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Insights provided by a new searchable repository for post-fire hydrology studies and associated data

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Abstract

Background As the number and size of wildfires increase worldwide, so too has the realization that wildfires and hydrology are closely linked. The field of post-fire hydrology has been growing in recent decades, but the resultant datasets and studies are spread across disparate repositories and can be difficult for researchers and decision-makers to access.

Results To help address this issue, we have created searchable lists of literature, datasets, and models related to post-fire hydrology which can be accessed—and added to—by any interested members of the community. Analysis of these lists demonstrates trends in publications over time and the diversity of specific topics covered. We identify geographic areas (e.g., CA, USA) and specific topics (e.g., surface runoff and erosion) which have received the most attention from researchers. Some of the least studied topics (e.g., evapotranspiration and snow) are receiving increased attention in recent years. We also note that most studies cover no more than 5 years post-fire.

Conclusions The field of post-fire hydrology would be more complete if it included more long-term studies, as well as research across a wider geographic range and covering under-studied topics including water quality, soil moisture, snow, and evapotranspiration. In order to simplify further explorations into post-fire hydrology by researchers and decision-makers, all literature and datasets discussed here are assembled in a publicly available and searchable database (ufdp.dri.edu).

Keywords Review, Data, Erosion, Fire, Hydrology, Sediment, Snow, Soil, Streamflow, Water quality

Resumen

Antecedentes Así como el número y tamaño de los incendios se incrementan a nivel mundial, también lo hace la comprensión de que los incendios y la hidrología están estrechamente relacionados. El campo de estudio de la hidrología post-fuego ha manifestado un crecimiento en décadas recientes, aunque las bases de datos y los estudios están distribuidos en repositorios dispares que pueden ser dificultoso acceder para los investigadores o tomadores de decisiones.

Resultados Para ayudar a resolver esta situación, creamos listas de literatura accesible, bases de datos, y modelos relacionados con la hidrología en el post-fuego que pueden accederse –y también agregarse a ellos– por parte de cualquier miembro interesado de la comunidad. El análisis de estas listas demuestra tendencias en las publicaciones en el tiempo y la diversidad en los tópicos cubiertos. Identificamos áreas geográficas (por ejemplo el California, EEUU) y tópicos específicos (i. e. escorrentía superficial y erosión) que recibieron la mayor atención de los

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investigadores. Algunos de los tópicos menos estudiados (i.e. evapotranspiración y nieve) han recibido una atención incremental en los años recientes. Notamos asimismo que la mayoría de los estudios cubren solo 5 años o menos después del fuego.

Conclusiones El campo de la hidrología en el post-fuego podría ser más completa si incluyese más estudios de largo plazo, como así también investigaciones que amplíen el rango geográfico y que cubran tópicos poco estudiados como calidad del agua, humedad del suelo, nieve, precipitación, y evapotranspiración. Para simplificar las exploraciones futuras en hidrología en el post-fuego por parte de investigadores y tomadores de decisiones, toda la literatura y las bases de datos discutidas acá fueron ensambladas y disponibles para el público en una base de datos disponible, titulada (ufdp.dri.edu).

Background

The number and size of wildfires have recently been breaking records around the world, including in the USA (Fig. 1), Australia (Robinne et al. 2021), and Canada (Jain et al. 2024). With this increased fire activity has come an increased realization that wildfires and hydrology are closely linked, and this linkage has important implications for ecology and water resources (Robinne et al. 2021; Williams et al. 2022). Many studies by both academic and government researchers have strived to learn more about this complex connection. However, the resultant datasets and studies are spread across disparate repositories and thus can be difficult for researchers or decision-makers to access (Horsburgh et al. 2020). The growing amount of information in post-fire hydrology is highly valuable for creating informed management and response plans. Increasing “whiplash” between wet and dry years has been growing the amount of dry fuel for wildfires as well as increasing the size and number of post-fire floods and debris flows, and this trend is expected to become worse in future years (Swain et al. 2025). There is therefore an urgent need to be able to quantify the

interactions between fire and hydrology for planning and mitigation efforts. Field observations are especially vital for improving the parameterization of computer models that are increasingly used to simulate post-fire responses. However, many datasets and reports are not automatically made available for use by others. Without easy access to these resources, their utility will be limited or—at best—delayed. To help address this issue, we have created a data clearing house with searchable lists of literature, datasets, and models related to post-fire hydrology, which can be accessed—and added to—by any interested members of the community. This resource can be used by those newly entering the field trying to ascertain the types of information already available, as well as experts hoping to share their information and expand their existing repertoire. The unique value of this work consists of providing a single website where users can browse and compare the data and publications available, rather than having to search through separate repositories for model input data, fire impacts data, review papers, etc.

