future societal challenges in the medium and long term. NBS actions were specifically mentioned, most often in relation to HWB outcomes, but NBS actions are relevant to all ten themes identified by over 150 individuals working across the policy-science-practice arena to improve nature-society interdependencies and lead to sustainable socio-ecological systems (Table 1).

It is not possible to conduct a systematic evidence map for all of these outcomes and their interactions. Therefore, a pragmatic and participatory approach of consulting with an Advisory Panel policy-makers in the four countries of the UK was conducted to identify the priority challenges.

Stakeholder engagement: participatory co-design of systematic mapping priorities

A Steering Group that comprises members of the EEF Programme Advisory Group, including NERC and CEE, will guide and review the project scope and deliverables. Additionally an Advisory Panel was set-up to guide the review scope and make decisions on the direction and policy relevance of the mapping.

A key preliminary background step in the selection of focus topics for the systematic evidence mapping review was collaboration with the Advisory Panel that comprised policy-makers and government agency staff who operationalise, or advise on the operationalisation of NBS interventions, from the environmental and human wellbeing (HWB) community of the UK. Policy champions (n = 7) were identified in the four component parts of the United Kingdom (Scotland, England, Wales and N. Ireland) and selected because of their

work on the interface between science, policy and practice. Each of the policy champions contacted policy-makers or other people who operationalised policy (n = 95) initially using their personal knowledge of the NBS action arena in their country but also using recommendations from interviewees and searching the websites of relevant government organisations.

In total 46 individuals agreed to be interviewed over a 5 week period from 8th February to 14th March 2019. Many individuals contacted excused themselves due to the workload associated with the impending withdrawal of the UK from the European Union (scheduled at that time for 29th March 2019). The aim of the interviews was not to determine differences across the regions in the priority societal challenges and associated NBS actions and HWB outcomes per se, but rather to ensure that the focus of the evidence mapping review was likely to have maximum utility across the UK. The majority of the interviews were conducted by telephone (72%), just under a quarter conducted in person (either as individual interviews or in focus groups) and two responses were provided in writing. Each interviewee worked through a series of 10 questions and their responses were recorded via a standard reporting format (see Additional file 1). All interviewees were informed about the aims and deliverables of the project and following each interview the write-up was returned to the interviewee for validation. This process in one sense was to check that the output from the interview was correctly recorded but also allowed a period of reflection by the interviewee and the opportunity to add further thoughts. Several individuals from the same government departments and agencies were contacted, if recommended, to allow triangulation of results.

Table 1 Mapping 10 themes taken from the final EEF report to NBS actions

Research themes	NBS actions
Land and marine use	Reduced impact of natural disasters e.g. increased flood regulation via restored/created/increased lakes or wetlands in river-basins, in coastal systems to protect against tidal storms and sea level rises. Create, enlarge, connect and improve green and blue infrastructure to enhance ecosystem services
Climate change	Carbon sequestration in vegetation and soil to enhance climate resilience
Economics of resource use	Natural capital accounting. Net additional jobs in the green sector fuelled by new green investments
Soils	Enhanced soil diversity, quality and health
Biodiversity	Greater ecological connectivity, rewilding resulting in reduced spread of pests and alien species
Environmental policy	Synergies and trade-offs within and across policy sectors when implementing NBS actions
Human health	Wide range of co-benefits from green infrastructure including microclimate regulation through shading, improved air quality through enhanced deposition, mitigation of chemical pollution especially in aquatic systems, habitat and food provision for biodiversity and associated cultural services, noise shielding, and recreation, reduction in chronic stress and stress-related diseases. Potential co-harms from wildlife and vector borne infection diseases
Technology	Equipment to monitor environmental impact of actions. Biomimicry and industrial design
Circular economy	Using nature to save energy, conserve water, reduce infrastructure costs, boost important biodiversity, and increase the health and wellbeing of citizens, enhance use and recycling of waste
International focus	Improved natural resource use across international boundaries, improved transboundary relationships

In total the interviewees worked for 21 different UK government departments or government agencies. The majority were in the environmental sector (63%) including the agencies responsible for the protection and enhancement of the environment and nature in the landscape, cityscapes and seascapes in each of the four countries of the UK. Just under a fifth (17%) worked in one of the devolved governments, 13% of interviewees worked in local authorities or national parks and 7% of interviewees worked directly in the health sector (NHS and Public Health England).

