



1 **An integrated wildfire event database for improved fire science**
2 **research for the continental United States, 1992-2021**

3

4 Eric S. Kasischke¹, Nancy H. French¹

5 ¹Michigan Tech Research Institute, Ann Arbor, MI 48014, United States of America

6 *Correspondence to:* Eric S. Kasischke (ekasisch@umd.edu)

7



8 **Abstract.** This paper describes a wildfire event dataset that was initially created by mining
9 information from three existing national datasets that have provided the foundation for
10 numerous wildfire studies in the continental United States over the past two decades. The goal
11 for creating this dataset was to address existing uncertainties and ambiguities in the the existing
12 datasets by using information from regional reports and datasets and searches of the world wide
13 web. Wildfire events not contained in the three datasets were added as new records.
14 Approaches were developed to harvest information for records where there were significant
15 differences in the size of the same fire from different datasets. Specific attention was paid to
16 fires named as complexes, those contained multiple fires, smaller events that had merged to
17 form larger events, events that had joined, events where the size was incorrectly reported, and
18 duplicate events. This new wildfire event dataset provides more accurate information on the
19 number and sizes of individual wildfires and improved information for quantifying annual area
20 burned and changes in extreme wildfire activity over a three-decade period (1992 to 2021) at
21 different spatial scales. Results are presented that illustrate the differences in wildfire
22 characteristics developed from the new dataset and those currently being used by the fire
23 science community.

24



25 **1 Introduction**

26 This paper describes the development of a wildfire event dataset that integrated information found in
 27 fire management agency reports, tables, and data repositories with satellite-derived wildfire event
 28 information. This new dataset provides a comprehensive accounting of wildfire events (unplanned
 29 landscape fires) for three decades (1992 to 2021) for the continental United States (CUS), which
 30 includes the 48 contiguous states plus Alaska. It provides data valuable for assessing wildfire
 31 occurrence and trends, and regional spatial and interannual patterns in wildfire activity. This integrated
 32 dataset is being used in studies to assess the influence of extreme wildfires or mega fires (fires greater
 33 than 10,000 ha in size following Linley et al., 2022) on trends in wildfire burned area, fire regimes, and
 34 smoke generation at regional and sub-continental scales.

35 Since the late 2000s, the U.S. Forest Service (USFS) sponsored efforts to compile information from fire
 36 management reports obtained from multiple sources, resulting in the publication of five versions of a
 37 wildfire occurrence dataset described by Short (2014, 2017, 2021, 2022). This dataset contains records
 38 of fire events of all sizes, covering the period from 1992 to 2020. These datasets have greatly facilitated
 39 wildfire studies in the United States (Table S1). Recently, a new wildfire event dataset was released,
 40 which was developed from wildfire events submitted through the US National Incident Management
 41 System Incident Status Summary (ICS-209) forms (ICS dataset), which typically includes events larger
 42 than 100 acres, but also includes smaller events where incident management teams were assigned. This
 43 dataset includes records from 1999 to 2020 and has been used in a small number of studies (Table S1).

44 Because methods for measuring, estimating, and reporting wildfire size have changed over time and
 45 varies between fire management agencies, identification of mega fires in the USFS and ICS datasets
 46 can be challenging. First, under many circumstances groups of fire events have been managed as
 47 complexes, where the area burned from all the fires has been reported in a single record. The ICS dataset
 48 contains more complex events than the FS20 datasets, where in some years it contains a complex plus
 49 the fires within the complex as separate records. Second, fire events that had merged were often reported
 50 as multiple individual events or records in fire management reports and datasets. Third, in many
 51 instances, the sizes for larger wildfires are estimated, especially in rural areas where the fires are
 52 managed by private landowners or local fire departments, which has resulted in under or over estimation
 53 of fire size. And fourth, in regions with a high percentage of private landownership, many wildfires go
 54 unreported. Finally, it is important to note that the use of GPS and GIS technologies for the mapping of
 55 fire perimeters and estimating their size has increased over the three-decade timespan of the database,
 56 resulting in improved size and location accuracy and a decrease in the uncertainties associated with
 57 mapping wildfire occurrence, size and duration.



58 The creation of the MTBS fire perimeter dataset (1984 to 2024) has benefited numerous studies of
 59 larger wildfires in the CUSA (Table S1). The MTBS program defines large fires as those greater than
 60 1,000 ac (405 ha) in the western U.S. and 500 ac (202 ha) in the eastern U.S. This dataset has been
 61 widely used because fire perimeters have been mapped with a consistent methodology using primarily
 62 Landsat satellite imagery beginning in 1984 combined with Sentinel 2 imagery beginning in 2015. The
 63 approach used to create MTBS products is based on the contrast between burned and unburned
 64 vegetation using a combination of Landsat and Sentinel 2 spectral bands, providing an accurate and
 65 consistent means of mapping burned vegetation under most circumstances (Sparks et al., 2015). While
 66 the MTBS approach is recognized for producing accurate depictions of burned area in most situations,
 67 as will be shown in this paper, there were a small number of events where the algorithm and approaches
 68 used by the MTBS program did not accurately map burned area. In addition, the MTBS archive of
 69 wildfire records is incomplete for several reasons. First, the unavailability of Landsat data was high in
 70 some years, especially during the 1980s and 1990s (Short, 2015). And second, the production of MTBS
 71 wildfire perimeters is based on the identification of the location of events from fire management records
 72 and thus is dependent on the completeness of these records.

73 While most studies in Table S1 were based on using a single dataset, a limited number used data from
 74 two datasets. There were two studies that used the USFS and MTBS datasets separately to calculate
 75 wildfire characteristics, where two studies integrated information from them. Three studies integrated
 76 the ICS and MTBS datasets.

77 Here, the results from the first part of ongoing research to assess unplanned fire (wildfire)
 78 activity trends in the CUSA are presented: the development of an event-based wildfire dataset for the
 79 CUSA for a three-decade period (1992 to 2021). In developing this integrated wildfire dataset, we
 80 endeavored to correct known inconsistencies and issues associated with the various information
 81 sources. The objectives for this activity were to: (1) integrate wildfire event data from multiple sources
 82 (including data from the MTBS program) into a single dataset; (2) identify additional wildfires for
 83 individual MTBS records through the visual interpretation of MTBS perimeters; (3) resolve
 84 uncertainties and ambiguities in wildfire records reported as complexes; and (4) for matched records
 85 (those containing information from the MTBS program and fire management sources) determine the
 86 reasons for significant differences in the sizes reported by the two sources..

87 This new dataset has been named the integrated Wildfire Event Dataset (iWED). In this paper, the
 88 approaches used to obtain and develop the information contained in the records in this dataset are first
 89 described. Examples are presented to illustrate how the number and sizes of wildfire records were
 90 altered during the five phases of the dataset development. The average burned area derived using events
 91 from the iWED are compared to those calculated using wildfire records from the fire occurrence dataset
 92 of Short (2022) as well as area burned contained in the annual reports published by the National



93 Interagency Coordination Center (NICC) (NICC 2002-2020). The potential importance of the iWED is
 94 then illustrated through examination of alterations in the number and area burned in mega and mega-
 95 plus fires in different CUSA regions.

96

97 **2 Technical Approach**

98 The iWED contains information for wildfire events ≥ 100 ha (247 ac) in size for the 49 states within
 99 the continental U.S. from 1992 to 2021. Figure 1 provides a flowchart summarizing the datasets, tools,
 100 and study phases used during its development. Sect. 2.1 summarizes the variables for each record
 101 contained in the iWED and its availability. Sect. 2.2 discusses the datasets and information sources used
 102 for the dataset development. The web-based tools and common analysis approaches used are presented
 103 in Sect. 2.3. The iWED was developed during the five phases presented in Sect. 2.4. A number of steps
 104 used in the different phases used the same procedure. To avoid repetition, these common procedures
 105 are presented in full the first time they are discussed and thereafter referred to by a procedure number
 106 (Table 1). The comparisons of average burned area developed from the iWED to area burned from other
 107 sources as well as an assessment of variations in extreme wildfire activity (mega and mega-plus fires)
 108 are presented in Sect. 2.5.

109

110 **2.1 Data Availability and Dataset Contents**

111 The integrated Wildfire Event Database, version 1 (iWED v1) was published in the fall of 2025 and is
 112 available from the Oak Ridge National Laboratory Distributed Active Archive Center for
 113 Biogeochemical Dynamics (Kasischke et al., 2025). Improvements to iWED v1 were made through the
 114 addition of events from the ICS dataset, refinement of the reclassification of MTBS Unknown records
 115 as Prescribed Fires, and further identification of MTBS wildfire records containing multiple perimeters.
 116 These improvements are contained in version 2 of the iWED, which is currently under review for
 117 publication (Kasischke et al. 2026, in review).

118 The iWED v1 is held in a CSV format and contains 19 variables for each of the 45,612 records contained
 119 in the dataset (see Table 2 in Kasischke et al., 2025). Variable 1 is a unique number for each record.
 120 Variables 2 to 8 provide information related to the development of the iWED. An important feature of
 121 iWED is the retention of information about the sources used to develop information for each record.
 122 Variable 2 is an alpha-numeric code where the number identifies one of the seven primary sources
 123 where the information for a record was obtained (Table 3 in Kasischke et al., 2026) The letters for this
 124 variable identify records named as complexes (cx) or that were determined to be duplicates (d). The



alpha-numeric codes contained in variable 3 provide a summary of the processes used to change information for a record or provide additional information for the record. Variable 3 consists of thirty-one separate alpha-numeric codes, where the number identifies twelve information sources and the letters designate specific changes that occurred (Table 4 in Kasischke et al., 2026). Over 34% of the records (15,742) contain additional information in variable 2. During Phase 2 of the iWED development (Sect. 2.4), 1,308 MTBS events were found that contained multiple perimeters. Variables 4, 5, and 6 provide the number of small, medium, and large perimeters, respectively, found for these MTBS records. Variables 7 and 8 provide links to notes that identify unique attributes for a record as well provide discussions on the steps used to develop additional information for a specific record. These notes are provided in Table 5 as separate CSV file (see Kasischke et al., 2025). In version 2 of the iWED, there are 1,092 notes associated with 6,833 records. Variables 9 to 15 contain data imported from fire management datasets and reports (including fire name, year, state, start day of year, end day of year, ignition source, and size in acres), and Variables 16 to 18 contain data imported from the MTBS dataset (MTBS perimeter size in acres, event name, event identification number) where variable 19 contains the MTBS fire type (Prescribed, Unknown, Wildfire) for each event and identifies those Unknown or Prescribed Fires which were determined likely to be a wildfire or prescribed fire based on visual interpretation of MTBS perimeter shape (Sect. 2.3) and Unknown fires that were most likely Prescribed fires based on their locations. In addition, variable 19 identifies MTBS Wildfires that were identified as a Prescribed Fire in a report and MTBS Unknown and Prescribed Fires that were matched with a fire management event.

The information obtained for each wildfire event contained in the iWED included the latitude and longitude for the event (when available), which is typically the start location for fire management events and the centroid of the perimeter(s) for an MTBS event. These positional data will be provided in a subsequent version of the iWED, to be released once the authors have submitted a publication that uses this information.

2.2 Data and Information Sources

There are three types of records in the iWED. Those where the information comes from fire management records and sources (FM records), those where the information comes from the MTBS dataset (MTBS records), and those where the information comes from both fire management and MTBS source (matched records). Information on individual fire management events contained in the iWED came from seven sources: (1) records contained in the US Forest Service fire occurrence dataset for 1992-2015 (Short, 2017; hereafter referred to as the FS15 dataset); (2) records contained in the US Forest Service fire occurrence dataset for 1992-2018 (Short, 2021; hereafter referred to as the FS18 dataset); (3) records contained in the US Forest Service fire occurrence dataset for 1992-2020 (Short, 2022; hereafter referred to as the FS20 dataset); (4) records contained in the ICS dataset, which was



160 created from wildfire events mined from the US National Incident Management System for 1999–2020
 161 (St Denis et al., 2023; hereafter referred to as the ICS dataset); (5) records contained in datasets and
 162 information contained annual reports published by state, regional, and national governmental
 163 organizations (see Table 1 in Kasischke et al., 2026, which provides the URL locations for these
 164 sources); (6) information harvested from daily or weekly incident management situation reports
 165 (ISMRs) published online by the National Interagency Fire Center (NIFC) (NIFC, 1992 to 2021) and
 166 the Alaska Interagency Coordination Center (AICC) (AICC, 1992 to 2021); and (7) data or information
 167 harvested from documents or media reports found through searches of the world wide web. For each
 168 fire event, information obtained from these sources included fire name, year of the event, location
 169 (either latitude/longitude or a description of the location), fire start and end date, ignition source, and
 170 fire size.

171 The MTBS data used in this study were obtained from the Monitoring Trends in Burn Severity program
 172 (Eidenshink et al., 2006; Picotte et al., 2020). Three separate MTBS products were used: (a) fire event
 173 information obtained from the MTBS geographic information system (GIS) database (MTBS, 2026a)
 174 (fire name, fire size, MTBS identification number, start date, latitude, longitude, and fire type); (b) fire
 175 perimeters contained in the MTBS GIS database (MTBS, 2026a); and (c) false-color Landsat images
 176 contained in pdf files produced by the MTBS program (MTBS 2026b).

177 In addition to the fire perimeters in the MTBS dataset, four other datasets were used in analyzing
 178 individual events and complexes of wildfires: (a) fire perimeter datasets produced by WFIGS
 179 (<https://data-nifc.opendata.arcgis.com/datasets/nifc::wfigs-current-interagency-fire-perimeters/about>
 180 last accessed on 15 June 2026), NIFS/GeoMAC (<http://data-nifc.opendata.arcgis.com> last accessed on
 181 15 June 2026), and CalFire (<https://www.fire.ca.gov/what-we-do/fire-resource-assessment-program/fire-perimeters> (last accessed on 15 June 2026); (b) the MODIS burned area product dataset
 182 (MCD64A1 v.6.1; Giglio et al., 2018); (c) the Landsat BAECV product (Hawbaker et al., 2020); and
 183 (d) the archive of fine-resolution, color aerial photographs available through Google Maps
 184 (<https://www.google.com/maps> last accessed on 15 June 2026).
 185

186 .

187 2.3 Web-Based Applications and Visual Interpretation of Imagery

188 In addition to the worldwide web-based search engines used to access and download datasets and
 189 government and media-based reports, four other web-based applications were used during the
 190 development of the iWED:

- 191 1. The Wildland Fire Emissions Inventory System (WFEIS) website
 192 (<https://wfeis.mtri.org/calculator> last accessed on 15 June 2026) was used for a variety of analyses



193 during the creation of the iWED. The WFEIS was originally designed to calculate carbon and smoke-
 194 product emissions from wildland and prescribed fires in the United States (French et al., 2014; Billmire
 195 et al., 2025). The WFEIS is a web-based geospatial Application Programming Interface (API) that
 196 integrates geospatial information on wildfire or prescribed area burned, fuel loads, and weather
 197 conditions to calculate biomass consumed and emission products using fuel consumption models
 198 developed by the U.S. Forest Service (Prichard et al., 2006). The WFEIS user has the option to select
 199 the source of burned area information, geographic area of interest, and time period of interest (where
 200 the available years are based on the source of the area burned data). Alternatively, the user can select a
 201 specific event from a fire perimeter dataset using the assigned name or ID number of an event. The
 202 WFEIS contains fire perimeters from the MTBS, WFIGS, NFIS/GeoMAC and CalFire datasets and
 203 burned area pixels created from processing of Landsat and/or MODIS data. In this application,
 204 information from multiple sources are overlaid onto a base map provided by OpenStreetMap
 205 (<https://www.openstreetmap.org/#map=5/38.00/-101.34> last accessed on 15 Jun 2026), and provides
 206 the capability to: (a) visualize the location of a fire event perimeter; (b) identify geographic features
 207 within and adjacent to a perimeter; and (c) display and visually compare perimeters from multiple
 208 sources as well as burned area pixels from MODIS and Landsat.

