DELIVERING BIODIVERSITY: PRIORITY ACTIONS FOR FRESH WATER

BRITISH ECOLOGICAL SOCIETY

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EXECUTIVE SUMMARY

The Environment Act 2021 introduced priority targets for water and biodiversity in England. In November 2023, the British Ecological Society convened a workshop with nearly 40 experts, to discuss how well the water targets would deliver for biodiversity in fresh water, what the priorities for action are, and approaches for measuring the state of the water environment. This report summarises the workshop discussions.

Water quality improvement is vital for meeting biodiversity targets, but significant gaps in understanding of the complex relationships between fresh water quality, other stressors and biodiversity make the efficacy of the proposed targets for water difficult to predict.

A more comprehensive approach to monitoring to assess the state of, and threats to, biodiversity is critical, and sustained investment in monitoring is essential.

Priority actions for freshwater biodiversity are reducing pollution from agriculture, wastewater and other sources of contaminants using regulation, incentives, investment and advice. Fresh water habitat connectivity needs to be improved, and better predictive models, based upon sustained and systematic data collection, need to be developed.

There is no single “best” indicator of change in the water environment. Several indicators are required, and we need to know which pressures they are sensitive to and what their uncertainties are. Priority should be given to developing new indicators for microbial communities, non-native species, and ecosystem resilience.

The current Good Ecological Status approach to assessment has benefitted monitoring through the inclusion of biological indicators. However, this approach was not intended to deliver a comprehensive assessment of taxonomic and functional biodiversity, and so does not capture the nuanced nature of aquatic ecosystems. The approach also has limitations with respect to smaller freshwater bodies, emerging threats, and shifting climate baselines.

The proposed Defra B6 indicator is recognised as a national scale “barometer” of change, but would not reveal the complexities of specific, interacting stressors in particular waters. The indicator should be developed to consider what “naturalness” will look like with shifting climate baselines. It should also account for changing pollutant mixtures and include key ecosystem processes.

INTRODUCTION

The Environment Act 2021 required the government to set legally binding targets for environmental improvement in England, including much-needed targets for biodiversity. These targets are intended to drive wide-ranging actions to deliver nature recovery through, for example, large-scale habitat restoration, improved habitat connectivity, and species recovery, and by addressing pollution, unsustainable resource use, and climate change.

In November 2023, the British Ecological Society held a workshop on what is needed to improve the abundance of freshwater and estuarine species and the quality of the habitats that support them. Nearly 40 ecologists, who are experts in the aquatic environment, and civil servants working on this topic at Defra, Natural England and the Environment Agency participated in the workshop. Collectively, they discussed how well Environment Act targets for water would deliver against biodiversity targets, what the priority actions for water are, and what the key approaches for measuring deterioration and improvement in the water environment are. Participant feedback was collated and thematically grouped and is summarised in this report.

BIODIVERSITY TARGETS UNDER THE ENVIRONMENT ACT 2021

2030 species abundance target: To halt the decline in species abundance by 2030.

Long-term species abundance target: To increase species abundance by 2042 so that it is greater than in 2022 and at least 10% greater than in 2030.

Long-term species extinction risk target: To improve the Red List Index for England for species extinction risk by 2042, compared to 2022 levels.

Long-term wider habitats target: To restore or create more than 500,000 hectares of a range of wildlife-rich habitat outside protected sites by 2042.

PART 1: DEFRA'S WATER TARGETS

WATER TARGETS

The priority delivery targets for water under the Environment Act 2021 are to:

a. Reduce nitrogen, phosphorus, and sediment pollution from agriculture into the water environment by at least 40% by 2038 with respect to 2018, with an interim target of 10% in all water bodies and 15% in catchments containing protected sites, by 2028.

b. Reduce phosphorus loading from treated wastewater by 80% by 2038, with an interim target of 50% by 2028 against a 2020 baseline.

c. Restore 75% of our water bodies to good ecological status.