Despite an increasing amount of hydrologic data made publicly available in recent years, only a small portion

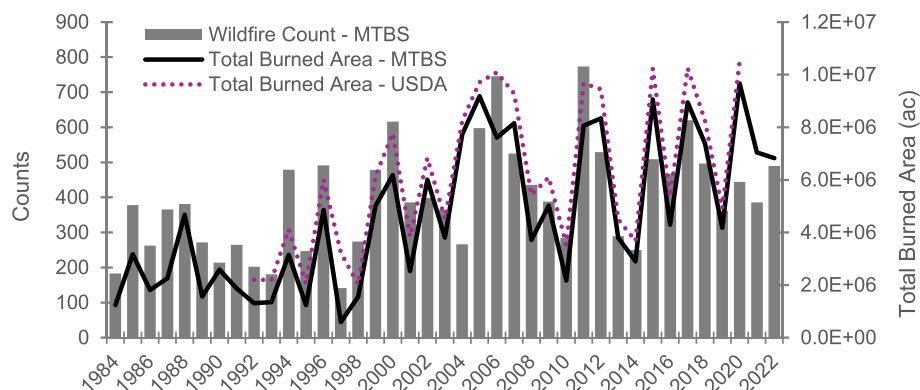


Fig. 1 Fire counts (bars) and total burned area (black line) per year in the USA for all wildfires over 1000 acres, according to MTBS for 1984–2022. Total burned area from the USDA for 1992–2020 is shown for comparison as dotted purple lines. (MTBS data downloaded from mtbs.gov and USDA data from fs.usda.gov/rds/archive/catalog/RDS-2013-0009.6 on March 3, 2025)

of that data is used by others (Horsburgh et al. 2020). A major goal of our data clearing house is to increase the visibility and use of datasets related to post-fire hydrology. Since wildfires occur unpredictably, many post-fire studies rely on combining information from long-term hydrologic monitoring with spatial information about fire occurrence, two datasets created for different goals and housed in different repositories. Field studies of fire impacts often only last a short number of years and are therefore not included in standardized, long-term archives. The data clearing house we have created allows users to identify sources for the disparate types of datasets needed to study post-fire hydrology (e.g., streamflow and fire severity information which are broadly available but from very different sources) as well as increases the visibility and searchability of disparate datasets from individual post-fire studies (which often are not included in standardized databases).

A geographically diverse set of studies is needed to understand the nuances of post-fire hydrology, as the hydrologic response to wildfire can vary greatly (e.g., some fires causing increases in streamflow while others cause decreases) depending on geology, climate, vegetation, and fire behavior (Wine and Cadot 2016; Goeking and Tarboton 2022). Different types of fires can also produce very different impacts. Previous literature reviews have argued that more work is needed looking specifically at prescribed fire (Hiers et al. 2020) and at natural fire regimes with frequent mixed-severity burns (Stephens et al. 2021) since many studies focus on recent large, high-severity wildfires burning in fire-suppressed forests. Better understanding of how different types of fires affect different landscapes is vital for land management planning and post-fire response. In this article, we introduce a resource (in the form of an online clearing house for data and literature) to facilitate the use of existing information by others. We discuss what our collection reveals about the types of literature and datasets that cover the broad area of post-fire hydrology. Our goal is to provide an overview of what work has been done and what areas (both geographic and thematic) remain relatively understudied. This article does not analyze or synthesize any of the findings of the works discussed, leaving this to existing review literature covering more manageable sub-categories of post-fire hydrology (e.g., Ebel et al. 2023 review of modeling hydrologic response to wildfire, Paul et al. 2022 review of water quality impacts, and Koshkin et al. 2022 on the impacts of fire on snowpacks). Our scoping review provides insights into the type of research being conducted and areas where observations are rarer, rather than making generalizations about any research results.

Methods

We assembled literature (including peer-reviewed journal articles, books, reports, and theses) as well as datasets related to post-fire hydrology into curated tables. Our definition of “post-fire hydrology” is broad, encompassing both the fluxes of water most traditionally associated with hydrologic science (streamflow, infiltration, transpiration, etc.) as well as erosion and water quality, which are both consequences of water flow processes. This range of topics mirrors that covered by Ebel et al. (2022) in their review of hydrologic recovery after wildfire, capturing commonly studied processes which directly impact the water available to ecosystems and human water systems downstream of fire.

