2019

# Examining Injury Trends in Wildland Firefighters to Develop an Injury Screening Assessment Pilot Project

Isabella Grace Callis
*University of Montana, Missoula*

# EXAMINING INJURY TRENDS IN WILDLAND FIREFIGHTERS TO DEVELOP AN INJURY SCREENING ASSESSMENT PILOT PROJECT

By

ISABELLA GRACE CALLIS

Bachelors of Athletic Training, South Dakota State University, Brookings, SD 2017

Professional Paper

presented in partial fulfillment of the requirements
for the degree of

Master of Health and Human Performance
in Generalist

The University of Montana
Missoula, MT

Official Graduation Date May 2019

Approved by:

Scott Whittenburg, Dean of The Graduate School
Graduate School

Dr. Valerie Moody, Chair
Health and Human Performance

Dr. Charles Palmer, Member
Health and Human Performance

Dr. Joe Domitrovich, Member
Exercise Physiologist, Missoula Technology and Development Center

Callis, Isabella, M.A., Spring 2019 Health and Human Performance

Examining Injury Trends In Wildland Firefighters To Develop An Injury Screening Assessment Pilot Project

Chairperson: Dr. Valerie Moody

Fire suppression is an arduous profession that poses many work hazards and risks for wildland firefighters (WLFF) on a daily basis. One of the major threats to WLFF health on the line is musculoskeletal injury. Injury on the fire line and during personal training inhibits WLFF from performing their job to their full capacity. Currently there are no prevention strategies utilized to reduce the number of injuries this tactical population is experiencing. By accurately tracking injuries in WLFF, development of prevention strategies could assist in reducing the cost of injuries, maintain overall health in WLFF, and decrease work-related disability.

A review of three data sets on injuries sustained by WLFF during the 2017 and 2018 fire seasons confirmed injury trends that currently exist in the literature. Verifying these trends affirmed the need to incorporate preventative techniques in WLFF and address specific strategies to mitigate the rising numbers of injuries.

A pilot study has been developed with smokejumpers utilizing athletic trainers to complete movement and mobility screenings at the beginning, middle and end of fire season. By completing mobility screenings, any imbalances or weaknesses in smokejumpers that could place them at increased risk of injury will be identified. To combat the increased risk of injury, athletic trainers will develop corrective exercises for the smokejumpers to incorporate into personal training to ultimately decrease their risk of injury. In addition, introducing athletic trainers to WLFF in this capacity will open the door for these two professions to collaborate further in the future.

## Table of Contents

## Background

Between the years 2007 and 2017 over 77,000 fire incidents across the United States burned upwards of 75 million acres of private and public lands.[1] These numbers have increased in recent years and continue to grow with fires burning longer and in worse conditions.[2] This leads to an increased cost of fire, with reports from the National Interagency Fire Center (NIFC) stating wildfire suppression nearly broke $3 billion in the year 2017.[1,2]

Fire suppression is not only costly in time, acreage and money but also in physical exertion. Wildland firefighters (WLFF) are the men and women that work tirelessly to protect the public from these natural disasters. Fire suppression is an arduous profession that poses many work hazards and risks for WLFF on a daily basis. Hazards include but are not limited to high heat exposure, hiking in uneven terrain, and extensive periods of exhaustive physical activity. Daily exposure to these conditions poses an increased risk of injury to WLFF.

Previous research has identified many areas that pose threats to the health and wellbeing of WLFF on the line. These areas include smoke exposure, nutritional deficiencies, and other physiologic responses of fire fighters to the varying workloads and climate exposure. However, knowledge regarding the impact of injuries sustained by WLFF is not yet fully understood. Documentation of injuries at base camps has been widely inconsistent with multiple agencies playing a hand. The commonly documented injuries often involve mechanisms that occur during physical training rather than on the line completing fire duties. This lack of consistent reporting and improper classification fails to give reliable data on injury prevalence on the line. In addition, studies that have achieved data collection strongly rely on self-reported figures. This again creates a credibility gap due to WLFF not having the diagnostic tools to give appropriate injury details. In order to fill these gaps in the literature, credible injury data needs to be gathered and analyzed. By accurately tracking injuries in WLFF, development of prevention strategies could assist in reducing the cost of injuries, the maintenance of overall health in WLFF, and a decrease in work-related disability.

## Review of Literature

### Wildland Fire Overview

In 2017 over 10 million acres burned in the United States as the result of 71,499 fires.[1] When compared to only 20 years prior in 1997, 66,196 fires burned just less than 3 million acres of land.[1] The driving force in the rise in wildfires occurring in the United States is due to the changing climate conditions. Parts of the country with historically cooler temperatures and frequent precipitation are becoming unpredictable in their weather patterns due to rising average temperatures.[3] Climate changes have caused vegetation that is more prone to burn to accumulate at daunting rates as well, providing fuel for fires.[3] This combination of factors has led to more severe, frequent, and sizeable fires in recent years.

As fires are burning longer and more aggressively, fire seasons are increasing to 300 days in some parts of the country, an average of 78 days longer than in 1970.[3] Due to this, there is a rising need for WLFF every year that are required to work longer hours in an extended season. In addition, as development increases along the Wildland Urban Interface (WUI), crews are becoming increasingly critical in order to keep people and properties safe from fire. In 2015 the Forest Service reported an increase in their fire staffing by 114 percent since 1998, an increase of around 5,700 employees to 12,000.[3]

Ultimately the rising trends in fire are causing a surge in the cost of wildfires year to year. In 2017, the NIFC reported the total cost of suppression to be $3 billion.[4] When compared to 1997, the cost was under $300 million generating a 10-fold increase.[4] The Forest Service alone spent $2.4 billion on wildfire suppression in 2017.[3] The increasing cost is hurting the U.S. Forest Service because it is forcing them to allocate more employees for wildfire suppression rather than other functions they serve termed “non-fire activity”.[3] These include duties such as forest restoration and management, recreation, research, and others.[3] Non-fire activity is what helps maintain forest lands to mitigate the potential for wildfire in future years. If the cost of fire continues to increase as it is predicted to, there is a significant threat to the sustainability of all other services that support our national forests.[3]

Interagency Effort in WLFF

The U.S. Forest Service is the driving force of wildfire suppression, but with rising trends in fire it is becoming a multiagency effort.[5] Partners at the federal, tribal, state and local levels gather resources and create a fluent environment for fire suppression to take place.[5] Wildfire knows no boundaries; fires burn on lands that are under multiple jurisdictions thus this interagency effort is unavoidable. Each agency has their own assets to bring to the table, allocating resources such as aircraft, engines, equipment and personnel creating a combined effort to successfully suppress wildfire.[5]

The National Wildfire Coordinating Group (NWCG) facilitates interagency wildfire operations by providing leadership between federal, state, local, tribal, and territorial partners.[6] Members of the NWCG include: Bureau of Indian Affairs, Bureau of Land Management, Fish and Wildlife Service, Forest Service, International Association of Fire Chiefs, Intertribal Timber Council, National Association of State Foresters, National Park Service, and United States Fire Administration.[6] Among the primary objectives for the NWCG include setting standards for national interagency wildfire operations and effectively communicating objectives to each partner group.[6] In addition to setting national standards, the NWCG sets wildland fire position standards, qualifications, requirements and performance support capabilities that facilitate the implementation of the core standards.[6] Another objective of the NWCG is supporting National Cohesive Wildland Fire Management Strategy goals. The National Strategy was developed in 2009 in order to work collaboratively across all stakeholders and landscapes. By collaborating between agencies The National Strategy accomplishes three goals: utilizing the best science in order to restore and maintain landscapes, create fire adapted communities and improve fire response.[7]

The NWCG and the National Cohesive Wildland Fire Management Strategy are vital to making the interagency fire suppression operations successful. Without their delegation of standards and qualifications, fire suppression could quickly become more dangerous. The amount of agencies involved in fire suppression is no small number, especially as fires grow larger every year. Communication becomes essential to successfully suppressing fires in an efficient and safe manner between all agencies.

