Environmental Evidence

SYSTEMATIC MAP PROTOCOL

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What evidence exists on the impacts of flow variability on fish and macroinvertebrates of temperate floodplain rivers in Central and Western Europe? A systematic map protocol

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Abstract

Background: Flow variability is considered a fundamental factor affecting riverine biota. Any alterations to flow regime can influence freshwater organisms, and this process is expected to change with the projected climate change. This systematic map, therefore, aims at investigating the impacts of natural (resulting from climatic variability), anthropogenic (resulting from direct human pressure), and climate change-induced flow variability on fish and macroinvertebrates of temperate floodplain rivers in Central and Western Europe. Particular focus will be placed on the effects of extreme low and high discharges. These rare events are known to regulate population size and taxonomic diversity.

Methods: All studies investigating the effects of flow variability on metrics concerning freshwater fish and macroinvertebrates will be considered in the map, particularly metrics such as: abundance, density, diversity, growth, migration, recruitment, reproduction, survival, or their substitutes, such as biomonitoring indices. Relevant flow variability will reflect (1) anthropogenic causes: dams, reservoirs, hydroelectric facilities, locks, levees, water abstraction, water diversion, land-use changes, road culverts; (2) natural causes: floods, droughts, seasonal changes; or (3) climate change. Geographically, the map will cover the ecoregion of Central and Western Europe, focusing on its major habitat type, namely "temperate floodplain rivers and wetlands". The review will employ search engines and specialist websites, and cover primary and grey literature. No date, language, or document type restrictions will be applied in the search strategy. We expect the results to be primarily in English, although evidence (meeting all eligibility criteria) from other languages within the study area will also be included. We will also contact relevant stakeholders and announce an open call for additional information. Eligibility screening will be conducted at two levels: title and abstract, and full text. From eligible studies the following information will be extracted: the cause of flow variability, location, type of study, outcomes, etc. A searchable database containing extracted data will be developed and provided as supplementary material to the map report. The final narrative will describe the quantity and key characteristics of the available evidence, and identify knowledge gaps and knowledge clusters, i.e. subtopics sufficiently covered by existing studies allowing full systematic review and meta-analysis.

Keywords: Climate change, Drought, E-flow, Environmental flow, Flood, Freshwater ecology, Hydrology, Riverine biota

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Background

River discharge has been called the "master variable that limits and resets river populations throughout entire drainage networks" [1], or "the maestro that orchestrates pattern and process in rivers" [2]. The natural flow regime is crucial to maintaining river ecosystems in good health [3], whereas any departures from the natural state, referred to as 'flow alterations', result in overwhelmingly negative responses of these ecosystems [4, 5]. Therefore, this systematic map will deal with river flow as the principal abiotic component of riverine ecosystems.

Flow regime may change due to numerous factors. In this map, the relevant causes of change will include (1) anthropogenic causes: dams, reservoirs, hydroelectric facilities, locks, levees, water abstraction, water diversion, land-use changes, road culverts; (2) natural causes: floods, droughts, seasonal changes [6]; or (3) climate change. These three groups do not only vary in the mechanism of change, but also imply further differences. For example, studies regarding the impact of climate change on riverine biota are predominantly model-based, whereas anthropogenic and natural impacts are more frequently assessed through field sampling.

For the purpose of this research, "natural flow variability" refers to near-natural streams, relatively unimpacted by direct human pressure, as opposed to rivers with flow regime changed due to anthropogenic causes. Such an approach (tolerance for some degree of disturbance) is not uncommon in the European context [7, 8]. Climate change is indicated as a separate cause due to its growing, predominantly negative impact on riverine ecosystems [9]. Climate change has already altered flow regimes in Europe [10], and affected stream macroinvertebrate communities [11].

