

**A UK Research Framework for Freshwater Conservation
Inter Agency Freshwater Group
Version 2, published 3rd December 2014**

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1 Introduction

On a global scale freshwater ecosystems have lost a greater proportion of their species and habitats than those on land or in the sea (Millennium Ecosystem Assessment, 2005). At a UK scale there is a consensus that there are no completely pristine freshwater ecosystems (UK NEA, 2011a,b) and the distribution and abundance of some species is rapidly declining (Burns *et al.*, 2013). The loss and degradation of these ecosystems has been caused by a wide range of pressures which continue to act, either in isolation or (more commonly) cumulatively. Many of these pressures are universal, and include land-use management practices, pollution (e.g. acidification and eutrophication), invasive species, water abstraction and transfers, physical modifications (e.g. associated with flood defence or water use). Climate change is a further major pressure, acting directly on freshwater habitats (e.g. through changes in thermal and flow regimes) and interacting with catchment pressures in a variety of ways. This combination of pressures has created critical freshwater biodiversity conservation cases around the world and in the UK.

The protection of freshwater biodiversity is a fundamental objective in its own right but ecosystem degradation often leads to deterioration in water availability and quality, which increasingly places at risk the goods and services derived from natural freshwater ecosystems. However there is considerable uncertainty about how ecosystem services are related to ecosystem structure, functioning, habitat type, size, spatial extent and fragmentation (UK NEA, 2011a,b). In addition as water is so intrinsic to human activity and survival there will be inevitable trade-offs between ecosystem condition and human use of water in the context of sustainable development. However, the EC Water Framework Directive (WFD) recognises that *“water is not a commercial product like any other but rather a heritage that needs to be protected, defended and treated as such.”* It is therefore vitally important that we have the research needed to pursue the sustainable management and conservation of freshwater ecosystems.

Fresh waters in the UK form a valuable component of the representative network of habitats included in our series of sites with special designations for wildlife. The majority of these sites contain water in some form (interstitial, running or standing, seasonal or permanent) and many are dependent on groundwater. Specific freshwater habitats and populations of species have provided the justification for the designation of individual conservation sites. UK freshwater habitats and species are also of international conservation importance in the context of the Habitats and Species Directive and their location on the western margins of the European continent.

The Joint Nature Conservation Committee (JNCC) is the statutory adviser to Government on UK and international nature conservation, on behalf of the statutory nature conservation bodies (SNCBs), (Natural England, Natural Resources Wales, Northern Ireland Environment Agency and Scottish Natural Heritage). The SNCBs work together closely on freshwater habitats, drawing together the specialist skills of the separate agencies within a devolved UK under the umbrella of the Inter Agency Freshwater Group (IAFG). The IAFG and JNCC are committed to providing advice and long-term thinking on solutions to biodiversity conservation challenges.

¹ The Inter Agency Freshwater Group (IAFG) is a group of representatives from the statutory nature conservation bodies that works on UK-level freshwater issues under the auspices of the Joint Nature Conservation Committee.

2 Developing a shared framework

As part of our collaborative working, the IAFG has developed an agreed framework for freshwater research. Although it has been written primarily to guide the research priorities of the SNCBs in undertaking their biodiversity duties, it is also designed to influence the priorities of others (environment agencies, government departments, research councils) who have a role in freshwater and catchment management research, so that conservation needs are properly considered. This framework also seeks to bridge the gap between research strategies that have traditionally been divided into 'water' and 'biodiversity' themes. Research in freshwater conservation spans both of these themes and this framework takes a fresh approach in emphasising the inter-relationships (rather than divisions) between them.

The framework is based on the protection of naturally functioning freshwater ecosystems, recognising the full range of catchment and hydrological processes on which they depend and the human pressures that influence them. It emphasises the importance of ecosystem resilience in a changeable and changing freshwater environment subject to multiple human pressures.