The scale of the respondents' remit varied between local to national scale responsibility. Several were also contributing to international groups such as European Union or IUCN. Most individuals that were interviewed had responsibility for several habitat types within the UK. Collectively the respondents' sphere of activity covered all main broad habitats in UK as defined by the National Ecosystem Service Assessment [16]. The marine was the least represented—by only 14 people; all other habitats were represented by 27–35 people.

Many of the government agency staff reported that they provided advice on NBS interventions to both policy-makers (41) and those operationalising NBS actions (32). Those more directly involved in policy-making and operationalising NBS interventions were less well represented in the cohort of interviewees (8 and 12 respectively), reflecting the total number of people working in government or government agencies who perform these roles.

In total the 46 respondents recorded 205 societal sub-challenges as priorities for investigating by systematic evidence mapping. The recording tool (Additional file 1: Table S3) was found to be a useful instrument to discuss the broad and multi-faceted inter-related aspects of NBS interventions in the UK. It is notable that many respondents commented that it was difficult to assign their top priority to a single sub-challenge and cautioned against a strictly quantitative analysis. A respondent interviewed in Scotland, for example, reported:

Multiple benefits, co-design and working with nature ... were the main elements and advantages of NBS and we need evidence on all three of these elements in order to judge the merits of NBS actions on human wellbeing. ... Important to understand that place making and green infrastructure are integrating concepts and currently do not fit easily into Table 3 which is rather compartmented (S8).

Similarly another interviewee found that it was not possible to assign a priority HWB outcome to a specific NBS action. They considered that NBS interventions