On the biotic level, fish and macroinvertebrates will be considered in this systematic map, two important groups of organisms from the point of view of ecology of running waters. Both are widely accepted determinants of the river ecological status, especially in the context of the Water Framework Directive (WFD) of the European Union. Previous studies suggest that the body of evidence on flow-ecology relationships for these two biotic groups is the largest among riverine fauna [12, 13]. They are therefore frequently used in environmental flow assessments worldwide [4, 14]. Macroinvertebrates play a prominent role in river ecosystem structure, and are frequently used as indicators of water quality [15]. Aquatic invertebrate fauna is highly diverse, and is of great importance for other riverine organisms, particularly fish. Fish communities also have several advantages as indicator organisms: (1) they are present in almost all lotic ecosystems; (2) because of their long lifespan, they reflect cumulative effects of long-term anthropogenic stressors; (3) because of their high mobility, they are particularly sensitive to disturbances in hydromorphology [16]. It is useful to use both fish and macroinvertebrates, because they respond differently to stressors, operate on dissimilar scales, and represent unique trophic levels [17].

Despite rapid proliferation of studies on flow-ecology relationships over the last two decades, few attempts have been made so far to synthesise the existing evidence in a systematic way [5, 6, 13, 18–20]. Only two most recent ones: the systematic map by Rytwinski et al. [6] and the forthcoming systematic review proposed by Harper et al. [18], followed the guidelines established by the Collaboration for Environmental Evidence [21]. Poff and Zimmerman [5] and Webb et al. [20] devoted their systematic reviews of ecological responses to flow alterations at the global scale. A different approach was adopted by McManamay et al. [19] who dealt with both natural and human-altered flow effects on biota in the South-Atlantic region of the United States. Harper et al. [18] proposed to investigate the impact of hydroelectric power production on fish populations in temperate regions worldwide.

This systematic map will focus on both anthropogenic flow alterations and natural flow variability. Geographically, the scope of the review will cover the well-established freshwater ecoregion of Western and Central Europe [22] (an interactive map of Freshwater Ecoregions of the World is available at: http://www.feow.org/), focusing on its major habitat type, namely temperate floodplain rivers and wetlands. Figure 1 depicts the region's territory.

Temperate floodplain rivers in Europe have been recently gaining interest in the context of environmental flow studies and ongoing river and floodplain restoration efforts [23]. Their comparison with tropical or (semi-) arid floodplain rivers, however, is still scarce [24, 25]. Although floodplains are biodiversity hotspots, floodplain rivers are often under pressure of abstraction and storage of flow. The existing environmental flow frameworks focus too much attention on preserving instream flows, whereas the role of high flows sustaining floodplain habitats has been largely neglected [26].

Environmental flow studies are advocated to be performed at a regional scale [27]. Because the temperate climate zone in Europe spans from northern Portugal to western Russia, this systematic map will be limited to one particular ecoregion of Western and Central Europe, as proposed by Abell et al. [22], where temperate floodplain rivers are the dominant type of habitat. This well-established classification of freshwater ecoregions was based on characteristics such as the occurring freshwater species (primarily fish), and catchments delineation as well as ecological and evolutionary processes rather than relying solely on physiogeographic or taxonomic features.

