Burning Bear™

Prescribed Burn Training Program

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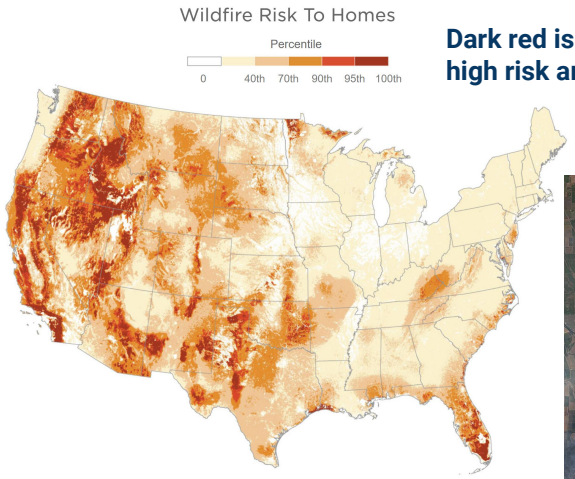
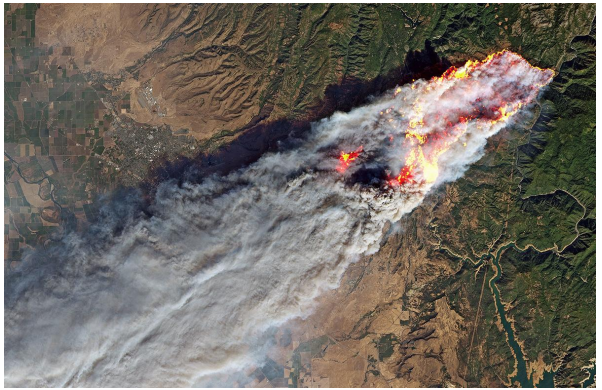
Fires are becoming more frequent, larger and deadly.



Dark red is 100th percentile of high risk areas of wildland fires.



- **1.9 million homes** are at risk in **15 high-risk states**[1]
- 2020 - more than **8,200 fires** have **burned over 4 million acres.**[2]
- Devastating California wildfires predicted to **cost US economy $85 billion**.[3]

[1]NPR Oct.21,2020 [2]NBC News Oct. 4, 2020 [3]Brian Lada - AccuWeather meteorologist & staff writer
https://www.npr.org/2020/10/21/924507691/millions-of-homes-are-at-risk-of-wildfires-but-its-rarely-disclosed

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Wildland Fires Are Necessary for our Ecosystem

Wildland Fires Can Be A Benefit

- Forest fires help to kill disease
- It provides nutrients for new generations of growth
- It refreshes the habitat zones
- Low intensity fires don’t usually harm trees

BUT

- A forest fire sets up the potential for soil erosion to occur
- Forest fires always bring death in some form
- Uncontrolled fires can cause local or regional air pollution
- Homes can be destroyed without compensation

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Fire Fighter (FF) live training can be dangerous.

- Between 1977 and 2018, **361 FFs died during training activities**[1]
- **8,175 firefighting injuries** incurred **during training activities**[2]
- **9 out of 10 FFs can't get real-time expert feedback** while training
- **Lack of training, experience**, or medical clearance was implicated in **fatalities for 100 out of 176 firefighters**[3]

[1]U.S. Firefighter Deaths Related to Training, 2009–2018 Rita Fahy, May 2020
[2,3]US Firefighter Injuries in 2019 NFPA Research

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What is *Fire Control Burn*?

Prescribed fire cuts the intensity of a wildfire by 76% and its burned area by 37%. International Journal of Wildland Fire 2003

The concept of 'fighting fire with fire' is using prescribed fire to burn out its fuel, such as dry vegetation, to stop it's spread. This operation is controlled by a burn boss, who is in charge of all aspects of the burn. Burn bosses are familiar with firebreak preparation, appropriate weather conditions during/after the burn, equipment required, area being burned, and is responsible for deciding whether to proceed with the burn operation.

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The problems with today's control burn training.