## Wildland Fire Crew Types

The different crews that work diligently to suppress fire are ordered to a standard type: Type 1, Type 2, Type 2 with IA (initial attack) capability.[8] The crews that make up the fire management response system are listed in Table 1 along with their specific duties.

| **Table 1**. Definitions of Crew Types | |
|---|---|
| **Crew Type** | **Job Duties** |
| Hand Crew | – 18-20 crewmembers[9]<br>– Construction of fire lines utilizing hand tools, chainsaws, pulaskis, shovels, and drip torches[9]<br>– Mop-up and rehabilitation of burned areas[9]<br>– Suppression through direct and indirect tactics[10] |
| Engine Crew | – 3-5 crew members[8]<br>– Utilization of a heavy-duty off-road vehicle which carries up to 800 gallons of water and foam for wildland fuels and protection of structures[9]<br>– Used for initial attack in fires for patrolling, providing structure protection, and conducting mop-up[10]<br>– Performance of strenuous activities including mobile attack with engines, hose lay, digging line with hand tools, burnout operations and mop-up[9] |
| Fuel Crew | – Up to 10 crew members[9]<br>– Work on fuel projects including hazardous fuel reduction and restoration of fire adapted ecosystems[9]<br>– Thinning of timber, woodlands, or shrubs with chainsaws[9]<br>– Utilization of prescribed fire to reduce fuels[9]<br>– Pilling and chipping of slash[9]<br>– Chemical application to undesirable fuels[9]<br>– Monitoring of pre and post fire effects[9]<br>– Occasionally utilized for fire suppression[9] |
| Helitack Crew | – Ranges between 7 and 24 crew members[10]<br>– Firefighters delivered via helicopter for fire suppression utilizing hand tools and chainsaws[9]<br>– Helicopters equipped with bucket or fixed tank to drop water or retardant[9]<br>– Helicopters utilized to deliver helitack crews for initial attack, and transport personnel and cargo[9]<br>– Trained to rappel from helicopter in remote areas[10] |
| Hostshot Crew | – 20 crew members[9]<br>– Utilized primarily for wildfire suppression, fuels reduction, and other management duties[9]<br>– Very specialized, therefore placed in most rugged terrain on most active and difficult areas on wildfires[9]<br>– Physical fitness is vital[9]<br>– Take part in same duties as Hand Crews: construction of fire lines utilizing hand tools, chainsaws, pulaskis, shovels, and drip torches; mop-up and rehabilitation of burned areas[9] |

| | |
|---|---|
| Smokejumpers | – Varies from 8-20 crew members depending on aircraft size[9]<br>– Highly trained and experienced firefighters delivered to wildfires by airplanes and parachutes[9]<br>– Provide wildfire suppression, hazardous fuel reduction services to land managements agencies[9]<br>– Must have previous firefighting background including engines, helitack, hotshot crews, or fuels and suppression crews[9] |
| Wildland Fire Modules | – 7-10 crew members[9]<br>– Assist in planning, fire behavior monitoring, ignition, holding, project preparation and execution[9]<br>– Typically assigned to fires that are managed for multiple objectives to provide expertise[9]<br>– Ability to be self sufficient for extended periods of time and provide many functions in remote areas[9] |
| Prescribed Wildland Fire Crew | – Participate in prescribed fire and wildfire activities: burn unit prep, fire operations, maintenance of equipment, and supplies, mop up, and monitoring[9] |

## Physical Demands on Wildland Firefighters

Wildfire suppression is an arduous task that requires both mental and physical exertion. Physically, WLFF expend a lot of energy daily due to the nature of their job and the duties required as broken down in Table 1. For certain crew types, such as smokejumpers, more specific physical requirements must be met. These include the ability to perform parachute jumps and landings on uneven terrain and lift and carry more than 100 lbs.[11] Ultimately, all crew types construct fire lines, complete mop-up and rehabilitation at fire incidents (Table 1). Cuddy et al[12] assessed the work patterns in WLFF in order to determine the mean total energy expenditure (TEE) which was calculated to be 19.1 ± 3.9 MJ/day (4565.01 ± 932.1 kcal/day). This energy expenditure comes from using Pulaski's, shovels, and other hand tools to construct fire lines, in addition to hiking steep terrain while carrying a pack of 50 lbs.[11] While these tasks stress the body through the energy expended, environmentally the body is stressed due to extreme temperatures in a hot and arid atmosphere and higher altitudes for extensive hours at a time.[13] WLFFs work for 12-16 hours a day for up to 14 days in a row, with the potential of extensions to 21 days if the demand is high.[11,13] The combination of sustained physical labor, high ambient temperatures and continuous physical labor causes concern for the safety and well being of WLFF.

Due to the high demands of physical exertion in the WLFF profession, individuals are required to meet certain physical standards. The "Pack Test" is an arduous level performance test that entails carrying a 45 lb pack for 3 miles in 45 minutes.[11] Smokejumpers have additional demands that need to be met due to the nature of their job. The "Smokejumper Fitness Test" includes a 1 ½ mile run in 11 minutes or less, 25 push-ups, 7 pull-ups, 45 sit-ups and carry 110 lbs for 3 miles in 90 minutes or less.[11] These physical standards are important for WLFF to attain before performing wildfire suppression. Without being physically fit, individuals may put themselves at higher risk for injury, heat illness, or burnout if not prepared.

## Wildland Firefighter Injuries

Currently in the literature there are few studies that assess the number and type of injuries sustained by WLFF. The majority of the research on WLFF has focused on other responses to hazardous exposures, such as respiratory responses and physiological reactions to training and the environmental conditions.

Britton et al[14] utilized a report from the Department of Interior (DOI) that had all nonfatal injuries sustained by WLFF between 2003 and 2007. These injuries were reported to the DOI by either the employee themselves or the supervisor.[14] Britton[14] evaluated three outcomes from the report including the type of injury, body part injured, and severity of injury. In total there were

1301 injures reported between 2003 and 2007. The reported injuries were broken down into nine different categories: bites and stings; fire/smoke and flash burn; equipment, tools, and machinery; slips/trips/falls; struck by or against; motor vehicles; plants; weather; and other.[14] Through this analysis, Britton et al[14] discovered that the most common mechanism of injury was slips/trips/falls, accounting for 365 out of the total 1301 injuries (28%). Slips/trips/falls were also determined to be the most common mechanism for sprains and strains (49%) and fractures and dislocations (43%).[14] As for the most common body region affected, the lower extremity accounted for 35% of total injuries, mainly occurring from slips/trips/falls (71%).[14] In addition to the three main outcomes, the time of year associated with each injury was recorded. It was found that the most injuries took place during the peak season of fire, between July and September.[14,15]

In addition to finding the trends in WLFF injuries due to mechanism and body region, Britton et al[15] broke down the injuries sustained by WLFF into crew types. Evaluating the data by crew types allows evaluation of how the job assignments affect the type, severity, and region of injuries. The same data set from the DOI between 2003 and 2007 was utilized in order to complete this study. Job assignments were broken down into eight categories: handcrews (Type 1 and 2), engine crews, smokejumpers/helitack crew, overhead/camp crews, and other.[15] Engine crews reported the most injuries, n=437 (33.6%), and Type 1 and Type 2 hand crews following up with n=220 (16.9%) and n=249 (19.1%), respectively.[15] Slips/trips/falls were consistently the most common cause of injury across all crew types (28.1%).[15] Overall, sprains/strains were the most common reported injury (29.4%).[15] Slightly less than half of all injuries suffered by engine crew members (45%) and smokejumper/helitack crews (45%) resulted in this category. Again these trends should not be taken lightly. Correlations between injuries and crew types as well as the mechanism of injury are vital to initiating prevention programs.

Purchio[16] recognized this gap in the literature and developed a questionnaire to create a better understanding of injuries in this occupational group. The 20 open and closed question survey was released to the U.S. Forest Service (USFS) to WLFF that have served within the last five years. These self-administered questionnaires covered three different topics: WLFF demographic information, types of injuries sustained, and the potential influence environmental factors play on the injuries sustained.[16] In total 453 injuries were reported within the five-year time frame. The participants represented all eight different crew types and spanned across all Geographic Area Coordinating Centers.[16] Purchio[16] reports joint sprains and muscle strains being the most common injuries in the subject group, 25% and 15% respectively. One of the most common mechanisms of injury reported was slips/trips/falls at 29.9%. Purchio[16] found that the body regions most affected by injury were to the low back (16%), knees (17%), and ankles (13%). 85% of the total injuries disclosed occurred while on the line. The format of this questionnaire didn't require all questions to be answered. Due to this factor, some gaps exist in each category. In addition, it is all self-report data, and therefore possible that no health care professional diagnosed any of the injuries disclosed through the survey. Moving forward with this type of data it is important to recognize its limitations in use.

Mangan[17] investigated injuries in a different manner. This study focused on what effects physical training (PT) may have on the injury occurrence to WLFF. One piece of this qualitative study consisted of a survey released to WLFFs throughout the U.S.[17] There were multiple categories of questions that all related to PT with one section specifically focusing on self-reported injuries sustained during PT. With a total of 1206 responses, 31% (n=319) of participants disclosed an injury during PT, whereas 69% (n=707) did not.[17] The total amount of injuries reported through the survey summed to be n=515, with almost half (42%) of these injures occurring to the knee and ankle and 51% of the injuries classified as sprains/strains.[17] These findings align consistently with the results from Britton et al[14,15] and Purchio.[16]

Reporting of Injuries/Current Methods of Injury Data Collection

One of the main limitations for research with WLFF is the lack of documentation standards throughout the multiple agencies. As previously mentioned, wildfire suppression is an interagency effort, and there is no consistency in injury reporting methods. Furthermore, most methods that do exist rely on self-report of injuries. This excludes any health care professional from diagnosing injuries sustained, making the resources not as credible. For example, the Department of Interior (DOI) utilizes the Safety Management Information System (SMIS) to record occupational illness, injury, or "accidents" involving DOI employees, volunteers, contractors, and visitors to DOI facilities.[14, 18,19] This system relies on reporting from either the employee themselves or their supervisor.[14, 18,19] In addition to the lack of credible reporting, as of 2002 when the Fire Management Accident Report Module (FMAR) was implemented, claims include both wildland and structural fire management. Therefore, this reporting system isn't wildfire specific, which inhibits the ability to categorize by injury and mechanism effectively.