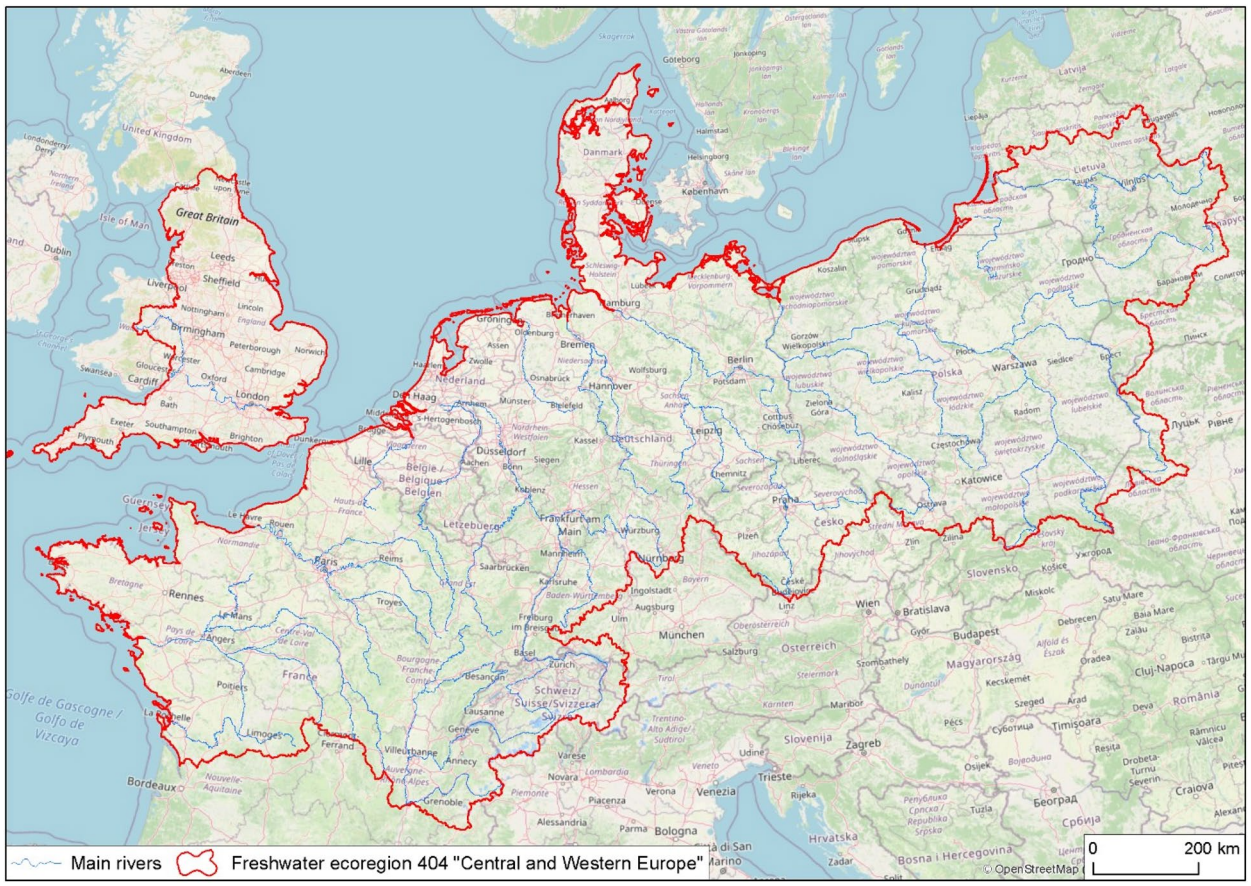

Fig. 1 Geographical scope of the systematic map: Central and Western Europe freshwater ecoregion (404) with the major habitat of temperate floodplain rivers and wetlands

Therefore, environmental conditions "within a given ecoregion are more similar to each other than to those of surrounding ecoregions and together form a conservation unit" [22].

Despite some overlap with the existing evidence syntheses, especially Piniewski et al. [13] and Rytwinski et al. [6], the proposed systematic map will be a valuable contribution to the subject. The work by Piniewski et al. [13] focused on the responses of biota (fish and macroinvertebrates) to floods and droughts in Europe, but—unlike the proposed systematic map—it did not take into account non-extreme flow variability, and did not follow the CEE guidelines. Moreover, the study was published in 2017, whereas the searches were performed in 2014. The search period covered years 1961–2011. Therefore, the proposed systematic map to be developed in 2021 will definitely capture new evidence.

The systematic map by Rytwinski et al. [6] about the impact of flow regime changes on fish in temperate regions included both anthropogenic and natural causes of flow alteration, accounting for a substantial overlap with the proposed map. However, despite the similarities in scope, the two systematic maps differ in several ways. The aforementioned study grouped all natural causes of flow variability (e.g. floods, droughts) together with climate change without a distinction between them. The currently proposed systematic map will differentiate between the various causes of flow regime changes, facilitating the identification of knowledge clusters and gaps among these studies. Moreover, the proposed research question will differ in terms of eligible populations (e.g. addition of macroinvertebrates), outcomes (e.g. addition of biomonitoring indices), and study types (e.g. addition of modelling studies). The preliminary search string tested in Web of Science Core Collection reached approximately 42,000 results. When tested for the same time frame (1900–2017) and biota (fish, with macroinvertebrate terms removed), the search string yielded 29,000 results compared to around 10,500 found in Web of Science Core Collection by Rytwinski et al. [6]. The addition of new inclusion criteria together with development of a more robust search string will hopefully