Further targets are to:

d. Halve the length of rivers polluted by harmful metals from abandoned mines by 2038, against a baseline of 1,500km.

e. Reduce the use of public water supply in England per head of population by 20% by 2038 with respect to the reporting year 2019-20, with interim targets of 9% by 2027 and 14% by 2032 and reduce leakage by 20% by 2027 and 30% by 2032.

f. Have water companies cut leaks by 50% by 2050, with interim targets of 20% by 2027 and 30% by 2032.

g. Require water companies to have eliminated all adverse ecological impacts from sewage discharges at all sensitive sites by 2035 and all sites by 2050.

h. Target a level of resilience to drought so that emergency measures are only needed once in 500 years.

KEY MESSAGES

1. Improving water quality will help improve freshwater biodiversity. However, we currently lack the mechanistic understanding to assess how beneficial the water targets will be for meeting biodiversity targets.

2. A more comprehensive approach to monitoring biodiversity is needed, as is further research to understand the impacts of water targets on biodiversity.

3. Current water targets do not provide flexibility for emerging threats such as novel chemical pollution and climate change.

4. Other key priorities for improving freshwater biodiversity that are not included in the water targets include reducing chemical pollution, physical modification of habitats, and invasive species, as well as monitoring and restricting private wastewater treatment infrastructure.

1) HOW FAR WILL THE WATER TARGETS TAKE US TOWARDS MEETING THE BIODIVERSITY TARGETS IN FRESHWATER HABITATS?

Improving water quality is key to improving freshwater biodiversity. For example, there are clear and simple relationships between water quality and lake ecosystem state. Highly focused and immediate action to improve water quality is called for. However, biodiversity recovery may take a long time (up to 10-20 years in some cases), as some examples in the UK show, and there are important uncertainties that are highlighted below.

We currently lack the mechanistic understanding to say how beneficial the prioritised water targets will be for meeting biodiversity targets.

We know that actions to improve water quality are key to the protection and enhancement of biodiversity. However, the magnitude and timescales of such responses are challenging to predict because the interactions between water quality targets and biodiversity targets are very complex. There is currently a lack of evidence regarding the relative impact of many of the stressors addressed by the water targets on freshwater species abundances and on overall biodiversity. To allow this question to be answered with any certainty, we need a better understanding of the many factors that impact the biological status of fresh waters, and more high-resolution species data that will allow us to determine which groups of species each water target is likely to impact.

Macroinvertebrates, fish, macrophytes, and diatoms are well-established indicators of biodiversity and ecological quality. However, the complex and emerging mix of threats that fresh waters face today means that those species considered sensitive and threatened will likely change through time. As such, we need to expand the biological indicators that we use to assess freshwater ecological quality, to incorporate ecological communities that are now known to be sensitive to emerging threats. A more holistic view of freshwater biodiversity will allow us to build a more accurate picture of the associations between different habitats, pressures, and various aspects of biodiversity (e.g. microbes, algae, invertebrates and vertebrates). Importantly, improving the collection of co-occurring biodiversity and pressure data is the only way to track the success of proposed interventions.

We also need data to understand:

1. the sensitivity of species to different water quality target thresholds. Currently, we have little evidence to suggest that the planned reductions will be enough and need to prioritise research to understand targets that are most uncertain.
2. how the water targets interact. Meeting one target will not improve all elements of biodiversity and improving several targets may have different outcomes than each one individually because of synergies and antagonisms amongst them.
3. how pressures change over space and time to provide a holistic picture of the cumulative impacts on water bodies.

Achieving water targets will have different impacts on biodiversity in different freshwater systems.

The impact of the proposed reductions will be different in different freshwater systems. For example, reducing phosphorus loads by a large percentage in a phosphorus-rich aquatic environment may not have the desired effects, and if a river is already very heavily modified, invertebrates probably won't fully recover even if other water targets are achieved. It will be most effective to target water bodies where ecological responses to specific management interventions are likely, as the collection and magnitude of stressors acting upon each waterbody will differ, meaning that the efficacy of any actions will be highly context-dependent. Importantly, there is not going to be a single action for all water bodies that will improve biodiversity.

Data are needed from standing waters.

There needs to be greater clarity regarding which water bodies these targets relate to. Most targets and most of the workshop discussion focused on rivers, but this is not representative of all aquatic habitats. Smaller running waters and standing waters (lakes, ponds, wetlands, canals, and slow flowing rivers) need to be included in all targets, where the pressures, and species impacted, will be different from those in larger rivers. Small streams or standing waters have not been as well represented in EA monitoring networks in the past, and so there are fewer data available for these water bodies. This needs to be addressed as a priority, as without data we cannot properly represent these important water bodies in the water targets.