The framework has a hierarchical structure linking high-level themes to more detailed research areas, and linking all levels of research detail to policy needs under different drivers. The way in which the framework is structured is intended to help rationalise the different emphases of the SNCBs and other organisations in research related to freshwater conservation. Some issues are considered to be fundamental to the biodiversity duties of the SNCBs, while others are more peripheral where we might reasonably expect others to instigate research. This does not imply that some research areas are less important, but rather that the lead responsibility for such research is not considered to lie in the sphere of biodiversity conservation.

This framework is considered to be a useful starting point for SNCBs and others in understanding respective research priorities and creating more detailed research proposals. It provides a structure for more extensive debates on specific research areas and individual projects.

3 Research themes and the relationships between them

The SNCBs are involved, or have an interest, in a wide variety of research connected to the freshwater environment. This includes the classification and status assessment of biological communities and species, the characterisation of appropriate environmental conditions for biodiversity, the effects of human activities on freshwater habitats, communities and species, and the development of management solutions to human impacts. The effects of climate change and the development of adaptation responses is now an important research area that will increasingly shape our views about biodiversity management inside and outside of designated wildlife sites. The concept of ecosystem services is also becoming increasingly important in the conservation and management of all habitats, and is helping to maximise the value we place on the natural environment.

There is no perfect way to categorise these different research areas. Whatever high-level themes are chosen, there will always be research issues/projects that could fall under different categories, cut across categories, or could be categorised separately to reflect their particular importance. For instance, climate change is a critical research area that could be pulled out as a separate theme to emphasise its importance. However, we also need to integrate climate change research into our understanding of catchment and ecological processes in freshwater systems, which argues for its integration within other research themes. The latter approach has been taken in this research framework.

Three high-level themes have been adopted for this paper, outlined below. For each, an explanation is given of the relevance of the theme to policy, and of the level of responsibility that might be ascribed to SNCBs in instigating research, given their biodiversity duties. The intention is not to ascribe levels of priority to different themes and research areas, since all of the areas are considered vital to freshwater conservation. Rather, the focus is on trying to characterise the lead responsibility for different research areas, and particularly whether this should be considered to lie with the SNCBs in the discharge of their biodiversity duties.

- ***Theme 1 - Environmental processes, impacts and management***

Summary - This theme covers all natural processes, human activities and management solutions that shape the condition of freshwater habitats. For instance, it encompasses the characterisation of climate change effects on hydrological, thermal and pollution regimes in fresh waters. It also covers the development of management responses to control the effects of different types of human activity, such as agriculture, the discharging of effluents, the abstraction of water, the physical alteration of freshwater habitats, and the introduction and control of non-native species. The characterisation of ecosystem services and research to develop methods for habitat restoration are also included in this theme.

Relevance to policy – Research under this theme forms the basis for defining the nature of the management response to factors affecting the integrity of the freshwater environment. As such it supports action on specially designated wildlife sites and under the WFD and the country biodiversity strategies.

Level of SNCB responsibility – Although research falling under this theme is critical to the conservation of freshwater habitats, the SNCBs do not generally have a lead responsibility to instigate research. The lead agency role in this area would generally be considered to be the UK environment agencies (which in Wales and Northern Ireland are integrated with their respective SNCBs in a single body). However, there are important research areas within the theme that promote a positive approach to freshwater habitat restoration that should be considered mainstream to the work of the SNCBs; for example, research on large-scale renaturalising of rivers and their floodplains.

- ***Theme 2 - Ecosystem integrity and resilience***

Summary - This theme covers the relationship between freshwater biological communities (and component species) and the condition of their habitat. Research under this theme seeks to characterise the response of biological communities to human impacts, in order to help define suitable environmental thresholds for use in developing management regimes. Integrity is divided into four overlapping components: hydrological, physical and chemical integrity, and biological stressors (particularly non-native species and fish stocking) that have direct impacts on biological communities through competition or predation, but also includes the characterisation of the effects of multiple stressors. This theme also covers the role of connectivity in affecting the resilience of communities to pressures, and the characterisation of hysteresis effects in biological responses to improving environmental conditions. Research under this theme provides the basis for identifying local 'environmental regimes' aimed at limiting impacts on characteristic biological communities and species to an acceptable level. Biological monitoring underpinned by Theme 3 evaluates the extent to which these environmental regimes provide the necessary level of protection.