allow for the identification of new pieces of evidence. Geographically, the work by Rytwinski et al. [6] covered temperate regions globally, therefore, entirely encompassing the territory proposed in the current protocol. The study, however, primarily yielded results from the outside of the proposed eco-region: "the most studied were USA (50% of cases), Canada (11% of cases), and Australia (7% of cases)". It also only included articles written in English due to the project resource restrictions. As indicated by the authors, the "untranslated articles would add strength to the accuracy of the map and any resultant syntheses." The proposed map will incorporate results in other languages as well. Finally, the search for grey literature substantially focused on Anglo-Saxon websites and institutions (mostly based in Northern America or Australia and Oceania), as indicated in the map protocol [6, 28], possibly omitting evidence from other regions. The proposed map will look for grey literature at institutions based in Europe and conducting research within the indicated eco-region.

Stakeholder engagement

This map is a part of research project RIFFLES ('The effect of RIver Flow variability and extremes on biota of temperate FLoodplain rivers under multiple pressurES'). The topic of the review was extensively discussed at the project kick-off meeting in January 2020, attended by a representative of the public administration (a specialist working with biomonitoring data at the Chief Inspectorate of Environmental Protection in Poland) and an advisory group consisting of researchers from Austria, Germany, and the UK. The stakeholders supported the idea of conducting an evidence synthesis. Throughout further expert discussions and preliminary scoping, it was concluded that a systematic map should be carried out first. The knowledge clusters indicated in the final report could contribute to the identification of areas qualifying for a systematic review.

Relevant stakeholders (for details see section "Supplementary searches") will be contacted and asked for their contribution to the systematic map, particularly for submission of or reference to any relevant literature, including grey literature. If needed, the stakeholders will also be asked for advice regarding other aspects of the systematic map, e.g. clarification of inclusion criteria.

An open call for additional information, announced through a publicly available post on social media (as opposed to private, targeted communication with the aforementioned stakeholders), will also be held.

Objective of the Review

The primary question for this systematic map is as follows:

What evidence exists on the impacts of natural and/or anthropogenic flow variability on fish and macroinvertebrates of temperate floodplain rivers in Central and Western Europe?

The proposed systematic map will provide an overview of the existing literature on the impacts of anthropogenic flow alterations and natural flow variability on fish and macroinvertebrates of temperate floodplain rivers in Central and Western Europe. The planned key outputs will be:

1. A database of evidence containing detailed coding and extracted meta-data.
2. An evidence atlas (a cartographic representation of the included evidence).
3. A series of heat maps to systematically identify knowledge clusters (subtopics that are well-represented by research studies) and knowledge gaps (subtopics that are un- or under-represented by research studies).
4. A list of knowledge clusters suitable for full systematic review and meta-analysis.
5. A list of knowledge gaps, i.e. areas requiring further primary research.

Definitions of the question components

Population(s) Fish and macroinvertebrates (both native and introduced) of temperate floodplain rivers in the Central and Western Europe ecoregion as designated by Abell et al. [22] (Fig. 1).

Intervention/exposure(s) Natural flow variability or anthropogenic flow alteration indicated as components of flow regime and/or cause of flow regime change; flow regime alteration induced by climate change.

Comparator(s) No flow variability/flow alteration or alternative levels of flow variability/flow alteration. Studies using design with spatial or temporal trends (with no true comparator) will also be included, particularly in the case of research on natural flow variability.

Outcome(s) any component of fish and/or macroinvertebrates population/s (from single species to community level) such as abundance, density, diversity, growth, migration, recruitment, reproduction, survival, or their substitutes.

Methods

This review will follow the Collaboration for Environmental Evidence guidelines [21], and will conform to the ROSES reporting standards [29] (Additional file 1).

Searching for articles

The literature will be collected through: academic databases, web-based search engine, and specialist websites, as well as direct stakeholder contact, an open call for relevant studies, and searching through references of the eligible evidence syntheses.

Search strings and search terms

The search string has been developed through trial searches conducted in Web of Science between March 2020 and March 2021. More than 30 search strings were tested. The search results were screened at title/abstract level to check for their possible relevance. At least 20% of investigated records had to be assessed as possibly relevant in order to accept a given modification of the search string. Records from several of the tested search strings are included in the supplementary material (Additional file 2).