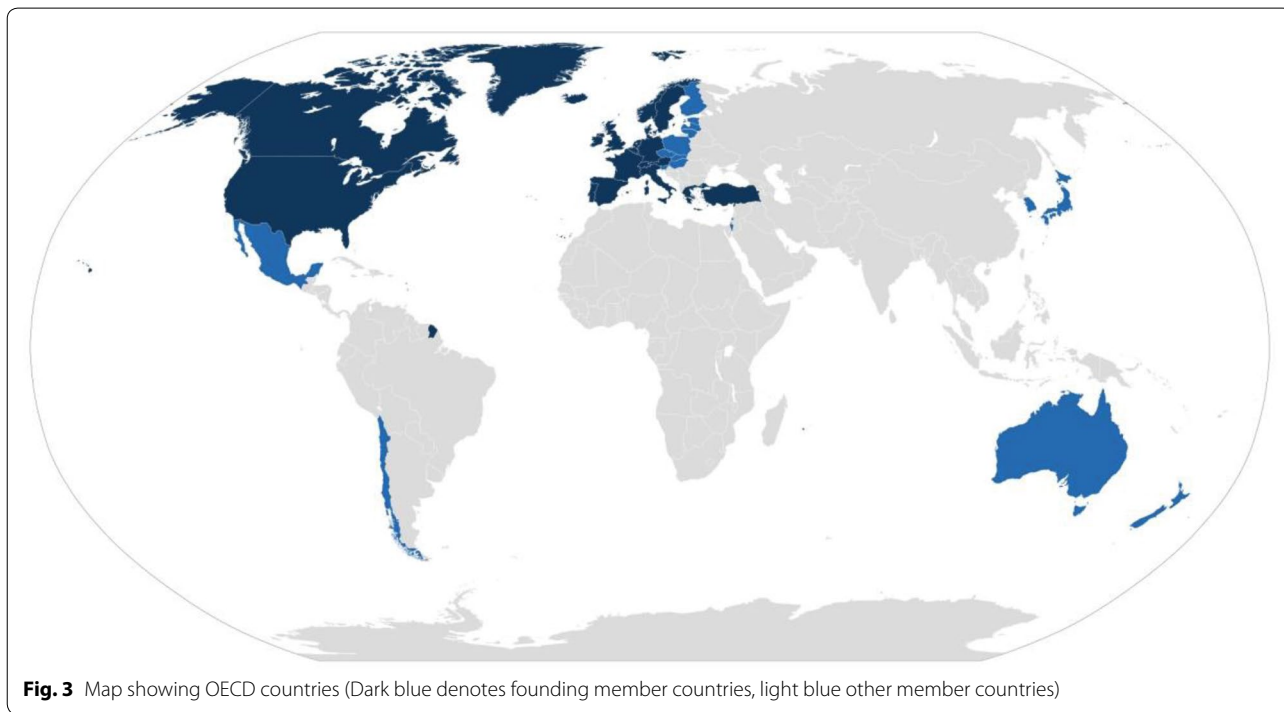
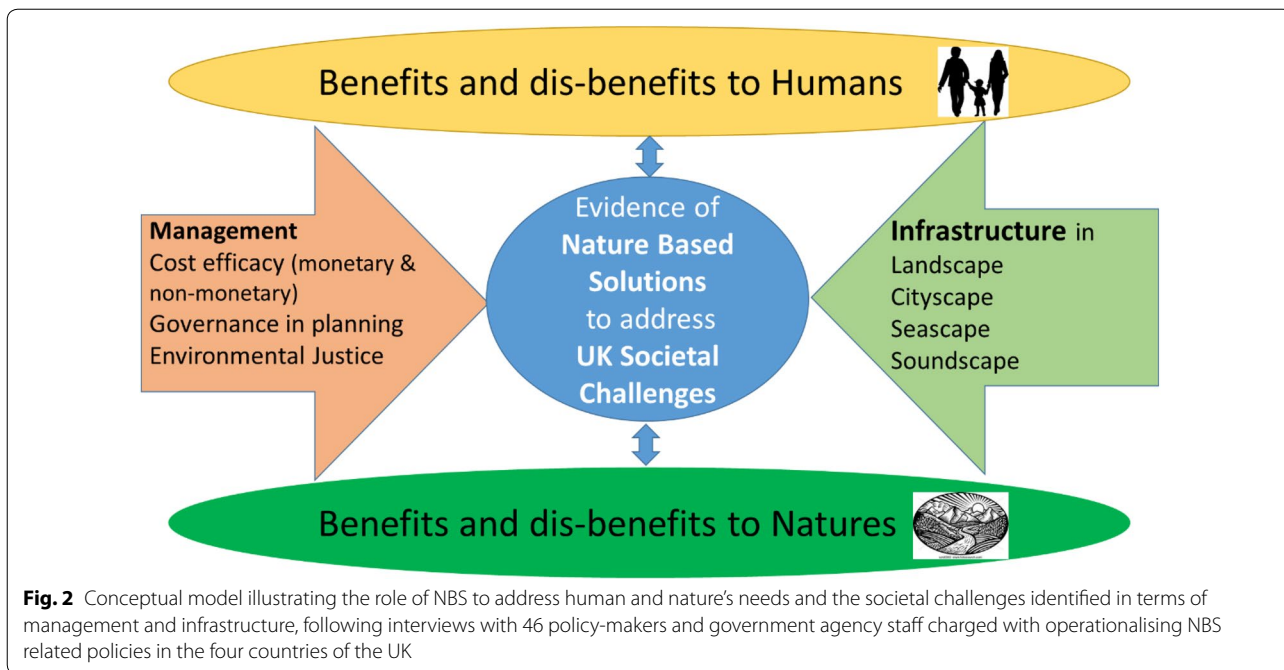
should address all 10 of the HWB domains of McKinnon et al. [15].