209

210 2. The OpenStreetMap website was used to display the latitude and longitude positions of fire
 211 management events. Through a comparison of the WFEIS and OpenStreetMap displays, it could be
 212 determined if the position of a fire management event was within an MTBS perimeter (Procedure 1 in
 213 Table 1).

214 3. The Google Maps website (<https://www.google.com/maps> last accessed on 15 June 2026) was
 215 used in several ways. First, the latitude and longitude for many wildfire events were not provided, where
 216 instead, a written description of the event's location was given (typically in miles and direction from a
 217 geographic feature). By locating the geographic feature (most commonly a city or town) in Google
 218 Maps and using its Measure tool, a latitude and longitude could be obtained (Procedure 2 in Table 1).
 219 Second, the Google Maps website was used to obtain recent, fine-resolution, color aerial photography
 220 for some fire events, as well as to identify distinct topographic features (e.g., buttes, ridges, steep slopes,
 221 canyons) within a fire perimeter. These images were used to identify landscape features which may
 222 have contributed to the incorrect mapping of burned area in specific MTBS events (Procedure 3 in Table
 223 1).

224 4. The Google AI mode has recently been added to the Google search engine
 225 (<https://www.google.com/?zx=1779714057006> last accessed on 30 July 2026). When the ICS dataset
 226 was added to the iWED, this mode was used to harvest information on all events named as complexes



227 in the ICS dataset, where the names, sizes, or numbers of fires were identified for a number these events.
 228 The Google AI mode was used during a final quality control check on other events that were named as
 229 complexes for which information had not been previously found, as well as events for which positions
 230 were not available.

231 While digital processing of data from airborne and satellite remote sensors is widely used in analyses
 232 of geospatial data, visual interpretation of remotely-sensed imagery and other data products (e.g.,
 233 topographic maps and fire perimeter shapes) was an important analysis tool used during the
 234 development of the iWED. Visual interpretation was used for:

235 1. Identifying MTBS records or events that contained multiple fire perimeters. For MTBS events
 236 containing multiple perimeters, the fraction of the total MTBS event size in each perimeter was
 237 estimated using visual interpretation, which in turn was used to calculate each perimeter's size
 238 (Procedure 4 in Table 1).

239 2. Distinguishing likely wildfires from planned (prescribed) fires based on MTBS perimeter
 240 shape;

241

242 3. Matching of MTBS perimeters with fire management events through comparison of the
 243 perimeter and fire event locations (Procedure 1 in Table 1);

244 4. Identifying merged or joined fires;

245 5. Comparing MTBS to fire management perimeters and/or burned area pixels to assess the
 246 accuracy of MTBS fire size; and

247 6. Identifying events where the algorithm used by MTBS algorithm did not correctly map the
 248 burned area.

249 More detailed discussions on the use of visual interpretation in the creation of the iWED are presented
 250 in Sect. 2.4.2, and examples are presented in the online Supplement to this article.

251 **2.4 Dataset Development Phases**

252 Each phase in the development of the iWED involved a set of steps designed to identify
 253 additional wildfire events for entry into the iWED (Phases 1 and 2), resolve uncertainties that existed
 254 in events named as complexes (Phase 3), and identify reasons for differences between fire management
 255 and MTBS sizes in matched records (Phases 4 and 5).



256 2.4.1 Phase 1

257 The initial phase of iWED development was to combine and reconcile information from existing fire
 258 management records.

259 **Step 1** - The very first step in the creation of the iWED was to populate the dataset with events from
 260 primary fire management sources. A preliminary version of the iWED was created in 2016 prior to the
 261 release of the FS18 and FS20 datasets. Data from fires ≥ 100 ha (247 ac) were extracted from records
 262 contained in the FS15 dataset, including name, year of fire, latitude, longitude, state, start date, end date,
 263 ignition source, and fire size (in acres). These events represented the initial FM records contained in the
 264 iWED. When the FS18 and FS20 datasets became available, comparisons were made to identify events
 265 not already in the iWED, which were then added as new records. The primary source for a record in the
 266 (Variable 2) in the iWED was updated if the fire event was contained in either the FS18 or FS20 dataset.

267 **Step 2** - Wildfire events not contained in the iWED were identified through searches of records
 268 contained in other regional and national datasets as well published reports and web pages. New events
 269 were identified based on a combination of event name, size, start date and location and added to the
 270 dataset as new FM records. Wildfire event data for 2021 was based on events identified in fire
 271 management reports and datasets. Information for new events were used to add FM records to the
 272 iWED. The names of some events that were Unnamed in the FS15/18/20 datasets found in these other
 273 datasets were substituted for those records and were identified in Variable 3 of the dataset by the alpha-
 274 numeric '3n'.

275 **Step 3** - As part of ongoing research, the daily/weekly incident management situation reports (IMSRs)
 276 from NICC were reviewed to create a daily burned area variables for each event in the iWED for all
 277 western ecoregions, including the western Great Plains, but excluding Alaska. During this process,
 278 additional fire events were identified that were not contained in the iWED. During this review, all events
 279 $> 1,000$ ac not contained in the iWED were added to the dataset as new records. Based on the results of
 280 this review, the IMSRs for the remaining areas in the Great Plains were reviewed, and additional events
 281 $> 1,000$ ac were added to the iWED. For areas east of the Mississippi River, additional fires > 500 ac
 282 were added to the iWED. These thresholds were selected because smaller wildfires were under-reported
 283 in the IMSRs during the 1990s. One issue in obtaining information from these additional events was
 284 that the IMSRs did not contain latitude and longitude information. Instead, many of these events
 285 contained a written description of the fire's location, typically the direction and distance from a town
 286 or city. This information was used to obtain a latitude and longitude by using Google Maps. (Procedure
 287 2, Table 1) Information on a fire's location that was not provided in an IMSR was often obtained in a
 288 report found through a search of the world wide web. Finally, some of the unnamed fires in the FS20
 289 dataset were named in the IMSRs as well as other sources. These names were substituted for these



290 events in the iWED and the source for these names noted in variable 3 of the dataset using the alpha-
 291 numeric '4n'.

292 **Step 4** – The decision to add wildfire events from the ICS dataset came after version 1 of the iWED
 293 was published (Kasischke et al., 2025). At this point, some of the ICS wildfire events had already been
 294 obtained from spreadsheets that were available from the website hosting these events. The ICS
 295 contained a more complete set of information, including more accurate latitude and longitude
 296 information. The events from the ICS dataset that were added as new FM records were identified by
 297 the number 12 in Variable 2 of the dataset. The primary source (variable 2) for ICS events that had
 298 previously been obtained from the website was also changed. There were unnamed FS20 events that
 299 were matched with ICS events. The ICS names were substitute for these events and the source for these
 300 names noted in variable 3 of the dataset using the alpha-numeric code '12n'.

301 **Step 5** - During the importing of fire management events from other sources, it became apparent that
 302 there were differences in the approaches used to report wildfire complexes. Groups of wildfires were
 303 often managed as complexes, where each complex was given a name. In the daily/weekly IMSRs,
 304 information (including size) was frequently only reported for the complex and not for the individual
 305 fires in the complex. In fire management datasets, information was sometimes reported only for the
 306 complex and at other times for individual fires within the complex or a combination of the two. After
 307 importing events from other sources, it became clear that overlapping or duplication of events had
 308 occurred. An example is when the FS20 dataset contained a single record named a complex where the
 309 individual events were contained in a regional fire management dataset or report. To resolve this issue,
 310 every record named as a complex was assigned the letters 'cx' along with the numeric designator
 311 denoting the primary source for the data in Variable 2 of the dataset. Events named as complexes were
 312 carefully reviewed during Phase 3 of the dataset development (Sect. 2.4.3).

313 2.4.2 Phase 2

314 This phase focused on incorporating events contained in the MTBS dataset. First, all MTBS Wildfire,
 315 Unknown, and a limited number of Prescribed Fire events were added to iWED as new records. Next,
 316 MTBS events that could matched with the fire management record entered during Phase 1 were
 317 identified, resulting in the creation of matched records. Finally, unmatched MTBS records with an
 318 Unknown and Prescribed Fire type were examined to identify those that could be reclassified as
 319 Wildfires or Prescribed Fires.

320 **Background** - The standard procedure used by the MTBS program to create a fire perimeter from
 321 satellite remote sensing data is to select Landsat and Sentinel 2 scenes based on the locations of wildfire
 322 and prescribed fire events from fire management reports (Eidenshink et al. 2006). For most events, the



MTBS analyses resulted in a single perimeter that was associated with a single fire management or prescribed fire event. Many MTBS Wildfire and Prescribed Fire records included additional perimeters from fires that were immediately adjacent to the targeted event. In addition, multiple perimeters for an MTBS record occurred when a fire jumped a natural (e.g., river, reservoir, lake) or man-made barriers (e.g., road or railroad right-of-ways). A large number MTBS records with an Unknown type were produced when analysts identified additional fire perimeters in the Landsat/Sentinel 2 scenes used for mapping known wildfires and prescribed fires. This latter process also produced MTBS records that contained multiple perimeters. Finally, a set of MTBS events were generated as part of a USGS program to map burned area in the Flint Hills ecoregion of eastern Kansas and Oklahoma, MTBS perimeters were generated from 1986 to 2007 for the entire region (<https://burnseverity.cr.usgs.gov/products/prairieFires> last accessed on 19 February 2026). While most of the records from this effort were assigned an Unknown type by the MTBS program, the 311 records generated in 2011 were assigned a Prescribed Fire type and were used in developing the iWED.

Step 1 – All MTBS events typed as Wildfire, Wildland Use Fire, Unknown, and Prescribed Fires from 2011 in the Flint Hills region were added to the iWED as new records, where Wildland Use Fires were relabeled as Wildfires. Information that was imported included MTBS fire name, latitude, longitude, fire start date, MTBS ID number, and the dates of the pre-fire and post-fire Landsat scenes that were used to generate the MTBS products.

Step 2 – The MTBS records were then matched with fire management records through comparison of fire names, sizes, locations (latitude and longitude), and start date, resulting in the creation of a single, matched record. For many records, the FS15/18/20 datasets provided the names and MTBS Identification Numbers for events that were matched with fire management events, which aided in the matching of events in the iWED. It was found that the FS15/18/20 records contained two categories of MTBS events. The first category contains a non-hyphenated identifier containing 21 characters. The first two letters of this identifier are letters identifying the state where the fire centroid was found with the latter 19 characters being numbers based on the latitude, longitude and the start date for the fire. The second category of MTBS events contained a hyphenated identifier based on different land management agencies. The publicly available MTBS dataset (MTBS 2026a) only contained the first category of MTBS events. Two procedures were used to confirm the matching of MTBS and fire management records when an uncertainty existed. First, the WFEIS was used to display the MTBS perimeter and OpenStreetMap to display the position of the fire management event. A match was confirmed using Procedure 1 (Table 1) or by using the WFEIS to simultaneously display the MTBS perimeters and other perimeters from the CalFire, NIFS/GeoMAC, and WFIGS datasets, where a match was confirmed when there was close agreement between the two perimeters (Procedure 5 in Table 1). There were 41 MTBS Prescribed Fire records and 240 MTBS Unknown records that were matched with



a fire management record, indicating that the fire type for these records was incorrect. These records were assigned a new variable 19 in the iWED as either Prescribed-WF or Unknown-WF. There were 17 MTBS wildfire records from Alaska that were matched with prescribed fire events found in an AICC IMSR. It was concluded these events had been given an incorrect type by the MTBS program and were assigned a new variable 19 in the iWED as a Wildfire-PR type and identified in Variable 7 (notes).

Step 3 - There were 869 MTBS Wildfire records that could not be matched with a fire management as well as 5,428 unmatched MTBS Unknown/Prescribed Fire records, prompting further examination during Phase 2 of the development of the iWED. Reviewing the location of all unmatched MTBS Unknown/Prescribed fire records revealed that a large number of these occurred in areas where MTBS Prescribed Fire perimeters were common. These areas included National Wild Refuges, National Forests, state conservation and game management areas, state forests, military reserves, and state lands containing wetlands. All unmatched MTBS Unknown records that were found in areas with a high number of MTBS Prescribed fires were given an Unknown-PR type (1,800 events). A significant number of the remaining unmatched events (1,836 out of 3,628 events) occurred in the Flint Hills region of eastern Kansas and Oklahoma where prescribed burning is the prevalent source of landscape-scale fire activity (Short 2014) (see Sect. S4 in the online Supplement to this article).

Step 4 - By reviewing the shape and general landscape features of the perimeters for a large number of MTBS Wildfire and Prescribed Fire records, a set of characteristics were compiled that were used to identify the likely type of an Unknown MTBS event (see Sect. S1 in the online Supplement to this article). The first step was to view the perimeter shape for each unmatched, Unknown MTBS record using the WFEIS, and based on the characteristics of the perimeter's shape, reclassify them as a Wildfire, Prescribed Fire, or Unknown. The 311 MTBS Prescribed Fire records from the Flint Hills region were also viewed. Variable 19 of the iWED dataset contains information on the MTBS fire type, including those MTBS fires initially given an Unknown type that were reclassified as Wildfires (Unknown-WF) or Prescribed (Unknown-PR) fires using visual interpretation. This step included the review of the 3,628 unmatched MTBS Unknown/Prescribed fires.

Step 5 - When viewed using the WFEIS, it was discovered that many of the unmatched MTBS Unknown records contained multiple fire perimeters. The existence of multiple perimeters was identified by assigning '7mu' to variable 3 in the dataset as well as noting the number of large, medium, and small perimeters in Variables 4 to 6 of the dataset. The identification of perimeter size was based on a relative, not absolute scale. Events with a single perimeter were assigned a '7s' to variable 3. For MTBS records with multiple perimeters, Procedure 4 (Table 1) was used to calculate each perimeter's size. Perimeters greater than 100 ha (247 acres) were added to the iWED as a new record, where the MTBS names were altered by adding "Fire 1", "Fire 2", etc. to the name. Because of the discovery that many of the



unmatched MTBS Unknown records contained multiple perimeters, all unmatched MTBS Wildfire records were also visually interpreted to identify those with multiple perimeters.