Relevance to policy – This theme covers research on quantitative ecological targets for use in environmental management. It is essential for defining targets for conservation objectives on designated wildlife sites, for supporting environmental standards under the WFD, and for defining BAP objectives and actions.

Level of SNCB responsibility – This theme is central to the work of the SNCBs, providing the means for expressing the needs of freshwater biological communities in terms that can be directly translated into management decision-making.

- **Theme 3 - Biodiversity assessment and audit**

Summary - This theme covers the methods and datasets that provide a direct assessment of habitats and their integrity, biological communities or component species. These may involve classifying near-natural habitat conditions or community types, or characterising the status of a biological community, group or species. Where necessary it includes taxonomic and genetic research to clarify the biodiversity importance of a particular taxonomic group or population. The application of monitoring methods to individual sites does not form part of the theme, or part of this research framework, as it is not a research issue. We also appreciate that long-term datasets and environmental monitoring frameworks and priorities have been (or are being) developed and maintained by others, e.g. the Environmental Change Network and the Countryside Survey.

Relevance to policy – Research in this area provides the basis for site designations, and for defining and locating high priority habitats and species. It also enables problems with the condition of biological communities to be detected, triggering management action beyond that detectable by research in Theme 2.

Level of SNCB responsibility – This theme is central to the work of the SNCBs, in supporting guidance on designated site selection criteria and conservation objectives, and in reporting processes (such as for Article 17 of the Habitats Directive and priority habitat condition reporting).

There is a logical connection between these themes that relates to the sequencing of change in ecosystems, and this forms the basis for applying ecological research to management decision-making and policy development (Figure 1). Theme 1 underpins the development of a management framework to conserve freshwater habitats; Theme 2 underpins the definition of environmental targets that direct the management framework; and Theme 3 underpins the evaluation of biological status that both informs the development of management targets and helps to determine whether management targets and the management framework are producing desired results.

Climate change is lodged in Theme 1 since it is another pressure (albeit a wide-reaching one) affecting environmental processes in freshwater ecosystems that needs to be evaluated alongside other pressures. However, in reality climate change research is often integrated across the three themes to provide a specific understanding of climate change influences on habitat conditions and biological communities.