How do the water targets account for shifting baselines?

Emerging threats, such as the constantly evolving use of chemicals in urban and rural settings, or the increased plastic input to fresh waters mean that priority vulnerable species and threats to biodiversity will need to be reassessed regularly. Climate change will also impact different water targets (e.g. increases in sediment runoff due to increased storm events) and biodiversity (e.g. reductions in salmon spawning success due to increased temperature), which will need to be considered. If an overarching aim is to ensure that the water targets help us meet the biodiversity targets, then the water targets will need to remain flexible to meet changing threats to freshwater biodiversity.

Specific concerns regarding current water targets.

Sediment pollution: the target of reducing sediment pollution by 40% needs more clarity. How is sediment defined? There is currently no effective way of measuring sediment in water and thus this target will be difficult to monitor.

Phosphorus loading from wastewater: the framing of wastewater should not be one dimensional. Wastewater contains a lot more than phosphorus. It contains microbes, pharmaceuticals, hormone disrupting chemicals, legacy pollutants and microplastics, all of which can significantly impact freshwater taxa. We currently lack the data to determine if reducing phosphorus should be the priority target from wastewater, relative to its other components.

Public water supply: using 'per head of population' as the chosen metric for reducing water demand is concerning as this is complicated by increases in total population size. There is also no consideration of the distribution of population within this target. Population distribution needs to be accounted for when planning spatially distinct priority actions.

Nutrients: during the workshop there was some debate about the likely magnitude and time scales of biodiversity responses should nutrient loading to fresh waters be reduced, though evidence suggests that this would have positive impacts. Some experts also flagged that efforts to reduce nitrogen will not go far enough.

2) HOW SHOULD PRESSURES NOT SPECIFICALLY COVERED BY WATER TARGETS BE PRIORITISED?

Other key priorities that are not discussed in the water targets include reducing chemical pollution, physical modification of habitats, invasive species, and private wastewater treatment infrastructure.

Many of the reasons that freshwater bodies fail to meet good ecological status are due to chemical pollution. Additional actions need to encompass reductions in chemical pollution, specifically including reductions in Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS), insecticides, pesticides, and other organic chemicals. Physical modification is also an important reason for water bodies not achieving good ecological status. Human barriers and modified habitats (e.g. weirs, riparian habitat removal) that limit connectivity, natural flow regimes and the high and lows of annual water cycles can have important consequences for biodiversity. Creation and restoration of habitat that supports freshwater biodiversity, and removal of barriers that can negatively impact biodiversity, need to be included as key water targets and need to be implemented with a catchment-based approach.

Invasive species pressure is omitted from these targets and presents a risk to achieving biodiversity targets. The Great Britain Invasive Non-Native Species Strategy should be included within this framework.

Private wastewater treatment infrastructure is likely to be a significant pressure on biodiversity targets in many catchments, but the monitoring and restriction of these practices are also not currently covered in the water targets.

Catchment scale management needs to be considered when determining priority actions.

As each waterbody will have unique features that will limit or enhance the impact of actions on biodiversity targets, actions should be spatially prioritised.

It is also imperative to consider the ecological connections between water bodies and the wider catchments within which they reside. Connectivity within the freshwater system is crucial for the success of interventions. By managing water bodies at the catchment scale, it will be possible to ensure that species can disperse/migrate (e.g. away from pressures) and that the effectiveness of priority actions (e.g. containing/ reducing pollution) will not be minimised by differing upstream actions. Globally, loss of biodiversity has been much greater and faster in fresh waters than in other ecosystems to date because of the combined effects of pollution, habitat degradation, over-abstraction, invasive non-native species and reduced catchment-scale connectivity (Tickner et al. 2020).

Big data and computational tools are needed to determine which targets need to be prioritised, and in which locations.