Systematic mapping question prioritization

During a meeting between the review team and Advisory Panel each policy champion reported the priority societal challenge identified from their interviews and discussed the background to these priorities in relation to their level of perceived importance as well as the need for an evidence review. This process of discussion with policy champions considered all the priority topics and also the secondary topics mentioned by the interviewees. During the meeting it was discussed how the top priority from each policy champion compared to the findings from the other UK countries and a final representative selection of topics was agreed to be taken to the next stage of the process.

When selecting the topics for this systematic mapping review, the specific topic areas of focus of the other four projects funded by UKRI-NERC were avoided to remove any risk of overlap (see Additional file 2). As indicated above, a number of interviewees commented on topics which they considered had a sufficient evidence-base and advised that there was no need for a specific focus on these societal challenges. This included valuation of woodland, water and soil services associated with natural flood management, air quality and health benefits and outdoor education.

The priority societal challenges identified as requiring evidence linking NBS and HWB outcomes primarily addressed management issues and infrastructure creation (Fig. 2). These two issues were also priorities in the conceptual framework of the IUCN [1] along with restoration, protection and issue-specific aspects. The management issues for which policy-makers requested additional knowledge were primarily: (i) cost-efficacy: they recognised both monetary and non-monetary factors but reported that it was essentially a financial decision whether or not to enact an NBS intervention; (ii) governance in planning: this was recognised as a major challenge, especially relating to evidence on how to create management practices which would foster cross-department decision-taking and encourage wide stakeholder engagement; (iii) environmental justice: a key evidence gap identified was how NBS interventions can deliver benefits to urban and rural communities in ways that could reduce inequalities. In addition, interviewees highlighted the acoustic environment as an often unconsidered but important aspect impacting on human wellbeing in the experience of the natural environment. They noted that the soundscape is also under threat, experiencing rapid change in a similar way to the landscape and seascape. Interviewees commented



on both the positive aspects of the soundscape such as bird song and sea waves crashing on the shore and negative aspects such as irritating early morning bird song and traffic noise. The policy-makers and agency staff interviewed were responsible for a wide range of rural, urban, coastal and marine habitats. Consequently

the regional policy champions reported that all these environments should be included in the evidence mapping review.

The results of the refining of mapping scope with the Advisory Panel were discussed with representatives of the UKRI-NERC Environment Evidence for the Future

Table 2 Key elements of the study research question

Population	Intervention	Comparator	Outcome
Human populations in OECD countries	Adoption or implementation of NBS to address a specific challenge related to cost-efficacy of NBS, governance in planning, environmental justice, and the acoustic environment (cityscapes, seascapes and soundscapes)	With/without NBS actions, before/after,	Positive or negative effect on domains of human well-being defined by McKinnon et al. [15]

Program Steering Group and a strategy for the systematic mapping was agreed.

Objectives of the review

This systematic mapping process will identify and codify studies that investigate the impacts of NBS on HWB. Given the wide scope to this topic and participatory approaches was used (see background above) to identify priority NBS for relevant societal challenges being faced in different parts of the UK. Policy makers and government agency staff engaged in operationalising NBS interventions prioritised three management issues (NBS cost-efficacy, governance in planning, environmental justice) relevant to the landscape, seascape and cityscape, and a fourth infrastructure issue (acoustic environment i.e. soundscape), summarised in Fig. 2. The emphasis will therefore be on identifying and mapping evidence with regard to these particular societal challenges, and not for example, on other topics that are either well covered already, such as climate adaptation (see [7]), or that are covered in other systematic mapping reviews, such as flood management (parallel EEF topic see Additional file 2), or woodland expansion. Further, due to the focus on UK stakeholders and their operational needs, the mapping will centre on evidence from OECD countries. The resulting systematic map will be used to synthesize relevant literature and map the evidence to inform on the state of evidence concerning research into the impacts of NBS on HWB.