The resulting search string consists of three components: population (subject and habitat), intervention/exposure, and exclusions (Table 1). All three are combined using Boolean operators "AND", "OR", and "NOT". The exclusions ("NOT" operators) have been added in order to remove clearly non-relevant articles (e.g. from medical or paleontological journals). The asterisk (*) represents any character, including no character (e.g. River* includes River, Rivers, Riverine, etc.). Phrases in quotation marks search for exact phrases. Preliminary testing proved that using multiple macroinvertebrate taxonomic names yields most promising results.

When the tested search string is not accepted by the database or search engine, the search terms will be customised and presented in the final report as supplementary material. Search strings and search terms proposed as per each database are included in Additional file 3. English search terms will be used to conduct all searches. No date, language, or document type restrictions will be applied. We expect the results to be primarily in English, although records with English title/abstract and main text in other languages within the study area will also be investigated and presented in the systematic map results. Given the geographic location of the selected ecoregion (Fig. 1) and the analysis of the outcomes of two complete evidence syntheses [6, 13], we expect for a great majority

Table 1 Proposed search string designed for Web of Science advanced search. TS stands for "Topic" and includes searching within the fields: title, abstract, and keywords; TI stands for "Title"; SO stands for "Publication Name" (e.g. title of the journal)

	Search terms
Population	TS = (fish OR fishes OR *invertebrate* OR fauna OR larva* OR adult OR fry OR juvenile OR smolt OR parr OR salmo* OR "aquatic insect*" OR *zoobenthos OR macrobenthos OR Chironomidae OR Sphaeriidae OR Bithyniidae OR Lymnaeidae OR Muscidae OR Simuliidae OR Oligochaeta OR Erpobdellidae OR Amphipoda OR Physidae OR Valvatidae OR Asellidae OR Baetidae OR Caenidae OR Ephemeridae OR Glossiphoniidae OR Nemouridae OR Calopterygidae OR Gammaridae OR Leptoceridae OR Limnephilidae OR Haliplidae OR Ceratopogonidae OR Gomphidae OR Limoniidae OR Gerridae OR Tabanidae OR Hydropsychidae OR Lepidostomatidae OR Unionidae OR Planorbidae OR Ancylidae OR Platycnemididae OR Corixidae OR Sialidae OR Perlodidae OR Aphelocheiridae OR Ephemerellidae OR Heptageniidae OR Brachycentridae OR Odontoceridae OR Rhyacophilidae OR Hydrochidae OR Ameletidae OR Phryganeidae OR Dytiscidae OR Perlidae OR Sisyridae OR Polycentropodidae OR Sericostomatidae OR Viviparidae OR Haemopidae OR Lepidoptera OR Hydrachnida OR Corduliidae OR Libellulidae OR Naucoridae OR Notonectidae OR Hydrophilidae OR Scirtidae OR Spercheidae OR Culicidae OR Rhagionidae OR Gordiidae OR Hydroptilidae OR Elmidae OR Gyrinidae OR Empididae OR Ptychopteridae OR Libellulidae OR Athericidae OR Tipulidae OR Dendrocoelidae OR Neritidae OR Hydrobiidae OR Acroloxidae OR Molannidae OR Pedicidae OR Dreissenidae OR Aeshnidae OR Nepidae OR Planariidae OR Ecnomidae OR Noteridae OR Coenagrionidae OR Balanidae OR Piscicolidae OR Leptophlebiidae OR Pleidae OR Dryopidae OR Ephydridae OR Psychomyiidae OR Cambaridae OR Potamanthidae OR Siphlonuridae OR Psychodidae OR Chrysomelidae OR Corduliidae OR Goeridae OR Thiaridae OR Conchostraca OR Myidae OR Crangonidae OR Mysidae OR Beraeidae OR Helophoridae OR Cardiidae OR Taeniopterygidae OR Thaumaleidae OR Lestidae OR Dolichopodidae OR Oligoneuriidae OR Leuctridae OR Curculionidae OR Pontogammaridae OR Stratiomyidae OR Spongillidae OR Mesoveliidae OR Arthropleidae OR Turbellaria OR Hydrozoa OR Capniidae OR Dixidae OR Veliidae OR Araneae OR Hydraenidae OR Cordulegastridae OR Chloroperlidae OR Cyzicidae OR Polymitarcyidae OR Neoephemeridae OR Corbiculidae OR Isonychiidae OR Pyralidae OR Syrphidae OR Hirudinidae OR Astacidae OR Philopotamiidae OR Idoteidae OR Corophiidae OR Lynceidae OR Hebridae OR Blephariceridae OR Argulidae) AND TS = (river* OR stream* OR lotic OR fluvial OR catchment* OR watershed* OR beck* OR brook* OR burn* OR creek* OR rivulet* OR tributar* OR watercourse* OR waterway* OR "flowing water*" OR "running water*" OR "freshwater*")
Intervention/ exposure	AND TS = (hydrolog* OR drought* OR flood* OR discharge OR streamflow* OR "stream flow*" OR flow OR flows OR spate OR dam* OR reservoir* OR "hydroelectric facility*" OR "water abstraction" OR "water diversion" OR "lock" OR "locks" OR levee* OR "water abstraction" OR "land-use change" OR culvert* OR "climate change")
Exclusions	NOT TI = (paleo* OR palaeo* OR pleistocene OR holocene OR fossil* OR "heavy metal*" OR "toxic metal*" OR medic*) NOT SO = (paleo* OR palaeo* OR medic*)