This study uses a scoping review approach to survey the available knowledge within this field and identify gaps (Arksey and O'Malley 2005), rather than an in-depth systematic review of research findings as the latter would be overly complex for a single article. As described by Grant and Booth (2009), this scoping review provides a “preliminary assessment of potential size and scope of available research literature” while aiming to identify the “nature and extent of research evidence” and synthesizes the information in a tabular format without performing any quality assessment of the reviewed resources.

We used Google Scholar to search for literature including some combination of the word “fire” and either “hydrology,” “water,” “soil,” “debris flow,” “hyperconcentrated flow,” or “snow.” We also asked colleagues working in the field to share their personal lists of related documents. Finally, we used backward citation tracking (Hirt et al. 2023) to add relevant entries from the works cited lists of review papers identified in our initial searches. We then verified that each document discussed the impact of fire on at least one of the following topics: runoff (overland flow), streamflow, erosion, sediment load (including hyperconcentrated flows and debris flows), water quality (temperature or contaminant concentration), soil moisture, snow, soil infiltration properties, soil water repellency (hydrophobicity), and/or evapotranspiration. If not, the document was removed from our list. Duplicate entries were removed manually after using Microsoft Excel to highlight repeated titles. We did not search for keywords in any non-English languages, and therefore our results are limited to documents that are either originally in English or have English translations posted online. Information about each document was summarized using a standardized table, noting bibliographic information (authors, publication year, title, type of publication (report, article, etc.), publisher, and digital object identifier) as well as metadata on the document's content such as which of the sub-topics in Table 1 were included, whether the document was a review, and (for

Table 1 Count of documents identified in our literature search that covered each sub-topic within post-fire hydrology, as well as the percent of all documents which discussed each topic. Note that the percentages add to more than 100 since many documents covered more than one topic

Topic	Count	Percent of documents
Overland flow	266	49%
Erosion	219	40%
Sediment load	184	34%
Soil infiltration	162	30%
Streamflow	141	26%
Soil water repellency	136	25%
Water quality	97	18%
Soil moisture	88	16%
Snow	60	11%
Evapotranspiration	44	8%

non-reviews) the length and geographic location of the study as well as whether the work was observation- or model-based. If applicable, we also noted the land cover type and specific wildfire(s) discussed in the document. Finally, we noted whether the document's supporting data were publicly available, and if so included links to the dataset(s). The online version of our final curated list includes links to each publication. For the small number of documents that were not publicly accessible online, we hosted the document on the website directly and provided a direct link to the PDF.

We also created a list of data sources and models used by the studies in our literature search, supplemented by suggestions from experts in the field. Our aim was to provide an easily searchable list of data that are potentially useful to studies of post-fire hydrology, allowing researchers and resource managers to perform an initial assessment of the types of data available and compare the attributes of different datasets. We organized the datasets into a table with links to the dataset in question, as well as information on the data type, spatial coverage and resolution, time span, temporal resolution, file type, data curators, and whether the dataset was specifically collected for a post-fire study. We also included the requested citation of the data in order to increase the likelihood that any users of these datasets will properly reference them in future work. We categorized the assembled data sources into the following types: precipitation, streamflow, soil moisture, land cover, fire (i.e., fire perimeters and burn severity maps), snow, soil properties (e.g., hydrophobicity, infiltration rates, sorptivity, soil texture/type), surface elevation (e.g., digital elevation models, measurements of erosion), sediment (including debris flows), water quality

(temperature, turbidity, and/or chemical concentrations), and watershed boundaries and stream systems. These categories include both information useful as inputs to hydrologic models (e.g., fire severity, precipitation) and data that can be used either for model validation or for direct statistical analysis of post-fire impacts (e.g., streamflow), as well as data on intermediate factors that mediate the impact of fire on hydrology (e.g., hydrophobicity and infiltration rates).

Findings

Literature search

Our literature search identified 557 documents related to post-fire hydrology, spanning years 1934–2025 (Supplementary Material: Literature List). The majority of published work studies runoff, streamflow, erosion, sediment loads, and soil infiltration or water repellency. Relatively few study fire impacts on snow, soil moisture, or evapotranspiration (Table 1). Most of the literature identified consisted of peer-reviewed journal articles (85%). Fifty-one of these documents were review articles, while the rest mainly included original research or observations. Only 38 reports and guidance documents were identified, though this may be partly due to increased difficulty in finding reports online compared to journal articles (which was one of the motivations for creating our searchable resource list). *Hydrological Processes* and *Journal of Hydrology* were the most common journals to feature articles on post-fire hydrology. Approximately 1/3 of our identified journal articles were in hydrology-focused journals, while nearly 20% were from other types of earth science journals and fewer than 7% were in fire-focused journals. The remainder were spread among journals on land management, forestry, environmental science, soil science, and chemistry.