Experts are using co-occurring species, habitat and pressure data, alongside hydrological data to model which pressures are impacting biodiversity (e.g. the biodiversity of invertebrates and microbes) the most. However, the results of these modelling exercises are only as good as the input data. There is a great need for the collection of a greater array of spatially and temporally explicit species data from fresh waters to improve modelling outputs.

PART 2:
PRIORITY ACTIONS FOR FRESH WATER

In April 2023, Defra published the integrated Plan for Water. This sets out the interventions needed to accelerate progress towards a healthy water environment, and a sustainable supply. It established the new Water Restoration Fund to channel environmental fines and penalties into projects that improve the water environment. It also commits the government to transforming the management of the water system, including a review of the legislative and regulatory framework.

Defra want to ensure that biodiversity outcomes are incorporated alongside water quality. Workshop participants aimed to identify high impact, “no regret” actions to implement in the short-term (next 5 years), that will contribute most towards delivery of the species abundance targets.

KEY MESSAGES

1. Reducing agricultural pollution will cause widespread improvement in waterways. Priority actions include strongly incentivising regenerative agriculture methods, funding evidence-based nature-based solutions, farming away from waterways, establishing livestock fences and permitting the regeneration of riparian woodlands to buffer freshwater ecosystems against farmland run-off.
2. Improving wastewater treatment via better monitoring, regulation and improvements to infrastructure is another top priority. In particular, preventing combined sewage overflow dry spills and targeting under-performing sewage works and misconnected sewers.
3. Actions to restore connectivity, and to reduce metal pollution, road-runoff and emerging contaminants such as pharmaceuticals should also be prioritised.
4. To understand what further actions are required and measure progress towards the biodiversity targets, a much more widespread, systematic monitoring approach is needed to provide data which will help inform models.

1) REDUCE POLLUTION

a. Agricultural pollution

Changes to farming to prevent agricultural pollution should be a top priority for restoring England's waterways. While privatised water companies are currently receiving a lot of public attention for their sewage discharges, this is not replicated for the farming industry, which is a major polluter. Given that 68% of England is farmland, improvements in agricultural practices to minimise pollution are likely to deliver the greatest and most widespread benefits.

Effective uptake and implementation of Defra's Environmental Land Management Schemes (ELMS) is essential, and measures within ELMS that reduce agricultural run-off need to be rewarded appropriately. Regenerative agriculture practices such as cover cropping to reduce/eliminate the use of fertilisers, pesticides and herbicides should be prioritised. Other priority actions include fencing around watercourses to keep livestock out and buffering headwaters from pollution by farming back from rivers and allowing riparian woodlands to regenerate (see Point d).

Studies of agri-environment schemes have shown that farmers will undertake more straightforward actions, but that these may not have the best outcomes for biodiversity (Collins et al. 2016; Arnott et al. 2019). The highest payments should be given for undertaking more challenging actions that ultimately provide the greatest benefits. In addition, farmers are receiving mixed messages from advisers on what they should prioritise. They need clear, independent advice on environmental sustainability.

b. Improve wastewater treatment works

Preventing sewage overflows from Wastewater Treatment Works (WwTW) and septic tanks is a top priority, especially combined sewage overflow 'dry spills', i.e. illegal discharges. This would involve better monitoring of WwTW performance and discharges, and enforcement of greater sanctions for those who do not comply with regulations.

It was noted that targeting small, failing sewage plants can make a significant difference, as can prioritising WwTW in headwaters to improve biodiversity along the entire river length, rather than improving the quality of water just before it goes into the sea.

Additional foci should include prevention of heavy wastewater discharges into chalk streams, many of which are already in a poor condition, and projects to update wastewater infrastructure must also incorporate climate risk.

c. Metal pollution

Metals have a major impact on freshwater macroinvertebrates. Reducing contamination from several sources, including some industries, landfill, urban areas, sewage sludge, and metal mines into waterways could result in substantial water quality and biodiversity improvements. Recent research suggests that reducing zinc and copper release into the environment would be especially beneficial to these communities. To achieve this, actions would need to target widespread inputs from urban areas and transport networks (tyre and brake wear, rail infrastructure, galvanised steel) and agricultural land (biosolids, animal manures), and locally-important sources such as abandoned mines (already a target in the Defra Environmental Improvement Plan 2023).

d. Riparian vegetation and wetlands

A recent report compared more than 700 different actions from farmers and landowners to improve ecosystem services. It found that many actions lack evidence proving impact, but that wetland restoration and reinstating riparian vegetation are proven the best options for improving water quality.