of non-English studies to be published in French, German, or Polish. Relevant evidence (meeting all eligibility criteria) from other languages within the study area, however, will also be included.

Testing comprehensiveness of the search

A total of 54 articles of known high relevance to the systematic map were screened against preliminary search results to examine whether the proposed search string can successfully locate relevant evidence. All articles, except two which are not available in Web of Science, were successfully captured by the developed search string. The list of benchmark articles is included in the supplementary material (Additional file 4).

Publication databases

The following databases will be browsed:

1. Digital Access to Research Theses (DART)
2. Directory of Open Access Journals (DOAJ)
3. Electronic Theses Online Service (eThOS)
4. ProQuest Dissertations & Theses Global
5. ProQuest Environmental Science Collection
6. Scopus
7. Web of Science BioSciences Information Service of Biological Abstracts (BIOSIS) Citation Index (including: Biological Abstracts, Reports, Reviews, and Meetings)
8. Web of Science Core Collection (including: Science Citation Index Expanded, Conference Proceedings Citation Index – Science, and Emerging Sources Citation Index)
9. Web of Science Zoological Record

Searches will be conducted using subscriptions of the Warsaw University of Life Sciences.

Internet searches

Searches will also be performed in Google Scholar, considered to be an effective tool in browsing for grey literature [29].

The search will be conducted for the first 500 results. All the relevant results will be extracted as citations using Publish or Perish software [30], and subject to duplication removal and screening workflow alongside records from other sources.

Specialist searches

In an attempt to capture grey literature, English and Polish language websites dedicated to research projects and freshwater research will be browsed manually for relevant publications. Records from organisational websites will be screened separately before being combined with other results.

List of websites to be searched:

1. Centre for Ecology & Hydrology (https://www.ceh.ac.uk/)
2. Centre for Environment, Fisheries and Aquaculture Science (https://www.cefas.co.uk/)
3. CORDIS, database of European Commission research projects (https://cordis.europa.eu/projects/en)
4. European Centre for River Restoration (https://www.ecrr.org/)
5. European Federation for Freshwater Sciences (http://www.freshwatersciences.eu/effs/)
6. European Regional Centre for Ecohydrology of the Polish Academy of Sciences (http://www.erce.unesco.lodz.pl/)
7. Food and Agriculture Organization of the United Nations (http://www.fao.org/home/en/)
8. Freshwater Information Platform (http://www.freshwaterplatform.eu/)
9. International Centre for Ecohydraulics Research (http://www.icer.soton.ac.uk/)
10. International Centre for Water Resources and Global Change (ICWRGC) (https://www.waterandchange.org/en/)
11. LIFE Programme (https://ec.europa.eu/environment/life/project/Projects/index.cfm)
12. Natural Resources Wales (https://naturalresources.wales/?lang=en)
13. Research project REFORM (REstoring rivers FOR effective catchment Management) (https://www.reformrivers.eu/)
14. Research project REFRESH (Adaptive Strategies to Mitigate the Impacts of Climate Change on European Freshwater Ecosystems (http://www.refresh.ucl.ac.uk/)
15. United Nations Environment Programme (https://www.unep.org/)

Supplementary searches

The reference sections of evidence syntheses (including both systematic and non-systematic literature reviews) included in the screening process will be hand-searched, and any articles not found previously will be added to the library.

