Fire Prevention and Safety (FP&S)

Research and Development (R&D)

Fiscal Year (FY) 2015 Grant Award Results

June 2022

FEMA

Cover photo by Chandler Probert, NCSU, EMW-2015-FP-00753

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1. Introduction

The goal of the Research & Development (R&D) Activity within the Fire Prevention & Safety (FP&S) Grant Program is to reduce firefighter line-of-duty fatalities and injuries through research to improve firefighter safety, health, or well-being.

The Federal Emergency Management Agency (FEMA) made five awards under the Fiscal Year (FY) 2015 FP&S R&D Grant Program, for a total of $6,100,101 federal share. This report contains the results of each grant award, which ended in 2020.

Table 1: FY 2015 FP&S R&D Grant Awards

Grant Number	*Awarded Entity*	*Total Federal Funds Awarded*
EMW-2015-FP-00213	Arizona Board of Regents, University of Arizona	$1,500,000
EMW-2015-FP-00361	Underwriters Laboratories Inc.	$1,492,192
EMW-2015-FP-00753	North Carolina State University	$1,428,569
EMW-2015-FP-00848	NDRI-USA, Inc.	$1,500,000
EMW-2015-FP-00888	University Corporation for Atmospheric Research	$179,340

2. EMW-2015-FP-00213 Results

Table 2: Project Information for EMW-2015-FP-00213

Project Information	*Details for EMW-2015-FP-00213*
Project Title	The Firefighter Multicenter Cancer Cohort Study (FFCCS): Framework Development and Testing
Organization	Arizona Board of Regents, University of Arizona
Principal Investigator	Jefferey Burgess, MD, MS, MPH
Award Total	$1,575,000 ($1,500,000 Federal)
Period of Performance	07/20/2016 - 01/19/2020

2.1.1. SPECIFIC AIMS

Under this research proposal, the project partners developed and tested a framework for establishing a long-term firefighter multicenter prospective cohort study focused on carcinogenic exposures and effects. In the long term, the FFCCS intends to identify mechanisms causing firefighter cancer by enlisting 10,000 firefighters that will be followed for up to 30 years. The specific aims of this initial project were to:

1. Establish an oversight and planning board (OPB) for study oversight, communication among fire organizations, and development of a long-term funding plan.
2. Create and test a data coordinating center (DCC) and harmonize survey data protocols.
3. Create an exposure assessment center (EAC) to develop and evaluate an exposure tracking system paired with quantitative exposure data to construct a firefighter carcinogen exposure matrix.
4. Create a biomarker analysis center (BAC) to evaluate the association between cumulative firefighter exposures and epigenetic effects.

2.1.2. FIRE SERVICE RELEVANCE

Firefighters are at increased cancer risk compared to the general population. Although firefighters are exposed to multiple occupational carcinogens, the mechanisms by which these exposures cause cancer, or means to reduce these exposures, are not sufficiently understood. Since cancer has a long latency period, biomarkers are also needed to assess the effects of carcinogenic exposures before cancer development, when preventive interventions could be effective. Development of a large multicenter firefighter cancer prospective cohort study can address these needs, but a study framework had to first be developed and tested among a smaller initial set of fire service partners.

2.1.3. METHODS

1. The OPB was established by the Fire Protection Research Foundation to provide study oversight and explore a long-term funding and sustainability plan.
2. The DCC was established by the University of Miami. University of Miami designed and evaluated the multicenter study framework, including standardized survey data collection tools and analysis protocols to address study objectives and linkage with long-term outcome data as well as serving as the Central IRB of record for the regulatory study documents.
3. The EAC, led by the National Institute for Occupational Safety and Health (NIOSH), evaluated exposures, collected biological samples, identified the primary determinants of exposure, and developed a job exposure matrix for the fire service.
4. The BAC, established by the University of Arizona, collected blood, buccal, and urine samples.