394

2.4.3 Phase 3

Five steps were used during Phase 3 to assess the sources for uncertainties in records named as complexes during Phase 1:

Step 1 – For each unmatched fire management record named as a complex, searches of fire management databases, reports, and the world wide web (Procedure 6 in Table 1) were carried out. For some events where the names and sizes of the fires found for the complex were found where the total area for the individual fires matched the size in the record. For these events, the individual fires were added to the iWED as new records and the record for the complex event removed. In other events, the total area for the fires in the complex was different than the complex size from the record. In these cases, the individual fires were added as new records, where the complex size was allocated to the fires in proportion to their reported sizes (Procedure 7 in Table 1). The record for the complex event was removed from the dataset. For some records, only the names or numbers of the fires within the complex were found. For these events, the complex record was replaced in the iWED by multiple records (equal to the number of fires within the complex) whose sizes were calculated as the complex size divided by the number of fires. For complexes where the number of fires was identified with no names, the individual fires were renamed by adding “Fire 1”, “Fire 2”, etc. to the complex name. For smaller complexes, this approach sometimes resulted in events < 247 acres in size. These events were noted column 7 of the dataset and retained in the iWED to allow calculation of total area burned by including the smaller events from the complete FS20 dataset.

Step 2 – Viewing a matched record using the WFEIS often revealed a fire contained a single perimeter whose MTBS size was nearly equal to the fire management size. Because of the similarity in size, it was concluded that the complex contained a single fire. These records were identified by the alpha-numeric code 7s in variable 3 as well as in variable 7 (notes) of the iWED.

Step 3 – Viewing MTBS event of a matched record using the WFEIS sometimes revealed a fire contained multiple perimeters, where for some events Procedure 6 (Table 1) identified the names and/or number of fires in the complex. Procedure 4 (Table 1) was used to estimate the size of each perimeter. In addition to Procedures 1 and 5 (Table 1) were used to match fire management records with the additional MTBS perimeters.



Step 4 – It was sometimes found for matched records that the MTBS size was considerably larger than the fire management size, where viewing the MTBS event revealed this fire had a single perimeter. Using Procedures 1 and 8 (Table 1), it was determined that the MTBS event resulted from the merging or joining of multiple fires. (Merging occurs when two fires join when both fires are still active and growing. Joining occurs when two fires join after the end date for one of the fires.) Whether or not multiple fires had merged or joined was determined by one of three methods. First, for some records, the merging of fire events was reported in the NICC or AICC IMSRS, in other fire management reports, or reports found in searches of the world wide web (Procedure 9 in Table 1). Second, if Procedure 6 (Table 1) identified the multiple fire management perimeters within an MTBS perimeter and the WFEIS contained MODIS burned pixels that matched the perimeters, the dates for these pixels were used to determine whether the fires had joined or merged (Procedure 10 in Table 1). For all other events, the start and end dates for the fire management events were used, where the evidence the fires had joined and not merged was when the end date for one fire was prior to the start date for the other fire (Procedure 11 in Table 1).

Step 5 – For some records where there was significant difference between the FS20 and MTBS size, a review of other reports (including NICC and AICC IMSRs, other fire management reports, or reports found through a search of the world wide web) found a fire management size for the event that was closer to the MTBS. For some records, fire management perimeters were found that matched the MTBS perimeter size, or Landsat or MODIS burned area pixels were used to confirm that the fire management size was incorrect (Procedure 12 in Table 1). For these records, the fire management size was adjusted by substituting the reported size or perimeter size for the FS20 size. For each event, this adjustment was noted by adding an alpha-numeric designation in Variable 3, with a number identifying the source of the information followed by ‘ad’.

2.4.4 Phase 4

Phase 4 focused on matched records where the difference in MTBS size was greater than 30% of the size of the fire management event. The reasons for these differences were determined following Steps 2 to 5 in Sect. 2.4.3 plus an additional step.

Step 1 - When multiple perimeters were found for an MTBS event using the WFEIS and it was determined that the fire management size represented two or more of the perimeters. For these events, the fire management sizes for the perimeters were calculated using Procedure 7 (see Table 1). For these records, the individual fires were renamed by adding “Fire 1”, “Fire 2”, etc. to the fire name, adding records to the iWED.

2.4.5 Phase 5



While fire management and MTBS sizes for the majority of matched records were within 15% of each other, there remained a significant number that were not. The fifth phase of the development of the iWED analyzed records where there was a 15 to 30% difference between the fire management and MTBS sizes. This phase included the same steps used in Phase 4, plus two additional steps.

Step 1 – The WFEIS was used to identify those matched records where the MTBS size was more accurate based on evidence provided by fire management perimeters, Landsat burned area pixels, and/or MODIS burned area pixels, with additional evidence provided through visual interpretation of false-color Landsat images.

Step 2 – Matched records where MTBS events where burned area was incorrectly mapped were identified through comparisons using the WFEIS of MTBS perimeters with fire management perimeters, Landsat burned area pixels, and/or MODIS burned area pixels and analyses made through visual interpretation of false-color Landsat images containing the MTBS perimeter and/or fine-resolution aerial photography obtained from Google Maps. All MTBS events where it was determined that burned area was incorrectly mapped were identified in variables 3 and 7 or 8 in the iWED dataset.

2.4.6 Geographic Areas

To implement the development of the iWED, the CUSA was divided into twelve geographic regions based on single state or groups of states (Table S1). This division allowed for a systematic review and comparison of events from fire management datasets and reports as well as the MTBS dataset. These regions were also used to assess how the development of the iWED altered the average burned area calculated from different datasets. Some assessments were carried out for four sub-continental areas using two of the regions (Southeast and Southwest), the Eastern United States (EUS; consisting of the Middle South, North Central, Northeast, and Northern Plains regions) and the Western United States (WUS; consisting of the Alaska, California, Great Basin, Northwest, and Southwest regions).

2.5 Assessments and comparisons

The first assessment identified the processes that resulted in changes to the number of events and sizes of events during the development of the iWED (Sect. 5.1). The second assessment examined the net differences in the number of fire events and annual area burned resulting from using different information sources in the iWED compared to the FS20 and MTBS datasets (Sect. 2.5.2). Comparisons were made based on differences in annual average burned area calculated using the events from four wildfire event databases (iWED, FS20, ICS, MTBS), where the comparison of the MTBS and iWED datasets also included number of events (Sect. 2.5.3). Comparisons were then made based on the number and area burned in extreme wildfires events (mega and mega-plus fires) (Sect. 2.5.4). These analyses



488 provide insights into the importance of having well-curated data for studying historical wildfire activity
 489 in the CUSA.

490 A large number of MTBS Unknown or Prescribed fire events in the Southern Plains that were
 491 reclassified as wildfires occurred in the Flint Hills ecoregion of Kansas and Oklahoma, where
 492 prescribed burning is the source for landscape-scale burning. For all analyses carried out for this study,
 493 only fires $\geq 10,000$ acres from the Flint Hill ecoregion were used. The rationale for inclusion of these
 494 fires is presented in Sect. S4 of the Supplement to this article.

495 **2.5.1 Sources of changes to fire management and MTBS events**

496 Through the development of the iWED, fifteen different outcomes were identified that altered
 497 the number of and/or the sizes of events compared to the baseline (FS20 and MTBS) datasets. Examples
 498 of the significant changes resulting from the development of the dataset are presented.

499 **2.5.2 Net changes to the number of wildfire events and the percentage change in burned area**

500 Two assessments were carried out for the CUSA and the four sub-continental areas. The first assessment
 501 examined net changes to the number of fire management and MTBS events for 1992 to 2021 that
 502 occurred as a result of the iWED development. This assessment quantified the number of matched
 503 events as well unmatched MTBS and fire management events. The second assessment examined how
 504 the different sources of data that contributed to the iWED increased average burned area compared to
 505 the FS20 dataset. Average area burned from 1992 to 2020 was calculated for the iWED and FS20
 506 datasets by using wildfires smaller than 247 acres obtained from the FS20 dataset. The second
 507 assessment examined percentage changes in FS20 that resulted from: (1) removals and adjustments to
 508 FS20 events; (2) retention of fire events from the FS15 and FS18 datasets; (3) addition of events from
 509 other fire management datasets and reports; (4) addition of events from IMSRs; (5) addition of events
 510 from reports found on the world wide web; (6) use of unmatched MTBS Wildfire events; (7) use of
 511 unmatched MTBS Prescribed Fire/Unknown events reclassified as wildfires; and (8) for matched
 512 records, substitution of MTBS size for fire management size.

513

514 **2.5.3 Comparisons of wildfire event datasets and reported burned area**

515 Comparisons based on annual burned area were carried out among the FS20, ICS, iWED, and MTBS
 516 fire event datasets as well as annual area burned reported in annual reports from the the National
 517 Interagency Coordination Center (NICC, 2002 to 2020). Comparisons were made between different
 518 datasets for the CUSA, the four subcontinental areas, the regions within the EUS and WUS areas (Table



519 S1), and the 49 states in the CUSA. Comparisons were made for different time periods based on the
 520 availability of data for the datasets being compared.

521 The reporting system used to create the ICS dataset is based on reporting wildfire greater than 100 acres
 522 or events requiring significant resources for suppression and control. As a result, this dataset contains a
 523 range of fire sizes, where the number of smaller fires is not consistent. For comparison with the FS20
 524 dataset, wildfires larger than 100 ha (247 acres) were used.

525 Differences in burned area derived from the FS20 and ICS datasets resulted from the number of wildfire
 526 events contained in each and their sizes. Under most circumstances, it was expected that the FS20
 527 dataset would contain more events because it had access to more wildfire reports than were entered into
 528 the national database used for the ICS dataset. Even when the number of wildfire events are the same
 529 for each dataset, burned area differences (either positive or negative) can occur if the sizes of individual
 530 events are different. The ICS dataset, however, includes fires named as complexes that were not entered
 531 into the FS20 dataset, where for several areas and years, the individual fires from complexes as well as
 532 the complex were included in the ICS dataset. To address this double-counting, the difference in burned
 533 area calculated using records from the ICS and FS20 datasets were examined on an annual basis to
 534 identify states and years where the burned area from ICS records was 25,000 ha or more greater than
 535 burned area from FS20 records. In 19 out of 20 cases examined, it was found that the ICS burned area
 536 was based on using the size of a complex as well as fires within the complex. For these cases, the burned
 537 area was recalculated with the individual fires removed. Annual burned area from wildfire events
 538 contained in the ICS and FS20 datasets were calculated for each year from 1999 to 2020. The statistical
 539 significance of the differences between the 21-year average burned areas was evaluated using a paired-
 540 test for means based on a one-tailed p value. Percentage differences between average annual burned
 541 area were compared using data from 1999 to 2009 and 2010 to 2020.

542 Annual burned area for each year between 1992 to 2020 was calculated using all wildfire events ≥ 247
 543 acres from the iWED and FS20 datasets plus wildfires < 247 acres from the FS20 dataset for each (these
 544 annual values were also used in comparison with the NICC annual values discussed in the next
 545 paragraph). The statistical significance of the differences between the 29-year average burned areas was
 546 evaluated using a paired-test for means based on a one-tailed p value. Percentage differences between
 547 average annual burned area were compared using data from 1992 to 2001, 2002 to 2011, and 2012 to
 548 2021.

549 Annual burned area reported by the NICC is dependent on the number of wildfire events used and their
 550 sizes for each state and year. The NICC reported burned area would be lower than those derived from
 551 wildfire event data if it was based on a fewer number of events and/or if the sizes of the fires used
 552 increased in the reports used for the event datasets. Reasons NICC burned area would be higher than



those generated from event databases include: (a) events used in the NICC burned area were missing from the fire event datasets; (b) the sizes of the some events included in both datasets were smaller in the events database; and (c) the NICC burned area included the size of a fire complex as well as the individual fires in the complex. The first step in comparing area burned reported in the NICC reports and those developed from the FS20 and iWED datasets was to quantify the number of years where NICC burned area was higher than those calculated from a fire management dataset for each state, as well as the number of years where the NICC burned area was > 25% higher. The statistical significance of the differences between the 19-year average NICC burned area and those calculated using events from the FS20 and iWED dataset were evaluated using a paired-test for means based on a one-tailed p value. Percentage differences between average annual burned area were compared using data from 2002 to 2011 and 2012 to 2020.

Numerous studies have used the MTBS dataset to analyze trends in wildfire burned area, with the justification that in the western US, fires > 405 ha represent > 90% of total burned area (see, e.g., Juang et al., 2022; Morton et al., 2013). This justification was evaluated by comparing burned area from all fire management events from the iWED dataset plus fire management events < 247 acres from the FS20 dataset from 1992 to 2020 to burned area from all MTBS wildfire events from the iWED dataset. Percentage differences between average annual burned area were compared using data from 1992 to 2001, 2002 to 2011, and 2012 to 2021.

571

2.5.4 Changes to the number of and burned area in larger and extreme wildfires

This assessment examined the differences in larger and extreme wildfires using the records from five datasets, including: (a) the initial set of fire management records imported into the iWED from the FS20 dataset from 1992 to 2020 and other fire management sources for 2021 (hereafter referred to as the FS20-plus dataset); (b) the MTBS Wildfire records initially imported into iWED (hereafter referred to as the MTBS-A dataset); (c) fire management records from the iWED dataset (hereafter referred to as the iWED-F dataset); (d) MTBS wildfire events from the iWED, including all Wildfire events and Unknown and Prescribed fires that were matched with fire management or reclassified as wildfires (hereafter referred to as the iWED-M dataset); and (e) all fire management records from the iWED where MTBS size was substituted for fire management size for matched records and all unmatched MTBS wildfire records (hereafter referred to as the iWED-F/M dataset).

These datasets were used to compare the number of and burned area in larger and extreme wildfires. The thresholds used by the MTBS program for creating fire perimeters were used to identify larger fires: ≥ 500 acres (202 ha) for the EUS and Southeast region and $\geq 1,000$ acres (504 ha) for the WUS



586 and the Southern Plains region. Two categories of extreme wildfires were defined. First, mega fires
 587 were those $\geq 12,350$ acres (5,000 ha) in the Southeast region and EUS and $\geq 24,700$ acres (10,000 ha)
 588 in the Southern Plains and WUS. Second, mega-plus fires were those $\geq 123,500$ acres (50,000 ha) in
 589 the Southeast region and EUS and $\geq 247,000$ acres (100,000 ha) in the Southern Plains and WUS.

590 From each dataset, the number of all fires, mega fires, and mega-plus fires were determined for the
 591 CUSA and four sub-continental areas using the fire records from each dataset. Burned area was
 592 calculated from all fires, mega fires, and mega-plus fires for each dataset. Comparisons were made
 593 between: (1) the FS20-plus and MTBS-A datasets; (2) the iWED-F and FS20-Plus datasets; (3) the
 594 iWED-M and MTBS-A datasets; and (4) the iWED-F/M and FS20-plus datasets. Comparisons were
 595 based on the difference in the number of fire records and the percentage difference in burned area.

596 **3 Results**

597 **3.1 Alterations to wildfire events through the development of the iWED**

598 When compared to the FS20, ICS, and MTBS datasets, the development of the iWED increased the
 599 number of records of individual wildfire events. Three types of records are contained the iWED. Those
 600 containing only information for a fire management event (FM records), those containing only
 601 information for an MTBS event (MTBS record), and those containing information on both a fire
 602 management and MTBS event (matched record). Table 2 summarizes fifteen processes used in the
 603 development of the iWED that resulted in significant alterations (outcomes) to the wildfire records.
 604 This table identifies whether these processes increased or decreased the number records and the average
 605 size of fire management and MTBS events contained in them, increased or decreased area burned
 606 calculated from all records, and increased the number matched records. This table also provides a
 607 summary of changes that resulted from the 15 processes. Finally, this table provides a list of the sections
 608 in the online Supplement that present examples of the changes that occurred as well as the figures
 609 illustrating specific changes.