In order to encompass as wide an array of studies as possible, we will organise an open call for relevant studies and directly contact relevant stakeholders.

List of proposed stakeholders:

1. Austrian Limnological Association (VOL)
2. Centre for Ecology & Hydrology (CEH)
3. Czech Limnological Society (CLS)
4. Deutsche Gesellschaft für Limnologie e.V. (DGL)
5. European Regional Centre for Ecohydrology of the Polish Academy of Sciences
6. French Limnological Association (AFL)
7. Freshwater Biological Association (FBA)
8. International Centre for Ecohydraulics Research
9. Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB)
10. Polish Angling Association
11. Polish Benthologic Society
12. Polish Hydrobiological Society (PTH)
13. Slovakian Limnological Society (SLS)
14. Stanislaw Sakowicz Inland Fisheries Institute
15. Swiss Society for Hydrology and Limnology (SGHL)

Assembling library of search results

A library of all search results will be uploaded to EPPI reviewer, literature review management software. Any possible duplicated records will be removed prior to screening.

Article screening and study eligibility criteria

Screening process

Screening will be conducted at two levels: title and abstract, and full text. All articles rendered possibly relevant through screening of both title and abstract will be retrieved at full text (reporting in the final report those which could not be accessed, e.g. not found, no subscription). The retrieved records will then be screened at full text, with each record assessed by one reviewer. Reviewers will not be assigned to articles they have authored at any stage of the screening.

Consistency check will be performed with all reviewers (4 in total) through independent screening of a random subset of articles at the title and abstract level, prior to the actual screening. It will be conducted in batches of 100 papers. Upon completion of screening of each batch, the results will be cross-examined, with all discrepancies reconciled and eligibility criteria clarified when necessary. If the level of agreement is low (below 80%), further consistency check will be performed on an additional subset of articles.

Similar approach will be applied at full-text screening stage, namely two reviewers using a random subset of 10% of all articles that were included at title and abstract, will perform consistency check. A level of agreement above 80% will be required before the actual screening is conducted. Studies found by other means than academic database or search engine searches (e.g. found through a reference from the stakeholders) will be added to the library after the consistency check is complete.

Eligibility criteria

Eligible population(s) Fish and macroinvertebrates (both native and introduced) of temperate floodplain rivers in the ecoregion of Central and Western Europe [22]. The ecoregion includes the following European countries: Austria, Belgium, Belarus, the Czech Republic, Denmark, France, Germany, Liechtenstein, Lithuania, Luxembourg, the Netherlands, Poland, Russia, Slovakia, Switzerland, Ukraine, and the United Kingdom; and the large river basins of: Ouse, Mersey, Trent, Thames, Severn, Loire, Seine, Rhône, Rhine, Ems, Weser, Elbe, Oder, Vistula, and Neman; draining into: the North Sea, Baltic Sea, Norwegian Sea, Irish Sea, Atlantic Ocean, and Mediterranean Sea (Rhône) (only Belgium, the Netherlands, and Luxembourg are entirely within the area, and some countries have merely marginal coverage, e.g. Austria, Russia, Slovakia, Ukraine; more about the ecoregion: https://www.feow.org/ecoregions/details/404). Studies concerning lakes, wetlands, estuaries, or coastal areas will be excluded.

Eligible intervention(s)/exposure(s) Natural flow variability or anthropogenic flow alteration indicated by cause and/or component/s of flow regime, including: magnitude, frequency, duration, timing (seasonality), rate of change, or their substitutes (e.g. water velocity or depth). Eligible causes of flow regime include (1) anthropogenic causes: dams, reservoirs, hydroelectric facilities, locks, levees, water abstraction, water diversion, land-use changes, road culverts; (2) natural causes originating from climatic variability: floods, droughts, seasonal changes; or (3) climate change (mixed natural and anthropogenic cause).