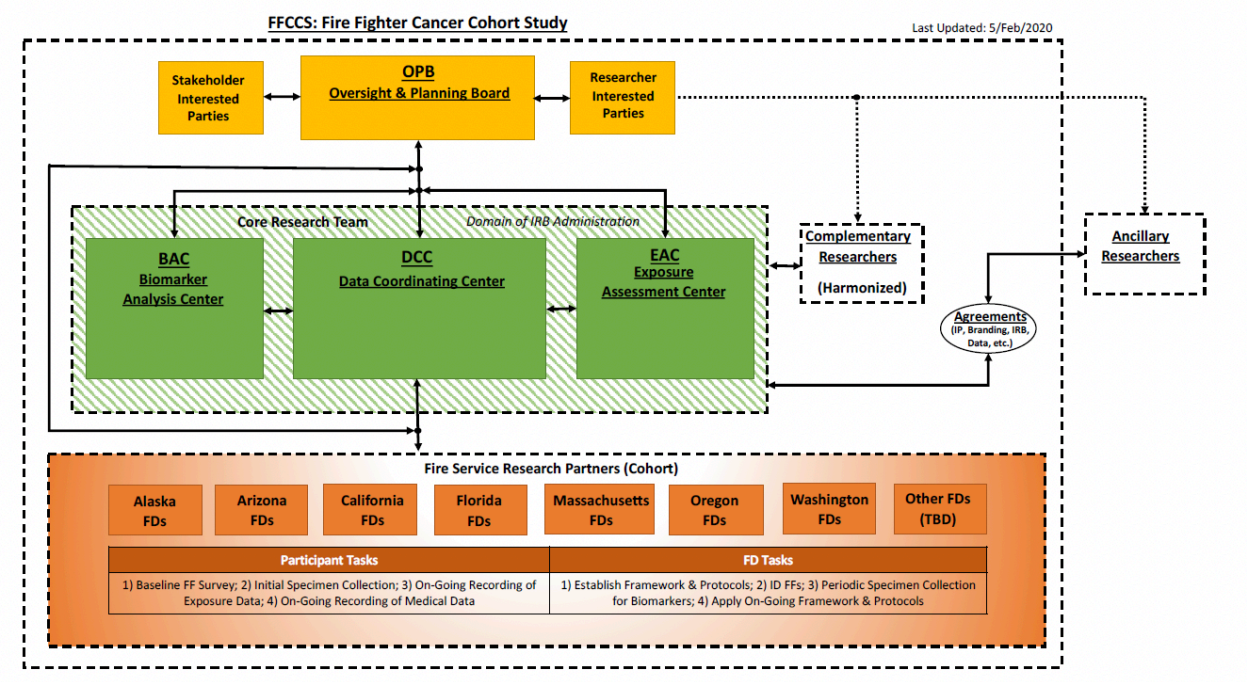

Figure 1: Illustration of FFCCS framework and relationships between primary project groups (OPB, DCC, EAC, BAC and partner fire departments).

2.1.4. OUTCOMES

The FFCCS Framework was successfully established as a fire service/academic/government agency partnership. Fire service affiliates and representatives were appointed to the OPB. Recruitment materials, surveys, and study protocols have been developed as well as a study website (https://www.ffccs.org/). Between July 2016 and August 2020, 1,110 firefighters were recruited. Since then, enrollment has continued to increase. Baseline blood and urine have been collected and analyzed by the EAC and BAC and follow-up samples are continuing to be analyzed, including epigenetic markers of cancer effect and cancer risk. Building on the successful FFCCS Framework, additional grant proposals to extend enrollment into the FFCCS cohort and to analyze stored samples have been funded.

2.1.5. SIGNIFICANCE, IMPLICATIONS, AND RECOMMENDATIONS FOR THE FIRE SERVICE

The FFCCS has been instrumental in providing a framework for evaluating exposures and carcinogenic effects in firefighters. This is demonstrated by successful applications for additional funding to build on the FFCCS framework, the initial publications that are continuing to expand knowledge of cancer risk among firefighters, and the fire service/academic partnership presentations which are disseminating the study results. Furthermore, the value of the FFCCS will continue to increase over time with increased participation, and the generation and dissemination of study results.

2.1.6. ADDITIONAL INFORMATION

A website has been established to provide a virtual home for all FFCCS activities. The web site is located at https://www.ffccs.org/.

3. EMW-2015-FP-00361 Results

Table 3: Project Information for EMW-2015-FP-00361

Project Information	*Details for EMW-2015-FP-00361*
Project Title	Study of Coordinated Fire Attack in Acquired Structures
Organization	Underwriters Laboratories, Inc.
Principal Investigator	Stephen Kerber, PhD
Award Total	$1,566,802 ($1,492,192 Federal)
Period of Performance	07/29/2016 - 01/29/2020

3.1.1. SPECIFIC AIMS

The goal of this study was to evaluate how tactical choices and coordination of ventilation and suppression impact conditions throughout the structures where firefighters operate to improve their safety and effectiveness.

The specific aims were to:

1. Improve firefighter effectiveness and safety by increasing knowledge of fire dynamics.
2. Understand what coordinated ventilation and suppression is and how to best accomplish the mission of the fire service.
3. Expand fire service research beyond the purpose-built residential-scale structures previously studied to explore several occupancy types in acquired structures.

3.1.2. FIRE SERVICE RELEVANCE

Tactical considerations were developed based on results from the respective experiments for each of the three structure types. A tactical consideration is an evidence-based concept for the fire service to consider implementing to enhance efficiency and effectiveness, and to increase knowledge to accomplish their mission. While the tactical considerations developed were unique, two commonalities emerged, including the need to conduct an appropriate size-up and the need to understand the timeline of coordination. Fire departments across the country are likely to have different definitions of what constitutes a coordinated fire attack. Building stock, response models, and local policies and procedures likely influence these definitions. A size-up of the critical factors is

a must on every fire ground. Some of the key elements of a size-up would include building geometry, fire location and extension, construction type, existing and potential ventilation/flow paths, access, weather, and available resources. It is important to note that there is uniqueness to these elements based on structure type, but the general categories persist.