The *primary question* is:

What evidence is there for nature based solutions and their impacts on human wellbeing for societal challenges related to cost-efficacy, governance in planning, environmental justice, and the acoustic environment? The key elements of the primary question were identified by the steering group and review team during a steering group meeting that built upon the participatory mapping consultation process. These elements are outlined in Table 2.

A number of *secondary questions* are used to add precision to the facets of the primary question of stated interest to UK stakeholders:

Societal challenges

- What evidence is there for specific economic cost–benefit analyses of individual NBS actions?
- What evidence is there concerning the role of NBS actions in addressing environmental justice and socio-economic inequalities?
- What evidence is there that governance issues are being highlighted with regard to implementing NBS actions?
- What is the evidence for NBS actions focused on the acoustic environment (soundscape)?

Generic questions for collection from evidence-search:

- What is the current state and distribution of evidence?
- What habitat types are being covered?
- What aspects of human wellbeing are associated positively and negatively with NBS actions?
- How much evidence is there for really long-term impacts—what is actual length of studies in terms of years?

Methods

The systematic map has been developed in accordance with the RepOrting standards for Systematic Evidence Synthesis (ROSES) for systematic map protocols (Additional file 3).

Searching for articles

Languages

Searches of databases and the internet will be undertaken using only English, due to limited resources and the language competences of the mapping review team. In addition, key academic and organisational sites within France will be searched using French language specific search keywords in line with the main systematic search string protocol.

Search string

A scoping exercise was conducted on the “Web of Science Core Collection” database to build-up the search strings (see Additional file 4). Terms describing the intervention (NBS) and the outcome (HWB) were combined iteratively with additional searches on the four

population qualifiers (environmental justice, governance in planning, cost-efficacy, and the acoustic environment—highlighted in bold) until searches resulted in a suitable number of hits and that captured key sources identified from the relevant literature. The list of words selected for the intervention, outcome and population qualifiers represents the range of key-words used in articles on the subject of NBS and human well-being. Our final search string was therefore designed to capture articles covering (1) nature-based solutions; and (2) human wellbeing; where they also consider: (3) environmental justice; (4) governance; (5) cost-efficacy; and (6) acoustic environment. The final combined search string that produced the highest efficiency (number of hits compared to the test list) is presented below (the 6 key themes in bold followed by linked phrases):

((TS=(“nature based” OR “nature-based” OR “**nature based solution**” OR “nature-based solution” OR NBS OR “green infrastructure” OR “natural infrastructure” OR “blue infrastructure” OR “ecosystem approach” OR “natural capital” OR “ecosystem service” OR “ecological restoration” OR “landscape restoration” OR “ecological engineering” OR “ecosystem-based” OR “green solution” OR “green space” OR “urban green space” OR urban NEAR “national park” OR “blue space” OR “sustainable management” OR “sustainably manage” OR “grey-engineering” OR “eco-technology” OR “nature-engineering” OR “green roof” OR “sustainable urban drainage” OR “local indigenous knowledge” OR “renaturalisation” OR “agri-environment scheme” OR “managed realignment” OR “habitat restoration” OR “multiple benefits” OR “best management practice” OR “BMP” OR “greening” OR “working with nature” OR “environmental stewardship” OR “biophili” OR “urban agriculture” OR “community garden” OR “rewilding” OR “wildness” OR “wilderness”) AND

TS=(**wellbeing** OR well-being OR “well being” OR “ecosystem service” OR skill* OR empower* OR livelihood OR “human capital” OR “human health” OR “physical health” OR “public health” OR “human welfare” OR “urban health” OR “mental health” OR nutrition OR longevity OR “life expectancy” OR “maternal health” OR “child health” OR “health care” OR “food security” OR “physical security” OR “human rights” OR “progress indicator” OR happiness OR freedom OR “happy planet index” OR “thriving places” OR “globally responsible” OR “ecosystem resilience” OR “urban ecosystem” OR co-benefit* OR “living standard” OR “living standards” OR wealth NEAR human OR poverty NEAR human OR justice OR transparency OR governance OR security OR right* NEAR human OR “cultur* value” OR “adaptive capacity” OR “personal safety” OR “societal value” OR green NEAR value OR “social relation” OR “spirituality”