A majority of the documentation methods in WLFF focus on fatal injuries. Currently, there are four population-based data systems and one case-based system that capture fatality data for WLFF.[20] The U.S. Bureau of Labor Statistics (BLS), United States Fire Administration (USFA), National Fire Protection Association (NFPA), and the National Wildfire Coordination Group (NWCG) all operate the various population-based systems that report fatalities among WLFF to some capacity.[20] The National Institute for Occupational Safety and Health (NIOSH) is a more case-based system that holds investigations through the Fire Fighter Fatality Investigation and Protection Program (FFFIPP).[20] Even though there is a much greater amount of documentation of fatalities of WLFF, each report varies creating challenges to accurately characterize WLFF fatalities too.

One of the most consistent pieces of documentation that currently exists at wildland firefighter bases is the ICS-206 WF.[21] The ICS-206 is a medical incident form that Emergency Medical Technicians (EMT) fill out at base camps when they give medical attention to WLFF. The only setback is that most incidences where the form is filled out are medical emergencies that require immediate attention and transportation. This leaves any musculoskeletal or ligamentous injury undocumented and usually untreated due to diagnosis of these injury categories outside of an EMTs scope.

In order to maintain consistent documentation of all injuries and incidences the Wildland Fire Injury and Illness Report (WFIIR) was developed. This form consists of a variety of questions that pertain to the history of injury as well as demographic information. History questions include: type of terrain, type of duty being performed at time of injury, mechanism of injury, nature of injury, and body region affected. Other open ended questions are included to allow the patient to describe mechanism, and for EMTs to disclose immediate care and detail exam findings.[21] Demographic questions focus on crew type, agency employed through, and employment type (full/part time, etc).[21] Even though EMTs are not as proficient in musculoskeletal and ligamentous injury diagnoses and care, the WFIIR at least allows a trained medical professional to give a more credible documentation of the injuries occurring to WLFF. Collection of this documentation form provides a more reliable database of injury occurrences on the line.

Injury Prevention in WLFF

By getting a good base of understanding about the injuries sustained by WLFF, this can help direct injury prevention methods in the field. One initiative that has focused on prevention techniques through a variety of modalities is called The Black. This project was created as an online resource for WLFF in order to improve the safety and performance on the line. One method of providing information is through a podcast called “On the Line”. Topics categories range from exertion, health, heat, recovery, and nutrition.[22] Other social media platforms are utilized such as Facebook, Instagram, and Twitter to increase access to a broader audience. The Black has also hosted local events in Missoula, MT such as a forum to discuss the best way for local WLFF to access information pertaining to injury prevention and other methods of staying healthy on the line or in the off season.[23] The most recent development is an online website containing educational modules focusing on mental training, physical training, injury prevention and tactical hydration and nutrition.

The implementation of prevention strategies in WLFF populations is slowly picking up steam. Physical therapists with Alpine Physical Therapy in Missoula, MT took the time to evaluate the biomechanics of tree cutting utilizing an ax. Jess Kehoe and Leah Versteegan are updating training manuals to include physical techniques in order to prevent injuries on the job.[24] Items such as proper lifting technique, decreasing strain of the lower back by holding chainsaws closer to the torso, and swinging crosscut saws with their hips rather than their arms will be included. Nothing like this has been done before with WLFF, and it will be a major benefit to allow employees to better prepare their bodies for season in hopes of decreasing injury.[24]

The public is slowly beginning to see the demands of fire suppression and the need for preventative measures to be implemented in this occupational group. As the fire seasons grow longer and more intense, the focus is starting to shift on the health of WLFF that perform in this mentally and physically demanding job. However, due to the multiagency effort and lack of consistent documentation methods for injuries it has been difficult for research to effectively determine the trends of WLFFs physical health. There is a need to continue assessing injuries in WLFF and determine if there are trends in the literature related to injury occurrences, mechanisms, and body regions so that prevention programs can be developed and implemented in the field.

## Methods

Information for this analysis will come from three different pools of data. One source is the IMS/EMS Yearly Review collected by the USDA. Each review is a collection of injuries reported to medical staff on base camps for that entire fire season. Through a Freedom of Information Act request, we obtained the IMS/EMS Review for the 2017 fire season and intend to receive the 2018 report as well. A second set of data will come from the collection of the Wildland Fire Injury and Illness Report (WFIIR), which was distributed to all of Region 1 during the 2018 fire season. The WFIIR is filled out by medical personnel at base camps and will be returned at the end of the fire season for analysis. Lastly, at the end of fire season a survey will be released to WLFF to self-report any injuries sustained for the current season.

Once all the data is collected we will assess injury trends to continue to build on existing data. Specifically we will determine any correlations that exist with mechanism of injury and injury types and treatments and referrals given for specific injury incidents. Ultimately the goal is to see if the new data we have gathered through our three resources will mirror the current injury data that exists in the literature, as Britton et al[14,15,18], Purchio[16], and Mangan[17] have all described.

Moving forward

By collecting and assessing the data on injury incidents in WLFF, a specific course of action can be developed for the implementation of a pilot program detailing an injury prevention model. Assessing the trends in the new data will affirm the need for incorporating preventative training techniques in WLFF and address specific strategies to cease the rising numbers of injuries. This will allow us to firmly target the areas that should be assessed at the beginning of the fire season through various diagnostic screening tools. Subsequently a training regimen to target the weaknesses revealed and guide the WLFF through these practices to decrease their risk of injury will be created.

# CHAPTER 2:

# DATA ANALYSIS AND PILOT PROJECT DEVELOPMENT

Update on Data Collection

Data was obtained from three different sources for analysis: IMS/EMS Region One Review for 2017, a self-report electronic survey, and injury data from Grayback Forestry Missoula Base of Operations for the 2018 fire season. There was no data available from the Wildland Fire Injury and Illness report (WFIIR) form piloted last fire season.

Results Summary

The three pools of data we collected resulted in a total of 4914 injuries/illnesses. The primary areas of focus within these results are the injury trends across all three data sets and identifying the consistent mechanisms of injury. Other demographic information was also reviewed for the respective resources.

**Table 1.** Classification of injuries sustained by WLFF.

| Injury/Illness Classification | **IMS/EMS Review (n/4855)** | **Grayback Forestry (n/51)** | **Self-report survey (n/8)** | **Total no. of injuries per classification** | **Total Percentage** |
|---|---|---|---|---|---|
| **Bites and Stings** | 110 (22.7) | 10 (19.6) | - | 120 | 2.4% |
| **Burns** | 22 (0.5) | - | - | 22 | 0.5% |
| **Cardiac** | 10 (0.2) | - | - | 10 | 0.2% |
| **Eye Injuries** | 159 (3.3) | 2 (3.9) | - | 161 | 3.3% |
| **Gastrointestinal/Urinary** | 348 (7.2) | 1 (2.0) | - | 349 | 7.1% |
| **Heat Illness** | 31 (0.6) | 2 (3.9) | - | 33 | 0.7% |
| **Musculoskeletal** | 553 (11.4) | 13 (25.5) | 8 (100) | 574 | 11.7% |
| **Poison oak/ivy** | 13 (0.3) | 10 (19.6) | - | 23 | 0.5% |
| **Respiratory** | 1535 (31.6) | 3 (5.9) | - | 1538 | 31.3% |
| **Skin** | 1346 (27.7) | 8 (15.7) | - | 1354 | 27.6% |
| **Spinal and Head Injury** | 354 (7.3) | 1 (2.0) | - | 355 | 7.2% |
| **Teeth** | 42 (0.9) | - | - | 42 | 0.9% |
| **Misc.** | 332 (6.8) | 1 (2.0) | - | 333 | 6.8% |
| **Total** | 4855 (100) | 51 (100) | 8 (100) | 4914 | 100% |

Raw score (percentage of total from each data source)

Injuries Sustained

Table 1 details the different classifications of illness/injury sustained by WLFF for all three data sources. The primary categories reported during the 2017 fire season were respiratory illnesses (31.3%) and skin (27.6%). In total there were 574 (11.7%) musculoskeletal injuries between all three data sets. Table 2 identifies the body regions affected for each data source, which identified the lower extremity (32.8%) as the most commonly affected body region overall. Table 1 and 2 provide further detail on the injuries/illnesses reported in each data set.

The IMS/EMS review for the 2017 fire season had a total of 553 musculoskeletal injuries. There were 45 different injury classifications that specified each musculoskeletal injury into diagnosis and body region. Of the musculoskeletal injuries reported, knee pain was the most common reason for seeking medical attention (12.1%) followed by muscle ache (10.7%), and sore muscles (8.0%).