Additionally, a coordinated fire attack on an actual incident involves more moving pieces than simply suppression and ventilation, with search and rescue being an important task that was beyond the scope of this research project. However, across all experiments there was a consistent response in fire behavior. When ventilation was provided (by opening the front door for access, or by conducting horizontal or vertical ventilation) to a ventilation-limited fire and the suppression was delayed, the ventilation led to an increase in the oxygen available for combustion and an increase in the heat release rate of the fire.

3.1.3. METHODS

Forty full-scale fire experiments were conducted in acquired structed. This study expanded upon three prior ventilation studies, including Impact of Ventilation on Fire Behavior in Legacy and Contemporary Residential Construction[1], Effectiveness of Fire Service Vertical Ventilation and Suppression Tactics in Single Family Homes[2], and Effectiveness of Fire Service Positive Pressure Ventilation During Fire Attack in Single Family Homes Incorporating Modern Construction Practices[3]. This study also expanded on a prior suppression study, Impact of Fire Attack Utilizing Interior and Exterior Streams on Firefighter Safety and Occupant Survival: Full Scale Experiments,[4] and a prior study of basement fires, Understanding and Fighting Basement Fires[5], that applied knowledge gained in the laboratory to acquired structure experiments.

Phases I and II of this study took place in acquired single-family homes and multi-family garden-style apartments, respectively. Several different fire scenarios were tested using tactics that included horizontal, vertical, hydraulic, and positive pressure ventilation coordinated with interior or exterior/interior suppression. Fuel packages were representative of furnished rooms found in homes across the country. Fuels were consistent within each respective experimental series so the variations in coordinated methods could be compared. The variables of tactics, timing of tactics, and

[1] Link: https://d1gi3fvbl0xj2a.cloudfront.net/files/2021-07/DHS_2008_Grant_Report_Final.pdf

[2] Link: https://fsri.org/sites/default/files/2021-07/UL-FSRI-2010-DHS-Report_Comp.pdf

[3] Link: https://d1gi3fvbl0xj2a.cloudfront.net/files/2021-07/Positive_Pressure_Ventilation_FD_Summary_Report_Website.pdf

[4] Link: https://d1gi3fvbl0xj2a.cloudfront.net/files/2021-07/DHS2013_Part_III_Full_Scale.pdf

[5] Link: https://d1gi3fvbl0xj2a.cloudfront.net/files/2021-07/Understanding_and_Fighting_Basement_Fires.pdf

coordination of tactics were carefully controlled to maximize connections between prior research projects. The garden-style apartments were particularly unique as the door to each apartment opened to a shared, enclosed stairwell. Figure 2 shows activity at a Phase II experiment.

Figure 2: Fire conditions at the start of exterior fire control after horizontal ventilation at one of eleven Phase II apartment fire experiments.

Phase III of this project explored the impact of ventilation on fire dynamics through a series of experiments in several units within a strip mall. The fire service's existing training and experience is predominantly in residential type occupancies with residential type fuels, which results in the use of residential style tactics on non-residential style buildings. With the increased and varied fuel loading, open space, and access challenges, these tactics may not be as effective.

3.1.4. OUTCOMES

Three reports were created to document the experiments, the results, and considerations that can be used when assessing coordination on the fireground. Each report focused on a different acquired structure type – Single-Family Homes[6], Multi-Family Dwellings[7], and Strip Malls[8].

[6] Link: https://d1gi3fvbl0xj2a.cloudfront.net/files/2021-07/Coord_Tactics_Single_Family_Homes.pdf

[7] Link: https://d1gi3fvbl0xj2a.cloudfront.net/files/2021-07/Coord_Tactics_Multi_Family.pdf

[8] Link: https://d1gi3fvbl0xj2a.cloudfront.net/files/2021-07/Coord_Tactics_Strip_Malls.pdf

3.1.5. SIGNIFICANCE, IMPLICATIONS, AND RECOMMENDATIONS FOR THE FIRE SERVICE

The forty full-scale experiments conducted for this study improved the technical foundation of the coordination of fireground tactics. Although the types of structures differed and there was uniqueness to each set of experiments, a common finding was that ventilation alone (i.e., without coordinated suppression) did not improve conditions for firefighters or the occupants they protect. Coordinated ventilation and suppression, where crews on the fireground worked in concert to ensure minimal time lag between the initiation of the tactics, led to the best outcomes.

3.1.6. ADDITIONAL INFORMATION

A video overview of the Study of Coordinated Fire Attack Utilizing Acquired Structures project and other project-related information is available at https://fsri.org/research/study-coordinated-fire-attack-utilizing-acquired-structures.