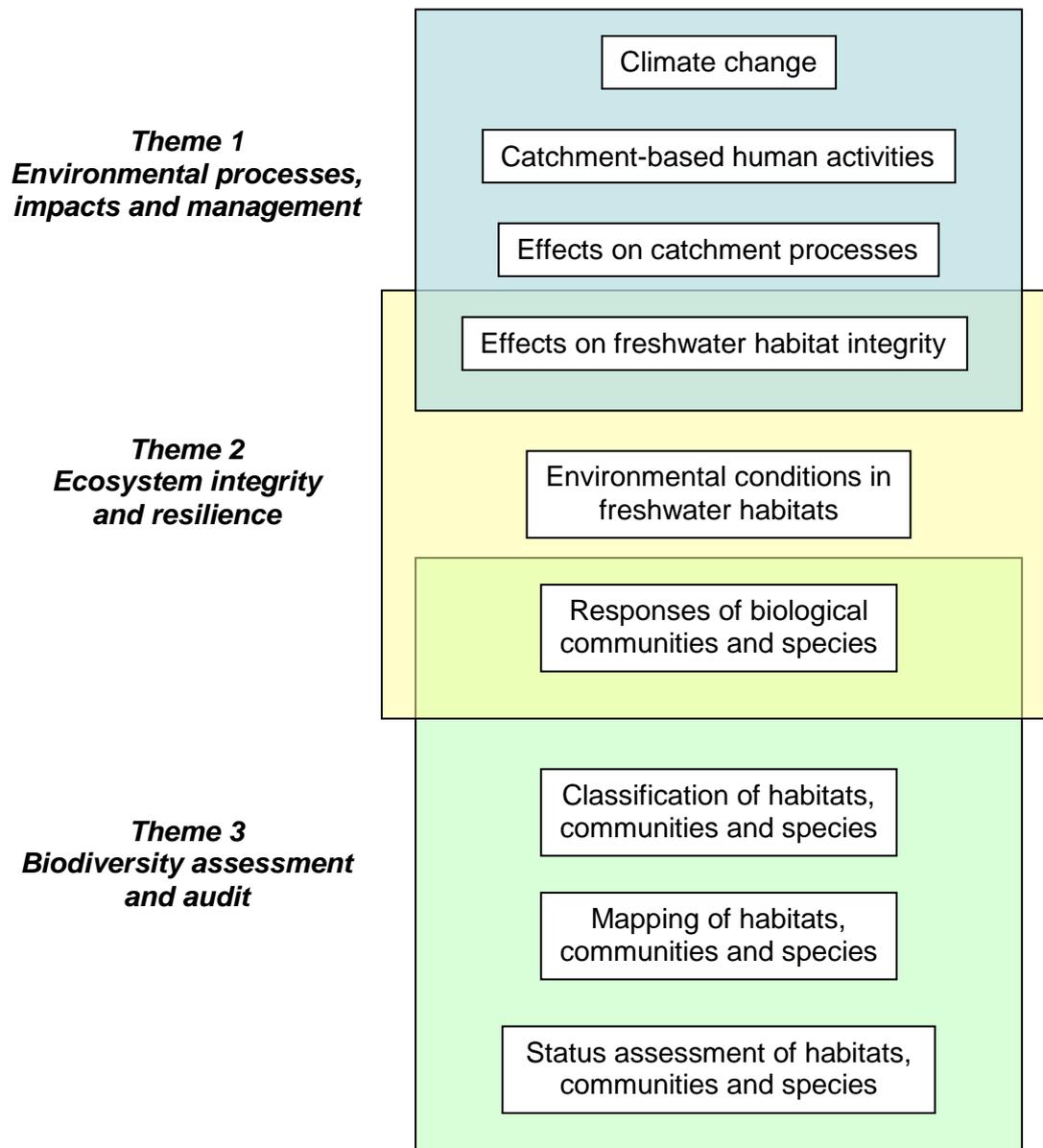


Figure 1. Relationship between research themes, indicating key components of each theme

4 Sub-themes and key research areas

Table 1 outlines the next layer in the research hierarchy (sub-themes) and outlines key research areas for each. Also included are notes on the relevance of each research area to different aspects of freshwater policy and to operational management of fresh waters. These notes demonstrate and justify the evaluation of the level of SNCB responsibility for different areas of research, which has been divided into three categories as follows:

- **Direct responsibility:** lies directly within the remit of the SNCBs in the discharge of their biodiversity duties. (However, this does not prevent collaboration with other partners, either in terms of shared working or joint funding of projects).
- **Shared responsibility:** research areas for which SNCBs and other agencies/research partners are likely to have equal responsibility and involvement.
- **Indirect responsibility:** SNCBs seek to influence and encourage research in these areas but they are more closely aligned to the remit and priorities of other agencies and partners.