610 **3.2 Changes to the number of records and burned area**

611 The development of the iWED resulted in a dataset containing 45,951 fire records (Table 3). All wildfire
 612 and MTBS events that were used during the development of the iWED were retained, with two
 613 exceptions. First, the individual FM and MTBS records for matched records were not retained. Second,
 614 the individual FM records and MTBS records for fires that had merged were not retained.

615 The dataset includes 21 fire management records and six MTBS Wildfire records that are duplicates.
 616 The dataset includes 44 fire management events named as complexes where, based on the number of
 617 fires within the complex, it was determined that the size of each fire was less than 247 acres. There are



13 MTBS records with multiple perimeters where it was determined that the size of each was less than 247 ha. The net effect of all the alterations to events was to add 1,530 new FM records to the dataset for the CUSA, increasing the number of these records by 4.3%. The largest increase occurred in the Southeast (7.3%) and Southern Plains (10.2%) regions. The lowest increase occurred in the WUS (1.1%) where increases from adding records were offset by the large number of records were involved in merged fires.

The option to use unmatched MTBS records assigned a Wildfire type would further increase the number of wildfires by a smaller amount for the CUSA (3.4%), with the highest increases in the Southern Plains (5.1%) and Southeast (7.2%) regions. The option to use unmatched, Unknown/Prescribed MTBS records that were reclassified as wildfires further increased the number of events would increase the number of wildfire events by 1.8% for the CUSA, with the largest increase (5.7%) in the Southeast region.

For the CUSA, the net effect of adding fire management records and adjustments to wildfire size through the development of the iWED increased average annual burned area by 2.4% compared with using data FM records from the FS20 dataset (Table 4). This increase ranged from 1.8% in the WUS to 6.0% in the Southeast. The sources for these increases varied across the different sub-continental areas for the different data sources. While adjustments to FS20 size contributed to fire management changes in all areas, it was a primary contributor only in the EUS, where it accounted for 23% of the total increase. Additions of ICS events were a primary contributor in the EUS (35% of the increase) and the Southern Plains (40% of the increase). Fire management events harvested from reports and datasets were important only in the WUS (32% of the increase). Finally, events harvested from NIFC IMSRs were an important contributor in the Southeast (60% of the increase), Southern Plains (38% of the increase), and WUS (31% of the increase (Table 4).

Using unmatched MTBS events given a Wildfire type or reclassified as wildfire is a unique feature available for increasing the number of events available for wildfire studies. Using the unmatched MTBS Wildfire events would increase average burned area by 1.7% for the continental US, with the largest increases occurring in the Southeast (4.0%) and Southern Plains (5.7%) (Table 4). Using unmatched MTBS Unknown/Prescribed fire events reclassified as wildfires would increase average burned area by 2.7% for the CUS, with the largest increase in the Southern Plains (18.2%) (Table 4).

The iWED provides the opportunity to use the MTBS size instead of fire management size for matched events. Using such a substitution approach did not appreciably change the calculation of average burned area except in the EUS and WUS and resulted in a 0.9% increase in the Southeast (Table 4). The 4.2% reduction in the Southern Plains was largely due to two mega-plus fire matched records whose FS20 sizes (>170,000 ha) were much higher than their MTBS sizes (120,000 ha) (Fig. S29).



652 Using all the additional fire management and MTBS wildfire records and making MTBS adjustments
 653 increased average burned area by 6.4%, with increases of greater than 13% in the Southeast and
 654 Southern Plains (Table 4).

655 One additional observation was made when reviewing annual burned area for wildfires smaller than
 656 100 ha from the FS20 dataset was that these smaller fires were under-represented for periods in the
 657 1990s for eight states (Table 5). During these periods average area burned in the smaller fires was 6 to
 658 22 lower than in the other years. In four of the states, average burned area in these smaller fires
 659 represented more than half of the total burned area from all fires. This shortcoming is meaningful when
 660 analyzing longer-term trends in burned area.

661 3.3 Comparisons between wildfire event datasets and reported burned area

662 Table 6 presents the average annual burned area calculated from the records from the ICS and FS20
 663 datasets for the geographic areas used in this study using data from 1999 to 2020. Those areas where
 664 the paired t-tests identified statistically significant differences in annual burned area are identified. In
 665 addition, this table presents the percentage difference between FS20 and ICS average burned area for three
 666 periods: 1999 to 2020, 1999 to 2009 and 2010 to 2020. These last data are presented to determine if the
 667 percentage of FS20 burned area remained constant between the decadal periods.

668 ICS average burned area was 14.2% lower than FS20 average burned for the CUSA. Annual ICS burned
 669 area was significantly lower for the four sub-continental areas (ranging from 31.7% in the EUS to 12.7%
 670 in the WUS) and six out of the ten regions (ranging from 41.5% in the Northern Plains to 5.6% in the
 671 Southwest) (Table 6). There were three states (Indiana, Ohio, and Utah) where the ICS burned area was
 672 higher than the FS20 burned area, but the differences were not statistically significant. At a state level,
 673 the lowest differences occurred in the WUS, where seven states had significant differences between
 674 ICS and FS20 burned areas, and the ICS percentage ranged from 12.0% in Wyoming to 1.9% in Arizona
 675 (Table 6). The highest significant differences occurred in the EUS states, including West Virginia
 676 (68.3%), South Dakota (50.6%), and Tennessee (41.9%). Of note was the fact that the percentage of
 677 ICS burned area compared with FS20 burned area increased between the two decadal periods for all
 678 sub-continental areas, all regions except for the Rocky Mountain, and all but seven states (Table 6).
 679 These results indicate that the ICS dataset is less suitable for studying wildfire trends than the FS20
 680 dataset.

681 Table 7 presents the average annual burned area calculated from the records from the FS20 and iWED
 682 datasets for the geographic areas used in this study using data from 1992 to 2020. The structure of this
 683 table is identical to that for Table 6 except that it includes three decadal time periods instead of two.
 684 Average burned area calculated using records from the iWED dataset were higher than burned area



685 calculated using those from the FS20 dataset for the CUSA, all sub-continental areas, all regions, and
 686 all but two states. These differences were statistically significant in all areas except for two regions and
 687 15 states (Table 7). Reasons for FS20 burned area being higher in Table 7 included substitution of
 688 MTBS size for fire management size (where the MTBS size was smaller) and correction of the fire
 689 management size. The results in Table 7 reveal that for the CUS, EUS, Southeast, and WUS and for all
 690 but the Northern Plains region, the percentage difference between iWED and FS20 burned area
 691 decreased between the 1990s and 2020s, indicating that the compilation of fire records for the FS20
 692 dataset most likely improved over this time period.

693 Table 8 presents the average annual burned area based on information obtained from the NICC annual
 694 reports and calculated from the FS20 and iWED datasets for the geographic areas used in this study
 695 using data from 2002 to 2020. Those areas where the paired t-tests identified statistically significant
 696 differences in annual burned area are identified. This table also presents the percentage differences
 697 between the NICC and FS20 average burned area and the NICC and iWED average burned area for
 698 three time periods. Finally, this table identifies the number of times NICC burned area was greater than
 699 FS20 and iWED area burned for a state, and the number of times when NICC burned area was 25% or
 700 more greater.

701 Over the 19 years for which information from the NICC reports and the FS20 dataset were available,
 702 there were 389 instances from 42 states where the NICC burned area was higher than the burned area
 703 calculated from the FS20 events and 466 instances when the FS20 burned area was higher (Table 8).
 704 There were 151 instances where the NICC burned area was >25% higher. As a result of the split in the
 705 frequency of years where the NICC burned area was higher or lower than that from the FS20 dataset,
 706 there were 22 states where the average burned area from the NICC reports was greater than that from
 707 the FS20 dataset and 20 where the NICC average burned area was lower, with half of these being
 708 statistically significant (Table 8). For the CUS, average NICC burned area was only 1.0% higher than
 709 the FS20 burned area over the entire 19-year period, which was not statistically significant. For the
 710 EUS, NICC burned area was 3.1% higher than FS20 burned area, where the lower burned areas in the
 711 Middle South, North Central, and Northeast regions were offset by the higher burned areas in the
 712 Northern Plains region (Table 8). While the FS20 burned area was 10.6% higher in the Southeast, this
 713 difference was not statistically significant; however, there were two states in this sub-continental area
 714 where NICC burned area was y higher (Table 9). The FS20 burned area was 9.7% higher in the
 715 Southern Plains, where the FS20 burned area was higher in two states and lower in one. Finally, the
 716 NICC burned area in the WUS was 0.9% lower than FS20 burned area, where higher burned area in
 717 California and Alaska were offset by lower burned area in the Great Basin, Northwest, Rocky Mountain
 718 and Southwest regions (Table 8).



719 The differences in burned area for the 2002 to 2011 and 2012 to 2020 time periods plus the number of
 720 years where NICC burned area was > 25% higher provide indicators for identifying potential years
 721 where it is likely that the FS20 dataset is missing wildfire events. For example, many of the states in
 722 the EUS have low annual burned area where NICC burned area is higher than FS20 burned and have a
 723 number of years where the NICC/FS20 difference is > 25% (see, e.g., North Carolina, Tennessee,
 724 Virginia, Indiana, Iowa, Missouri, Wisconsin, Maine, Massachusetts, New York, Ohio, Pennsylvania,
 725 and North Dakota in Table 9). Other states where this combination exists include Kansas (from 2012
 726 to 2020), Colorado (from 2002 to 2011), and New Mexico from 2002 to 2011). While the percentage
 727 difference is high in Montana over all time periods, there was only one year where it was > 25%. Since
 728 Montana is a state where the number of fires reported as complexes is high, it is likely that the higher
 729 NICC burned area in this region may have resulted from a combination of incorrect reporting of fire
 730 size and reporting of both complexes and fires within them.

731 Average annual burned area calculated using records from the iWED dataset resulted in higher burned
 732 area (compared to the FS20 burned area) for the majority of the geographic areas with the exception of
 733 a few regions and states where substitution of MTBS for fire management size resulted in reductions
 734 (see, e.g., the Northwest region and Oregon in Table 8). Because of the higher burned areas, compared
 735 to the FS20 burned area, there were ten fewer states where NICC burned area was greater than iWED
 736 burned area, as well as for WUS, and the Middle South, North Central, and Great Basin regions (Table
 737 8). Even though the use of the IWED dataset resulted in less situations where NICC burned area was
 738 higher, there were still 332 instances where in a state for a specific year where the NICC burned area
 739 was more than 25% higher than the iWED burned area, as well a number of periods when average
 740 NICC burned was higher than iWED burned area for some states. These results indicate there is a strong
 741 possibility that the iWED data set is missing wildfire events.

742 Table 9 presents average annual burned area calculated from MTBS wildfire events and iWED fire
 743 management events plus FS20 events smaller than 247 acres for the geographic areas used in this study
 744 using data from 2002 to 2020. Those areas where the paired t-tests identified statistically significant
 745 differences in annual burned area are identified. Also presented area percentage of iWED burned by
 746 represented in the MTBS burned area for four time periods. While studies have used the MTBS wildfire
 747 events to study trends in burned area based on the observation that the area within MTBS perimeters
 748 represents >90% of burned area in the WUS, this percentage was < 90% in 10 out of 15 WUS states
 749 and > 90% in one Southern Plains state (Kansas) (Table 9). In 23 EUS states, MTBS burned area
 750 represented less than 50% of area burned in fire management events from the iWED dataset. Another
 751 characteristic of the MTBS burned area data is that the percentage of iWED burned area increases from
 752 the 1990s to the 2010s, including 6 out of the 10 western states where the MTBS percentage for all
 753 years was greater than 90%. This result means that increases in burned area detected using MTBS data



754 are the result of a more representative sampling of wildfire activity during the 2010s relative to earlier
 755 years.

756 **3.4 Differences in extreme wildfire activity**

757 Through the development of the iWED, there were ten processes that changed the number and sizes of
 758 mega and mega-plus records, with three changing FM records, three changing MTBS records, and four
 759 changing matched records (Table 10). Three of these processes increased the number of mega and
 760 mega-plus events (both fire management and MTBS), two processed decreased the number and/or size
 761 of fire management and MTBS events, and five processed both increased and decreased the number
 762 and sizes of events.

763 A common result for the CUS across all five datasets used to study extreme wildfire activity was that
 764 while mega fires represented only ~8% of the total number of larger wildfires, they accounted for nearly
 765 50% of average area burned where mega-plus fires represented < 0.5% of the area burned but accounted
 766 for nearly 15% of average area burned (Table 11). There were distinct differences in the level of extreme
 767 wildfire activity in the four sub-continental areas. When mega and mega-plus fires were combined, the
 768 percentage of the number of events and burned area in these events was highest in the Western US
 769 (14.6% and 67.3%, respectively) and lowest in the Eastern US (2.8% and 33.8%, respectively), with
 770 the Southeast and Southern Plains falling between the two (Table 12). A distinguishing feature of the
 771 Eastern US is that it experienced no mega-plus fires between 1992 to 2021. Another common
 772 characteristic across the five datasets was that a large majority of the number and burned area in the
 773 larger wildfires occurred in the WUS. Because of this distribution, the percentage differences for the
 774 CUSA largely follow those in the WUS.

775 Table 12 contains a summary of the total number of larger wildfire records (> 202 acres in the Eastern
 776 US and Southeast and > 405 ha in the Southern Plains and Western US) and the numbers of extreme
 777 records (mega and mega-plus fires) and average area burned from these events for the CUS and four
 778 sub-continental areas. These results are based on data from 1992 to 2021 from five different datasets
 779 (Sect. 2.5.4). Additional results in Table 12 include the percentage differences in the numbers and
 780 average burned area between the five datasets.

781 To a great extent, the large differences in the total number of fires between the FS20-plus and MTBS-
 782 A datasets explains the differences in total burned area presented in Table 9, where the largest
 783 differences in percent burned area occurred in the EUS and Southeast. For the CUSA there were 44
 784 more mega fires in the FS20-plus dataset, with the highest difference in number and burned area in
 785 mega-plus fires occurring in the Southeast and Southern Plains (Table 12). While the FS20-plus dataset
 786 contained one more mega-plus fire than the MTBS-A dataset in the Southern Plains, it contained one



less mega-plus fire in the Southeast (one of the mega-plus fires in the Big Turnaround Complex that was identified in an NIFC IMSR).

The iWED dataset contained 848 more larger fire management events than the FS20-plus dataset, with 28 of these being mega-fires and 8 being mega-plus fires. The largest increases in the number of mega (17) and mega-plus (7) fires occurred in the WUS as a result of merging of fires. The largest increases in burned area occurred for mega fires in the Southern Plains, and mega-plus fires in Southeast and WUS. While there were large increases in the number of mega-fires, increase in the burned area for these fires in the Southeast and WUS was limited by the merging of mega-fires to form mega plus fires.

The development of the iWED changed the number of MTBS events as illustrated in the iWED-M versus MTBS-A comparisons in Table 12. Overall, the increase in the number of larger fires was based on increases through adding of Unknown and Prescribed Fires reclassified by as wildfires and decreases through identification of MTBS records with multiple perimeters as well as identifying MTBS perimeters that had merged. The increase of 67 mega fires and 2 mega-plus fires in the Southern Plains occurred as a result of using mega and mega-plus MTBS records that had been reclassified as wildfires from the Flint Hills region. In the EUS, the decrease in mega fires occurred by identifying MTBS events containing multiple perimeters. In the WUSA, the decrease in mega fire number and area burned was the result of identifying fires that had merged to create mega-plus fires, whose number and burned area increased (Table 12).