4. EMW-2015-FP-00753 Results

Table 4: Project Information for EMW-2015-FP-00753

Project Information	*Details for EMW-2015-FP-00753*
Project Title	Revolutionizing the Protective Hood: Particulate Protection, Cleaning Effectiveness
Organization	North Carolina State University
Principal Investigators	Roger Barker, PhD, R. Bryan Ormond, PhD, Alex C. Hummel, PhD
Award Total	$1,499,997 ($1,428,569 Federal)
Period of Performance	07/28/2016 - 12/31/2019

4.1.1. SPECIFIC AIMS

In response to the introduction of particulate-blocking firefighter hoods, the goal of this study was to develop system-level methodologies for evaluating protective hood materials and designs. The specific aim was to study performance trade-offs between traditional hoods and the new particulate-blocking alternatives for protection (particulate and flashfire), comfort, durability, and situational awareness.

4.1.2. FIRE SERVICE RELEVANCE

Particulate-blocking hoods were first introduced as a direct response to the heightened awareness of carcinogenic soot deposition on the head, face, and neck of firefighters brought to the forefront by a 2015 fluorescent aerosol test conducted on a traditional knit hood. The clearly visible deposition of particulate on the neck of the test subject alarmed the fire service to the potential weakness in their

protective gear. The chief concern of this study was providing firefighters with an unbiased assessment of the utility of particulate-blocking hoods compared to traditional hoods so that they could determine within their own departments if these new pieces of equipment could better protect them from smoke exposures without negatively impacting their ability to do their jobs effectively.

4.1.3. METHODS

Material-level performance evaluations of thermal protection, particulate protection, total heat loss, mechanical strength, moisture absorption, and air permeability were conducted according to NFPA 1971 prescribed methods, where applicable. For hood-level evaluations, the PyroHead™ flash fire manikin and the thermal sweating head form testing platforms at the NCSU Textile Protection and Comfort Center were further optimized and compared to their corresponding material-level assessments. The fluorescent aerosol test was used with multiple static head forms to evaluate the particulate-blocking abilities of different hood designs at different wind speeds. To assess the durability of hood materials, simulated on-the-job stressors were used including 100 washes with 200 don/doff cycles and accelerated exposures to sunlight. The final phase of the research involved field assessments with firefighters at firefighting training centers where the laboratory data was compared to field data.

4.1.4. OUTCOMES

The most important finding in this research was that the construction and design of the protective hoods have more of an impact on the performance than any of the individual materials that are used. The current market of hoods revolves around three particulate-blocking technologies (filtration or membrane-based) and constructions as either 2 or 3-layered versions. The relationships between NFPA 1971 requirements for material-level assessments of hood composites show that to have complete particulate protection firefighters do not necessarily have to sacrifice thermal protection, comfort, or situation awareness depending on the layering of the materials. Hood-level testing showed that 2-layer particulate-blocking hoods can provide comparable flashfire protection (especially when worn with the full head ensemble) to traditional hoods while also allowing for similar thermal comfort and ability to feel heat on the fire scene.

Hood-level testing of both particulate-blocking and traditional hoods showed that particulate-blocking hoods can provide a 10x increase in protection compared to traditional hoods if doffing procedures are followed to minimize contamination transfer (see Figure 3 below). A smoke outward leakage headform demonstration (shown on cover of this report) and the Quantified Smoke Inspection Method (QSIM) were developed to help firefighters inspect their own hoods after use to determine if they are still blocking particulates. The QSIM was adopted in the 2020 revision of NFPA 1851. Regardless of material, all the hoods exhibited decreases in mechanical burst strength following extended sunlight exposure, but the thermal protection and particulate-blocking were not impacted. The mechanical strength of the hoods was not significantly impacted following the laundering/donning/doffing cycles.