More than half of our identified literature on post-fire hydrology described observations from the Western USA (Fig. 2, Table 2). California was the most common state to be covered (and more common than any single country) representing 22% of our literature list. While the Western USA does have much more fire than other regions of the country (Fig. 2A–C), this still leaves many areas understudied, which may have post-fire effects that vary greatly from the Western USA due to differences in climate, geology, vegetation, hydrology, fire regimes, and land management. The distribution of wildfires globally is changing, with climate change increasing fire activity in areas that have historically experienced relatively little fire (e.g., Halofsky et al. 2020, Jain et al. 2024; Krawchuk et al. 2009; Senande-Rivera et al. 2022) while increased agricultural activity reduces fire occurrence in other areas (Andela et al. 2017). Both types of changes mean that diversifying post-fire observations will be

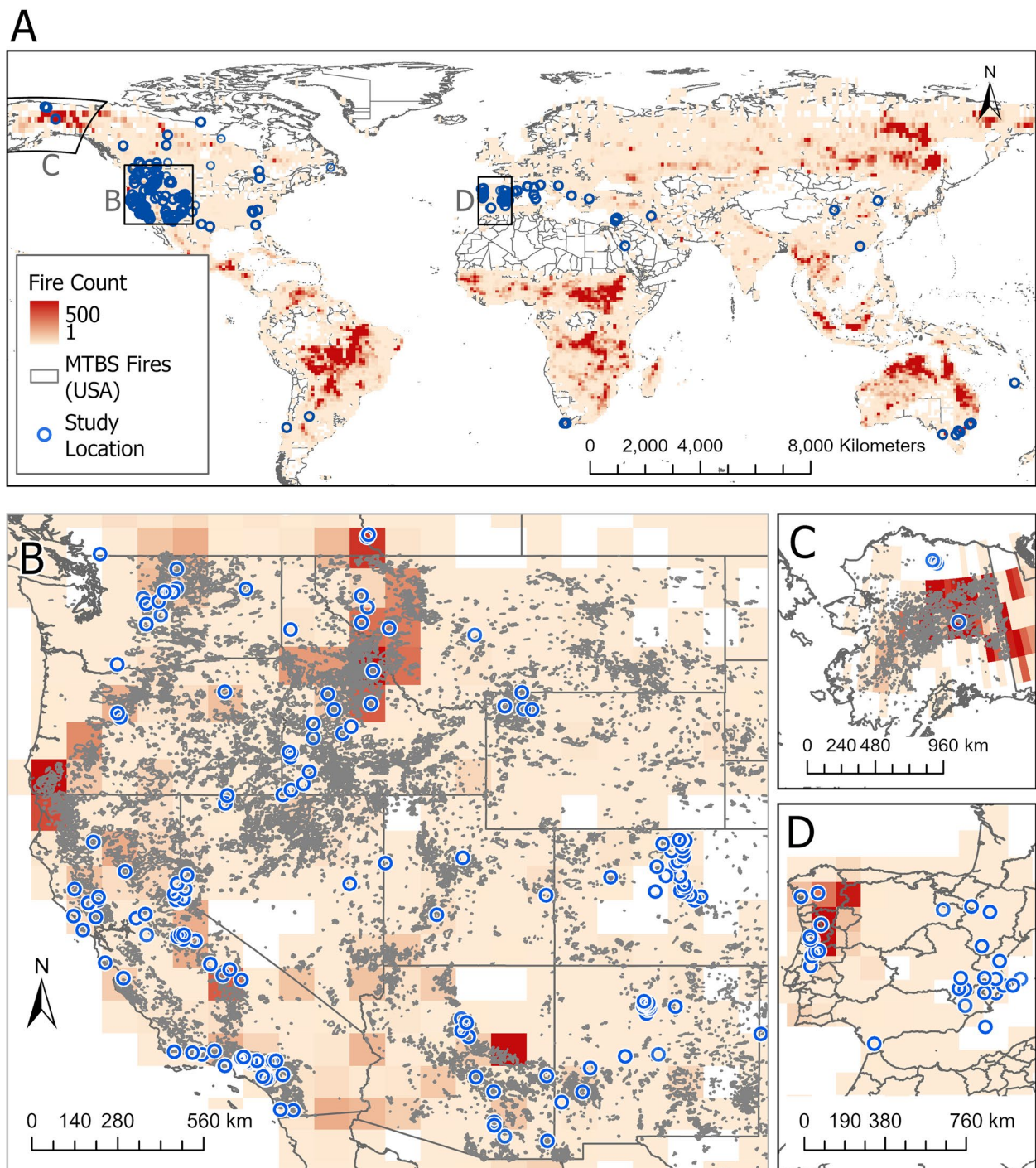


Fig. 2 Map of fire studies identified in our literature search worldwide (A), in the Western USA (B), Alaska (C), and Western Europe (D). Blue circles indicate study locations while background color indicates fire counts from the European Space Agency's Advanced and Along Track Scanning Radiometer (ATSR) World Fire Atlas for 1996 to 2006 (Krawchuk et al. 2009). Gray areas in panels B and C indicate large wildfires in the USA from 1984 to 2022 (downloaded from mtbs.gov on May 24, 2024). Note that both fire databases may omit smaller fires (on the order of 1 km²), and the World Fire Atlas may miss Short-duration fires due to a satellite overpass frequency of 3 days while sometimes erroneously including gas flares and hot bare soils (Mota et al. 2006)