Table 1. Hierarchical consideration of research issues

Sub-theme	Key research areas	SNCB responsibility	Examples of specific research gaps	Policy relevance	Operational relevance
Theme 1: Environmental processes, impacts and management					
Climate change	Evaluation and prediction of effects on hydrological, thermal, and pollution regimes on freshwater habitats	Indirect	<ul style="list-style-type: none"> Improved resolution of thermal modelling to underpin better prediction of consequences for freshwater biodiversity Links between climate change and acidification/eutrophication 	Designated sites legislation, WFD, biodiversity strategies, climate change agenda	Water regulation regimes, pollution control regimes, physical habitat restoration
	Climate change adaptation	Direct	<ul style="list-style-type: none"> More strategic evidence of the importance of natural ecosystem function in climate change adaptation 	Designated sites legislation, WFD, biodiversity strategies, climate change agenda	Provides improved underpinning of restoration of natural processes
Catchment-scale impacts	Develop tools for modelling effects of abstraction, diffuse and point source pollution and physical habitat modification on conditions in freshwater habitats	Indirect	<ul style="list-style-type: none"> Refinement of methods for modelling natural hydrological regimes in rivers and lakes Improved integration of point and non-point source pollution modelling at catchment scale Improved integration of hydrological and water quality modelling 	Designated sites legislation, WFD, biodiversity strategies	Water regulation regimes, pollution control regimes, physical habitat restoration, river basin management plans

Sub-theme	Key research areas	SNCB responsibility	Examples of specific research gaps	Policy relevance	Operational relevance
Management solutions	Decision-support tools for planning management measures to meet defined levels of environmental quality (pollution control, abstraction etc.)	Indirect	<ul style="list-style-type: none"> • Methods for apportioning nutrient load reductions between different pollution sources • Tools to support strategies for addressing small point-source loads • Refining existing decision support tools, e.g. flow/habitat models 	Designated sites legislation, WFD, biodiversity strategies	Water regulation regimes, pollution control regimes, habitat restoration planning, strategies for controlling non-native species
	Demonstrating best management practice, e.g. for renaturalising rivers and floodplains	Direct	<ul style="list-style-type: none"> • Strategic case studies with associated modelling 	Designated sites legislation, WFD, biodiversity strategies, Wetland Vision (for England)	Operational approaches to restoring rivers and floodplains
	Developing novel practical techniques to control human impacts, e.g. non-native species control	Shared	<ul style="list-style-type: none"> • Biological and other control techniques for non-native species (e.g. for non-native crayfish, <i>Crassula helmsii</i>) • New techniques for/trials of sustainable phosphorus removal and reuse from wastewater streams (e.g. slow sand filtration) • Characterising natural wetland treatment systems for efficient removal of phosphorus from effluents 	Designated sites legislation, WFD, biodiversity strategies, non-native species policies	Provides practical control tools

Sub-theme	Key research areas	SNCB responsibility	Examples of specific research gaps	Policy relevance	Operational relevance
Ecosystem services	Defining the benefits of naturally functioning freshwater and wetland ecosystems to flood risk and water resource management	Direct	<ul style="list-style-type: none"> • Development of tools applying management principles and demonstrating benefits • Projects demonstrating flood risk reduction as a consequence of ecosystem restoration 	Sustainability agenda, economic evaluation of freshwater habitats, EC Floods Directive	Provides support for action under designated site legislation, biodiversity strategies and implementation of sustainable flood management
Theme 2: Ecosystem integrity and resilience					
Hydrological integrity	Defining ecologically acceptable hydrological regimes in riverine and lake habitats	Indirect	<ul style="list-style-type: none"> • Controlled experiments on habitat and community responses to hydrological alterations in mesocosms and representative field sites 	Climate change, designated sites legislation, WFD, biodiversity strategies	Decision-making on the management of abstraction and water regulating structures and climate change adaptation
Physico-chemical integrity	Defining ecologically acceptable fine sediment delivery regimes	Indirect	<ul style="list-style-type: none"> • Rivers: effects of siltation on riverine habitats and species and the establishment of adequately protective targets • Lakes: suspended solids targets to protect characteristic submerged macrophyte communities 	Climate change, designated sites legislation, WFD, biodiversity strategies	Decision-making on catchment management measures to control fine sediment inputs
	Evaluating the ecological consequence of altered thermal regimes in freshwater habitats	Shared	<ul style="list-style-type: none"> • Improved characterisation of community responses to altered thermal regimes and development of predictive models incorporating dispersal and connectivity issues 	Climate change, designated sites legislation, WFD, biodiversity strategies	Climate change adaptation responses, e.g. enhancing biological connectivity, temperature regulation measures, species translocations