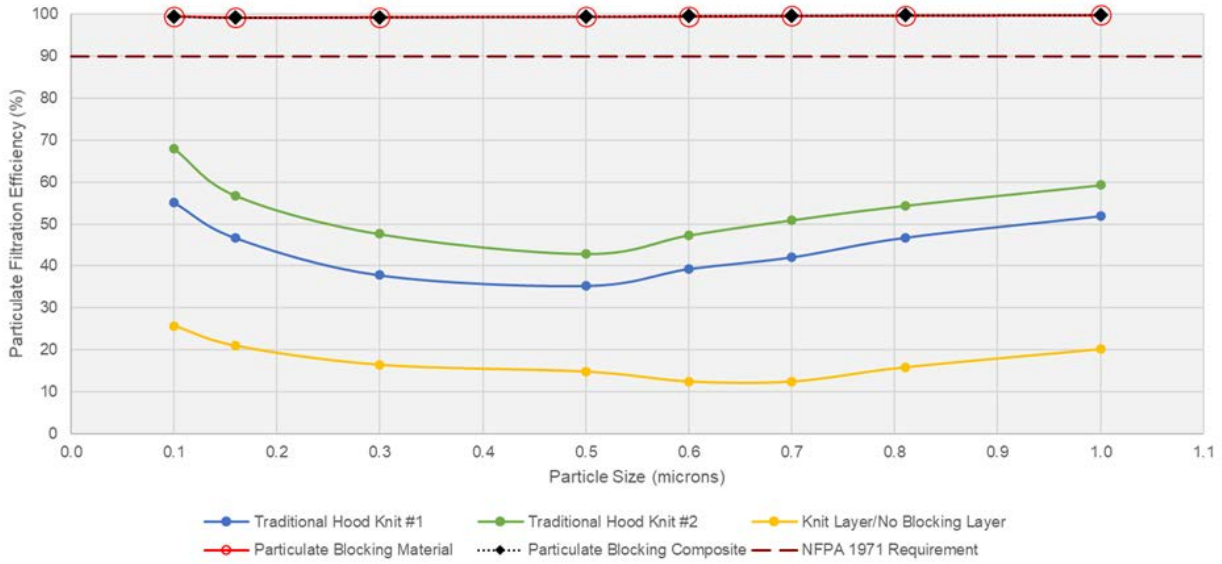

Figure 3: Particulate-Blocking Efficiency (PBE) of Traditional and Particulate-Blocking Hood Composites.

4.1.5. SIGNIFICANCE, IMPLICATIONS, AND RECOMMENDATIONS FOR THE FIRE SERVICE

Traditional 2-layer knit composites can provide between 35%-70% particulate-blocking efficiency across the relevant particle sizes that are common in structural fire smoke. All the currently NFPA 1971-certified particulate-blocking hoods block more than 90% of particles. This is significantly enhanced particulate protection compared to traditional knit hoods while not necessarily sacrificing in the other performance areas. The selection of hood should depend on fire department preferences such as fit, department tactics, and cost, with the most important element being the appropriate fit for everyone. The traditional 2-layer particulate-blocking hoods can provide comparable thermal protection and comfort to traditional hoods and may be optimized for most firefighters. The 3-layer hoods provide much higher thermal protection with a trade-off of thermal comfort and situational awareness but may be needed if a department requires increased thermal protection or as instructor hoods. Hoods, as with the rest of the turnout ensemble, should be kept out of prolonged sunlight exposure as this will weaken the mechanical strength of the knit materials and could result in damage during normal wearing.

4.1.6. ADDITIONAL INFORMATION

Dr. R. Bryan Ormond discusses his particle-blocking firefighter hood research and other firefighter personal protective equipment (PPE) projects with Jim Burneka on episode 60 of The 25 Live podcast in October 2020, which is available at: https://firefightercancerconsultants.com/episode-60-dr-bryan-ormond/

In an August 2021 NFPA Fire Protection Research Foundation webinar “Traditional and Particle-blocking Firefighter Hoods: Pros, Cons, and Trade-offs,” Dr. Ormond discussed the overall outcomes of the hood project. The webinar is available at:

here: https://players.brightcove.net/1640544031001/default_default/index.html?videoId=6267787968001&t=104s

The Ormond Research Group website provides an overview of present and past activities at https://sites.textiles.ncsu.edu/ormondresearchgroup/news/.

5. EMW-2015-FP-00848 Results

Table 5: Project Information for EMW-2015-FP-00848

Project Information	*Details for EMW-2015-FP-00848*
Project Title	Health and Wellness of Women Firefighters
Organization	NDRI-USA, Inc.
Principal Investigator	Sara Jahnke, PhD
Award Total	$1,574,999 ($1,5000,000 Federal)
Period of Performance	07/20/2016 - 01/19/2020

5.1.1. SPECIFIC AIMS

This study was designed to examine the health concerns of women in the fire service focused on reproductive health, behavioral health, cardiovascular risk factors, injuries, and morale. The specific aims were to:

1. Conduct an epidemiologic survey to collect data on a broad range of health domains including reproductive health, injury, mental health, cancer risk, cardiovascular risk factors, and experiences within the fire service from a large national sample of both career and volunteer women firefighters.
2. Conduct an evaluation of chemical concentrations and toxicity of breast milk collected from breastfeeding firefighters at baseline and at intervals after a structure fire, compared to breast milk from non-firefighters. This aim addressed the question of when it is safe for women firefighters to breastfeed newborns after fighting a fire.
3. Develop next steps and recommendations with the fire service for priority policy, practice, intervention, and prevention efforts.

5.1.2. FIRE SERVICE RELEVANCE

One of the challenges with recruitment and retention of women in fire service is the lack of knowledge about gender-specific health issues. Women in the fire service express frustration with a lack of research to guide decision-making on important topics such as reproductive health. Progress

in firefighter safety and health research for female firefighters has lagged dramatically behind that for male firefighters. While great strides are being made, particularly in areas such as cancer and cardiovascular risk factors for men, difficulty accessing enough women firefighters to secure large enough sample sizes has made similar gains for women challenging. This is of concern, especially in areas related to prevention and intervention to improve the health, well-being, and safety of women firefighters. Another area that has gone nearly untouched since preliminary data in the 1990s is the negative impact of occupational exposures on reproductive, maternal, and child health. Policy and practice decisions have been based largely on anecdotal evidence, general beliefs about reproductive health, and assumptions. These gaps in knowledge place female fighters at unnecessary risk and have been identified as contributing to the low recruitment and retention of women in the fire service. It may also place fire service leadership at legal risk given they must make policy decision based on inadequate evidence. This study was designed to protect the health of female firefighters and their children in generations to come.