Riparian woodland restoration (with habitat-appropriate and native species) has a huge role to play in reducing pollution in waterways. Recovery of such vegetation can occur without planting, provided floodplain connectivity allows propagule dispersal. Farming back from rivers and ditches in headwaters, while creating buffers of very wide rough grassland and/or riparian woodland buffers, were also seen as key actions to reduce diffuse pollution and stimulate downstream recovery.

e. Urban areas, development and transport

In order to more fully address diffuse pollution, contamination from road runoff (e.g. tyre particles and microplastics, metals, road salts) needs to be mitigated as a priority. Unfortunately, requirements for nutrient neutrality for new developments have faced threats from the current government, but it will be important to preserve them if we are to successfully reduce diffuse pollution.

2. RESTORE CONNECTIVITY

Improving river-floodplain connectivity and re-wetting floodplains as facilitated by embankment removal and a 'farming back' approach is key to freshwater restoration success at the landscape scale, allowing for increased seed dispersal, riparian woodland and floodplain wetland development and an overall extensification of freshwater habitat. This would afford increased habitat availability for many aquatic and semi-aquatic species, improving ecosystem functioning and resilience.

Removing barriers to the flow of water, such as weirs and dams, can have a big impact. However, this is not currently being done in a strategic way, for example with upstream barriers being removed, but not those downstream.

Lake shore restoration will also reinstate ecosystem processes that improve the lateral connectivity between aquatic and riparian areas, improving biodiversity, and delivering potential co-benefits with respect to the reduction of agricultural and diffuse pollution into lakes.

Smaller water bodies are vital for connectivity but are often overlooked in monitoring and protection initiatives. Connectivity can be improved by creating new ponds, resurrecting formerly deliberately infilled 'ghost ponds', and by restoring old ponds that, with good water quality, can act as biodiversity hotspots and also as "stepping stones" for aquatic species allowing them to move through the landscape. Some experts stated that smaller streams require greater protection, and that actions to achieve this should be targeted at the waterbody level, as stream length and location along the river can change which actions should be prioritised.

Reduced abstraction and mitigation of extreme flows were also identified as useful actions.

3. SUSTAIN AND IMPROVE MONITORING, MODELLING & ENFORCEMENT

a. Improve monitoring

Monitoring is currently patchy in terms of time, space and the types of variables being monitored. Further, an approach based upon a combination of fixed "sentinel" sites and non-fixed "agile" monitoring would not necessarily provide information where needed. For example, such an approach may not provide the continuity required to accurately monitor progress toward targets. We need to be able to trace the sources of pollution and resolve conflict over who is responsible. In general, monitoring schemes should include measurements of those factors that are known to drive biodiversity loss.

Without an improved monitoring approach, it will be impossible to know if the biodiversity targets are achieved and which water targets are responsible for the improvement.

Monitoring should be systematic and include new technologies, machine learning and citizen science. Molecular approaches to monitoring (e.g. eDNA) have the potential to generate large volumes of biodiversity data. Priority should be given to assessing key uncertainties around the taxonomic coverage of reference libraries, inference of organism abundance and the development of informative metrics from sequencing data to allow widespread adoption of molecular methods for assessing biodiversity. High throughput mass spectrometry also provides powerful approaches to assess water quality. It may also help to link data collection with other initiatives such as the FDRI (Floods and Droughts Research Infrastructure).

It is essential that monitoring is undertaken over the long term, as very few measures will meet the targets within five years; effective restoration efforts can take decades to show results in terms of species diversity. Resourcing for monitoring needs protecting against funding cuts; the continued monitoring of sites with long-term data is critical to establishing trends. Any change in effort away from these sites would be severely detrimental.

b. Indicators

We need biodiversity indicators that are sensitive to a range of pressures. For these indicators, it is important to clarify the timescales over which they are likely to respond to action (which can be decades), to manage expectations. See Part 3 for further discussion of indicators.

c. Modelling

Sustained investment in monitoring of both key biodiversity metrics and of known and emerging environmental stressors, is needed to provide the data required to develop and train predictive models. Ecologists and ecological modellers should work with water systems modellers to develop models that dynamically link water quality with biodiversity indicators. This will enable modelling of the whole system and assessment of co-benefits and trade-offs of different water management decisions and targets. Modelling will also improve understanding of how nature-based solutions for water work at scale, as those currently being rolled out are piecemeal.