**Table 2.** Musculoskeletal Injury by body region.

| | IMS/EMS Review | Grayback Forestry | Self-report survey | Total | Total percentage (n/574) |
|---|---|---|---|---|---|
| Abdomen, Thoracic | 2 | 1 | - | 3 | 0.5% |
| Back | 62 | 2 | 2 | 66 | 11.3% |
| Head, Neck | 19 | 1 | - | 20 | 3.5% |
| Lower Extremity | 180 | 3 | 5 | 188 | 32.8% |
| Upper Extremity | 65 | 6 | 1 | 72 | 12.5% |
| NOC* | 225 | - | - | 225 | 58.4% |
| TOTAL | 553 | 13 | 8 | 574 | 100% |

*NOC = not otherwise classified

Grayback Forestry reported a total of 51 injuries for the 2018 fire season. Table 3 details the injuries sustained by Grayback Forestry members, revealing the most common injury/illness as poisoning (general systemic) from bee stings and poison oak (29.4%) followed by sprains/strains (19.6%).

| **Table 3.** Types of Injuries Sustained by Grayback Forestry WLFF. | | |
|---|---|---|
| Type of Injury | Number of Injuries | Percentage |
| Bite/sting/poison | 15 | 29.4% |
| Sprains/strains | 10 | 19.6% |
| Laceration | 6 | 11.8% |
| Dermatitis | 6 | 11.8% |
| Infection | 2 | 3.9% |
| Fracture | 2 | 3.9% |
| Heat prostration | 2 | 3.9% |
| Respiratory disorder | 2 | 3.9% |
| Foreign body | 2 | 3.9% |
| Concussion | 1 | 2.0% |
| Contagious disease | 1 | 2.0% |
| Puncture | 1 | 2.0% |
| Contusion/bruise | 1 | 2.0% |
| **TOTAL** | **51** | **100%** |

| **Table 4.** Types of Injuries Sustained by WLFF from self-report survey. | | |
|---|---|---|
| Sprains/strains | 5 | 55.6% |
| Fracture | 1 | 11.1% |
| Contusion/bruise | 2 | 22.2% |
| No response | 1 | 11.1% |
| **TOTAL** | **9** | **100%** |

The self-report survey that was distributed at the end of fire season had 35 total responses. 15 responses were incomplete and excluded from the analysis. Of the 20 complete responses to the survey, 9 revealed injuries that had occurred during the 2018 fire season and all except one were classified as musculoskeletal. No illnesses were reported through this survey. Table 4 details the types of injuries revealed from the survey, where the three primary injuries were joint sprains/muscle strains (55.6%) followed by contusions (25%), and fracture/dislocation (12.5%).

Mechanism Of Injury

Understanding how these injuries are occurring is pertinent for the review of this data. The IMS/EMS review did not include mechanism of injury, but both Grayback Forestry and the self-survey reported these details. Table 5 presents the data on mechanism of injury for these two sources, revealing the most common mechanism as bite/sting/poison (33.3%) and slips/trips/falls (21.7%). However, if we were to exclude the illnesses and only analyze the musculoskeletal injuries from each data set, slips/trips/falls accounts for 61.5% followed by struck by/against an object (15.4%).

| **Table 5.** Mechanism of Injury for Grayback Forestry and self-survey. | | | | |
|---|---|---|---|---|
| **MOI** | **Grayback Forestry** | **Self-report survey** | **Total** | **Percentage** |
| Ingestion/Inhalation | 4 | - | 4 | 6.7% |
| Slips/trips/falls | 11 | 2 | 13 | 21.7% |
| Bite/sting/poison | 20 | - | 20 | 33.3% |
| Struck by/against object | 7 | 1 | 8 | 13.3% |
| Tools/machinery/equipment | 2 | 1 | 3 | 5% |
| Strain or injury by twisting | 2 | - | 2 | 3.3% |
| Overexertion | - | 3 | 3 | 5% |
| Miscellaneous/other | 5 | 1 | 6 | 10% |
| No response | - | 1 | 1 | 1.7% |
| TOTAL | 51 | 9 | 60 | 100% |

Demographics

Related to demographics, the self-report survey was the only source that gave thorough statistics on the individuals sustaining injuries. 20 respondents to the survey gave their demographics, which Table 6 summarizes.

| **Table 6.** Demographic Characteristics of Wildland Firefighters. | | | | | | | |
|---|---|---|---|---|---|---|---|
| Gender | % (n/20) | Age | % (n/20) | Crew Type | % (n/20) | Employment | % (n/20) |
| Male | 85% | 25-34 | 35% | Hand | 10% | Full time Year Round | 13 |
| Female | 15% | 35-44 | 45% | Fuels | 0% | Full time Seasonal | 5 |
| **TOTAL** | **20** | 45-54 | 20% | Engines | 35% | Other | 2 |
| | | **TOTAL** | **20** | Hotshot | 20% | **TOTAL** | **20** |
| | | | | Helitack | 5% | | |
| | | | | Smokejumper | 5% | | |
| | | | | Prescribed Wildland Fire | 5% | | |
| | | | | Wildland Fire Module | 5% | | |
| | | | | Unidentified | 15% | | |
| | | | | **TOTAL** | **20** | | |

Discussion

Due to the nature of wildfire suppression, and the arduous and hazardous environments WLFF face daily, injuries are bound to happen. However, with lack of injury prevention program implementation and trends of increased fire severity each year, WLFF are at even more risk. The aim of this project was to continue identifying the types of injuries WLFF are suffering through their occupation and compare to the trends in the literature. With this information we can begin delineating prevention tactics in the field to reduce the risk of injury to WLFF.

## Demographics

Analysis of demographic data to examine trends in WLFF that are reporting injuries permits a focused approach in injury prevention programming to target groups that are reporting higher incidence of injury. Self-report data from the current study suggests that WLFF at most risk for injury are male engine crew members between the ages of 25 and 34. This is further supported in the literature with similar crew types and age ranges reporting higher levels of injury.[15]

## Injuries Sustained

Tracking injuries in WLFF is difficult due to variability in reporting systems across agencies and the reliance upon self-reporting mechanisms. This limits data available in the literature describing injuries sustained by WLFF, requiring us to rely heavily on the work completed by Purchio[16] and Britton et al.[14-15, 18] In our WLFF injury study, musculoskeletal injuries accounted for 11.7% (n=574/4914) of all reported injuries/illnesses. Of the musculoskeletal injuries reported, the most commonly effected body region was the lower extremity, 32.8% (n=188/574). This finding is supported by Purchio[16] and Britton et al[14] who reported that lower extremity injuries were more likely to occur in WLFF 39.3% and 35.2% of the time, respectively.[14, 16]

As presented in Tables 3 and 4, the most common musculoskeletal injuries seen through our study were sprains/strains for Grayback Forestry and the self-report survey. This is another consistency found in the existing literature on injuries in WLFF. Britton et al[14] reports 29.4% of their injuries between 2003 and 2007 were sprains/strains. Purchio[16] reports a similar trend with joint sprains (25%) and muscle strains (15%) as the most prominent injuries reported.

Throughout the literature, slips/trips/falls have consistently been the cause for the majority of injuries that occur to WLFF. In Britton et al[14] 28.1% of injuries occurred due to slips/trips/falls. Similarly in Purchio[16] 29.9% of 453 injuries reported were caused by slips/trips/falls. In the two data sources used in our study that detailed the mechanism attributable for each injury, bite/sting/poison was the most prominent mechanism (33.3%) followed by slips/trips/falls (21.7%). In addition, there is a consistent association between the mechanism of injury and the type of injury sustained between all data sets. Slips/trips/falls accounted for over half of the sprains/strains reported in our study. This was the same trend as found in Britton et al[14]; slips/trips/falls accounted for almost half of all sprains and strains (49%) and additionally for fractures and dislocations (43%). Ultimately, the injury trends are consistent across all data sources, including our own data incorporated from this study.

By confirming these trends, we can now turn our focus to implementation of injury prevention strategies. These trends allow us to determine the central areas that should be targeted through injury prevention strategies.

## Injury Prevention Programming Strategies

Tactical professions such as law enforcement, military, and rescue services are starting to realize the importance of injury prevention techniques in order to keep their employees healthy.

Tactical athletes have occupational demands placed on them daily and unique physical training strategies that are necessary to fulfill their duties in their respective profession. When injuries begin to occur and keep these individuals from accomplishing their responsibilities appropriate interventions need to be implemented. Even though wildland firefighters are considered tactical athletes, there are minimal methods in place to reduce injury in this population. By assessing methods that are already in use with other tactical professionals we can better incorporate injury prevention techniques into the wildland firefighter setting. One of the prevention methods on the rise is incorporating athletic trainers into tactical athlete situations. Athletic trainers are historically found working in conjunction with athletes at different levels: high school, college, professional, recreational. However, athletic trainers bring a wide variety of skills that some occupational settings have recognized and begun to take advantage of to prevent injuries in their employees.