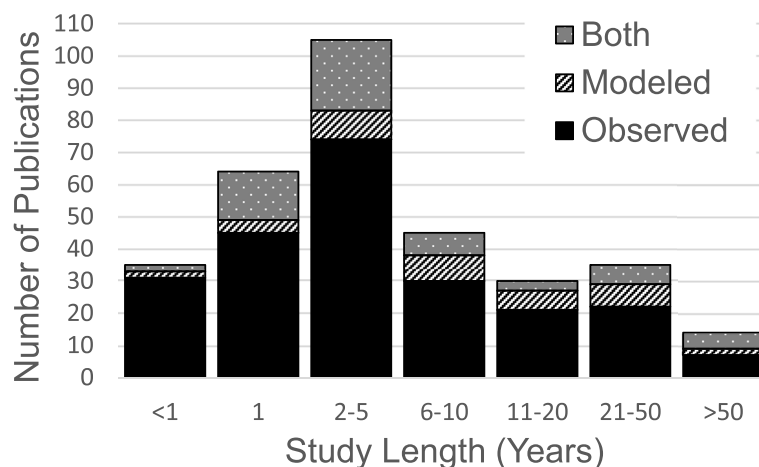
Table 2 Count of documents in our literature search from within different countries and regions

Region	Count	Percent
USA (Western)	258	57.6%
USA (Other)	56	12.5%
Spain	34	7.6%
Australia	23	5.1%
Canada	20	4.5%
Portugal	16	3.6%
Israel	7	1.6%
Global	6	1.3%
Multiple	5	1.1%
China	3	0.7%
France	3	0.7%
Greece	3	0.7%
Africa	3	0.7%
Italy	2	0.5%
Russia	2	0.5%
Argentina	1	0.2%
Chile	1	0.2%
Croatia	1	0.2%
Europe	1	0.2%
Iran	1	0.2%
New Caledonia	1	0.2%

increasingly vital for predicting the impacts of fire introduction or removal in many locations. A relatively small number of fires have been studied in depth compared to the total number of fires that have occurred in the world (Krawchuk et al. 2009; Senande-Rivera et al. 2022). A small number of high-profile fires, like the Rim fire, which burned parts of Yosemite National Park, have led to relatively large numbers of studies. While these

in-depth investigations of individual fires are important, they may skew our understanding of post-fire hydrology since this knowledge is gained from a relatively small set of geographic locations and fire types. It is possible that the large prevalence of American studies in our list may be partially due to our search being restricted to English-language documents. Spain, Portugal, and Australia were the next most common sources of post-fire hydrology literature. Similar to Ebel et al. (2023), we found very few studies in South America, Africa, and Asia despite the large number of fires occurring in these geographic areas (Fig. 2).