- **Timing with a small window** - Limited to 1 class per year and dependent on ideal conditions
- **Available and accessible location** - suitable land must be available to burn.
- **Limited Class Size**
- **Current Training**
  - Chalkboard training
  - Training on a actual control burn or wildfire.
  - Live burn training is difficult to schedule and carry out successfully.
- **Estimated cost: $2,500 per student (4-day class)**

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Can control burn training be better?

“The planning & systematic procedures of burning a designated area, & keeping it “controlled,” must be done in a hands on approach.”
Bruce Barron - Division Chief
Central San Mateo County Training Division

“It is absolutely unsafe and a disservice to the fire service to give out these certificates to those who only attend classroom only training.”
Logun Fagundes - Firefighter, Engineer
Santa Clara County Fire Department

“...firing is a skill the fire service must get right, and creating a classroom only or one day firing class is negligent and irresponsible.”
Ryan Hamre - Battalion Chief,
Hayward Fire Department, Training Division

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Virtual Reality (VR)
Fire Control Burn Program

Guardian Airwaves' **Burning Bear**™ program:

- 3D VR simulation training for fire control burn.
- Has preset environmental conditions with user or instructor inputs.
- Its prototype was tested by 125 wildland firefighters.
- Platform allows single or multiple trainees at a time.

Our modules are:

Repeatable

Measurable

Not injurious to its trainees

.

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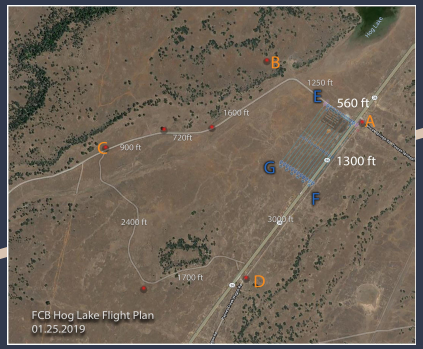
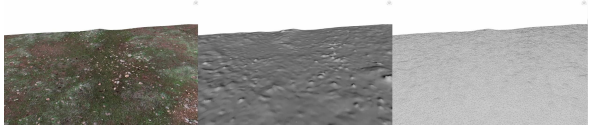
The Prototype



The **Burning Bear**™ prototype was modeled after the Hog Lake area in Tehama County. Its terrain is flat with annual grass. Slopes surround this area with nearby hills.



Aerial Photogrammetry for 3D Image based modeling.

Topography Map

This location is ideal for advancing levels of control burn training. We started with a simple environment of short annual grass with fuel moisture of 10 and various North wind speeds of 3-12 mph. The challenge was to get the grass burning in the shape and rate of a flame spread based on real fire behavior data. Visual effects of smoke and burned areas were added to indicate a live burn. Its grass was also affected by wind dynamics. These environmental factors were presented on a virtual clipboard.

Firefighters, (CAL FIRE, USFS, USFW, Glenn County) with extensive experience in control burning, rated the **Burning Bear**™ prototype's firing simulation with a score of 8 out of 10. They were able to use the drip torch and fusee flare as done in real-life training and the vegetation burned as expected.

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Training Goals

The **Burning Bear**™ VR training goals are simple, but require high computing processing to produce realistic real-time environmental conditions and with an experienced visual effects team.

- Analyze the topographic map of the designated burn area.
- Inputs of variables of fuel type, weather data (temperature, relative humidity, wind speed and direction) by the proctor or trainee themselves.
- Develop a burn plan for the prescribed area using standard NWCG procedures, with single or multiple trainee in the same virtual environment. A contingency plan for fire escape should also be formed.
- Execute that burn plan in successfully burning that designated area without fire escaping the area.
- Conduct a post-event review of the event (including the given weather conditions' effects on burn operations and coordination of burners).

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Virtual Reality (VR)
Fire Control Burn Program

Collaborative Partner

CALIFORNIA DEPARTMENT OF FORESTRY & FIRE PROTECTION
CAL FIRE
SINCE 1885

Tehama Glenn Unit (TGU)

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Future Research

Will ML Modernize Firefighting Training?