The armed forces are one of the few tactical athlete populations at this time that recognizes the benefits of providing athletic trainers for their employees. Over the course of the last several years, certified athletic trainers are being hired to assist both active duty soldiers and their dependents. These athletic trainers are being hired either as independent contractors or part of the Government Civil Service System.[25] In their initial appearance in the military setting in 2003, athletic trainers were hired by the Marine Corps in order to reduce injury by prevention through their Sports Medicine and Injury Prevention program (SMIP). As of 2013 there are 27 athletic trainers that work within the SMIP at entry level training sites around the nation.[26] The United States Navy has gone so far as to contract the services of six ATCs directly with the SEALs teams.[27] In August 2018 the Marine Corps showed no signs of slowing down either, and announced an investment up to $8.6 million annually for athletic trainers over the next ten years.

The service will spend $1.3 million in 2018 on athletic trainers, about $4.5 million in 2019 to increase the number of athletic trainers to 33 and then $8.6 million a year from 2020 to 2022. This will ultimately open up 66 positions for athletic trainers for the operating forces.[28]

Other tactical athletes have begun incorporating athletic trainers as well. In Fairfax, Virginia they began integrating an Injury Care and Prevention Program managed by a certified athletic trainer into law enforcement.[29] Law enforcement is a physically demanding job that has one of the highest rates of injuries and illnesses of all occupations.[29] By providing onsite clinical injury care, there is a prompt response to injury, which in turn helps decrease medical costs and generates a better prognosis for injured employees. In addition, athletic trainers can provide resources for additional wellness components including nutrition, stress reduction, maintaining appropriate blood pressure, concussion education and management, and general health education. Using an athletic trainer in a large county police force has proven to reduce overall medical costs by 22.05% and musculoskeletal medical costs by 21.2%.[29] Satisfaction with the athletic training services was assessed in 2010 through a survey and had very pleasing results. Law enforcement employees reported 96% satisfaction with the athletic trainer, 95% satisfaction with treatment and 94.5% satisfaction with the clinic.[29]

By highlighting the opportunities that already exist within the tactical athlete population, it shows the breadth of the athletic training field and how the services they provide can benefit new populations.

## Pilot Study: Integrating Athletic Trainers with Wildland Firefighters

### Project Summary

The pilot study will be conducted with the smokejumpers at the Missoula Smokejumper Base. To start we will be conducting movement and mobility screenings at the start of the season with each smokejumper who volunteers. Through this screening we will obtain injury history information for each smokejumper, and complete a functional movement screening, balance assessment, and flexibility assessment. Feedback on the screenings will be provided and corrective exercises prescribed. We will reassess mid-season and follow up at the end of season in order to track progress. Throughout the duration of fire season one AT will provide weekly consultation hours as well to allow smokejumpers to ask questions about their corrective exercises or update ATs on new injuries. An AT will record any new injuries that smokejumpers obtain throughout fire season in order to compile a complete data set of injuries. At the end of fire season and after the end of season movement and mobility screening, we will assess the satisfaction from WLFF on the athletic training services provided.

By providing movement and mobility screenings and providing consultation hours, we are hoping to reduce the number of injuries that occur to smokejumpers during fire season and maintain job performance. Each piece of the mobility and movement screening is explained in detail in Table 7 to give further support for their use.

### Movement Screening

Analysis of fundamental movements is a relatively new development in the rehabilitation and strength performance world. Assessing movement patterns in individuals to identify weaknesses or inefficiencies is a means to prevent them from adding fitness to dysfunction. The Functional Movement Screen (FMS) is a screening system that allows a practitioner to assess the fundamental movement patterns of an individual and provide an objective score. FMS is a screening tool comprised of seven different movements that tests individuals in both a dynamic and functional capacity. The main goal of performing FMS is to decrease the potential for injury, prevent re-injury and enhance performance ultimately leading to an improvement in quality of life.[30] For our purposes in this pilot study, the focus is on decreasing the potential for injury. This is not to be confused with FMS being used as a method to predict injury. There are inconsistencies in the research that prove this as an unreliable method for the use of FMS.[31-35] Instead FMS is utilized to determine asymmetries and imbalances with an individual that should be addressed through corrective exercise. By reestablishing functional movements through exercise, we anticipate a decrease in the risk of injury in WLFF.

Typically in a full FMS assessment, the seven movements are scored on a scale of zero to three for each movement, creating a composite score out of 21 points. An FMS specified value of 14 or below is suggested to indicate an elevated risk of injury.[36] However, Kazman et al[37] suggests that each movement needs to be assessed independently and the individual movement scores should be considered more than a composite score which was the original intentions of the screen. Only considering composite scores can be misleading for individual's going through the screening process. An individual with a high score (17-19) may believe they are at lower risk for injury when they actually need to address the low score on single events. That is why for this pilot study all seven movements will not be assessed; rather only the Deep Squat, Hurdle Step, and Rotary Stability will be included. These movements were selected based off of the demands placed on WLFF on a daily basis and the injury trends that have been identified in the literature.

Table 7 gives a further explanation of each movement and what the clinical implications are for each measure.

**Table 7.** FMS Tests included in the pilot study.

| FMS Test | Description of Test | Clinical Implications | Translation to Fireline |
|---|---|---|---|
| The Deep Squat[30] | **Starting position:** feet approximately shoulder width apart and the feet aligned in the sagittal plane. Hands on the dowel to assume a 90-degree angle of the elbows with the dowel overhead.<br><br>**Action:** dowel is pressed overhead with the shoulders flexed and abducted, and the elbows extended. Individual descends as far as they can into a squat position while maintaining an upright torso, keeping the heels and the dowel in position. Hold descended position for a count of one.<br><br>As many as three repetitions may be performed. If the criteria for a score of "3" is not achieved, the athlete is then asked to perform the test with a 2x6 block under the heels. | **Poor performance a result of the following:**<br>• Limited mobility in the upper torso can be attributed to poor glenohumeral and thoracic spine mobility.<br>• Limited mobility in the lower extremity including poor closed kinetic chain dorsiflexion of the ankles or poor flexion of the hips may also cause poor test performance.<br>• Limited stability/motor control of the core can also affect test performance. | The Deep Squat challenges total body mechanics and functional mobility of both the lower extremity and upper extremity. WLFF with asymmetries in the lower extremity could have decreased function on the fireline. A decrease in mobility causes compensations in movement patterns somewhere else, which will result in injury when the limits are reached. |
| Hurdle Step[30] | **Starting position:** individual places feet together, and toes touching the base of the hurdle. Hurdle is adjusted to the height of the individual's tibial tuberosity. The dowel is grasped with both hands and positioned behind the neck and across the shoulders.<br><br>**Action:** Individual asked to maintain an upright posture and step over the hurdle, raising the foot toward the shin, and maintaining alignment between the foot, knee, and hip, and touch their heel to the floor (without accepting weight) while maintaining the stance leg in an extended position. The moving leg is then returned to the starting position.<br><br>The hurdle step should be performed slowly and as many as three times bilaterally. If one repetition is completed bilaterally meeting the criteria provide, a "3"is given. | **Poor performance as a result of the following:**<br>• It may simply be due to poor stability of the stance leg or poor mobility of the step leg.<br>• Imposing maximal hip flexion of one leg while maintain hip extension of the opposite leg requires the athlete to demonstrate relative bilateral, asymmetric hip mobility. | Due to most injuries occurring from slips/trips/falls on the fireline, this test will replicate the WLFF ability to stabilize their body when stepping on uneven terrain while hiking to and from the fireline. |

| FMS Test | Description of Test | Clinical Implications | Translation to Fireline |
|---|---|---|---|
| Rotary Stability[38] | **Starting position:** Quadruped position, shoulders and hips at 90-degree angles relative to the torso, with the 2 x 6 board between their hands and knees. Knees positioned at 90 degrees and ankles dorsiflexed.<br><br>**Action:** flex at the shoulder and extend the same side hip and knee. Leg and hand are raised enough to clear the floor by approximately 6 inches. The same shoulder is then extended and the knee flexed enough for the elbow and knee to touch.<br>This is performed bilaterally, for up to three attempts each side.<br><br>If the individual cannot complete this maneuver (score a "3"), they are then instructed perform a diagonal pattern using the opposite shoulder and hip in the same manner as described for the previous test. They are also allowed three attempts at this test. | **Poor performance as a result of the following:**<br>• Requires asymmetric trunk stability in both the sagittal and transverse planes during asymmetric upper and lower extremity movement.<br>• If the trunk does not have adequate stability during these activities, kinetic energy will be dispersed (lost), leading to poor performance and increased potential for injury. | The use of chainsaws and clearing brush requires stabilization from the core to maintain good posture while working. The rotary stability test allows the clinician to identify any lack of core strength, which could put them at higher risk for injury to their back. |
| | **Spinal flexion clearing exam:** this movement is not scored; it is performed as a pain assessment. Clearing exam takes place after attempt at rotary stability. If pain occurs then a zero is given for the test. Spinal flexion is cleared by assuming a quadruped position, and then rocking back and touching the buttocks to the heels and the chest to the thighs. The hands should remain in front of the body, reaching out as far as possible. | | |

FMS is a reliable assessment tool that can be utilized between multiple raters with consistent outcomes and in a variety of populations. Rater experience is one area of reliability that has been assessed for FMS. Teyhen et al[39] examined whether the tester's experience plays a role in the outcome score between experts (10 years or more experience) or novices (certified functional movements specialist with up to 1 year experience). While the experts displayed high levels of interrater agreement, the novices showed good to excellent agreement.[39] Schneiders et al[40] also investigated interrater reliability with FMS scoring and found interrater reliability for the composite score as excellent and for individual test components as good to excellent agreement. Literature also exists to support the use of FMS in tactical, occupational settings. Peate et al[41] found the development and implementation of functional movement enhancement programs to prevent injuries in high risk work settings such as firefighters is warranted. Firefighters are among many other tactical groups such as police, officer candidates, and military recruits that have all implemented FMS as screening tool for injury prevention.[37, 42-48]

Balance Assessment

Impaired balance is one major risk factor that has been associated with an increased risk of lower extremity injury.[49-51] As part of our screening we will conduct a balance assessment utilizing the anterior reach of the Y balance Test to provide an objective measure for individual's neuromuscular control to determine if they are at an increased risk for injury. To measure anterior reach, individuals stand with their distal foot of the testing limb at the starting line and then reach with their free limb in the anterior direction while maintaining single leg stance.