Sub-theme	Key research areas	SNCB responsibility	Examples of specific research gaps	Policy relevance	Operational relevance
	Defining ecologically acceptable nutrient regimes	Shared	<ul style="list-style-type: none"> • Rivers: controlled experiments on community responses to nutrient gradients in stream mesocosms and representative field sites; development of improved river eutrophication models • Rivers and lakes: effects of nitrogen on habitats and species • Lakes: effects of phosphorus on dystrophic lakes 	Designated sites legislation, WFD, biodiversity strategies	Decision-making on catchment management measures to control nutrient inputs/availability
Physical integrity	Defining acceptable limits of anthropogenic physical modification	Shared	<ul style="list-style-type: none"> • Controlled experiments on habitat and community responses to physical habitat degradation and restoration in mesocosms and representative field sites 	Designated sites legislation, WFD, biodiversity strategies	Decision-making on measures to protect/restore physical habitat form and function
Biological integrity	Characterising impacts from invasive non-native and locally absent species	Direct	<ul style="list-style-type: none"> • Development of early detection methods and response strategies, e.g. environmental DNA (eDNA) • Strategic case studies of the effects of non-native species on freshwater ecosystems 	EC Regulation on Invasive Alien Species, GB non-native species strategy, Invasive Alien Species Strategy for Northern Ireland, designated sites legislation, WFD, biodiversity strategies	Decision-making on control programmes for non-native species

Sub-theme	Key research areas	SNCB responsibility	Examples of specific research gaps	Policy relevance	Operational relevance
	Characterising impacts from fishery exploitation, fishery orientated fish removals and stocking enhancement	Shared	<ul style="list-style-type: none"> • Quantitative characterisation of the effects of different types and intensity of fish stocking on characteristic biological communities 	GB non-native species strategy, Invasive Alien Species Strategy for Northern Ireland, designated sites legislation, WFD, biodiversity strategies	Decision-making on fish stocking
	Understanding non-native species ecology, dispersal mechanisms and pathways of spread	Direct	<ul style="list-style-type: none"> • Ability to become established, likely ecological impact and potential control methods 	GB non-native species strategy, Invasive Alien Species Strategy for Northern Ireland, designated sites legislation, WFD, biodiversity strategies	Decision-making on control programmes for non-native species and fish stocking
Ecological connectivity	Understanding dispersal routes (and rates of dispersal) for species under natural and impaired conditions	Direct	<ul style="list-style-type: none"> • Impacts of in-channel barriers of different dimensions to upstream movement of characteristic species (fish and invertebrates) • Impacts of lack of lateral hydrological connectivity between open water habitats and floodplains 	Climate change, designated sites legislation, WFD, biodiversity strategies	Site designations, biological status assessments, physical habitat restoration
Multiple impacts on integrity	Defining acceptable limits of anthropogenic stress in the face of cumulative and multiple stressors	Shared	<ul style="list-style-type: none"> • Characterising the interactive effects of: <ul style="list-style-type: none"> ○ eutrophication and siltation ○ enhanced sediment inputs and physical habitat degradation ○ flow modifications and physical habitat degradation 	Designated sites legislation, WFD, biodiversity strategies	Water regulation regimes, pollution control regimes, physical habitat restoration (Establishing quantitative relationships between single stressors and the status of biological communities is a more pressing priority at present.)