Using information from both fire management, MTBS, and merged records from the iWED increased the number of mega fires by 93 and mega-plus fires by 9 compared to those contained in the FS20+ data. Notable changes in mega-fire burned area occurred in the WUS (19.4% increase), mega and mega-plus-fire burned area in the Southeast (24.5% and 10.6% increases, respectively), and mega-fire burned area in the Southern Plains (80.7% increase by including MTBS wildfires from the Flint Hills ecoregion (Table 12). There was a decrease in mega-plus-fire burned area in the Southern Plains resulting from substitution of MTBS size for fire management size (see Fig. S29 in the Supplement to this article).

812

813 4 Discussion and Conclusions

Existing wildfire event datasets have been developed through funding provided by the federal government and universities and exist only because of the dedicated efforts of scientists and researchers of the U.S. Forest Service (Short, 2021), the MTBS program (Eidenshink et al., 2006; Picotte et al. 2020), and the University of Colorado (St. Denis et al., 2023). The development of the FS20, MTBS, and ICS datasets has provided data used in a wide range of fire science research (Table S1 in the online Supplement). The development of the integrated Wildfire Event Dataset (iWED) provides researchers



820 with a fourth option to study wildfires at regional to national scales in the United States. The iWED
 821 development followed a systematic approach in adding and altering wildfire records (Fig. 1), resulting
 822 in changes to the number and sizes of fires events, as well as identifying duplicate records (Tables 2
 823 and 10). The three most important processes were further matching of fire management events with
 824 MTBS events, visual interpretation of images generated from geospatial data, and review of reports
 825 found on the world wide web to resolve uncertainties in fires named as complexes and differences in
 826 MTBS and fire management size.

827 While there were many matched MTBS and fire management records in the FS20 dataset of Short
 828 (2021), a review revealed that a number were incorrect. Additional matches were identified during the
 829 iWED development. A number of the matched records in the iWED included MTBS events that were
 830 assigned an Unknown or Prescribed Fires in the MTBS database, identifying events that had been
 831 misclassified. Many of the new matched records in the iWED occurred with fire management events
 832 mined or harvested from other fire management reports and datasets, IMSRs, and reports found through
 833 searches of the world wide web. A difference between fire management and MTBS size was a key
 834 criteria for further investigation of fire records, as were instances where the same MTBS was matched
 835 with multiple fire management events in FS20 records.

836 Visual interpretation was used during the matching process to determine if the position for a fire
 837 management event was within an MTBS perimeter. These position/perimeter comparisons were used
 838 to identify fire management events that had merged and MTBS perimeters that resulted from joined
 839 events. Visual interpretation of MTBS perimeter shape was used to identify MTBS Unknown and
 840 Prescribed Fire events that were likely wildfires (Figs. S1, S2). In addition, the first stages of the iWED
 841 development focused on fire management and MTBS events named as complexes and those where the
 842 size difference between MTBS and fire management events was greater than 25%. Through visual
 843 interpretation of the displaying MTBS events for these events, it was discovered that a number
 844 contained multiple perimeters. Based on this finding, visual interpretation was used on all unmatched
 845 MTBS events as well as a number of matched events, where nearly 10% contained multiple perimeters.
 846 Many of the additional MTBS perimeters were matched with fire management events. Simultaneous
 847 display of multiple MTBS events identified a number that shared common borders. For these events,
 848 additional analyses determined that a number represented merged fires and others that were separate
 849 but adjacent perimeters for a single event. Visual comparisons were also made of simultaneous displays
 850 of MTBS perimeters, other fire perimeters, and MODIS and Landsat burned area pixels for a variety of
 851 purposes (Figs. S12, S15, S19, S20, S22, S28).

852 A review of fire management reports, datasets, and daily/weekly Incident Management Situation
 853 Reports downloaded from the world wide web were used to identify fire management events for 2021
 854 and events not contained in the FS20 dataset. Searches of the world wide web were used for analyses



855 of specific events to identify additional information on fires named as complexes or matched events
 856 where there were significant differences between fire management and MTBS size. Among other
 857 things, these searches identified the names and sizes for many events named as complexes, fires that
 858 had merged, and fires whose size had been incorrectly reported.

859 The development of the iWED improved the fidelity of wildfire data relative to the FS20, ICS, and
 860 MTBS datasets through the identification of additional events and providing more accurate depictions
 861 of the sizes of many wildfires, in particular fires that had merged or joined, fires whose size was
 862 incorrectly reported, and records that represented multiple fires. The assessments carried out for this
 863 study, however, concluded the FS20, ICS, and MTBS datasets did not completely account for wildfire
 864 activity in all regions. For many regions, the ICS dataset contained fewer wildfire events than the FS20
 865 dataset, especially during the 2000s. The ICS dataset, however, contributed a number of additional
 866 records to the iWED. It was determined that the FS20 dataset did not contain a number of small fires
 867 (< 100 ha) from the 1990s through the early 2000s for eight eastern U.S. states (Table 5). Because small
 868 fires represent a significant portion of annual area burned in these states, their absence will affect studies
 869 examining trends in annual area burned in eastern U.S. regions that rely on fire management data.

870 The inclusion of three types of records in the iWED provides options that are not available in other
 871 datasets. Combining the FS20 events with unmatched MTBS and substituting MTBS size for FM size
 872 addresses many of the shortcomings of the individual datasets. In particular the combined dataset
 873 provides improved estimates of annual burned area (Tables 7 and 9) and a more accurate accounting of
 874 mega and mega-plus events (Table 12).

875 Comparisons showed there were differences in burned area developed from records in the FS20 and
 876 iWED datasets and those reported in the NICC annual reports, where in a number of instances the
 877 average NICC burned area was greater than those the FS20 or iWED values for some states and time
 878 periods (Table 8). While these differences in western states may be due to the reporting of a wildfire
 879 complex size as well as the fires within the complex for some years, the difference in eastern states may
 880 be due to an incomplete reporting of all wildfire events.

881 The development of the first two versions of the iWED presented in this study represents the initial
 882 steps in developing datasets for wildfire studies in the CUS. A third version of this dataset will add the
 883 latitude/longitude positions for each record. The approach used to develop the iWED (Fig. 1) provides
 884 a framework for the future updating of this dataset that is needed to extend information on wildfire
 885 activity across the CUS. The authors are currently working on updating the dataset with records for the
 886 WUS for the early 2020s, which would use records from newer versions of the FS20, ICS, and MTBS
 887 datasets if and when they become available. Additional information that will be added to this dataset
 888 includes information from fire perimeter datasets as well as daily burned area.



889 **Data availability**

890 Version 1 of the integrated Wildland Fire Event Dataset (iWED) is available from the Oak Ridge
 891 National Laboratory Distributed Active Archive Center (ORNL-DAAC)
 892 (<https://doi.org/10.3334/ORNLDAAAC/2452>) (Kasischke et al., 2025). Version 2 of the iWED is
 893 currently being reviewed by the ORNL-DAAC (Kasischke et al., in review).

894

895 **Author Contributions**

896 EK and NF contributed equally to the development of the goals and objectives for the dataset
 897 development and the approaches used during this development. NF procured funding from NASA that
 898 contributed to the dataset development. EK carried out the integration of data from multiple sources
 899 and implemented the various steps and procedures used to refine the information for the wildfire records
 900 contained in the dataset. EK wrote the initial version of the manuscript which was then edited by NF.

901 **Acknowledgements**

902 The authors would like to thank Mike Billmire and Chris Cook for their assistance during different
 903 stages of the development of the integrated Wildland Fire Event dataset and its submission for
 904 publication by the Oak Ridge National Laboratory Distributed Active Archive.

905 **Financial support**

906 The development of the integrated Wildfire Event Dataset (versions 1 and 2 was supported by the
 907 National Aeronautics and Space Administration through grant 80NSSC24K0299.

908 **References**

- 909 AICC, Daily Incident Situation Management Reports from 1992 to 2021 published by the Alaska
 910 Interagency Coordination Center (AICC) downloaded from <https://fire.ak.blm.gov/predsvcs/intel.php>
 911 (last accessed on 30 June 2026), 1992 to 2021.
- 912 Billmire, M., French, N.H., McKenzie, D., Koziol, B. T. Erickson, T.: The Wildland Fire Emissions
 913 Inventory System, <https://wfeis.mtri.org>, accessed on 15 June 2026.
- 914 Eidenshink, J., Schwind, B., Brewer, K., Zhu, Z. -L. Quayle, B., Howard, S.: A Project for Monitoring
 915 Trends in Burn Severity, *Fire Ecol.* 3, 3–21, 2007.
- 916 French, N. H., et al.: Modeling regional-scale wildland fire emissions with the Wildland Fire Emissions
 917 Information System, *Earth Inter.* 18, 1-26, 2014.



- 918 Giglio, L., Boschetti, L., Roy, D., Hoffmann, A. A., Humber, M., Hall, J. V.: Collection 6 MODIS
 919 Burned Area Product User's Guide Version 1.2, NASA: 30. [https://modis-](https://modis-land.gsfc.nasa.gov/pdf/MODIS_C6_BA_User_Guide_1.2.pdf)
 920 [land.gsfc.nasa.gov/pdf/MODIS_C6_BA_User_Guide_1.2.pdf](https://modis-land.gsfc.nasa.gov/pdf/MODIS_C6_BA_User_Guide_1.2.pdf), 2018
- 921 Hawbaker, T. J., Vanderhoof, M. K., Schmidt, G. L., Beal, Y. -P., Picotte, J. J., Takacs, J. D., Falgout,
 922 J. T., Dwyer, J. L.: The Landsat Burned Area algorithm and products for the conterminous United
 923 States, *Remote Sens. of Environ.*, 244, article no. 111801, 2020.
- 924 Juang, C. S. Williams, A. P. Abatzoglou, J. T., Balch, J. K., Hurteau, M. D., Moritz, M. A: (Rapid
 925 growth of large forest fires drives the exponential response of annual forest-fire area to aridity in the
 926 western United States, *Geophys. Res. Lett.* 49, e2021GL097131, 2022.
- 927 Kasischke, E. S., French, N. H., Billmire, M., Redhuis, D., Cook, C.: An integrated Wildfire Event
 928 Dataset (iWED_V1), 1992-2021. ORNL DAAC, Oak Ridge, Tennessee, USA.
 929 <https://doi.org/10.3334/ORNLDAAC/2452>, 2025.
- 930 Kasischke, E. S., French, N. H., Billmire, M. D., Cook, C.: An integrated Wildfire Event Dataset
 931 (iWED_V2), 1992-2021. ORNL DAAC, Oak Ridge, Tennessee, USA, in review, 2026.
- 932 Linley, G. D., et al.: What do you mean 'megafire'?, *Global Ecol. Biogeogr.*, 31,1906–1922, 2022
- 933 Morton, D. C., Collatz, G. J, Wang, J. D., Randerson, J. T., Giglio, L., Chen, Y.. Satellite-based
 934 assessment of climate controls on US burned area, *Biogeosci.* 10, 247–260 (2013).
- 935 MTBS: direct download of MTBS wildfire records from [https://burnseverity.cr.usgs.gov/direct-](https://burnseverity.cr.usgs.gov/direct-download)
 936 [download](https://burnseverity.cr.usgs.gov/direct-download) (last accessed on 30 June 2026), 2026a.
- 937 MTBS: direct download of individual MTBS event from <https://www.mtbs.gov/direct-download> (last
 938 accessed on 20 February 2026). As of 1 June 2026, this website is no longer available, 2026b.
- 939 NICC: Wildland Fire Summary and Statistics Annual Reports, 2002 to 2001, published by the National
 940 Interagency Coordinating Center, downloaded from [https://www.nifc.gov/nicc/predictive-](https://www.nifc.gov/nicc/predictive-services/intelligence)
 941 [services/intelligence](https://www.nifc.gov/nicc/predictive-services/intelligence) (last accessed on 30 June 2026), 2002 to 2020.
- 942 NIFC: Daily Incident Situation Management Reports from 1992 to 2021 published by the National
 943 Interagency Coordination Center, downloaded from [https://www.nifc.gov/nicc/incident-](https://www.nifc.gov/nicc/incident-information/imsr)
 944 [information/imsr](https://www.nifc.gov/nicc/incident-information/imsr) (last accessed on 30 June 2026), 1992 to 2021.
- 945 Picotte, J. J., et al.: Changes to the Monitoring Trends in Burn Severity program mapping production
 946 procedures and data products. *Fire Ecol.* 6, article no. 16, 2020.



- 947 Prichard, S. J., Ottmar, R. D., Anderson, G. K.: CONSUME 3.0 User's Guide. Seattle, WA, Fire and
 948 Environmental Research Applications Team, USDA Forest Service, 2006
- 949 Short, K. C.: A spatial database of wildfires in the United States, 1992–2011. *Earth System Science*
 950 *Data* 6, 1–27, 2014.
- 951 Short, K. C.: Sources and implications of bias and uncertainty in a century of US wildfire activity data,
 952 *Int. J. Wildland Fire*, 24, article no. WF14190, 2015.
- 953 Short, K. C.: Spatial wildfire occurrence data for the United States, 1992–2015 [FPA_FOD_20170508].
 954 4th Edition. Fort Collins, CO: Forest Service Research Data Archive. [https://doi.org/10.2737/RDS-](https://doi.org/10.2737/RDS-2013-0009.4)
 955 2013-0009.4, 2017.
- 956 Short, K. C.: Spatial wildfire occurrence data for the United States, 1992–2018 [FPA_FOD_20210617].
 957 5th Edition. Fort Collins, CO: Forest Service Research Data Archive. 2. [https://doi.org/10.2737/RDS-](https://doi.org/10.2737/RDS-2013-0009.5)
 958 2013-0009.5, 2021.
- 959 Short, K. C.: Spatial wildfire occurrence data for the United States, 1992–2020 [FPA_FOD_20221014].
 960 6th Edition. Fort Collins, CO: Forest Service Research Data Archive. [https://doi.org/10.2737/RDS-](https://doi.org/10.2737/RDS-2013-0009.6)
 961 2013-0009.6, 2022.
- 962 Sparks A. M., Boschetti, L., Smith A. M. S., Tinkham, W. T., Lannom, K. O., Newingham, B. A.: An
 963 accuracy assessment of the MTBS burned area product for shrub–steppe fires in the northern Great
 964 Basin, United States, *Int. J. Wildland Fire*, 24, 70–78, 2015.
- 965 St. Denis, L. A., Short, K. C., McConnell, K., Cook, M. C., Mietkiewicz, N. P., Buckland, M. Balch, J.
 966 K.: All-hazards dataset mined from the US National Incident Management System 1999–2020,
 967 *Scientific Data*, 10, article no. 112, 2023.

968



969 **Table captions**

970 1. Description of common procedures used during the different phases of the development of the iWED
 971 (see Fig. 1).

972 2. Summary of changes to wildfire records occurring during the development of the iWED.

973 3. Total number of fire management and MTBS records contained in the iWED.