Plisky et al[49] identified individuals with anterior reach asymmetries between their right and left limb greater than 4 cm were 2.5 times more likely to sustain a lower extremity injury. Therefore we will measure the anterior reach for each limb and calculate the difference for each WLFF to determine if asymmetry is present. WLFF will complete the anterior reach three times on each leg and a mean score will be calculated for each limb. In order to achieve optimal performance stability individuals will be allowed 4 practice trials for each limb prior to the three testing trials.[52]

Flexibility Assessment

For our flexibility assessment we will be focusing on the ankle joint. Specifically, we are going to measure ankle dorsiflexion through the weight bearing lunge test (WBLT). In order to find this range of motion, subjects will keep their test heel firmly planted on the floor while they flex their knee to the wall.[53] The opposite limb is positioned behind the test foot and used to maintain stability during the test. If individuals are able to touch their knee to the wall while maintaining heel contact, they are able to progress backwards from the wall and repeat the test. Dorsiflexion will be measured in centimeters and is defined as the distance from the great toe to the wall based on the furthest distance the heel maintained contact with the ground while the knee touches the wall.[53] Three practice trials will take place for each limb followed by three test trials with the average being recorded for each individual.

Assessing ankle dorsiflexion ROM is important to consider as part of an injury screening process because an overall decrease in dorsiflexion can put individuals at greater risk for injury. During normal landing mechanics the ankle plantar flexors play a major role in the absorption of landing forces, and any decrease in dorsiflexion results in a greater peak landing force due to the accompanied decrease in knee flexion and hip flexion.[54] A decrease in dorsiflexion ROM also results in greater knee valgus displacement and posterior ground reaction forces, which places excess stress on the knee capsule, especially the ACL.[54]

Timeline

An injury risk screening will take place at the beginning (mid-April), middle (end of June), and end of season (October). In order to give feedback to every smokejumper after their movement and mobility assessments, both ATs will need adequate time to review assessments and generate individual reports. This will quickly be followed by one on one meetings with each smokejumper and one AT to provide feedback and educate on corrective exercises prescribed. These meetings will take place within no more than a week of the initial screening in order to give timely results and allow smokejumpers to integrate corrective exercises to their physical training regimens.

After the assessments and consultations are completed, from mid-April until July 4$^{th}$ one AT will report to the Smokejumper Base 2 or 3 days a week for 2-3 hours at a time. This allows for smokejumpers to ask questions about their exercises, update on any new injuries, or for completion of additional screenings that may need to be finished or reviewed with WLFF. The last week of June another injury risk screening will take place and follow the same framework as the initial assessment. Then the following week, starting on July 4$^{th}$, one AT will be at the Smokejumpers Base on a daily basis for 2-3 hours every day to continue providing walk up consultations and maintenance or progression of corrective exercises for WLFF. The last week of October an end of season movement and mobility screening will take place. A graphic of the overall timeline is included to give an overall idea of the pilot project (Figure 1).

## Budget

The budget for this pilot study will be going towards personnel and equipment. Table 8 summarizes these rates further. The hours recorded are based on working with 70 smokejumpers total and over a 29 week time frame (mid-April through October). Each screening will take approximately 30 minutes per WLFF and is budgeted accordingly. Three Licensed Athletic Trainers will be utilized for assisting with all of the screenings and one licensed athletic trainer for AT consultation hours. Four Masters in Athletic Training students will assist with the screens at the beginning, middle and end of fire season. Two FMS kits will be needed in order to complete the injury risk screening assessments.

**Table 8.** Budget Breakdown for Pilot Project.

| **Certified Athletic Trainer (ATC)** | **Hourly Rate** | **Total Hours** | **# of people** | **Total Cost** |
|---|---|---|---|---|
| Beginning, middle, and end of season movement and mobility screening | $23.00 | 105 hours | 2 | **$4,830.00** |
| Injury assessment review and consultation with WLFFs | $23.00 | 105 hours | 2 | **$4,830.00** |
| Walk up AT consultation hours | $23.00 | 477 hours | 1 | **$10,971.00** |
| Allotted times for AT review and generation of reports from injury risk screenings | $23.00 | 52.5 hours | 2 | **$2,415.00** |
| Allotted times for AT documentation and program planning (mid-April through June – 11 weeks) | $23.00 | 10 hours | 1 | **$2,530.00** |
| Allotted times for AT documentation and program planning (July through October – 18 weeks) | $23.00 | 20 hours | 1 | **$8,280.00** |
| **Masters Athletic Training Students** | $10.00 | 105 hours | 4 | **$4,200.00** |
| **Equipment** | **Cost** | | **Quantity** | **Total Cost** |
| FMS kit | $271.95 | | 2 | **$543.90** |
| | | | **GRAND TOTAL** | **$38,599.90** |

Set up of Movement and Mobility Screening

The movement and mobility screenings will consist of six different stations, each ran by either a Licensed Athletic Trainer or a Masters in Athletic Training Student (Table 9). Prior to the movement and mobility screening, smokejumpers are expected to warm up as they deem necessary in order to complete these assessments to the best of their ability. Ideally this will take place right before each smokejumper begins the first step of completing an injury history questionnaire, allowing them to transition right away into the assessments. The smokejumpers will review their injury history with one of the Licensed Athletic Trainers. The purpose of the injury history is to identify a potential need for corrective exercises for any ongoing issues for a smokejumper, but also for consideration when analyzing reports.

Once the injury history has been adequately reviewed, the smokejumper will begin by completing the three FMS movements, followed by the weight bearing dorsiflexion lunge test and anterior reach balance. Smokejumpers will have the movements explained to them at each station. For all of the FMS movements the smokejumpers will be allowed three trials total. As for the weight bearing lunge test, each smokejumper is allowed three practice trials for each limb followed by three test trials with the average score being recorded. Finally for the anterior reach balance, smokejumpers are allowed up to four practice trials for each limb followed by three test trials with the best of the three being the final score. At the end of the screening each smokejumper will turn in their report and schedule a follow up time to consult with on of the licensed athletic trainers about their report. Appendix 1 includes the form that will be utilized to record injury history and report scores for each of the assessments completed with the smokejumpers.

**Table 9.** Set Up of Movement and Mobility Screening

| Station | Equipment Needed | Personnel |
|---|---|---|
| **Injury History** | Injury history questionnaire, filled out by smokejumper and reviewed with AT | Licensed AT |
| **The Deep Squat** | FMS Kit – 2x6 board, dowel | Licensed AT |
| **Rotary Stability** | FMS Kit – 2x6 board | Licensed AT |
| **Hurdle Step** | FMS Kit – dowel and hurdle | Licensed AT |
| **WB DF Lunge Test** | Tape measure | 2 Masters in AT Student |
| **Anterior Reach Balance** | Tape measure | 2 Masters in AT Student |
| **Schedule Follow Up** | Return scoring sheet to Licensed ATs and schedule follow up | |

Pilot Project Summary Report

Data to be Analyzed

- Movement screens pre, mid and post season
- WLFF Satisfaction Survey with AT Services
- Patient encounter log

Project Aim #1: Successfully develop a movement and mobility screening to incorporate for smokejumpers in order to reduce their incidence of injury.

- Licensed ATs will document injuries sustained during the 2019 fire season utilizing the WFIIR during AT consultation hours
- Compare injuries reported during the 2019 fire season to injury trends in the literature and to injury history given from each smokejumper
- Utilize MedBridge to generate corrective exercise programs and hand out to smokejumpers

Project Aim #2: Compile data set of FMS scores for future implementation in the WLFF community.