OR “traditional values” OR “sense of home” OR spiritual OR “religious beliefs” OR “religious values”)) AND

(TS=(“**environment*** **justice**” OR “environmental challenge” OR “green justice” OR “societal challenge” OR “cohesive communit*” OR “social cohesion” OR “social relations” OR stewardship) OR TS=(**govern*** **NEAR planning** OR urban NEAR planning OR urban NEAR polic* OR land-use NEAR planning OR environment* NEAR govern* OR “decision making” NEAR environment OR “policy challenges” NEAR environment) OR TS=(**cost-efficacy** OR cost-effectiveness OR “cost efficiency” OR “economic living standards” OR “material living standards” OR “green GDP” OR “circular economy” OR “green economy” OR bioeconomy OR natur* NEAR value OR “quality of life” OR “non-material benefits” OR green NEAR development* OR green NEAR “mental health”) OR TS=(**acoustic*** OR noise* OR sound* OR sensory))).

Comprehensiveness of search

A test list of 24 scientific articles was compiled (see Additional file 5) and used to assess the comprehensiveness of the search string.

Online academic databases

We identified a number of academic databases that cover the scope and range of journals in which evidence on the mapping subject was generally covered. We scoped the suitability of the searches and databases using only Web Of Science due to resource limitations. The same keywords and search string combination will be adapted for each of the other databases.

Web of Science Core Collection (Clarivate). See Additional file 6 for citation indexes included in the “Web of Science Core Collection” to which the review team had access via the team members’ institutions. The first scoping exercise was conducted using this database on 06/06/2019. It returned 25,521 articles (the search was run using only English language and covered SCIEXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI and CCR-EXPANDED, without any timespan restrictions). The search comprehensiveness value was 88% (24 articles in the test list were referenced in the WOS CC and 21 were retrieved by the string). A revised search was conducted and tested on 07/07/19 that sought to refine search terms to reduce redundancy across the combined searches and to reduce the number of irrelevant articles returned. The revised search resulted in the same comprehensives (88%) but the search returned a more manageable and relevant set of 6642 articles (Additional file 7).

Additional databases that will be accessed during the systematic review include: Scopus (Elsevier), PubMed, Social science premium collections, Directory of Open Access journals.

Search engines

Searches for academic and grey literature will be performed using the following search engines and using the simplified search string: “nature based solutions and human well-being” and the first 250 hits (sorted by relevance) will be screened, following guidance from Haddaway et al. [17]:

- Google (<https://google.com>)
- Google Scholar (<https://scholar.google.com/>)
- BASE (<https://www.base-search.net>) and/or CORE (<https://core.ac.uk/>).

Specialist site searches

Consultation with the steering group identified a number of specialist organisations that could hold relevant grey literature. The following will be searched for relevant grey-literature publications, using manual searches of their websites and automatic search facilities with the simplified search string “nature based solutions and human well-being” if possible.

Organisation	Website
Centre For Ecology And Hydrology (CEH)	https://www.ceh.ac.uk
James Hutton Institute	https://www.hutton.ac.uk
European Commission (CORDIS)	https://cordis.europa.eu
Natural Health Service	https://naturalhealthservice.org.uk
NORA	https://nora.nerc.ac.uk
Natural England	https://www.gov.uk/government/organisations/natural-england
Natural resource Wales (NRW)	https://naturalresources.wales/?lang=en
Scottish Natural Heritage (SNH)	https://www.nature.scot/
National Trust (NT)	https://www.nationaltrust.org.uk/
World Wildlife Foundation (WWF)	https://www.worldwildlife.org/
Department For The Environment, Food And Rural Affairs	https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs
Environment Agency	https://www.gov.uk/government/organisations/environment-agency
European Environment Agency (climate adapt)	https://climate-adapt.eea.europa.eu/
Environment Protection Agency Ireland	https://www.epa.ie/
EHS—Northern Ireland Environment Agency	https://www.daera-ni.gov.uk/north-ern-ireland-environment-agency