Ecologists are already modelling pollution apportionment and the impact of nature-based solutions at a regional scale, and there is scope to build upon these initiatives.

d. Regulation

Action based on the results of the monitoring and modelling, in the form of regulation and enforcement, is required. Voluntary measures are not working, therefore sufficient resourcing of the Environment Agency and other relevant bodies is required to support measures such as, i) stronger punitive measures where appropriate; ii) enforcement undertakings to restore polluted or damaged water bodies; iii) downgrading of environmental performance for poorly performing utilities; iv) education and investment to improve treatment standards; v) actions to investigate and address overlooked sources of water quality impairment such as sewer misconnections.

Waterways are connected and some traverse political boundaries. As such, the above actions need to be undertaken in a coordinated way by the four nations of the UK. It is vital that actions should be prioritised using the best available evidence, rather than responding only to the public narrative, which is sometimes in contrast with what the evidence says.

PART 3: INDICATORS FOR THE FRESHWATER ENVIRONMENT

1. WHAT IS THE BEST INDICATOR FOR MEASURING CHANGES IN THE WATER ENVIRONMENT?

KEY MESSAGES

1. No single “best” indicator will provide sufficient information on changes in the water environment.
2. Indicators of microbial communities, non-native species, and ecosystem resilience would greatly enhance current monitoring approaches.
3. Effective indicators would have known sensitivities to pressures and known uncertainties, clear narratives describing no/low impact expectations, and effective means of communication.
4. In addition, increased monitoring and understanding of complex chemical mixtures is needed to determine evolving threats to fresh waters.
5. Sustained investment in monitoring of the water environment is essential.

New indicators are needed for the water environment.

There are several potential aspects of the water environment and aquatic ecosystems that have the potential to yield useful indicators of status and change. These include new measures of anthropogenic stressors, biodiversity, and higher-level ecosystem properties.

With respect to stressors, there are strong arguments for improving monitoring of complex chemical mixtures (including e.g. agrochemicals, pharmaceuticals, plastics, PFAS (per- and polyfluoroalkyl substances)) to better understand their aggregate toxicity to resident biota. Several experts suggested that biodiversity monitoring would be greatly enhanced through indicators based upon molecular and microbiological approaches, to provide a holistic view of functionally important aquatic microbiomes, which also have great direct relevance to human health (e.g. exposure to potential pathogens, antimicrobial resistance). It was suggested that an eDNA sample bioarchive would facilitate future molecular ecological assessments. Monitoring of the presence, distribution and abundance of non-native species is also important, as it provides information on the potential for subsequent biodiversity impacts. Measures of functional aspects of species communities and ecosystem resilience are also viewed as desirable.

No single indicator will provide sufficient information on the water environment.

Despite these considerations, no single indicator could provide sufficient information on the changing state of the water environment. Instead, there was a clear view that a diverse set of indicators would be required and that these should collectively provide an assessment of physical, chemical, and biological aspects of the environment, and of the action of multiple human stressors. Achieving this would require integration of data across disciplines. This endeavour should include water quantity, water quality, biodiversity, and ecosystem service data. In doing this, we would be able to identify and quantify pressure-response relationships that could be used to guide future management and restoration measures.

Effective indicators should have several key attributes.

Any suite of indicators used to assess the state of the water environment should collectively have several key attributes:

- Known and strong sensitivities to identified ecosystem stressors, with (where possible) low or quantified uncertainties.
- Coverage of the taxonomic and functional biodiversity of several organism types, which are in turn related to ecosystem function (e.g. nutrient and carbon cycling).
- Well understood expectations of what communities would look like, and how indicators would reflect this, in the absence of specific pressures. Crucially, the current approach of using historical benchmarks to define these expected states can be limited due to shifting climate baselines.
- Established narratives and visualisations to facilitate the communication of findings to research and stakeholder communities, promoting effective decision-making, and to the wider public.