- Computational fluid dynamics (CFD) to create fire models that can, when expertly used, be powerful design and safety tools.
- Topography and fuels are significant factors affecting potential fire spread and burn severity.
- Predicting potential fire control locations for pre-fire planning and operational fire management.
- Will our training modules be the basis for actual tools in real-time fires
- Real fire before the Simulated fire or Simulate the fire before the Real Fire

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Burning Bear™

Virtual Reality(VR)
Fire Control Burn Program

Prototyping

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Does it meet the needs of its users?

Assessment of Virtual Reality Training for Firefighters

The Burning Bear™ was tested by 125 Northern California firefighters of CALFIRE-TGU, US Wildlife & Fish, US Forestry Service, and Glenn County. These firefighters held ranks from Chief Officer to Firefighter.

Burning Bear™ prototype is a VR control burn simulation on a flat terrain with annual grass.

The trainee was to assess the virtual environment, plan, and execute a control burn.

The product designer, software engineers, and a proctor were present during testing sessions. The team observed and readily assisted in the VR training process or hardware performance issues. Video captures from the perspective of the user were recorded and after-experience surveys were filled out by each participant.

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Usability Assessments

Burning Bear™ Prototype 1 Usability Assessment

Burning Bear™ Fire Control Burn Simulation Training

Usability Assessment	User Average Responses	Notable Comments from Participants
Effectiveness: Were you able to ignite the vegetation with the fusee and drip torch?	YES – 78% NO – 22%	"Grass lit as expected"/ "It was nice to see it light right away"/ "The VR fusee and drip torch were easy to use, worked like real"/ "I need the connector for the fusee so I am not bending down all the time." "The fusee wouldn't come with me."/ "I lost/dropped my fusee."/ "The drip torch hung in the air."
Efficiency: Time to burn out all the grass	8-10 minutes	"The field burned out quick."/ "Nothing to do, after." / "The drip torch fuel ran out too fast."
Number of drip torch tilts/pours	8	"The fuel dripped like real."/ "I wish I could feel how much fuel I have left by the can's weight do I know how much to conserve."/ "Size of can is realistic. its proportional to real-life. "Looks like a real one."
Fusee touch contact with grass	10-12 touch points	"If you sweep too fast, the fusee does not light the grass./ "I lost my fusee "Attach it to the user so it doesn't get lost, or have to travel back to the engine."
Learnability: How long did it take to complete the task?	7-9 min	"I was looking around."/ "I lost my way."/ "I didn't know what direction I was looking at."/ "The call-ups for the map were easy"/ "Fast learning curve with the tech, and the way you go."
Memorability: Did you remember what to do for the 6 mph & 12 mph scenarios?	100% Yes	"Pretty easy."
How long did it take you to complete the task the second time?	8 minutes	
Error Rate:	5 Types of Errors	Error Rating: 1 – Visual Misinterpretation 2 - Able to Continue Task Easily 3 - Recover with Difficulty 4 - Restart Module System (Reboot)
	Dropped igniting tools	3
	Slow in orienting to where North is.	2
	Move too far-off terrain	1
	Did not know about torch fuel gauge, ran out of fuel. HUD was blurry.	1 & 4: Did not complete task
	Participant kept teleporting to the air	4: Participant pointed up and teleported.
Satisfaction: 1-Poor, 2-OK, 3-Fair, 4-Good 5-Very Good, 6-Excellent	Overall Ratings were 5 Environment – 5 Fire behavior – 5 Complexity - 3	"Great concept!"/ "Will get better with time."/ "More smoke needed"/ "..needs varying flame lengths"/ "add different firing methods"/ "I would like to see more wind speeds."