- Record scores for each smokejumper at the pre, mid and post season movement and mobility screenings

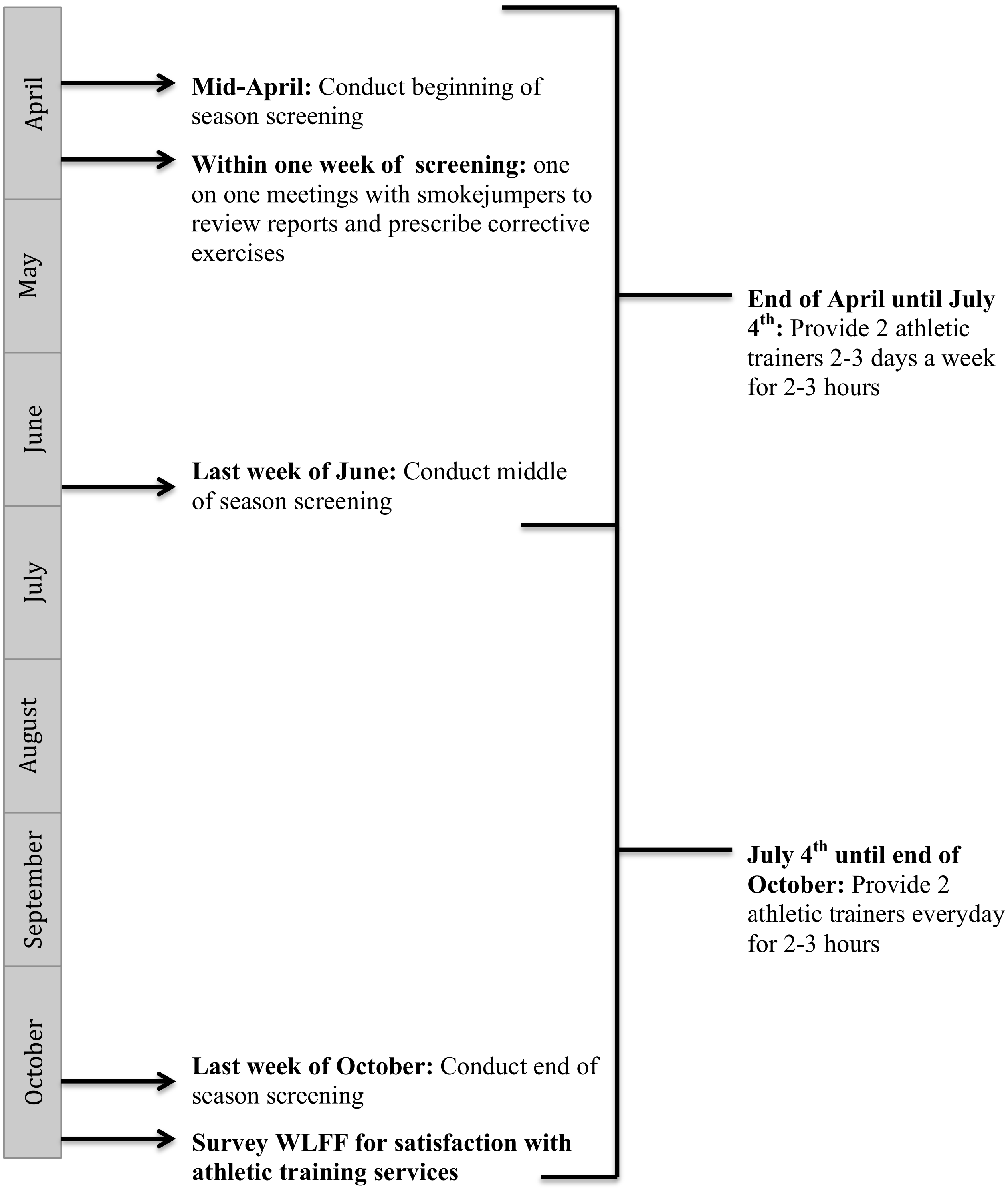
Project Aim #3: Introduce the athletic training profession to the WLFF community.

- Every encounter between the Licensed AT and a smokejumper will be documented in a patient encounter log in order to journal the nature of contact with the smokejumpers throughout the pilot project
- Smokejumpers will be given a satisfaction survey at the end of fire season to give feedback on AT services provided throughout the season

Conclusion

Conducting a pilot project would provide an opportunity to implement prevention techniques with this tactical population. Conducting injury risk screenings and prescribing corrective exercises in order to reduce injury rates would benefit the WLFF community and keep these employees performing at optimal levels. In addition, consistent documentation of injuries would help close the gap in the literature on injuries sustained by WLFF which could continue to drive forward the implementation of injury prevention techniques. These tactical athletes are in need of prevention tools to keep them on the line and performing their duties successfully.

**Figure 1.** Timeline of athletic training pilot project.



References:

1. National Interagency Fire Center. https://www.nifc.gov/fireInfo/fireInfo_stats_totalFires.html. Accessed on August 29, 2018.
2. Forest Service Wildland Fire Suppression Costs Exceed $2 Billion. USDA. https://www.usda.gov/media/press-releases/2017/09/14/forest-service-wildland-fire-suppression-costs-exceed-2-billion Accessed on August 29, 2018.
3. 2015 Fire Budget Report. United States Department of Agriculture. https://www.fs.fed.us/sites/default/files/2015-Fire-Budget-Report.pdf. Accessed on August 29, 2018.
4. Federal Firefighting Suppression Costs. National Interagency Fire Center. https://www.nifc.gov/fireInfo/fireInfo_documents/SuppCosts.pdf. Accessed on September August 29, 2018.
5. Wildland Fire. U.S. Forest Service. https://www.fs.fed.us/managing-land/fire. Accessed on September 1, 2018.
6. National Wildfire Coordinating Group https://www.nwcg.gov/. Accessed on September 1, 2018.
7. Forests and Rangelands. The National Strategy: The Final Phase in the Development of the National Cohesive Wildland Fire Management Strategy. https://www.forestsandrangelands.gov/strategy/thestrategy.shtml. Accessed on September 1, 2018.
8. National Interagency Coordination Center. 2018 National Interagency Mobilization Guide. Chapter 30: Crews. https://www.nifc.gov/nicc/mobguide/Chapter%2030.pdf.

Accessed on September 4, 2018.

9. Wildfire Jobs Department of Interior. https://www.firejobs.doi.gov/index.php?action=crews. Accessed on September 4, 2018.

10. National Parks Service. Wildland Fire Management Personnel. https://www.nps.gov/articles/wildland-fire-management-personnel.htm. Accessed on September 4, 2018.

11. Fire and Aviation Management: Risk Management. Essential Functions and Work Conditions of a Wildland Firefighter. https://www.fs.fed.us/managing-land/fire/safety/wct. Accessed on September 4, 2018.

12. Cuddy JS, Sol JA, Hailes WS, Ruby BC. Work Patterns Dictate Energy Demands and Thermal Strain During Wildland Fire fighting. Wilderness Environ Med. 2015;26(2):221-226.

13. U.S. Department of Labor. US Occupational Outlook Handbook: Firefighters. http://www.bls.gov/ooh/protective-service/firefighters.htm. Accessed on September 4, 2018.

14. Britton C, Lynch C, Ramirez M, Torner J, Buresh C, Peek-Asa C. Epidemiology of injuries to wildland firefighters. *American Journal of Emergency Medicine* 2013;31:339-345.

15. Britton C, Ramirez M, Lynch C, Torner J, Peek-Asa C. Risk of injury by job assignment among federal wildland firefighters, United States, 2003–2007. *Int Journal of Occ and Environ Health* 2013;19(2):77-84.

16. Purchio, T. Descriptive analysis of injuries sustained by wildland firefighters. *ScholarWorks at University of Montana* 2017.

17. Mangan A. A needs assessment: barriers to wildland firefighters fitness training. *Scholarworks at University of Montana* 2015.

18. Britton C. Risk factors for injury among federal wildland firefighters in the United States. *Iowa Research Online.* May 2010.

19. United States Department of Interior. DOI Safety Management Information System. https://safetynet.doi.gov/information/managers/smis.html. Accessed September 3, 2018.

20. Butler C, Marsh S, Domitrovich JW, Helmkamp J. Wildland Fire Fighter Deaths in the United States: A Comparison of Existing Surveillance Systems. J Occup Environ Hyg. 2016;14(4):258-270.

21. Medical Incident Report. https://www.nwcg.gov/sites/default/files/products/ics-forms/ics_206_wf.pdf Accessed on September 8, 2018.

22. On the Line Podcasts. http://ontheline.libsyn.com/ Accessed on September 8, 2018.

23. Wildland. The Black Performance. http://www.wildland.land/ Accessed on September 8, 2018.

24. Chaney R. Tactical athletes: Forest Service adds PT to logging training. https://missoulian.com/news/local/tactical-athletes-forest-service-adds-pt-to-logging-training/article_a506e320-ce4e-51b0-956e-a453be6373c1.html Accessed September 11, 2018.

25. National Athletic Trainers Association. Emerging Settings: Military. https://www.nata.org/professional-interests/emerging-settings/military. Accessed on February 7, 2019.

26. Vera Cruz J. Inside the military setting 2013. https://www.nata.org/sites/default/files/professional-interests-military-marines-nata-news.pdf. Accessed on February 7, 2019.