Indicator development could be furthered by cross referring to the list of D4 indicator components, considering their sensitivity to pressures, geographical variability, and species importance to ecosystem state and processes.

Long-term monitoring of the water environment is essential.

Committing to, and investing in, sustained long-term monitoring of water chemistry and aquatic biodiversity is crucial, as these data provide the underpinning of any indicators that may be developed and used operationally. Quality-controlled data from citizen science initiatives can provide extensive information on some aspects of the water environment (and boost public engagement), but professional survey remains essential to gather intensive data on complex ecosystem attributes and should remain a key pillar of national monitoring strategy. Uptake of innovative, real-time sensing approaches and data science could greatly improve our capacity to monitor short-term, episodic events, and respond rapidly to change.

2. SHOULD WE BE FOCUSING ON GOOD ECOLOGICAL STATUS (FROM THE WATER FRAMEWORK DIRECTIVE)?

KEY MESSAGES

1. Though including biological measures as part of ecosystem assessment is certainly positive, the current GES approach does not capture the highly nuanced nature of fresh waters.
2. Smaller water bodies have been poorly served by the current GES approach, because of resource limitations.
3. Water Framework Directive (WFD) status classes were not viewed as useful for long-term trend analysis, though the underlying data have potential to be repurposed to allow this.
4. Any assessment of state and status must explicitly consider shifting baselines associated with climate change, which do not feature in the current GES approach.

An important achievement of the Water Framework Directive (WFD) was the inclusion of biological indicators that have value in detecting the impacts of pressures facing fresh waters, providing additional insights to those derived from purely chemical measures. However, Good Ecological Status (GES) is something of a "blunt tool", in that several sources of valuable ecosystem data are not used as part of the assessment (e.g. neglected groups such as zooplankton [Jeppesen et al., 2011] and microbial communities [Smith et al., 2024]). In particular, the "one out, all out'" approach adopted in status assessment can be misleading, as it does not capture the highly nuanced nature of complex ecosystems and may obscure progress that is being made with respect to any specific aspect of the aquatic environment.

GOOD ECOLOGICAL STATUS

- The Water Framework Directive aims to achieve Good Ecological Status (GES) for all rivers, lakes, transitional and coastal waters, defined as a slight variation from undisturbed conditions.
- Taking the example of rivers, the elements that contribute to Ecological Status include:
  - biological elements (including fish, macroinvertebrates, macrophytes and diatoms); and
  - supporting elements (including hydromorphology, ammonia, pH, phosphorus, dissolved oxygen and 18 pollutants including some heavy metals and pesticides).
- Ecological status is determined according to the "one out, all out" principle i.e. that a waterbody can only achieve good status if all biological and supporting quality elements are assessed as good status or better.

Small water bodies

Smaller water bodies (e.g. ponds, streams) have been poorly served by the GES approach, which was developed for larger water bodies. This is because assessment of these additional water bodies would have been a major investment of limited resources, and pragmatic decisions had to be made. Important differences in the way that large and small water bodies function mean that we currently do not have a good overall impression of how well the GES approach works in the latter case. Although waterbody typologies (e.g. depth and alkalinity classes) are recognised in the WFD approach, there is a need for further granularity to account for the great spatial heterogeneity in, and context dependency of, the state of fresh waters. If possible, this higher spatial resolution could help with the prioritisation of catchments that need intervention measures.

Good Ecological Status in itself is of limited value for quantifying long-term trends

The attainment, or not, of GES is not to be seen as an informative way of reporting on longer-term trends in the state of the freshwater environment (e.g. what % of water bodies at GES is good enough?). Instead, GES provides a series of high-level "snapshots". There is potential to re-purpose and re-analyse the data underlying the status assessments to derive quantitative measures suitable for the analysis of such trends. Such investigation would provide insights into ecological dynamics, emphasising the importance of understanding and managing underlying pressures for biodiversity improvement.