5.1.3. METHODS

Aim 1 – National Survey

Due to the extremely low prevalence of women in the fire service in general, and the lack of a national database of firefighters, Aim 1 focused on recruiting women firefighters through a range of existing national fire service organizations and networks. Recruitment was primarily by email requesting participation from any women (career or volunteer) currently active in the fire service. Women were also asked to share the study information with their colleagues and friends who might be interested in participation. There was an extremely positive response from women in the fire service to the survey resulting in 2,398 career and 781 volunteer firefighters. Most participants were firefighters although, for both career and volunteer, there was a sizable sample of company officers and Chief level officers.

Aim 2 – Breast Milk Evaluation

A total of 35 breastfeeding women firefighters were enrolled in the study and 26 submitted post-fire breast milk samples in addition to baseline samples. Each breastfeeding firefighter was asked to identify a non-firefighter woman in their community who was breastfeeding, was similar with regard to age, race/ethnicity, and age of the firefighter, and interested in providing samples of breast milk as controls for the firefighting women. Ten non-firefighters were enrolled as controls with collection of surveys and breast milk. Consenting firefighter participants were supplied collection kits which contained baseline and post-fire surveys and sample bottles to collect samples of baseline and post-fire breast milk. Post-fire survey questions captured the type of fire, length of time spent on fire suppression activities, type of gear worn, and length of time post-fire for changing clothes and showering.

Aim 3 – Dissemination

A stakeholder panel was assembled to discuss preliminary findings from the first two aims and discuss implementation and dissemination of results for the fire service. The first area of focus was dissemination of findings related to maternal health outcomes and breast milk safety. Results were disseminated to assist in policy development through Women in Fire, International Association of Firefighters (IAFF) and International Association of Fire Chiefs (IAFC). IAFF has already started to highlight women's health and reproductive issues. The investigators plan to work in collaboration with these organizations as well as to develop a guidance document for health providers tasked with helping women make health choices before, during, and post-pregnancy.

The second area of focus stems from the data suggesting that discrimination and harassment has a significant deleterious effect on the health of women firefighters. To provide a resource to the fire service focused on improving the culture, the investigators developed a training cadre and training resources on inclusion and diversity titled "United in Service". The training included practical training components, facilitation resources and tools, and resource development. A key to the future success of this training is to decrease discrimination and harassment. The team of trainers are not only well versed in the fire service but serve in key influential positions within their departments and national organizations. The investigators are partnering with Women in Fire to pilot test trainings on a national basis.

5.1.4. OUTCOMES

Aim 1 – National Survey

This study has documented high rates of miscarriage and preterm labor among women firefighters as well as a lack of consistent policies for women firefighters. Data analysis is ongoing. Mental and physical health are significantly and negatively impacted by experiences of discrimination and harassment. Data showed low rates of obesity and high rates of fitness among female firefighters – a finding in contrast with high rates of obesity and poor fitness among males. Approximately a third of women reported a work-related injury in the previous 12 months and the study identified risk factors (e.g., obesity, low fitness, behavioral health issues, job dissatisfaction) for injury which can be leveraged for prevention efforts.

Aim 2 – Breast Milk Evaluation

Analysis of breast milk post fire found carcinogens even up to 72 hours post incident for interior firefighting. It is recommended that women who are breastfeeding not fight fires.

Aim 3 – Dissemination

The investigators are working with departments to draft model policies for women's health issues such as pregnancy/maternity leave. Stakeholders suggested that given the extreme impact of

discrimination and harassment, training resources were needed focused on inclusion and accepting diversity.

5.1.5. SIGNIFICANCE, IMPLICATIONS, AND RECOMMENDATIONS FOR THE FIRE SERVICE

This project provides a strong foundation of data for current efforts and future research. In addition to the data resulting from the current study and the subsequent policy and practice recommendations, this study has sparked a significant amount of conversation among colleagues and stakeholders in the fire service. The study highlighted the dearth of data on women firefighters and initial results have sparked several "next step" studies. In addition, there is a list of women firefighters who are interested in participating in research which will benefit future projects. As an example, the investigators are partnering with researchers at the University of Arizona to study AMH (a hormone that is an indicator of reproductive health) and will be recruiting participants from volunteers identified in this research. The IAFF has created a task group to focus on reproductive health of women firefighters and is publishing a series of articles on the topic, referencing the NDRI-USA, Inc. work, in their organizational magazine.

Most importantly, there has been an overwhelming response from women in the fire service who have expressed significant appreciation for the work NDRI-USA, Inc. has done, and the funding FEMA has provided to study their health concerns. Several have expressed frustration with not being able to find research on the risks they face related to reproductive health and breastfeeding. Others have expressed how much they appreciate research into the unique impact firefighting has on women and the gender differences between men and women firefighters.

Figure 4: Women in the fire service.