974 4. Percentage differences in average annual area burned based on the different sources for information
 975 used in the development of the iWED compared to the burned area calculated from the FS20 events
 976 imported into the dataset.

977 5. States where average burned area from smaller wildfires were significantly lower during periods in
 978 the 1990s and 2000s compared to that from later periods.

979 6. Comparison of average burned area from the ICS and FS20 datasets using records from 1999 to 2020,
 980 where the letter superscripts in the FS20 dataset column indicate the statistical significance for the
 981 difference between the ICS and FS20 average burned area (a: $p < 0.1$; b: $p < 0.05$; c: $p < 0.01$; d: $p <$
 982 0.001). % burned area difference = $[(\text{FS20 burned area}) - (\text{ICS burned area})] / (\text{FS20 burned area}) \times$
 983 100 . Data from states where average burned area was less than 100 ha yr⁻¹ are not included in this table.
 984 The data from these years, however, was used to calculate burned area at regional, sub-continental, and
 985 continental scales.

986 7. Comparison of average burned area calculated by using records from the FS20 and iWED datasets
 987 from 1992 to 2020, where the letter superscripts in the iWED dataset column indicate the statistical
 988 significance for the difference between the FS20 and iWED average burned area (a: $p < 0.1$; b: $p < 0.05$;
 989 c: $p < 0.01$; d: $p < 0.001$). % burned area difference = $[(\text{iWED burned area}) - (\text{FS20 burned area})] /$
 990 $(\text{iWED burned area}) \times 100$. Data from states where average burned area was less than 100 ha yr⁻¹ are
 991 not included in this table. The data from these years, however, was used to calculate burned area at
 992 regional, sub-continental, and continental scales.

993 8. Comparison of average annual burned area from data from NICC reports to that calculated using
 994 records from the FS20 and iWED datasets for 2002 to 2020, where the letter superscripts in the FS20
 995 and iWED datasets columns indicate the statistical significance for the difference between the NICC
 996 and the FS20 and iWED average burned area (a: $p < 0.1$; b: $p < 0.05$; c: $p < 0.01$; d: $p < 0.001$). %
 997 difference: NICC vs. FS20 = $[(\text{FS20 burned area}) - (\text{NICC burned area})] / (\text{FS20 burned area}) \times 100$.
 998 % difference: NICC vs. iWED = $[(\text{iWED burned area}) - (\text{NICC burned area})] / (\text{iWED burned area}) \times$
 999 100 . Data from states where average burned area was less than 100 ha yr⁻¹ are not included in this table.



1000 The data from these years, however, was used to calculate burned area at regional, sub-continental, and
 1001 continental scales.

1002 9. Comparison of average burned area from the MTBS and iWED datasets calculated using records
 1003 from 1992 to 2020, where the letter superscripts in the iWED dataset column indicate the statistical
 1004 significance for the difference between the MTBS and iWED average burned area (a: $p < 0.1$; b: $p <$
 1005 0.05 ; c: $p < 0.01$; d: $p < 0.001$). % MTBS burned area difference = (MTBS burned area) / (iWED burned
 1006 area) $\times 100$. Data from states where average burned area was less than 100 ha yr⁻¹ are not included in
 1007 this table. The data from these years, however, was used to calculate burned area at regional, sub-
 1008 continental, and continental scales.

1009 10. Processes used during the development of the iWED that changed the number and sizes of mega
 1010 and mega-plus fires.

1011 11. Percentage of the total number of mega and mega-plus fires as a function of total number of larger
 1012 wildfire records for different study areas and the percentage of area burned in mega and mega-plus fires.

1013 12. Summary of the number of and average burned in larger fire records using different wildfire event
 1014 datasets. Data are from 1992 to 2021. Also included are percentage differences between the number of
 1015 and area burned for different datasets.



1016 **Figure captions**

- 1017 1. Flowchart illustrating the datasets, methods, steps, and phases used during the development of the
1018 integrated Wildland Fire Dataset (iWED).



1019 **Table 1.** Description of common procedures used during the different phases of the
1020 development of the iWED (see Figure 1).

Procedure	Description
1	Comparing the perimeter for an MTBS record using the WFEIS with the position of a fire management record using OpenStreetMap. A matched record was confirmed when the position of the fire management record was within the MTBS perimeter.
2	Using Google Maps to identify the latitude and longitude of fire management records when their positions were not available from other sources.
3	Using Google Maps to display topographic maps or fine resolution, aerial photographs in order to identify landscape features that contributed to incorrect mapping of burned vegetation by the MTBS algorithms.
4	Using the WFEIS, MTBS records containing multiple perimeters were identified. For these records, visual interpretation was used to estimate the fraction of total MTBS size in each perimeter, which in turn was used to calculate the size of each perimeter. Perimeters whose sizes were ≥ 247 ac were added to the iWED as individual records.
5	Using the WFEIS to simultaneously display an MTBS perimeter and perimeters from other sources (CalFIRE, NIFS/GeoMAC, WFIGS) to match the fire management record with the MTBS record.
6	Searching fire management reports, NICC and AICC situation reports, and reports found on the world wide web to identify the number, names, and sizes of individual fires in a complex or fires that were adjacent to the event being assessed.
7	Allocating the FS18 size of a complex to the fires within the complex in proportion to the sizes identified through searches of reports or in proportion to the MTBS size when only the names or numbers of fires in a complex were found.
8	Using the WFEIS to simultaneously display a single MTBS perimeter and perimeters from other sources (CalFIRE, NIFS/GeoMAC, WFIGS) to determine whether multiple fire management records had merged or joined by using Procedures 1 and 5.
9	The merging of fire events was reported in a NICC or AICC IMSR, in other fire management reports, or reports found in searches of the world wide web.
10	Using the WFIES to simultaneously display fire management perimeters and MODIS burned area pixels, where the dates for the MODIS pixels were used to determine whether fires had merged or joined.
11	The joining of fires was confirmed when the end date for one fire was prior to the start date for the other fire.
12	Adjusting (changing) the FS20 size for a complex or event when it was judged the size was incorrect based on information found in other reports or comparisons with other geospatial data (such as other fire management perimeters and/or MODIS and Landsat burned area pixels).

1021

1022

Table 2. Summary of changes to wildfire records occurring during the development of the IWED.

Outcomes	Number of Records		Average Fire Size		Area Burned		Matched Records	Changes to dataset	Supplement	
	FM	MTBS	FM	MTBS	FM	MTBS			Section	Figure
Phase 1 - Importing information for fire management events										
1. Added information on FM events from the FS20 wildfire occurrence dataset	+				+			Data from 35,259 records were imported from the FS20 dataset. Data from 84 records were retained from FS15 and FS18 datasets.		
2. Added information on FM events from other sources	+				+			Data for 919 records were obtained from fire management sources for 2021. For all years, 1,697 records added from other fire management sources.		
Phase 2 - Matching of FM/MTBS records and analyses of unmatched MTBS records										
3. Added information on MTBS events		+				+		19,247 MTBS events added.		
4. Identified matched and unmatched MTBS records							+	13,057 MTBS records were matched with fire management records, including 38 MTBS Prescribed Fires and 221 MTBS Unknown fires. There were 906 MTBS Wildfires records and 5,322 MTBS Unknown/ Prescribed Fire records that were unmatched with a fire management event.		

1023

36



1024

Table 2 (continued).

5. Added records from unmatched MTBS records having multiple perimeters		+				-		551 unmatched MTBS records were found to have multiple perimeters, adding 1,946 events to the dataset.		
6. Identified unmatched MTBS Unknown records reclassified as Wildfires		+					+	3,714 Unmatched MTBS records with an Unknown or Prescribed Fire type were reclassified as wildfires.	S1	S1,S2
Phases 3 to 5 - Resolve uncertainties and ambiguities in complexes and identify sources of the differences between FM and MTBS size for matched records										
								There were 38 unmatched fire management records named as complexes where the names, number, and/or sizes of individual fires within the complex were identified, adding 68 records to the dataset.		
7. Added records from unmatched FM complexes having multiple fires	+		-					There were 701 matched records where the MTBS event contained multiple perimeters (1,859 total) that added 657 records to the dataset.		
8. Added records from matched MTBS events having multiple perimeters	+	+						358 matched records resulted from the merging of 827 fire management events and 416 MTBS events.	S2.1,S2.2	S3-S10,S14, S18,S19,S21,S23,S29
9. Identified merged events	-	-	+	+	+		-		S2.3	S10-S15,S19

1025

37





1026

Table 2 (continued).

10. Identified/joined events		+		-			+	There were 82 matched records where the MTBS event contained perimeter that was the result of joining of multiple fire management events (178 total), increasing the number of matched records.	S2.3	S16-S20
11. Identified events that spanned the US/Canada or US/Mexico border			-	-	-	-	-	There were 30 MTBS events whose perimeter(s) spanned the U.S./Mexico border and 26 MTBS events whose perimeter(s) spanned the U.S./Canada border.	S2.4	S21,S22
12. Corrected FM and MTBS sizes			+/-			+/-		Within matched records, adjustments were made to the fire management size in 250 records and MTBS size for 74 records.	S2.5	S4,S23-S26
13. Reallocated FM and MTBS sizes			-	-	-	-	-	In addition to reallocating MTBS size for events with multiple perimeters and those identified as joined, MTBS sizes were reallocated in 27 additional records and fire management size reallocated in 230 records.	S2.6	S3-S10, S14,S16-S21,S23, S27,S29
14. Identified MTBS events with incorrectly mapped area burned		-					-	There were 184 matched records where it was judged that the MTBS algorithm incorrectly mapped burned area.	S2.7	S24,S31-S34

1027

38

1028

Table 2 (concluded).

15. Identified duplicate FM and MTBS events and small fire complexes	-	-	-	-	-	-		The dataset contains 19 fire management and 5 MTBS records that were duplicates. There were 44 fire management records named a complex where it was determined each fire was smaller than 247 ac.		
--	---	---	---	---	---	---	--	---	--	--

1029





1030 **Table 3.** Total number of fire management and MTBS records contained in the iWED.

	Continental US	Eastern US	Southeast	Southern Plains	Western US
Total events	45,951	6,233	6,974	11,539	21,205
	<i>Fire management events</i>				
Unmatched	24,528	4,165	3,101	6,271	10,922
Matched with MTBS event	13,434	1,329	1,115	1,559	9,431
	<i>Unmatched MTBS events</i>				
Wildfire	1,253	224	287	371	371
Wildfire-Prescribed Fire	17				17
Unknown-Wildfire	2,365	189	257	1,709	210
Unknown	4,354	326	2,214	1,629	185

1031

Table 4. Percentage differences in average annual area burned based on the different sources for information used in the development of the iWED compared to the burned area calculated from the FS20 events imported into the dataset.

	Continental US	Eastern US	Southeast	Southern Plains	Western US
Adjustment to FS20 fire size	0.33	0.60	0.46	0.00	0.35
Retention of records from FSI5 and FSI8 datasets	0.05	0.06	0.02	0.10	0.05
Addition of ICS records	0.53	0.93	1.36	1.92	0.24
Records from other fire management datasets	0.59	0.60	0.19	0.89	0.59
Events from Incident Management Situation Reports	0.88	0.43	3.60	1.80	0.56
Events from reports found on the world wide web	0.04	0.02	0.39	0.05	0.01
Total fire management changes	2.43	2.63	6.03	4.76	1.80
Unmatched MTBS Wildfire records	1.68	3.17	4.03	5.66	0.83
Unmatched MTBS Unknown records reclassified as wildfires	2.66	2.71	2.79	18.62	0.47
Substitution of MTBS size for fire management size	-0.37	-0.22	0.94	-4.20	0.04
Total MTBS changes	3.97	5.66	7.76	20.08	1.34
Total fire management + MTBS changes	6.40	8.29	13.78	24.84	3.13





1036 **Table 5.** States where average burned area from smaller wildfires was significantly lower during
 1037 periods in the 1990s and 2000s compared to that from later periods.

State	Period	Average burned area (ha)	Period	Average burned area (ha)	
		Fire size < 100 ha		Fire size < 100 ha	Fire size ≥ 100 ha
Alabama	1992-1993	562	1994-2020	12,465	3,443
Iowa	1996-2005	128	2006-2020	1,659	638
Kansas	1992-1997	160	1998-2020	3,006	16,652
Kentucky	1992-1995	731	1996-2020	12,147	9,156
Nebraska	1992-1999	357	2000-2020	2,367	15,256
Pennsylvania	1992-2001	20	2002-2020	417	680
Tennessee	1992-1996	293	1997-2020	5,463	4,914
Virginia	1992-1994	216	1995-2020	2,224	4,180

1038



1039 **Table 6.** Comparison of average burned area from the ICS and FS20 datasets using records from 1999
1040 to 2020, where the letter superscripts in the FS20 dataset column indicate the statistical significance for
1041 the difference between the ICS and FS20 average burned area (a: $p < 0.1$; b: $p < 0.05$; c: $p < 0.01$; d: p
1042 < 0.001). % burned area difference = $[(\text{FS20 burned area}) - (\text{ICS burned area})] / (\text{FS20 burned area}) \times$
1043 100. Data from states where average burned area was less than 100 ha yr⁻¹ are not included in this table.
1044 The data from these years, however, was used to calculate burned area at regional, sub-continental, and
1045 continental scales.