Shifting baselines, through climate change, must be considered

An important question is about the suitability of the current GES approach given long-term shifts in ecological systems because of climate change. Such shifting baselines necessitate a major re-think of what "good ecological status" could look like over time, and of our expectations for ecological recovery with the abatement of other, more readily controlled, pressures facing the freshwater environment. We need to consider whether our view of the meaning of "good" or at least of "what is possible" should itself change over time.

SHOULD FUTURE AMBITIONS, TARGETS, AND INDICATORS FOR FRESHWATER & ESTUARINE BIODIVERSITY BE BASED UPON THE B6 INDICATOR?

KEY MESSAGES

1. The national scale "barometer" represented by the B6 indicator would obscure the effects of multiple stressors acting together on particular water bodies, or in specific catchments.
2. The B6 indicator's move away from "one-out-all-out" and inclusion of headwaters are viewed as positive developments.
3. The B6 indicator needs an explicit consideration of what naturalness would look like with shifting climate baselines.
4. Biodiversity components of the B6 indicator could be augmented to include measures of key ecosystem processes, and in ways that would indicate biodiversity net gain.

The B6 indicator can act like a national "barometer", providing a high-level overview of pressures and ecosystem state.

The B6 indicator will not reveal the impacts of multiple stressors in specific waterbodies and catchments.

However, B6 would not necessarily provide the required insights at a site- or catchment-specific level. A case in point is that the B6 indicator, as currently formulated, would not link up co-located stressors, to resolve situations where multiple stressors (e.g. nutrient pollution, invasive species, climate change) are acting in the same place at the same time. This means that we would miss important insights into whether stressors are interacting with each other, producing freshwater ecosystem responses that are more or less than the "sum of their parts". Further, this would hinder important learning over whether specific stressors are dominant in affecting freshwater ecosystems, and could therefore be priorities for intervention, and of which stressors might play a particularly important role in eroding freshwater ecosystem resilience.

Shifting climate baselines must be accounted for in the B6 indicator.

There is a common challenge between the B6 indicator and approaches based upon GES: shifting climate baselines. It is currently not clear what naturalness would look like, from the point of view of the B6 indicator, given the shift in climatic conditions. As such, the indicator components within the B6 indicator may need to be formulated to reflect the fact that some degree of biodiversity change and community turnover is inevitable, even with the management of more localised pressures on the aquatic environment. Alongside this, it was felt that the B6 indicator approach could be more powerful if it could suggest priority actions to deliver biodiversity net gain.

Additional biodiversity measures should be integrated within the B6 indicator.

There is a clear need for measures of biodiversity to be integrated within the B6 indicator, since biological responses can integrate the effects of several stressors over time. However, for several measures there is not a clear link to changes in biodiversity (rather an assumed link). Importantly, the biological metrics within B6 largely comprise those developed to be sensitive to nutrient stress under the WFD, leaving a clear gap and priority for the development of further biological indicators with different sensitivities. It was suggested that process-based indicators would be important additions to the approach (e.g. microbial nutrient cycling, grazing, litter decomposition, carbon cycling), and complementary to measures of biodiversity, but that this potential was under-developed.

The loss of the ‘one out, all out’ approach is welcome.

The fact that the B6 indicator would not use the WFD “one-out-all-out” approach, instead favouring an approach based upon averaging across metrics, is a positive development, though weighting could be used to emphasise elements of the indicator that are viewed as key.

Some physical and chemical indicators are currently absent from B6.

Another issue of concern is the apparent lack of measures of thermal stress within B6 (e.g. temperature trends, heatwave frequency and severity), and of oxygen stress (e.g. low concentrations at depth in productive standing waters). The area of emerging contaminants is also challenging within the B6 framework, in that there would need to be a mechanism that allows for updating of chemical risk indices, and then overall trends in chemical stress.

Although there are gaps in our understanding of the complex ecological processes that underpin biodiversity responses to water quality, many years of research in freshwater ecology provide a strong evidence base upon which to take action now. Immediate action to improve water quality in England, based on the water targets, is a necessity and should not be delayed. However, to achieve biodiversity targets it is imperative to include further priority actions for fresh waters, and to work to bridge the knowledge gaps highlighted in this report, as well as to remain flexible and diligent to emerging threats to fresh waters. The BES is hopeful that by prioritising these actions, England can turn the tide on biodiversity loss in the freshwater environment.

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