Eligible comparator(s) (1) Similar sections of the same waterbody with no exposure/intervention; (2) separate but similar waterbodies with no exposure/intervention; (3) before exposure/intervention within the same waterbody; (4) an alternative level of exposure/intervention on the same or different waterbody. Studies that evaluate temporal or spatial trends related to a change in flow regime will also be included, particularly in the case of research on natural flow variability. Studies which measure a single point in time, with no comparison to another site, will be excluded.

Eligible outcome(s) Change in a component of fish and/or macroinvertebrates population/s, such as abundance, density, diversity, growth, migration, recruitment, reproduction, survival, or their substitutes, including biomonitoring indices, such as European Fish Index (EFI),

Lotic-invertebrate Index for Flow Evaluation (LIFE), or biological monitoring working party (BMWP).

Eligible study type(s) Field studies, mesocosm, modelling, and literature reviews; laboratory studies and studies with no connection to the dominant type of habitat in the ecoregion (temperate floodplain rivers) will be excluded.

A list of records excluded at the title/abstract as well as full-text level will be provided, with reasons for exclusion. The provision of excluded literature at both levels (text/abstract and full text) will improve transparency and allow authors of similar reviews to investigate the results of the proposed search strategy in the future.

Study validity assessment

The validity of evidence will not be assessed within this systematic map but we will be coding study design elements that may provide some preliminary indication of internal validity.

Data coding strategy

Coding and meta-data will be extracted for all studies deemed relevant after the full-text screening stage. Meta-data extraction and coding will be performed by multiple reviewers (4 in total) after checking for consistency in coding. The coding will take place simultaneously (every record will be coded by one reviewer).

The consistency check will be performed with two reviewers through independent coding of a subset of 10% of relevant studies. Any discrepancies between the reviewers will be reconciled before the actual coding takes place. If the level of agreement is low (below 80%), further consistency check will be performed on an additional subset of articles.

If resources allow, if needed, we will contact authors by email requesting missing information or clarification. The corresponding author will be contacted via e-mail address provided in a given article. In the case of grey literature, the first author will be contacted, provided that their contact information can be found online.

The following coding categories will be extracted:

(1) Bibliographic information (e.g. title, author/s, year of publication, type of document, source, language);
(2) Study location (e.g. country, region, geographic location, waterbody name, type);
(3) Broad objectives of the study;
(4) Study design (e.g. type of study: field/mesocosm/modelling/evidence synthesis, length, number of site/s, sampling method);
(5) Intervention/exposure type (e.g. changes in flow magnitude, frequency, duration, timing);
(6) Cause of intervention (natural/anthropogenic/climate change);
(7) Comparator type (e.g. Before/After, Control/Impact);
(8) Outcome type (e.g. changes in growth, abundance);
(9) Taxon (e.g. fish/invertebrate, taxon name/s, taxonomic level, number of taxa);
(10) Ecological response (e.g. direction and magnitude of change in the studied biota population).

Study mapping and presentation

The extracted meta-data will be described narratively in the final report. The articles will be grouped and presented according to their distinct characteristics, e.g. modelling studies and evidence syntheses separately due to their non-comparability with other results. Similarly, relevant grey literature in languages other than English will be presented separately from other studies.

The identified evidence will also be provided in the form of an interactive open-access database containing detailed coding and extracted meta-data.

The contents of the database will be visualised geographically in an evidence atlas.

Knowledge gap and cluster identification strategy

Heat maps will be used to identify knowledge clusters and knowledge gaps through grouping the studies by coded categories and then investigating which topics cover enough evidence to warrant a systematic review. The identification will be concluded by a methodology expert outside of the reviewers' team in order to avoid internal bias.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13750-021-00225-z.

Additional file 1. ROSES form for systematic map protocols.

Additional file 2. Presentation of several changes tested during search string development.

Additional file 3. Search strings/search terms proposed for all of the databases indicated in the search strategy.

Additional file 4. A list of benchmark studies with bibliographic details.

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Authors' contributions
AK contributed to the conception and design of the protocol, and was the major contributor in writing the manuscript. SC contributed to the conception and design of the protocol. MP contributed to the conception and design of the protocol, and substantially revised the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials
Datasets supporting the formulation of this article are included within the article and its additional files.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests. Reviewers who have authored articles to be considered within the review will be prevented from unduly influencing inclusion decisions, for example by delegating tasks appropriately.

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