

## **Modeling Wildland Firefighter Travel Rates by Terrain Slope: Results from GPS-Tracking of Type 1 Crew Movement**

[www.nrfirescience.org/resource/21926](http://www.nrfirescience.org/resource/21926)

Escape routes keep firefighters safe by providing efficient evacuation pathways from the fire line to safety zones. Effectively utilizing escape routes requires a precise understanding of how much time it will take firefighters to traverse them. To improve this understanding, we collected GPS-tracked travel rate data from US...

Author(s): Patrick R. Sullivan, Michael J. Campbell, Philip E. Dennison, Simon C. Brewer, Bret W. Butler

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Book or Chapter or Journal Article

## **Lab-scale observations of flame attachment on slopes with implications for firefighter safety zones**

[www.nrfirescience.org/resource/17884](http://www.nrfirescience.org/resource/17884)

The Coanda effect is the phenomenon in which a jet entering quiescent fluid attaches to a nearby solid object due to inhibited entrainment of ambient fluid near the solid. Little is known about the influence of the Coanda effect on wildland fire behavior. Specifically, there is a lack of knowledge regarding how the flame attachment...

Author(s): Jonathan R. Gallacher, Brad Ripa, Bret W. Butler, Thomas H. Fletcher

Year Published: 2018

Type: Document

Book or Chapter or Journal Article

## **An empirically based approach to defining wildland firefighter safety and survival zone separation distances**

[www.nrfirescience.org/resource/16748](http://www.nrfirescience.org/resource/16748)

Wildland firefighters in the US are mandated to identify areas that provide adequate separation between themselves and the flames (i.e. safety zones) to reduce the risk of burn injury. This study presents empirical models that estimate the distance from flames that would result in a low probability (1 or 5%) of either fatal or non-...

Author(s): Wesley G. Page, Bret W. Butler

Year Published: 2017

Type: Document

Book or Chapter or Journal Article

## **Safe separation distance score: a new metric for evaluating wildland firefighter safety zones using Lidar**

[www.nrfirescience.org/resource/16910](http://www.nrfirescience.org/resource/16910)

Safety zones are areas where firefighters can retreat to in order to avoid bodily harm when threatened by burnover or entrapment from wildland fire. At present, safety zones are primarily designated by firefighting personnel as part of daily fire management activities. Though critical to safety zone assessment, the effectiveness of...

Author(s): Michael J. Campbell, Philip E. Dennison, Bret W. Butler

Year Published: 2016

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Book or Chapter or Journal Article

## **Recent findings relating to firefighter safety zones**

[www.nrfirescience.org/resource/16918](http://www.nrfirescience.org/resource/16918)

Designation of safety zones is a primary duty of all wildland firefighters. Unfortunately, information regarding what constitutes an adequate safety zone is inadequately defined. Measurements of energy release from wildland fires have been used to develop an empirically based safety zone guideline. The basis for this work is...

Author(s): Bret W. Butler, Russell A. Parsons, William E. Mell

Year Published: 2015

Type: Document

Conference Proceedings

### **Wildland firefighter safety zones: A review of past science and summary of future needs**

[www.nrfirescience.org/resource/16900](http://www.nrfirescience.org/resource/16900)

Current wildland firefighter safety zone guidelines are based on studies that assume flat terrain, radiant heating, finite flame width, constant flame temperature and high flame emissivity. Firefighter entrapments and injuries occur across a broad range of vegetation, terrain and atmospheric conditions generally when they are within...

Author(s): Bret W. Butler

Year Published: 2014

Type: Document

Book or Chapter or Journal Article

### **The effect of terrain slope on firefighter safety zone effectiveness**

[www.nrfirescience.org/resource/16934](http://www.nrfirescience.org/resource/16934)

The current safety zone guidelines used in the US were developed based on the assumption that the fire and safety zone were located on flat terrain. The minimum safe distance for a firefighter to be from a flame was calculated as that corresponding to a radiant incident energy flux level of  $7.0\text{kW}\cdot\text{m}^{-2}$ .

Current firefighter safety...

Author(s): Bret W. Butler, Jason M. Forthofer, Kyle S. Shannon, Daniel M. Jimenez, David Frankman

Year Published: 2010

Type: Document

Conference Proceedings

### **Firefighter safety zone: the effect of terrain slope of separation distance**

[www.nrfirescience.org/resource/16930](http://www.nrfirescience.org/resource/16930)

Perhaps one of the most critical decisions made on wildland fires is the identification of suitable safety zones for firefighters during daily fire management operations. To be effective (timely, repeatable, and accurate), these decisions rely on good training and good judgement. The current safety zone guidelines used in the US (...)

Author(s): Bret W. Butler, Jason M. Forthofer

Year Published: 2010

Type: Document

Conference Proceedings

### **Efforts to update firefighter safety zone guidelines**

[www.nrfirescience.org/resource/16935](http://www.nrfirescience.org/resource/16935)

One of the most critical decisions made on wildland fires is the identification of suitable safety zones for firefighters during daily fire management operations. To be effective (timely, repeatable, and accurate), these decisions rely on good training and judgment, but also on clear, concise guidelines. This article is a summary of...

Author(s): Bret W. Butler

Year Published: 2009

Type: Document

Book or Chapter or Journal Article

**Characterization of firefighter safety zone effectiveness - Final Report to the Joint Fire Science Program**

[www.nrfirescience.org/resource/11153](http://www.nrfirescience.org/resource/11153)

Firefighters are required to pay close attention to fire behavior and have safety zones readily available in case of unexpected fire behavior. However, safety zone location and size are often a matter of anecdotal evidence, personal experience, and untested models. This is particularly troublesome for younger firefighters that...

Author(s): Bret W. Butler

Year Published: 2005

Type: Document

Technical Report or White Paper

**Lookouts, communication, escape routes, safety zones**

[www.nrfirescience.org/resource/15460](http://www.nrfirescience.org/resource/15460)

In a presentation to the USDA Forest Service's national Fire and Aviation Staff, Gleason provides a clear overview of his proposed Lookouts, Communication, Escape Routes, Safety Zones (LCES) method of training firefighters for greater safety. After defining LCES, he discusses how it should be implemented on the ground. He emphasizes...

Author(s): Paul Gleason

Year Published: 1991

Type: Document

Management or Planning Document