	Burned area (ha yr ⁻¹)		% burned area difference		
	ICS dataset	FS20 dataset	1999-2020	1999-2009	2010-2020
Continental US	2,306,787	2,687,565 ^d	14.2	24.1	4.7
Eastern US	62,669	91,763 ^d	31.7	41.9	13.7
Middle South	22,779	32,493 ^b	29.9	45.1	4.5
Kentucky	6,823	9,854 ^b	30.8	38.1	6.3
Maryland	652	970 ^c	32.8	34.6	29.1
North Carolina	6,990	7,347	4.9	18.7	-4.2
Tennessee	2,772	4,774 ^b	41.9	58.0	17.6
Virginia	3,939	4,452 ^d	11.5	16.3	6.6
West Virginia	1,603	5,065 ^b	68.3	85.9	1.5
North Central	16,841	21,140 ^d	20.3	23.6	15.0
Indiana	141	122	-16.2	-40.6	8.5
Michigan	1,430	1,681 ^b	14.9	16.0	13.8
Minnesota	12,465	15,016 ^c	17.0	22.0	6.5
Missouri	2,355	3,108 ^c	24.2	23.3	25.0
Wisconsin	357	561 ^c	36.4	51.3	14.4
Northeast	2,561	3,107 ^b	17.6	21.1	13.8
New Jersey	1,273	1,751 ^b	27.3	33.1	22.3
New York	283	330	14.3	31.5	-1.5
Ohio	146	144	-1.7	-10.1	41.6
Pennsylvania	695	742 ^b	6.2	12.8	-2.7
Northern Plains	20,488	35,023 ^d	41.5	51.0	22.5
North Dakota	5,109	5,985 ^a	14.6	50.9	25.8
Nebraska	10,282	16,070 ^c	36.0	53.1	23.2
South Dakota	12,818	25,931 ^c	50.6	65.7	18.8

1046



1047 **Table 6 (concluded).**

<i>Southeast</i>	84,762	109,156 ^c	22.3	32.8	9.1
Alabama	2,609	3,608 ^c	27.7	32.5	22.6
Arkansas	2,845	3,169 ^a	10.2	22.3	-0.8
Florida	57,284	71,670 ^b	20.1	30.5	5.8
Georgia	13,512	18,799 ^a	28.1	40.6	15.2
Louisiana	3,895	6,309 ^d	38.3	50.0	22.8
Mississippi	3,188	3,835 ^c	16.9	26.0	6.5
South Carolina	1,429	1,765 ^c	19.0	22.7	13.3
<i>Southern Plains</i>	232,700	280,180 ^d	16.9	20.2	14.9
Kansas	13,054	17,890 ^b	27.0	29.3	25.9
Oklahoma	75,181	83,693 ^d	10.2	13.7	8.6
Texas	144,465	178,597 ^c	19.1	21.8	17.1
<i>Western US</i>	1,926,656	2,206,466 ^c	12.7	23.1	2.7
Alaska	393,622	601,440 ^b	34.6	53.3	5.5
California	326,035	329,480	1.0	10.2	-4.8
Great Basin	255,075	266,716	4.4	12.3	-8.0
Nevada	180,951	193,161	6.3	16.3	-10.4
Utah	74,124	73,555	-0.8	0.6	-2.5
<i>Northwest</i>	285,862	297,519	3.9	5.8	3.0
Oregon	177,204	184,129	3.8	4.9	3.1
Washington	108,658	113,390 ^a	4.2	7.5	2.7
<i>Rocky Mountain</i>	449,523	482,038 ^b	6.7	3.6	9.5
Colorado	54,211	56,499 ^c	4.0	4.1	4.0
Idaho	226,359	238,222 ^a	5.0	2.6	7.2
Montana	122,799	134,850 ^a	8.9	2.9	15.7
Wyoming	46,154	52,465 ^c	12.0	11.2	12.6
<i>Southwest</i>	216,539	229,274 ^d	5.6	7.9	3.7
Arizona	120,153	122,540 ^a	1.9	3.1	1.2
New Mexico	96,387	106,734 ^c	9.7	12.4	7.1

1048



Table 7. Comparison of average burned area calculated by using records from the FS20 and iWED datasets from 1992 to 2020, where the letter superscripts in the iWED dataset column indicate the statistical significance for the difference between the FS20 and iWED average burned area (a: $p < 0.1$; b: $p < 0.05$; c: $p < 0.01$; d: $p < 0.001$). % burned area difference = [(iWED burned area) – (FS20 burned area)] / (iWED burned area) x 100. Data from states where average burned area was less than 100 ha yr⁻¹ are not included in this table. The data from these years, however, was used to calculate burned area at regional, sub-continental, and continental scales.

	Average burned area (ha yr ⁻¹)		% burned area difference			
	FS20 dataset	iWED dataset	1992-2020	1992-2001	2002-2011	2012-2020
Continental US	2,508,022	2,693,038 ^d	7.4	11.4	6.1	6.2
Eastern US	138,449	149,646 ^d	8.1	12.4	6.4	6.8
Middle South	53,854	60,050 ^c	11.5	21.4	5.6	4.2
Maryland	1,030	1,300 ^b	26.1	8.3	22.6	65.6
Kentucky	17,813	21,494 ^b	20.7	47.7	4.3	3.0
North Carolina	12,295	12,671 ^b	3.1	4.5	2.3	2.5
Tennessee	8,349	9,386 ^c	12.4	18.8	12.4	2.7
Virginia	5,617	5,959 ^c	6.1	9.3	4.6	7.7
West Virginia	8,682	9,172 ^c	5.6	6.4	4.7	3.5
North Central	31,115	34,270 ^c	10.1	16.9	6.9	10.7
Indian	370	428 ^a	15.6	26.0	16.0	0.0
Illinois	431	431 ^d	0.0	0.0	0.0	0.0
Iowa	1,342	1,358	1.2	0.0	0.1	2.0
Michigan	2,236	2,319	3.7	13.4	0.5	1.8
Minnesota	17,672	18,490	4.6	14.1	-0.8	10.5
Missouri	7,685	9,855 ^d	28.3	24.2	47.6	20.8
Wisconsin	1,379	1,388	0.7	0.9	2.1	-1.8
Northeast	6,317	6,589 ^c	4.3	12.9	1.3	-2.8
Connecticut	107	107 ^d	0.0	0.0	0.0	0.0
Massachusetts	113	127 ^a	12.6	0.0	35.3	0.0
Maine	218	233	6.8	12.9	-2.2	0.0
New Jersey	3,766	3,987	5.9	15.1	1.1	-7.3
New York	840	846	0.8	3.8	-2.5	0.3
Ohio	321	349 ^a	8.6	0.0	19.5	0.0
Pennsylvania	854	842	-1.4	17.0	-5.5	2.1
Northern Plains	47,163	48,737	3.3	-2.7	7.3	8.5
North Dakota	6,668	7,098 ^b	6.4	2.7	3.9	11.8
Nebraska	15,397	17,225 ^a	11.9	7.4	18.9	13.5
South Dakota	25,098	24,414	-2.7	-9.4	0.9	1.7

1056



1057 **Table 7 (concluded).**

<i>Southeast</i>	161,229	182,526 ^d	13.2	16.2	15.5	3.2
Alabama	14,780	15,514 ^c	5.0	3.3	8.2	1.2
Arkansas	8,706	11,352 ^d	30.4	41.4	34.2	12.4
Florida	76,857	84,194 ^b	9.5	26.2	4.7	-8.2
Georgia	24,564	32,756 ^a	33.4	3.0	37.0	68.4
Louisiana	10,181	11,079 ^c	8.8	7.8	13.5	0.3
Mississippi	17,691	18,787 ^c	6.2	3.3	9.6	6.3
South Carolina	8,450	8,844 ^b	4.7	3.0	8.6	0.7
<i>Southern Plains</i>	265,865	356,672 ^d	34.2	41.5	22.2	51.5
Kansas	19,502	72,409 ^c	271.3	7.3	320.8	318.9
Oklahoma	80,240	114,322 ^d	42.5	39.7	45.8	38.8
Texas	166,123	169,941	2.3	51.3	-2.2	-3.1
<i>Western US</i>	1,942,477	2,004,195 ^d	3.2	8.4	2.4	1.2
Alaska	511,714	514,914	0.6	4.6	0.2	-0.6
California	292,091	308,573 ^d	5.6	8.1	6.2	4.3
<i>Great Basin</i>	239,343	255,325 ^b	6.7	10.6	7.6	8.7
Nevada	165,872	176,714 ^b	6.5	9.4	9.6	11.7
Utah	73,471	78,611 ^c	7.0	13.9	4.0	2.6
<i>Northwest</i>	255,490	260,973	2.1	14.4	-2.9	-2.5
Oregon	158,293	160,870	1.6	17.2	-6.6	-5.0
Washington	97,198	100,103 ^a	3.0	9.8	6.4	1.3
<i>Rocky Mountain</i>	431,052	445,458 ^d	3.3	7.4	2.9	1.2
Colorado	47,465	49,741 ^d	4.8	18.5	3.0	2.6
Idaho	222,322	230,989 ^c	3.9	7.0	4.2	1.2
Montana	114,487	1,171,241 ^a	2.3	6.2	1.9	1.1
Wyoming	46,778	47,603 ^a	1.8	7.5	-1.1	-0.3
<i>Southwest</i>	212,787	218,951	2.9	8.4	3.4	-1.9
Arizona	109,397	114,413 ^d	4.6	18.5	3.1	0.7
New Mexico	103,390	104,538	1.1	2.7	3.7	-6.4

1058



Table 8. Comparison of average annual burned area from data from NICC reports to that calculated using records from the FS20 and iWED datasets for 2002 to 2020, where the letter superscripts in the FS20 and iWED datasets columns indicate the statistical significance for the difference between the NICC and the FS20 and iWED average burned area (a: $p < 0.1$; b: $p < 0.05$; c: $p < 0.01$; d: $p < 0.001$). % difference: $\text{NICC vs. FS20} = [(\text{FS20 burned area}) - (\text{NICC burned area})] / (\text{FS20 burned area}) \times 100$. % difference: $\text{NICC vs. iWED} = [(\text{iWED burned area}) - (\text{NICC burned area})] / (\text{iWED burned area}) \times 100$. Data from states where average burned area was less than 100 ha yr^{-1} are not included in this table. The data from these years, however, was used to calculate burned area at regional, sub-continental, and continental scales.

	Average burned area (ha yr^{-1})			% difference: NICC vs. FS20			% difference: NICC vs. iWED			Years when NICC > FS20 or iWED			
	NICC reports	FS20 dataset	iWED dataset	2002 to 2020	2002 to 2011	2012 to 2020	2002 to 2020	2002 to 2011	2012 to 2020	FS20 All	FS20 by > 25%	iWED all	iWED > 25%
<i>Continental US</i>	2,956,403	2,985,584	3,172,337 ^d	1.0	1.1	0.9	7.3	7.5	7.1	389	151	332	134
<i>Eastern US</i>	133,240	137,337	145,221 ^c	3.1	3.6	2.3	9.0	8.8	9.3	214	111	192	106
<i>Middle South</i>	51,149	50,017	52,579	-2.2	1.4	-6.9	2.8	7.2	-3.0	52	14	41	14
<i>Kentucky</i>	14,451	16,817 ^b	17,484 ^c	16.4	7.7	30.9	21.0	12.7	34.9	8	0	6	0
<i>Maryland</i>	1,109	1,260 ^a	1,644 ^b	13.6	13.9	12.0	48.3	40.4	85.4	6	0	4	1
<i>North Carolina</i>	14,770	12,745 ^c	13,046 ^b	-13.7	-11.8	-16.7	-11.7	-9.8	-14.6	18	7	14	6
<i>Tennessee</i>	11,196	8,024	8,720	-28.3	-7.7	-43.7	-22.1	4.8	-42.1	10	3	7	3
<i>Virginia</i>	6,510	6,283	6,592	-3.5	6.7	-13.6	1.3	9.5	-6.9	7	3	8	3
<i>West Virginia</i>	3,042	4,843 ^c	5,049 ^c	59.2	41.6	88.7	66.0	48.5	95.4	3	1	2	1
<i>North Central</i>	34,176	32,795	35,125	-4.0	-6.2	1.2	2.8	-1.0	12.0	64	26	55	23
<i>Illinois</i>	275	576 ^d	576 ^d	109.6	99.8	130.8	-18.6	12.8	-31.1	2	1	2	1
<i>Indiana</i>	880	434 ^c	488 ^b	-50.7	-60.2	5.9	109.6	99.8	130.8	13	12	13	10
<i>Iowa</i>	2,448	1,970	1,994	-19.6	12.7	-32.4	-44.6	-53.0	5.9	12	4	11	4
<i>Michigan</i>	2,381	2,550 ^a	2,560 ^a	7.1	-2.2	21.4	7.5	-2.9	23.5	11	0	8	0
<i>Minnesota</i>	18,806	19,363	19,537	3.0	3.8	-0.6	3.9	2.4	9.9	7	0	5	1
<i>Missouri</i>	8,190	6,542	8,603	-20.1	-36.7	11.1	5.0	-10.5	34.2	11	9	9	7
<i>Wisconsin</i>	1,196	1,361 ^b	1,368 ^b	13.8	14.2	13.3	14.4	16.8	11.3	8	0	7	0

1059
1060
1061
1062
1063
1064
1065
47



1066

Table 8 (continued).

<i>Northeast</i>	6,477	6,016	5,962	-7.1	-21.9	13.0	-7.9	-21.1	9.9	79	61	80	61
Maine	261	146 ^d	144 ^d	-44.3	-59.4	-23.2	-44.8	-60.3	-23.2	15	14	15	14
Massachusetts	615	167 ^d	189 ^d	-72.8	-85.9	-41.0	-69.3	-80.9	-41.0	16	14	16	14
New Jersey	2,312	3,045 ^a	2,972	31.7	40.0	22.6	28.6	42.2	13.6	7	3	8	3
New York	613	845	839	37.9	-31.6	108.7	36.9	-34.1	109.3	14	11	14	11
Ohio	942	424 ^e	466 ^e	-55.0	-74.3	41.0	-50.5	-68.9	41.0	14	11	14	11
Pennsylvania	1,384	1,188 ^e	1,150 ^e	-14.1	-4.4	-22.4	-16.9	-12.3	-20.8	13	8	13	8
<i>Northern Plains</i>	41,438	48,510 ^b	51,555 ^b	17.1	24.6	10.7	24.4	29.6	20.1	19	10	16	8
North Dakota	9,562	7,359 ^a	7,940	-23.0	-37.7	10.4	-17.0	-34.7	23.3	12	7	9	5
Nebraska	8,903	16,198 ^e	18,453 ^e	81.9	326.3	48.0	107.3	390.0	67.9	0	0	0	0
South Dakota	22,973	24,953	25,163	8.6	32.3	-14.0	9.5	32.7	-12.6	7	3	7	3
<i>Southeast</i>	142,800	157,920	176,104 ^e	10.6	2.7	27.6	23.3	19.4	31.7	45	17	31	12
Alabama	13,720	14,709	15,574 ^a	7.2	16.9	-5.8	13.5	27.1	-4.7	9	4	6	4
Arkansas	11,499	10,951	14,021 ^b	-4.8	-4.7	-4.9	21.9	31.9	6.9	13	1	5	1
Florida	58,530	72,276 ^e	71,658 ^e	23.5	6.6	53.7	22.4	12.0	41.1	3	0	3	1
Georgia	34,982	28,141	40,367	-19.6	-17.1	-29.0	15.4	14.3	19.6	5	4	5	1
Louisiana	8,911	9,944	10,880 ^b	11.6	1.4	38.8	22.1	15.7	39.2	9	4	7	3
Mississippi	10,629	15,000 ^b	16,280 ^e	41.1	30.3	69.4	53.2	42.8	80.1	5	4	5	2
South Carolina	4,531	6,899 ^d	7,323 ^d	52.3	44.5	71.1	61.6	57.2	72.4	1	0	0	0
<i>Southern Plains</i>	329,238	361,299 ^a	481,453 ^c	9.7	18.4	-2.5	46.2	45.1	47.8	22	7	15	2
Kansas	32,486	23,936	104,260 ^e	-26.3	3.0	-38.1	220.9	374.3	159.2	9	4	4	1
Oklahoma	88,753	106,864 ^a	152,690 ^d	20.4	37.8	11.0	72.0	105.1	54.1	7	2	3	0
Texas	207,999	230,500	224,503	10.8	15.4	-1.6	7.9	12.6	-4.6	6	1	8	1

1067

1068

1069

Table 8 (concluded).