As in other reviews, we found a shortage of long-term studies in post-fire hydrology (Ebel et al. 2023). Study lengths ranged from a few months (mostly observational research) to over fifty years in length (approximately half of these longer studies relied on models rather than observations; Fig. 3). Most studies (62%) lasted no more than 5 years, making them unable to capture data on long-term impacts and recovery after fire. These relatively short timespans also mean that there is little data available on the effects of how repeated fires might impact an area over time, as opposed to the single catastrophic fires commonly studied. Second or third entry fires are likely to affect the landscape differently than fires that occur after decades of vegetation growth (Hankin and Anderson 2022), and therefore observations may be skewed toward more negative hydrologic impacts of fire. An increase in standardized, long-term interdisciplinary monitoring networks for post-fire hydrology (akin to the LTER network; lternet.edu/vision-mission) would greatly enhance our understanding of how wildfires impact hydrologic regimes across spatial gradients, including feedbacks to future fires.

**Fig. 3** Number of years that each study covers, divided into those that use primarily observations, models, or a combination of both

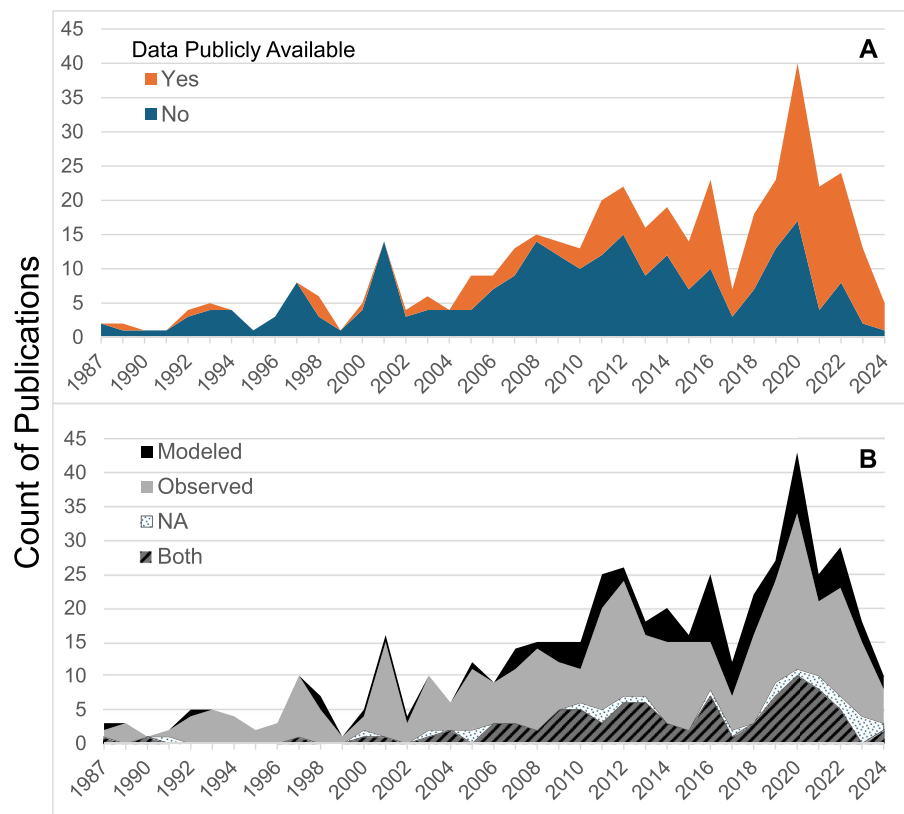


Fig. 4 **A** Number of studies using data that is either publicly available (yes) or not (no) published in each year. **B** Total number of documents published in each year from 1987 to 2024, divided into those that used models, observations, or a combination of both. “NA” refers to documents that don’t directly use data, such as review papers or instructional reports

The amount of literature on post-fire hydrology has been increasing over time (Fig. 4). The proportion of papers using models has also increased greatly in recent years (Fig. 4B), which is potentially attributable to the development of more relevant models in the early 2000s (e.g., WRF-Fire; Mandel et al. 2011) and/or increases in computing capacity over time. There appears to have been a decrease in production in 2017 and a peak in 2020. Both 2017 and 2020 experienced relatively large amounts of fire (Fig. 1; Robinne et al. 2021). It is likely that the many high fire years leading up to 2020 produced a large amount of data availability and opportunities for research funding, and much of this became publication-ready around 2020. Although some of this increasing trend may be inflated due to older publications not always being digitized or easily searchable, the increase over the past 20 years is unlikely to be affected by such omissions. For comparison, overall US publications in the field of natural resources increased by 16% from 2010 to 2022, while publications in the geosciences decreased by 10% (NSF 2024) and during this same time, journal articles related to post-fire hydrology increased by 15% (according to our literature search).