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User Experience Assessments

Burning Bear™ Prototype 1 Experience Assessment

Burning Bear™ Fire Control Burn Simulation Training

User Experience Assessment	Survey		Users Comments
Sensual	Sight		More smoke, more varying terrain, glitchy at times, more grass please, landmarks needed, flame length needs be higher to see fire from a distance
Sound: 1-Poor, 2-OK, 3-Fair, 4-Goo 5-Very Good, 6-Excellent	Burning Sound of Igniting Tools, Burning grass	Average rating is a 4 - Good	Nice crackling sound, "I didn't hear anything."/ "I heard it on the drip torch but not the fusee."
Touch:1-Poor, 2-OK, 3-Fair, 4-Goo 5-Very Good, 6-Excellent	Handling of the controller as if a drip torch or fusee	Average rating is a 2 - Ok	
Emotional		Apprehension	"I am good at firing but not game playing."/ "This is great! I want to see more!" / "We can really use something like this."
Social	N/A	Single user module, but they encouraged each other during the sessions	"I want a multi-user experience"/ "I want an instructor in with me for immediate feedback."
Contextual		The testing sessions took place in large rooms (10'x12, 8'x10') at a Fire Department training facility and agency headquarters	"This would be great in one training center."/ "Would be nice to have one at each station.."/ "needs more firing tools"
Compositional/Holistic		The scene is virtual and is limited by the actual physical space where the interaction can take place to move about the virtual environment.	"Very cool training system."

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Problems to address

The idea of using VR as a training module seems feasible to develop and in time be accepted as a training platform. Reviewing the ratings and user comments of the usability and user experience assessments, it seems the main problems of this prototype were:

- The VR igniting tools did not respond immediately at times.
- The users lost orientation and did not know where to start their fire line.
- No haptic feedback of the drip torch being lighter as its fuel is used.
- Visual feedback of fire behavior from a distance was minimal, needed more smoke.
- The igniting tools were dropped.
- Did not replicate a true crew training experience.
- The task was not complex enough.

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Prototype 2 - Iteration

Another reiteration of this module with the following recommendations should be prototyped and compared with the first version. The improvements would be:

1. optimize the GPU performance for a smooth interactive experience
2. include a compass in the HUD
3. couple the VR controllers with the actual physical igniting tools
4. add resistance to the controllers
5. increase fire behavior inputs to dramatize visual effects by a certain set percentage
6. provide a multiuser module
7. add complexity in terrain, landmarks, sun, shadows, and real-world effects.
8. more firing and suppression tools will be available.
9. Have a multi-user platform will be developed but needs to balance with computing performance.
10. Aerial zooming in on an aerial map with real-time location of crew members.

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Implementing this VR platform

There are many, many supportive articles stating virtual reality is the next platform for training. But to date, there has not been a fire control burn simulation publicized. Burning Bear™ is a unique program and its development is confidential and not to be shared outside of this engagement.

We are a VR simulation training software company. These modules must be inviting and challenging to motivate the trainee to accept VR training readily.

Our mixed and immersive reality simulation training (MIRST) approaches will:

- **Increase the number of highly skilled, confident firefighters**
- **Lower training costs, injuries, and fatalities**
- **Apply to multiple public safety sectors - state, local and federal firefighter organizations**

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Guardian Airwaves LLC designs and facilitates **MIRST™ (mixed reality and immersive reality simulation training)** for firefighters, first medical responders, and safety standards.

Our core belief is that
'Loss of Life & Property is Preventable'.

This can be accomplished through state-of-the-art training technology provided **by Guardian Airwaves LLC.**