27. National Athletic Trainer's Association. Current Status of ATCs in the Military. 2004. https://www.nata.org/sites/default/files/Status-of-ATCs-in-the-Military.pdf. Accessed on February 7, 2019.

28. Harkins G. Athletic trainers will head out to marine units after years-long delay. August 17, 2018. https://www.military.com/daily-news/2018/08/17/athletic-trainers-will-head-out-marine-units-after-years-long-delay.html Accessed on February 7, 2019.

29. Burke NC. Reducing law enforcement medical costs: utilizing the sports medicine model. https://www.nata.org/sites/default/files/reducing-law-enforcement-medical-costs.pdf Accessed on February 7, 2019.

30. Cook G, Burton L, Hoogenboom B. Pre-Participation Screening: The Use of Fundamental Movements As An Assessment of Function–Part 1. *North Am J Sport Phys Ther NAJSPT*. 2006;1(2):62. doi:10.1055/s-0034-1382055.

31. Warren M, Lininger MR, Chimera NJ, Smith CA. Utility of FMS to understand injury incidence in sports: current perspectives. *Open Access J Sport Med*. 2018:9-171. doi:10.2147/OAJSM.S149139.

32. Koehle MS, Saffer BY, Sinnen NM, MacInnis MJ. Factor Structure and Internal Validity of the Functional Movement Screen in Adults. *J Strength Cond Res*. 2016;30(2):540-546. doi:10.1519/jsc.0000000000001092.

33. Kraus K, Schütz E, Taylor WR, Doyscher R. Efficacy of the functional movement screen: A review. *J Strength Cond Res*. 2014;28(12):3571-3584. doi:10.1519/JSC.0000000000000556.

34. Dorrel B, Long T, Shaffer S, Myer GD. The functional movement screen as a predictor of injury in national collegiate athletic association division ii athletes. *J Athl Train*. 2017:1062-6050-528-15. doi:10.4085/1062-6050-528-15.

35. Warren M, Smith CA, Chimera NJ. Association of the functional movement screen with injuries in division i athletes. *J Sport Rehabil*. 2015;24(2):163-170. doi:10.1123/jsr.2013-0141.

36. Kiesel K, Plisky PJ, Voight ML. Can serious injury in professional football be predicted by a preseason functional movement screen? N Am J Sports Phys Ther . 2007; 2(3): 147-158.

37. Kazman, JB, Galecki, JM, Lisman, P, Deuster, PA, and O'Connor, FG. Factor structure of the functional movement screen in marine officer candidates. *J Strength Cond Res.* 2014; 28: 672–678.

38. Cook G, Burton L, Hoogenboom BJ, Voight M. Functional movement sscreening: the use of fundamental movements as an assessment of function-part 2. *N Am J Sports Phys Ther.* 2006;1(3):6132-139.

39. Teyhen DS, Shaffer SW, Lorenson CL, et al. The functional movement screen: a reliability study. *J Orthrop Sports Phys Ther.* 2012; 42(6): 530-540. doi: 10.2519/jospt2012.3838.

40. Schneiders, AG, Davidsson, A, Ho¨ rman, E, and Sullivan, SJ. Functional movement screen normative values in a young, active population. *Int J Sports Phys Ther*. 2011; 6: 75–82.

41. Peate WF, Bates G, Lunda K, Franics S, Bellamy K. Core strength: a new model for injury prediction and prevention. *Journal of Occupational Med and Toxicology.* 2007; 2(3):1-9.

42. Stanek JM, Dodd DJ, Kelly AR, Wolfe AM, Swenson RA. Active duty firefighters can improve functional movement screen (fms) scores following an 8-week individualized client workout program. *Work.* 2017;56(2):213-220. doi:10.3233/WOR-172493.

43. Orr RM, Pope R, Stierli M, Hinton B. A functional movement screen profile of an Australian state police force: A retrospective cohort study. *BMC Musculoskelet Disord*. 2016;17(1):1-7. doi:10.1186/s12891-016-1146-0.

44. O'Connor FG, Deuster PA, Davis J, Pappas CG, Knapik JJ. Functional movement screening: Predicting injuries in officer candidates. *Med Sci Sports Exerc*. 2011;43(12):2224-2230. doi:10.1249/MSS.0b013e318223522d.

45. Everard E, Lyons M, Harrison AJ. examining the association of injury with the functional movement screen and landing error scoring system in military recruits undergoing 16 weeks of introductory fitness training. *J Sci Med Sport*. 2018;21(6):569-573. doi:10.1016/j.jsams.2017.05.013.

46. Butler RJ, Contreras M, Burton LC, Plisky PJ, Goode A, Kiesel K. Modifiable risk factors predict injuries in firefighters during training academies. *Work*. 2013;46(1):11-17. doi:10.3233/WOR-121545.

47. Sefton JM, Lohse KR, McAdam JS. Prediction of injuries and injury types in army basic

training, infantry, armor, and cavalry trainees using a common fitness screen. *J Athl Train*. 2016; 51(11):849-857. doi:10.4085/1062-6050-51.9.09.

48. Frost DM, Beach TA, Callaghan JP, McGill SM. Using the Functional Movement Screen to Evaluate the Effectiveness of Training. *J Strength Cond Res*. 2012; 26(6):1620-1630. https://ovidsp.tx.ovid.com/sp-3.19.0a/ovidweb.cgi.
49. Plisky PJ, Rauh MJ, Kaminski TW, Underwood FB. Star Excursion Balance Test as a predictor of lower extremity injury in high school basketball players. *J Orthop Sports Phys Ther*. 2006; 36: 911-9.
50. Vrbanic TS, Ravlic-Gulan J, Gulan G, Matovinovic D. Balance index score as a predictive factor for lower sports results or anterior curciate ligament knee injuries in Croatian female athletes: preliminary study. *Coll Antropol.* 2007; 31:253-8.
51. Trojian TH,, McKeag DB. Single leg balance test to identify risk of ankle sprains. *Br J Sports Med*. 2006; 40:610-613.
52. Robinson RH, Gribble PA. Support for a reduction in the number of trials needed for the star excursion balance test. *Arch Phys Med Rehabil*. 2008; 89: 364-370.
53. Vicenzino B, Branjerdporn M, TeysP, et al. Initial changes in posterior talar glide and dorsiflexion of the ankle after mobilization with movement in individuals with recurrent ankle sprain. *J Orthrop Sport Phys Ther*. 2006; 36(7):464-71.
54. Fong CM, Blackburn JT, Norcross MF, McGrath M, Padua DA. Ankle-dorsiflexion range of motion and landing biomechanics. *J of Ath Training.* 2011; 46: 5-10.

**Appendix 1: Smokejumper Movement and Mobility Screen Scoring Sheet**

☐ Pre-season ☐ Mid-season ☐Post-season

NAME DATE

GENDER: ☐ Male ☐ Female DOB: AGE:

DOMINANT HAND: R L DOMINANT LEG: R L

PREVIOUS TEST SCORE:

INJURY HISTORY:

1. Have you ever injured or consulted a doctor about any injury to the:

| **Body Part/Region** | **YES** | **NO** | **Injury Sustained** |
|---|---|---|---|
| Head/Face | | | |
| Chest/Abdomen | | | |
| Neck | | | |
| Mid/Lower back | | | |
| Pelvis/Hip/Thigh | | | |
| Knee | | | |
| Foot/Ankle/Toes | | | |
| Shoulders | | | |
| Elbow/Forearm | | | |
| Wrist/Hand/Fingers | | | |

2. Have you ever had the following medical conditions?

| **Illness** | **YES** | **NO** | **Comments** |
|---|---|---|---|
| Diabetes (Type I or II) | | | |
| Blood disease (sickle cell, leukemia) | | | |
| Epilepsy/Seizure Disorder | | | |
| Gout | | | |
| Heart Disease | | | |
| High Blood Pressure | | | |
| Mental disorders/depression | | | |
| Tuberculosis | | | |
| Drug and/or alcohol dependency | | | |
| Cancer | | | |
| Asthma | | | |
| Gastrointestinal Disorder (i.e. ulcer, IB) | | | |
| Heat Illness | | | |
| Migraine Headaches | | | |
| Allergies | | | |

| | YES | NO |
|---|---|---|
| Have you had or do you have any other medical problems or injuries not listed on this form? | | |
| Do you have any medical or health problems that you are currently receiving treatment for? | | |
| Have you ever been advised by a physician not to participate in physical activity? | | |

If YES to any of the questions above, please explain:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Mobility and Movement Assessment:

| **TEST** | | **RAW SCORE** | | | **FINAL SCORE** | **COMMENTS** |
|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | | |
| DEEP SQUAT | | | | | | |
| HURDLE STEP | L | | | | | |
| | R | | | | | |
| ROTATIONAL STABILITY | L | | | | | |
| | R | | | | | |
| **TOTAL SCORE** | | | | | | |
| ANTERIOR REACH | L | | | | | |
| | R | | | | | |
| WB DF LUNGE TEST | L | | | | | |
| | R | | | | | |