The study areas within post-fire hydrology became more diversified as the number of publications on post-fire hydrology increased (Fig. 5). This may relate to the increased number of modeling studies since models often require multiple input parameters, as well as increased data availability for certain topics (e.g., from new satellites or drone technology for remote sensing). Some subject areas (such as fire impacts on snow and water quality) have seen an increase in their percent coverage in recent years, while others (such as erosion and overland flow) have seen a decrease. Those decreasing topics may represent subjects that have already been thoroughly studied and therefore do not provide as many opportunities for ground-breaking research.

The results of our scoping search are housed in a searchable online data clearing house, which provides tools for filtering literature based on subject and time span, as well as metadata about which fire is studied, length of study, and whether the study is based on modeling or observations (Figs. S1–S2; Supplementary Material). If the literature includes publicly available data, a link to that data is also provided. The aim is to help researchers and managers quickly sort through the

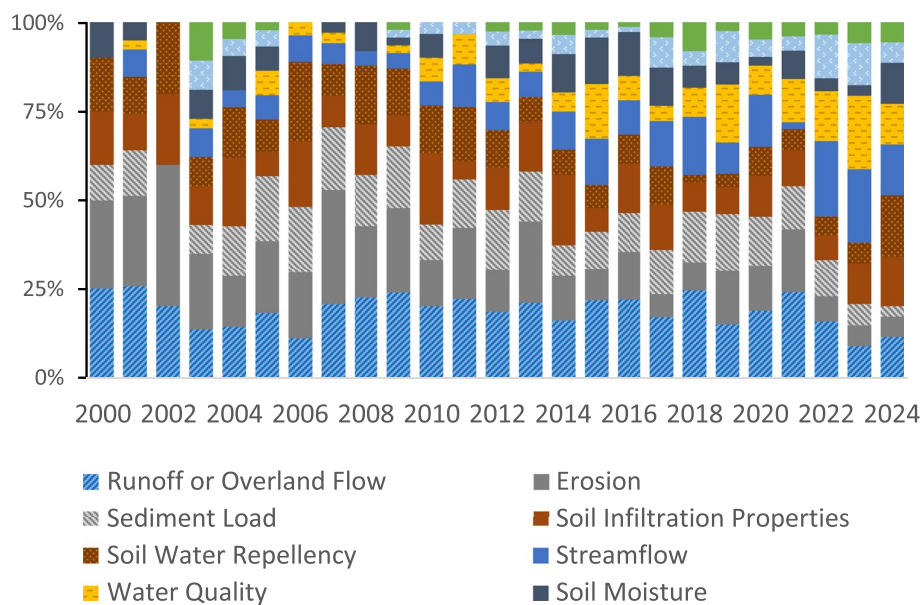


Fig. 5 Percentage of area of study for each year from 2000 to 2024

available literature to identify information most relevant to their specific post-fire hydrology question.

Data sources

The proportion of studies using publicly available data (or making their data publicly available) has been increasing over time, though it is still not universal (Fig. 4A). Since 2011, over 30% (and up to 83%) of our literature list's articles in each year used publicly available datasets. Data sharing facilitates cross-site comparisons, aggregation of information, and verification of findings (Horsburgh et al. 2020).

We identified over 300 sources of data relevant to post-fire hydrology (Supplementary Material: Data List). Nearly half of these are datasets explicitly created to measure post-fire impacts (e.g., measurements of soil hydrophobicity post-fire) while the remainder are general observations which may still be relevant (e.g., stream gage networks that happen to include some burned watersheds). These data sources range from government networks of gages spanning decades and whole continents (e.g., USGS stream gages with some data reaching back to the late 1800s) to field observations from within specific watersheds sometimes spanning under 1 year. Combining all of these in one location can serve to enable cross-site comparison studies and/or help future researchers make additional use of existing datasets (Horsburgh et al. 2020).

We identified over 70 different sources of precipitation data (both gridded datasets and gage networks), and fewer than 40 for other types of data (Table 3). Note

Table 3 Count of data sources for each data type category in our list of datasets relevant to post-fire hydrology (Supplementary Material: Data List). This list is primarily derived from the datasets used by the literature in Supplementary Material: Literature List and summarized in Table 1

Data type	Count	Percent
Precipitation	74	21.3%
Fire history	39	11.2%
Soil moisture	38	11.0%
Streamflow	37	10.7%
Snow	35	10.1%
Land cover	30	8.6%
Soil properties	29	8.4%
Water quality	20	5.8%
Sediment	19	5.5%
Watershed boundaries	13	3.7%
Surface elevation	13	3.7%

that these numbers do not capture the number of locations or years that data are available. While there are few sources for surface elevation and watershed boundaries, this is largely because these datasets often encompass large geographic areas and do not require on-the-ground measurements, and fall under the jurisdiction of government agencies such as the USGS to create authoritative data sources.