5.1.6. ADDITIONAL INFORMATION

Dr. Sara Jahnke discusses the importance of taking action to understand the female firefighter health and wellness issues in Fired Up and Plugged-In Podcast of Emergency Reporting, Episode 9: Addressing Female Firefighter Health and Wellness, Part 1.

Dr. Sara Jahnke and firefighter Heather Buren speak with host Jim Burneka about the health risks of women firefighters on The 25 Live Podcast - Episode 87.

Dr. Sara Jahnke and firefighters Heather Buren and Stephanie White speak with host Jim Burneka about women and men's reproductive health on Episode 10 of APS Radio: Reproductive Health and Maternity Policies.

Dr. Sara Jahnke and Dr. Jeffrey Burgess discuss the risks of breastfeeding while being a firefighter in a Tucson Weekly publication entitled "Arizona study examines health risks faced by female firefighters."

6. EMW-2015-FP-00888 Results

Table 6: Project Information for EMW-2015-FP-00888

Project Information	*Details for EMW-2015-FP-00888*
Project Title	Synthesizing and Disseminating New Scientific Insights into Transient Wildfire Behavior
Organization	University Corporation for Atmospheric Research
Principal Investigator	Janice Coen, PhD
Award Total	$188,307 ($179,340 Federal)
Period of Performance	07/20/2016 - 01/19/2020

6.1.1. SPECIFIC AIMS

This project aimed to improve wildland firefighter safety and reduce burn overs and entrapments with the following aims:

1. Recreate (via simulation) several events that led to (or could likely have led to) firefighter entrapment due to under-recognized, transient, or difficult to understand weather-fire behavior combinations.
2. Disseminate results through the research and practitioner communities for improved fire behavior awareness.
3. Introduce and help to familiarize practitioners with coupled weather fire modeling and its potential as a forecast tool to better anticipate dangerous fire behavior.

6.1.2. FIRE SERVICE RELEVANCE

The study focused on phenomena and sequences where advanced fire modeling could help interpret conditions in wildland fire that posed hazards to wildland firefighters. The hazards may not be generally recognized either because of dynamic wildland fire phenomena or a confluence of conditions that led to possible entrapment or burn over situations. Results of this study include

detailed visualization of developing hazards from real fire events that can be used to complement current training curricula.

6.1.3. METHODS

Primary activities centered around simulating wildland fire events and discussing significance with firefighters, creating visualizations, dissemination of results, and conducting a prototype forecast system to introduce the advanced modeling capability and its potential to practitioners. The simulations employed the CAWFE (Coupled Atmosphere Wildland Fire Environment) modeling system developed by Dr. Coen. CAWFE combines a numerical weather prediction model that incorporates the effects of complex terrain on airflow (and thus on fires) with a fire behavior model to simulate the intertwined influences of weather, fuel, and terrain on wildfire growth, plume development, and smoke transport. These are coupled so that heat and water vapor fluxes from the fire alter the atmosphere, notably producing fire winds, while the evolving atmospheric state affects fire behavior. Simulating the terrain-induced airflow effects at fire scales, the fire's forces on the air that alter winds, and the role of winds directing the fire spread allows CAWFE to accurately recreate much of the uniqueness in the evolution of each fire event.

Figure 5: A natural color image using visible and shortwave infrared bands to highlight the active Camp Fire using data acquired by the Operational Land Imager on Landsat 8 on November 8, 2018 at 10:45 a.m.