<i>Western US</i>	2,351,125	2,329,028	2,369,559	-0.9	-2.0	0.1	0.8	0.2	1.3	108	16	94	14
<i>Alaska</i>	653,704	656,090	655,241	0.4	-0.6	2.0	0.2	-0.4	1.4	7	0	9	0
<i>California</i>	352,589	363,614 ^a	382,114 ^c	3.1	9.7	-0.3	8.4	16.8	4.0	5	0	3	0
<i>Great Basin</i>	246,069	239,654	250,729	-2.6	0.8	-6.3	1.9	1.9	1.9	19	3	15	1
<i>Nevada</i>	166,260	161,948	169,950	-2.6	2.2	-7.6	2.2	1.3	3.1	10	2	9	1
<i>Utah</i>	79,808	77,706	80,779	-2.6	-2.0	-3.4	1.2	3.0	-0.9	9	1	6	0
<i>Northwest</i>	322,571	321,498	319,991	-0.3	-2.8	0.8	-0.8	1.1	-1.7	22	4	20	3
<i>Oregon</i>	203,321	199,120	195,733 ^a	-2.1	-4.7	-0.7	-3.7	0.1	-5.7	14	2	13	2
<i>Washington</i>	119,250	122,378	124,258 ^a	2.6	1.2	3.2	4.2	3.3	4.5	8	2	7	1
<i>Rocky Mountain</i>	508,766	492,541 ^a	502,224	-3.2	-6.8	0.0	0.2	-0.4	1.3	36	6	31	7
<i>Colorado</i>	73,244	64,038	65,954	-12.6	-35.2	6.4	-10.0	-32.8	9.2	10	5	7	5
<i>Idaho</i>	234,367	238,406	244,614 ^b	1.7	1.1	2.3	4.4	5.2	3.6	8	0	5	0
<i>Montana</i>	151,906	137,070 ^b	138,755 ^b	-9.8	-9.9	-9.6	-8.7	-8.7	-8.6	13	1	14	1
<i>Wyoming</i>	49,250	53,026	52,901	7.7	7.2	8.0	7.4	7.0	7.7	5	0	5	1
<i>Southwest</i>	267,425	255,632 ^b	259,260 ^a	-4.4	-8.8	3.3	-3.1	-5.5	1.3	19	3	16	3
<i>Arizona</i>	146,107	142,111 ^a	145,163	-2.7	-4.7	-0.2	-0.6	-1.5	0.5	10	0	7	0
<i>New Mexico</i>	121,318	113,521 ^a	114,098 ^a	-6.4	-12.7	9.9	-6.0	-9.3	2.8	9	3	9	3

1070





Table 9. Comparison of average burned area from the MTBS and iWED datasets calculated using records from 1992 to 2020, where the letter superscripts in the iWED dataset column indicate the statistical significance for the difference between the MTBS and iWED average burned area (a: $p < 0.1$; b: $p < 0.05$; c: $p < 0.01$; d: $p < 0.001$). % MTBS burned area difference = (MTBS burned area) / (iWED burned area) $\times$ 100. Data from states where average burned area was less than 100 ha yr⁻¹ are not included in this table. The data from these years, however, was used to calculate burned area at regional, sub-continental, and continental scales.

	Burned area (ha yr ⁻¹)		% MTBS burned area			
	MTBS dataset	iWED dataset	1992-2021	1992-2001	2002-2011	2012-2020
<i>Contiental US</i>	2,154,017	2,554,218 ^d	84.3	71.6	86.1	90.1
<i>Eastern US</i>	57,619	129,522 ^d	44.5	51.1	41.8	39.7
<i>Middle South</i>	15,513	42,753 ^d	36.3	54.5	21.2	26.2
Kentucky	6,183	18,380 ^d	33.6	69.9	10.8	9.6
Maryland	499	1,062 ^c	47.0	3.9	55.1	75.9
Tennessee	2,677	8,669 ^d	30.9	36.9	23.2	32.3
Virginia	2,901	5,839 ^d	49.7	43.1	44.0	62.0
West Virginia	3,235	8,734 ^d	37.0	50.4	12.0	17.0
<i>North Central</i>	14,015	31,287 ^d	44.8	34.5	60.0	27.0
Indiana	88	380 ^d	23.3	26.0	32.0	0.0
Iowa	68	1,358 ^d	5.0	0.0	13.2	0.0
Michigan	1,220	2,254 ^d	54.1	56.5	62.4	42.2
Minnesota	9,337	17,566 ^d	53.2	41.3	65.2	29.5
Missouri	3,096	7,908 ^d	39.1	26.6	65.3	31.5
Wisconsin	205	1,390 ^d	14.7	2.7	17.0	27.2
<i>Northeast</i>	2,155	6,539 ^d	33.0	34.4	35.8	28.4
Connecticut	0	107 ^d	0.0	0.0	0.0	0.0
Maine	19	232 ^d	8.0	6.4	24.3	0.0
Massachussetts	10	128 ^d	7.9	0.0	18.1	0.0
New Jersey	1,600	3,884 ^d	41.2	45.8	39.6	33.5
New York	157	850 ^d	18.4	0.0	42.2	23.7
Ohio	60	343 ^d	17.5	0.0	39.1	0.0
Pennsylvania	310	895 ^d	34.6	0.0	30.1	47.3
<i>Northern Plains</i>	25,937	48,943 ^d	53.0	60.3	44.4	54.3
North Dakota	2,930	6,989 ^d	41.9	63.9	43.0	23.4
Nebraska	11,099	16,459 ^d	67.4	83.8	62.5	59.4
South Dakota	11,908	25,495 ^d	46.7	46.1	39.2	58.8

1078



1079 **Table 9 (concluded).**

<i>Southeast</i>	77,268	170,550 ^d	45.3	35.8	55.9	41.1
Alabama	1,645	15,047 ^d	10.9	10.5	13.6	7.0
Arkansas	3,722	9,380 ^d	39.7	38.9	52.4	21.3
Florida	42,746	76,992 ^d	55.5	51.9	63.3	51.5
Georgia	20,851	32,278 ^d	64.6	23.1	78.7	58.5
Louisiana	4,359	10,349 ^d	42.1	35.4	52.4	33.6
Mississippi	2,495	18,009 ^d	13.9	7.4	17.4	21.9
South Carolina	1,450	8,494 ^d	17.1	10.7	24.5	18.4
<i>Southern Plains</i>	225,462	278,655 ^b	80.9	69.5	74.5	96.2
Kansas	49,306	20,719 ^b	238.0	112.9	304.2	245.0
Oklahoma	69,232	85,044 ^c	81.4	54.5	71.9	94.8
Texas	106,924	172,892 ^d	61.8	68.9	62.6	55.9
<i>Western US</i>	1,793,667	1,975,492 ^d	90.8	79.1	94.0	94.2
<i>Alaska</i>	464,141	512,989 ^b	90.5	52.4	99.5	94.7
<i>California</i>	276,829	301,735 ^d	91.7	80.5	87.3	98.4
<i>Great Basin</i>	231,517	249,116 ^d	92.9	90.7	93.3	95.1
Nevada	163,251	172,664 ^d	94.5	92.0	95.7	96.2
Utah	68,267	76,452 ^d	89.3	87.0	88.6	92.4
<i>Northwest</i>	237,692	256,427 ^d	92.7	85.1	92.6	95.4
Oregon	146,715	157,505 ^d	93.1	85.2	93.3	96.0
Washington	90,977	98,922 ^d	92.0	85.0	91.0	94.4
<i>Rocky Mountain</i>	397,699	440,562 ^d	90.3	88.5	90.8	91.0
Colorado	39,330	48,196 ^d	81.6	72.2	79.0	84.8
Idaho	214,320	226,818 ^d	94.5	92.9	93.8	96.5
Montana	103,685	118,361 ^d	87.6	79.6	91.4	88.5
Wyoming	40,364	47,186 ^d	85.5	90.2	83.5	84.2
<i>Southwest</i>	185,789	214,663 ^d	86.5	74.4	91.3	87.9
Arizona	100,916	111,176 ^d	90.8	79.0	95.1	90.2
New Mexico	84,872	103,487 ^d	82.0	71.7	87.3	83.7

1080

1081

Table 10. Processes used during the development of the iWED that changed the number and sizes of mega and mega-plus fires.

Process	MTBS number		MTBS size		FM number		FM size		Examples
	M	M-P	M	M-P	M	M-P	M	M-P	
1. Identifying matched MTBS Unknown and Prescribed Fire records	+								
2. Reclassifying unmatched MTBS Unknown and Prescribed Fire records	+	+							
3. Adding of fire management records					+	+			
4. Identifying MTBS records with multiple perimeters	+/-		-	-	+/-		-	-	S3,S4,S5,S6
5. Identifying FM records named as complexes that had multiple fires					-				
6. Adjusting or reallocating fire management and/or MTBS size	+/-		+/-		+/-		+/-		S13,S20
7. Identifying MTBS and fire management records that spanned international borders	-		-				-		S21,S22
8. Identifying matched records that had joined	-		-						S16
9. Identifying matched records that had merged	+/-	+	+/-	+	+/-	+	+/-	+	S11-S14,S20
10. Substituting MTBS size for fire management size					+/-	+/-	+/-	+/-	S29

1082

1083





Table 11. Percentage of the total number of mega and mega-plus fires as a function of total number of larger wildfire records for different study areas and the percentage of area burned in mega and mega-plus fires.

	Number of records			Burned area		
	Mega	Mega-plus	Total	Mega	Mega-plus	Total
Continental US	8.1	0.4	8.5	49.3	14.6	63.9
Eastern US	2.8	0.0	2.8	33.8	0.0	33.8
Southeast	3.8	0.3	4.0	32.4	18.5	50.9
Southern Plains	4.1	0.3	4.5	32.4	17.3	49.6
Western US	11.0	0.5	11.5	52.7	14.6	67.3



Table 12. Summary of the number of and average burned in larger fire records using different wildfire event datasets. Data are from 1992 to 2021. Also included are percentage differences between the number of and area burned for different datasets.

	Number of records			Burned area (ha yr ⁻¹)			Difference in number of records			% of burned area		
	Total	Mega	Mega-plus	Total	Mega	Mega-plus	Total	Mega	Mega-plus	Total	Mega	Mega-plus
<i>FS20-plus dataset</i>												
Continental US	16,841	1,314	61	2,164,061	1,074,668	297,444						
Eastern US	2,508	61	0	74,378	24,783	0						
Southeast	1,966	74	5	83,888	28,590	12,622						
Southern Plains	2,259	71	7	192,371	54,078	38,549						
Western US	10,108	1,108	49	1,813,424	967,217	246,273						
<i>MTBS-A dataset</i>												
Continental US	13,689	1,270	61	2,102,990	1,072,287	307,690	3,152	44	0	2.9	0.2	-3.3
Eastern US	1,360	60	0	59,096	23,749	0	1,148	1	0	25.9	4.4	0.0
Southeast	1,290	50	6	67,237	20,901	15,817	676	24	-1	24.8	36.8	-20.2
Southern Plains	1,666	59	6	168,307	47,415	33,637	593	12	1	14.3	14.1	14.6
Western US	9,373	1,101	49	1,808,350	980,223	258,237	735	7	0	0.3	-1.3	-4.6
<i>iWED-F dataset</i>												
Continental US	17,689	1,342	69	2,256,757	1,089,989	347,467	848	28	8	4.3	1.4	16.8
Eastern US	2,668	63	0	78,856	25,009	0	160	2	0	6.0	0.9	0.0
Southeast	2,028	77	6	90,149	28,336	17,320	62	3	1	7.5	-0.9	37.2
Southern Plains	2,498	76	7	206,188	56,713	38,549	239	5	0	7.2	4.9	0.0
Western US	10,495	1,126	56	1,881,564	979,931	291,599	387	18	7	3.8	1.3	18.4
<i>iWED-F versus FS20-plus records^b</i>												

1089
1090
1091
1092

1093

Table 12 (concluded).

	<i>iWED-M dataset</i>						<i>iWED-M versus MTBS-A records^c</i>					
Continental US	14,873	1,322	68	2,185,991	1,091,341	335,174	1,184	52	7	3.9	1.8	8.9
Eastern US	1,616	57		62,621	22,483		256	-3	0	6.0	-5.3	0.0
Southeast	1,585	54	5	75,611	22,868	16,155	295	4	-1	12.5	9.4	2.1
Southern Plains	2,003	126	8	228,021	92,464	37,432	337	67	2	35.5	95.0	11.3
Western US	9,669	1,085	55	1,819,738	953,526	281,587	296	-16	6	0.6	-2.7	9.0
	<i>iWED-F/M dataset</i>											
Continental US	19,950	1,407	70	2,359,302	1,129,930	347,630	3,109	93	9	9.0	5.1	16.9
Eastern US	3,056	62	0	86,647	24,015	0	548	1	0	16.5	-3.1	0.0
Southeast	2,569	80	5	104,413	31,609	16,155	603	6	0	24.5	10.6	28.0
Southern Plains	3,165	138	8	284,202	97,737	37,432	906	67	1	47.7	80.7	-2.9
Western US	11,160	1,127	57	1,884,041	976,568	294,043	1,052	19	8	3.9	1.0	19.4

^aPositive occurred when burned area from the FS20-plus records being greater than burned area from MTBS-A records.

^bPositive differences occurred when burned area from the iWED-F records being greater than burned area from FS20-plus records.

^cPositive differences occurred when burned area from the iWED-M records being greater than burned area from MTBS-A records.

^dPositive differences occurred when burned area from the iWED-F/M records being greater than burned area from FS20-plus records.

1094

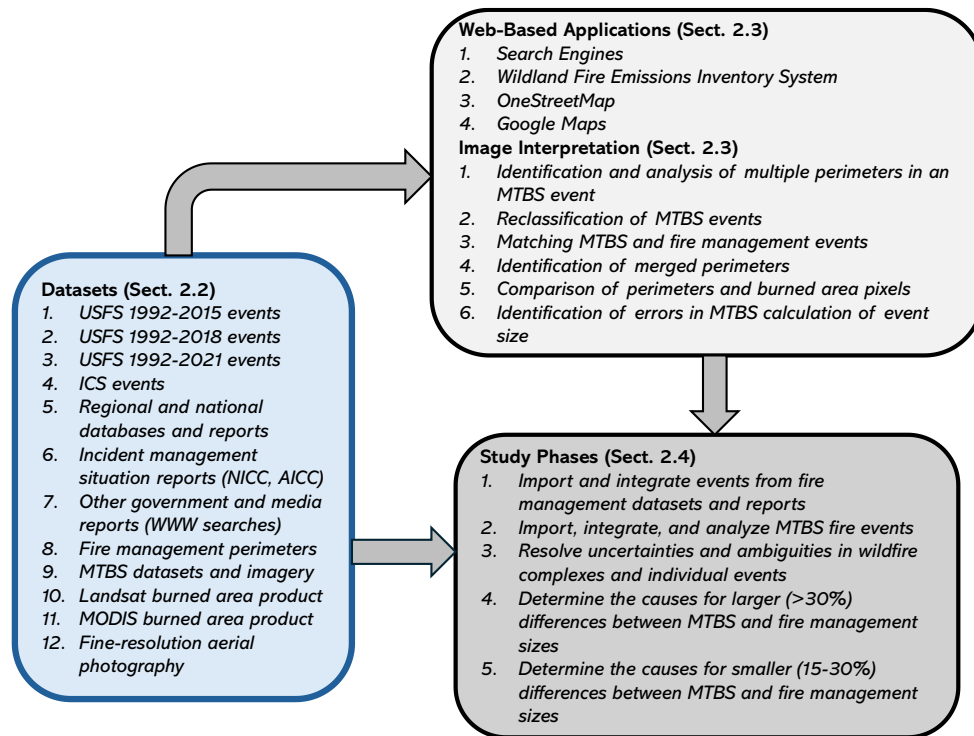
55





1095 **Figure 1.** Flowchart illustrating the datasets, methods, steps, and phases used during the
1096 development of the integrated Wildland Fire Dataset (iWED).

1097



1098