The dataset counts in Table 3 also do not capture the ease of sorting through or using different datasets. For example, USGS streamflow data (waterdata.usgs.gov/

nwis/sw) and Government of Canada sediment data (wateroffice.ec.gc.ca/search/sediment_e.html) are all in a standardized format within a searchable database which makes them easy to compare, but most data related to soil water repellency come from smaller studies and may contain different formats and units which make them more labor-intensive to compare to each other. This lack of standardized formatting among different repositories of hydrologic data is a recognized issue impeding use of openly available data (Horsburgh et al. 2020).

The searchable data clearing house created here allows users to compare time spans, spatial resolution, and geographic extent of different data sources to quickly assess their options. Often users have specific needs in terms of spatiotemporal extents and resolutions, and having a list of similar datasets with high-level metadata can ease the process of identifying the optimal dataset. For example, the Fire Occurrence Database (Short 2022) captures a larger number of fires than the Monitoring Trends in Burn Severity Database (Eidenshink et al. 2007), but covers a shorter range of years and does not include burn severity information (Fig. 1). For some uses, a longer record with greater information on fire effects is more important, whereas for other uses, the more complete but shorter and less detailed record would be more appropriate. Being able to compare metadata for these datasets side by side can help users make an informed decision about what information is available to suit their needs without having to visit a large number of websites. Such comparisons can also help identify different datasets which could potentially be combined for synthesis studies. Users can filter and sort information based on topic, time span, and whether the data were created specifically to study fire impacts (e.g., paired measurements in burned areas and unburned control plots) or if the data were collected for other purposes but may still be valuable for post-fire hydrology research (e.g., stream gauge networks created for general streamflow monitoring). Information on spatiotemporal resolution and extent is also provided to help users determine whether the dataset meets their needs (Fig. S3; Supplementary Material), and citation information is included to assist with proper data referencing.

Conclusions

In the past 20 years there has been a large increase in the number of publications addressing post-fire hydrology. The 15% increase from 2010 to 2022 is similar to the level of increases seen for research articles covering natural resources in general. These publications come from many different scientific journals and agencies, but are most commonly found in hydrology-focused journals. Over 50% of studies identified by our search

addressed overland flow, and 42% discussed erosion. In contrast, only 8% covered post-fire changes to evapotranspiration directly, and fewer than 17% of studies investigated soil moisture or snow. Most studies covered fewer than 5 years, and thus there is much more literature on the short-term impacts of fire than on the longer-term impacts. Most studies we identified took place in the USA, and California was the most common state to be a subject of post-fire hydrology studies. The lack of geographic diversity and long-term studies are key impediments to making informed decisions regarding water resources in fire-prone regions. Precipitation and streamflow were the most common types of datasets identified in our search. Not all datasets are publicly available or standardized, which may present an additional challenge to researchers. We have assembled the data and literature discussed here into a searchable website (ufdp.dri.edu) which will hopefully help researchers and decision-makers access information about post-fire hydrology more easily, facilitating future comparative studies and development of resource management plans. While it would be impossible to create a complete list of all information available, this website aims to be comprehensive enough to serve as a starting point for those newly entering the field of fire hydrology or as a resource for those hoping to expand on existing work and fill important knowledge gaps. The authors welcome any suggestions for additional literature, datasets, or models that should be added to the data clearing house, and will continue to update the website as new resources are discovered or become available.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s42408-025-00398-9>.

Supplementary Material 1.

Supplementary Material 2: Data List

Supplementary Material 3: Literature List

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Authors' contributions

GB collected the majority of entries in the literature and data lists, edited some of the metadata, and contributed figures and text to this manuscript. SS created the online data clearinghouse discussed in this paper, and contributed figures and text to this manuscript. Both authors read and approved the final manuscript.

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Data availability

Links to all articles and datasets referenced in this article can be found at ufdp.dri.edu as well as this article's supplementary material.

Ethics approval and consent to participate

This study did not involve human subjects.

Consent for publication

This manuscript does not present any individuals' data.

Competing interests

The authors declare that they have no competing interests.

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