Sub-theme	Key research areas	SNCB responsibility	Examples of specific research gaps	Policy relevance	Operational relevance
Theme 3: Biodiversity assessment and audit					
Classification	Developing/refining classification methods for different habitats/biological groups	Direct	<ul style="list-style-type: none"> • Rivers and lakes: developing environmental classifications characterising natural biological variation under reference conditions • Improved classifications for small standing waters and dystrophic standing waters • Improved taxonomic classification for freshwater fish 	Designated sites legislation, biodiversity strategies, WFD	Site designations, biological status assessments (e.g. Habitats Directive Article 17 reporting) and definition of environmental targets/ regimes
Inventory and mapping	Developing understanding of range and distribution of habitats/communities/species	Direct	<ul style="list-style-type: none"> • Inventory projects for habitats, communities and species (e.g. reference and current ranges of Habitats Directive Annex I and II freshwater features) • Development and application of eDNA techniques • Development and application of remote sensing techniques 	Designated sites legislation, biodiversity strategies, WFD	Site designations, biological status assessments (e.g. Habitats Directive Article 17 reporting) and definition of environmental targets/ regimes

Sub-theme	Key research areas	SNCB responsibility	Examples of specific research gaps	Policy relevance	Operational relevance
Status assessment	Developing 'reference conditions' and assessment tools for different habitats/biological groups/species	Direct	<ul style="list-style-type: none"> • Developing general indices of community change from reference conditions (e.g. for macroinvertebrates and macrophytes), as more direct biodiversity indicators than WFD pressure-sensitive metrics • Development of improved physical (meso-scale) habitat assessment in rivers capable of assessing impacts on habitat character and biotope extent at reach-scale • Landscape-scale approaches to status assessments, including assessment of spatial connectivity and biological communities 	Designated sites legislation, biodiversity strategies, WFD,	<p>Reporting of condition of designated sites and wider freshwater environment (Habitats Directive Article 17 reporting, biodiversity strategies)</p> <p>Adequacy of environmental targets and management regimes</p>

5 Collaborative working

The research areas outlined above are strategically significant not only for biodiversity objectives but also for environmental protection and sustainable development. We recognise that the outcomes from this research are important to other groups and organisations, particularly environmental managers, water companies, agriculture, industry and Government. The framework may also be of use to those responsible for 'water' or 'biodiversity' themed research budgets to help clarify the respective roles of such budgets.

In many areas, no one organisation has the resources to fund the necessary research by itself, and so concerted collaborative effort between researchers and research funders is vital. It is important that collaboration happens at an early stage in any project planning and continues through to project completion, so that biodiversity objectives are adequately considered. A range of relevant collaborative research initiatives are now in place in different parts of the UK and may provide a suitable vehicle for discussions, e.g. the Wales Environment Research Hub (<http://www.werh.org/>) and the Natural Heritage Research Partnership in Northern Ireland (<http://www.qub.ac.uk/sites/Quercus/>).

The individual SNCBs have their own research priorities, and some also have their own research strategies. This research framework is not intended to compete with these, but rather to help provide a UK framework within which freshwater research can be considered at sub-UK level. Ultimately, SNCB contributions towards the funding of specific research projects would be dependent on securing budgets through internal bidding processes.

At a more practical level, SNCBs are likely to have an interest in site-based fieldwork and may be able to advise on the best sites and access. The protected area series provides an excellent site network for freshwater research, covering a wide range of natural variation in UK fresh waters. Whether research is funded by the SNCBs or not, researchers are encouraged to make their data available through open access outlets such as the National Biodiversity Network (<http://www.nbn.org.uk/>). This helps to maximise the benefits of research to biodiversity conservation.

This paper was prepared collaboratively by Chris Mainstone (Natural England), Catherine Duigan (Natural Resources Wales), Tony Waterman (Northern Ireland Environment Agency), Iain Sime (Scottish Natural Heritage) and Alison Lee (Scottish Natural Heritage) on behalf of the Inter Agency Freshwater Group.

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