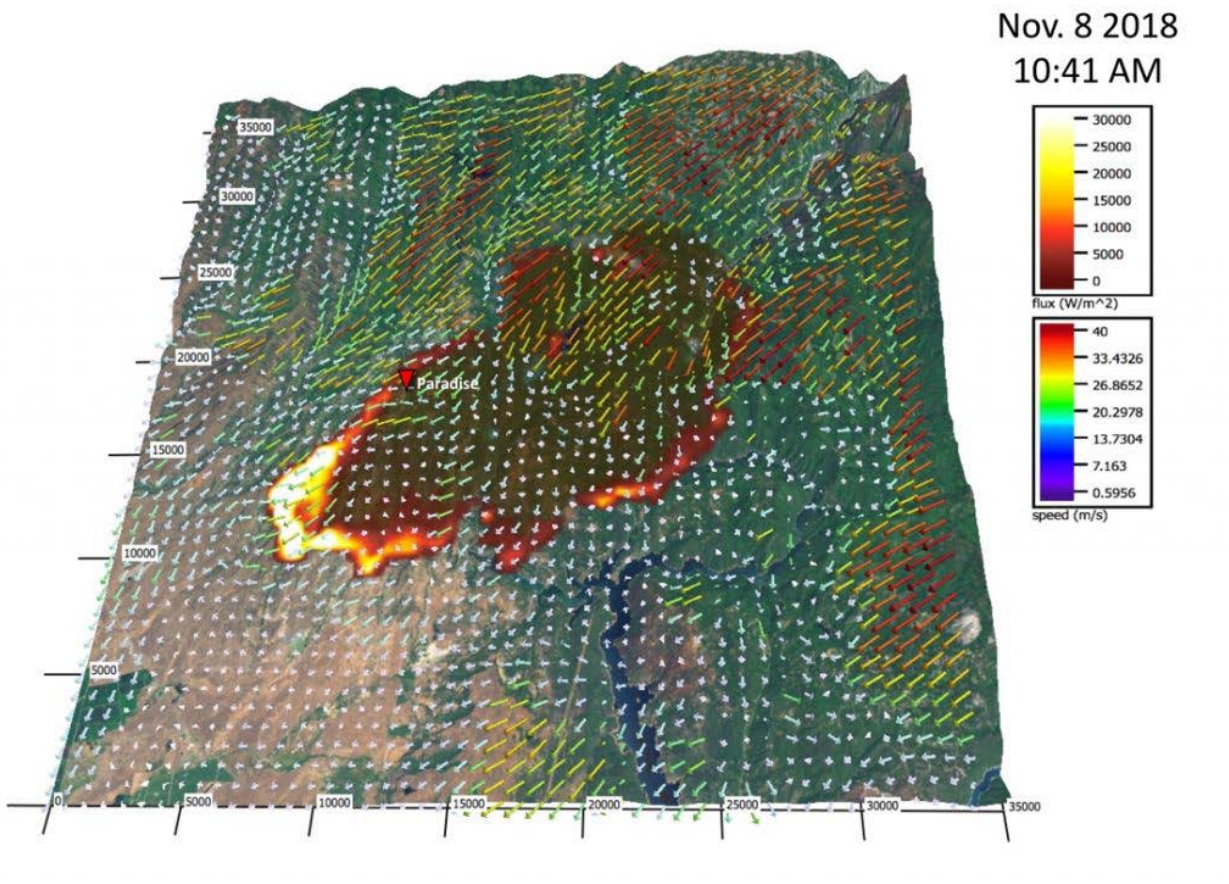

Figure 6: For comparison with Figure 5, this is a closely-timed frame (November 8, 2018 at 10:41 a.m.) from the VAPOR visualization of a CAWFE coupled weather-wildland fire model simulation of the spread of the Camp Fire that destroyed most of the town of Paradise, California.

6.1.4. OUTCOMES

This project generated knowledge on how complex atmospheric flows interact with fire behavior, infused it further within the weather and wildland fire communities, and created high-impact narrated animations that complement and enhance existing research, education, and training material. With input from other fire scientists and practitioners from different geographical regions and agencies, Dr. Coen examined six major wildland fire events occurring in 2017 and 2018 that included impact of gust fronts and shifting winds on fire behavior, fire-induced winds, large fire whirls, transient plume behavior, coastal airflows, and complex topographic airflow effects. It was demonstrated how seemingly unimportant topographic factors could lead to vastly different and explosive fire behavior. The investigator prototyped a coupled weather - fire forecast system during a month of extreme fire weather and wind event conditions in California. The study has generated publications, presentations, press, web material, interactions with practitioners, and widespread social media response including from firefighters. For example, simulations of the November 2018 Camp Fire have received over 8600 views on YouTube at

https://www.youtube.com/watch?v=dyfJYOZgiyA, 51,700 views on Facebook, and 23,500 views on Twitter as of November 2021.

6.1.5. SIGNIFICANCE, IMPLICATIONS, AND RECOMMENDATIONS FOR THE FIRE SERVICE

Among the contacts resulting from the widespread attention received by the Camp Fire simulations and subsequent work were fire suppression personnel. Interest was expressed in the use of CAWFE modeling results in firefighter educational materials. Visualizations of these different wildland fire hazards are being created for digital "firefighter safety tip sheets".

Important aims of the project were to raise awareness in the practitioner community of advanced wildfire modeling technology and its capabilities for re-creation of poorly understood fire events and to explore possible future utilization of the technology in fire response. Early in this project, an article introducing the modeling technology and its readiness as a forecasting tool appeared in Fire Management Today[9], a practitioner journal. During the project, there was outreach to both the scientific community and the practitioner community. This included workshops to discuss the State of the Science and science/practical needs for understanding wildfire behavior and smoke movement for both suppression and health. Practitioners (both prescribed fire managers and suppression personnel) were present in workshops. In particular, CAL FIRE and U.S. Forest Service attendees expressed interest in having detailed forecasts performed for their incidents.

6.1.6. ADDITIONAL INFORMATION

Channel 9 in Denver, CO provided an opportunity to Dr. Janice Coen to describe her research. This research included her simulations of the Camp Fire and others. The segment that originally aired on September 3, 2021, “Fire behavior research looks for a new way to predict wildfire behavior,” is available at https://www.youtube.com/watch?v=Ua5piedOcHE.

[9] Coen, J. L. and W. Schroeder, 2017: Coupled Weather-Fire Modeling: from Research to Operational Forecasting. Fire Management Today. 75:39-45. Link: https://www.fs.usda.gov/sites/default/files/fire-management-today/1952_fmt_75_15.pdf