Organisation	Website
European Commission Joint Research Centre	https://ec.europa.eu/info/departments/joint-research-centre_en
National Ecosystem Assessment	http://uknea.unep-wcmc.org/
SEFARI	https://sefari.scot/

French sites will be searched using search strings based on the English language search with text: e.g. based on the French National committee of the IUCN the official translation of NBS is “solutions fondées sur la nature”.

Organisation	Website
IUCN France	https://IUCN.fr
Muséum national d’Histoire naturelle	http://www.mnhm.fr
Information and Documentation Center on Noise	http://www.bruit.fr/
Document portal of the French Ecology Ministry	http://temis.documentation.developpement-durable.gouv.fr/recherche.html
Isidore academic search engine	https://isidore.science/
Publication search engine	https://www.cairn.info/

Article screening and study eligibility criteria

In order to make best use of available resources and tools, the systematic mapping review team will make use of the CADIMA tool to support the following steps in relation to article screening, eligibility and the coding process (<https://www.cadima.info/index.php>). CADIMA is a free-to-use web tool that can assist authors in recording, conducting and reporting CEE Evidence Syntheses. CADIMA is currently in its trial phase and is being made available through a joint project between CEE and the Julius Kühn Institute (JKI). The team will provide feedback to the CADIMA development team to aid its development.

Screening process

Using the predefined eligibility criteria detailed below, article/study screening will proceed according to a three stage hierarchical screening process; first title, then abstract and finally full text. In cases of doubt regarding or insufficient information to make a decision, articles will be retained for assessment at a later stage. Articles without an abstract but passing title stage screening will be transferred to full-text screening—this includes grey literature sources such as reports that do not have a clear executive summary. Full text eligibility will be conducted at the study level to ensure no double counting of articles based on the same study. The three screening stages

will be conducted by two or more reviewers. Where articles are authored by a reviewer these will be added to the test list to ensure reviewer independence in assessing eligibility.

To assess the consistency of the inclusion/exclusion decisions, a Kappa test will be performed, before the actual screening process, using a randomly selected set of 100 of articles, on the independent results of the review team (n=4) applying the eligibility criteria. CADIMA provides automated calculation of a kappa-statistic to test inter-reviewer agreement when applying the defined criteria (Table 3). The operation will be repeated until reaching a Kappa value higher than 0.6 and for any inconsistencies screeners will discuss and resolve any disagreements to resolve uncertainties before beginning the screening process.

Eligibility criteria

Article eligibility will be based on the list of criteria detailed in Table 3. The list of all articles/studies will be provided, informing the inclusion/exclusion decisions at the three screening stages. A list of studies excluded at full text will be provided alongside the criteria on which they were excluded.

Study validity assessment

We will not be undertaking a study validity assessment.

Data coding strategy

Coding strategy

Each article will be coded using keywords and expanded comments fields describing various aspects of the article/report (see Additional file 8 for full details). These keyword and comment fields were developed in the steering group meeting and are designed to prove the summary information required to answer the primary and secondary questions and support clear feedback to stakeholders consulted during the initial participatory phase. The key variables will include:

- Study description
 - Publication source (WOS research, Scopus research, Google Scholar research, etc.)
 - Basic bibliographic information (authors, title, publication date, journal, DOI, etc.)
 - Language (English/French)
 - Publication type (journal article, report, book, etc.)
- Study characteristics

- Country where the study was conducted
- Broad habitat type where NBS action is applied (UKNEA definition [18])
- Study focus (nature's benefits to humans; natural harms to humans; human harms towards nature)
- Study type (primary study, secondary study (e.g. measured NBS-environment link but uses secondary source to link HWB outcome), review, meta-analysis, other, etc.)
- Study design (quantitative, quasi-experimental, non-experimental, qualitative after Margoluis et al. [19])
- Study characteristics (NBS intervention): Type of NBS action [1], Length of NBS intervention, Length of post NBS intervention monitoring,
- Study characteristics (HWB outcome): HWB indicator used (HWB1, HWB2...),
- Study characteristics (governance, justice, cost-efficiency, acoustics)
- Outcome—key summary result of NBS action on HWB (positive, negative, no change, inconclusive, not addressed directly).

As far as possible, controlled vocabulary will be employed to code the variables (e.g. publication type, dates, country, etc.), using thesaurus or standards employed in academic reporting (see also coding in Additional file 7). To categorize the types of NBS actions we use IUCN categories [1]. To categorize HWB outcomes we will apply the broad groups defined by McKinnon et al. [15]. To categorize UK Broad habitat type where NBS action is applied we will utilise the UKNEA definition [18]. To categorize study design we will use the four categories of Margoluis et al. (2009).

A random selection of 10 screened articles will be double coded by two reviewers and potential disagreements will be discussed until a consensus is reached before continuing with the full list of screen articles.

Study mapping and presentation

Where there is more than one study found in an article each study will be recorded as a specific entry in the database.

The final database will be open access and included as an appendix to the systematic map publication. The final database will be deposited as a.csv file in the EIDC data depository (eidc.ceh.ac.uk).

Numbers of articles by publication year, and each continent and country will be provided. The final systematic map will include summary figures and tables of the study characteristics that cover knowledge gaps and knowledge clusters. These will be identified by cross-tabulating key meta-data variables in heat maps (e.g. NBS actions and

Table 3 Eligibility criteria for the screening process

Eligibility criteria	Geographical—only evidence from OECD countries will be included (Fig. 3)
	Population—study addresses societal challenges* identified in the consultation process
	Intervention—study involves implementation of NBS action with a link to targeted societal challenges
	Study type—study measures the effect (empirical, lab-based) of NBS actions through comparator (temporal, spatial) Secondary case studies (reviews or with referenced link to other complimentary evidence) will be included but marked as separate evidence group. Model based study or case study with inference, such as theoretical/discussion/opinion articles, or anecdotal, will not be included
	Outcome—study assess effects of NBS action on HWB outcome—being only environmental/biophysical outcomes (no HWB element either measured (primary) or considered against other evidence (secondary))

HWB outcomes) for each societal challenge. Based on these results, recommendations will be made on priorities for future research into the possible human health benefits of NBS with regard to each of the selected societal challenges.

Supplementary information

Supplementary information accompanies this paper at <https://doi.org/10.1186/s13750-019-0180-4>.

- Additional file 1.** Protocol to collect and report priority NBS actions and targeted human wellbeing outcomes.
- Additional file 2.** Project details of other projects awarded by UKRI-NERC.
- Additional file 3.** ROSES form.
- Additional file 4.** Search string building process.
- Additional file 5.** List of eligible studies identified for testing the search strategy.
- Additional file 6.** Web of Science Core Collection database subscription details.
- Additional file 7.** Assessment of search string for test list.
- Additional file 8.** Data coding template.

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Authors' contributions

JD is the project coordinator of the map. JD, JM, JC, AD conducted the scoping stage and wrote the draft manuscript. AH, RH, AG, VM, MQ, JD undertook the regional consultation and identified the priority societal challenge areas. JM assisted the team concerning methods and CEE guidelines. JM and JJ developed the search strategy. All authors read and approved the final manuscript.

Authors' information

JD, JM, JC, AD, SC, AG, AH, VM, MQ and RH are scientists.

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Availability of data and materials

Data sharing is not applicable to the systematic map protocol in that no datasets were generated for this article. Datasets produced by the systematic map will be shared publicly.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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