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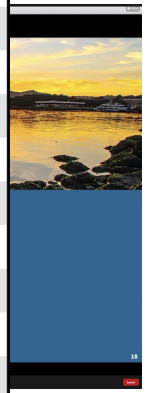
	FIRE NAME *(CAUSE)*	DATE	COUNTY	ACRES	*STRUCTURES*	DEATHS
1	**CAMP FIRE** *(Powerlines)*	November 2018	Butte	153,336	18,804	**85**
2	**GRIFFITH PARK** *(Unknown)*	October 1933	Los Angeles	47	0	**29**
3	**TUNNEL - Oakland Hills** *(Rekindle)*	October 1991	Alameda	1,600	2,900	**25**
4	**TUBBS** *(Electrical)*	October 2017	Napa & Sonoma	36,807	5,643	**22**
5	**NORTH COMPLEX** *(Under Investigation)**	August 2020	Butte, Plumas, & Yuba	318,935	2,352	**15**
6	**CEDAR** *(Human Related)*	October 2003	San Diego	273,246	2,820	**15**
7	**RATTLESNAKE** *(Arson)*	July 1953	Glenn	1,340	0	**15**
8	**LOOP** *(Unknown)*	November 1966	Los Angeles	2,028	0	**12**
9	**HAUSER CREEK** *(Human Related)*	October 1943	San Diego	13,145	0	**11**
10	**INAJA** *(Human Related)*	November 1956	San Diego	43,904	0	**11**
11	**IRON ALPS COMPLEX** *(Lightning)*	August 2008	Trinity	105,855	10	**10**
12	**REDWOOD VALLEY** *(Power Lines)*	October 2017	Mendocino	36,523	544	**9**
13	**HARRIS** *(Undetermined)*	October 2007	San Diego	90,440	548	**8**
14	**CANYON** *(Unknown)*	August 1968	Los Angeles	22,197	0	**8**
15	**CARR** *(Human Related)*	July 2018	Shasta County, Trinity	229,651	1,614	**8**
16	**LNU Lightning Complex** *(Under Investigation)**	August 2020	Napa/Sonoma/Yolo/Stanislaus/ Lake	363,220	1,491	**6**
17	**ATLAS** *(Powerline)*	October 2017	Napa & Solano	51,624	781	**6**
18	**OLD** *(Human Related)*	October 2003	San Bernardino	91,281	1,003	**6**
19	**DECKER** *(Vehicle)*	August 1959	Riverside	1,425	1	**6**
20	**HACIENDA** *(Unknown)*	September 1955	Los Angeles	1,150	0	**6**

** Fires with the same death count are listed my most recent. Several fires have had 4 fatalties, but only the most recent are listed.
***This list does not include fire jurisdiction. These are the Top 20 regardless of whether they were state, federal, or local responsibility.
* Numbers not final

11/3/2020



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Implementation

Implementing the defined recommendations in the next iteration, and many more after that will hone Burning Bear™ into an effective training platform. The ideas/ improvements would lower the barrier of participants truly experiencing of a fire control burn experience. Being able to pinpoint participant user and experience issues and eliminating them, allows for more testing of advanced and complex tasks in the following iterations. The simulation must be realistic to represent real world wildland fire, so their training is effective.

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User Assessments

Overall, user experience problems encompass psychological barriers, physical limitations, learning transitions when users are interfacing with augmented or virtual reality. The specific problems and needs were clarified with this VR interaction.

The prototype testing revealed successes and problems technically, operationally, and in interactions from the participants' observations, surveys, and facilitating team's observations. The usability and the user experiences of the firefighter's surveyed and observed interactions will be assessed with HCI tools as defined by Dr. Gilly Leshed, Senior Lecturer in the Department of Information Science at Cornell University. The results of the qualitative and quantifiable assessments of our prototype will be used for the next iteration of prototype development and testing of Burning Bear™.

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Does it meet the needs of its users?

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Assessment of Virtual Reality Training for Firefighters

The virtual reality (VR) prototype – Burning Bear™ presented in this document is to understand if its innovative concept met its user's needs and offered a learning experience that could further be developed for training. The Burning Bear™ was tested by 125 Northern California firefighters of CALFIRE-TGU, US Wildlife & Fish, US Forestry Service, and Glenn County. These firefighters held ranks of Division Chiefs, Battalion Chiefs, Crew Captains, Crew members, and a Strike Leader Trainee. Two full day sessions took place separately at CALFIRE – TGU training station and at US Wildlife & Fish Headquarters.

Burning Bear™ is a fire control burn training on flat terrain with annual grass in the summer. The task was for the trainee to assess the environment, plan how to execute a control burn in each time frame successfully. The trainee was instructed to use the virtual igniting tools - a fusee and drip torch. This training module was for a single firefighter trainee. A proctor was present in the same virtual environment and directed the trainee what to do and how to navigate within the VR environment.

The product designer, software engineers, and a proctor were present at each testing session. The team observed and readily assisted in the VR training process or hardware performance issues. Video captures from the perspective of the user were recorded and after-experience surveys were filled out by each participant.

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Virtual Reality (VR)
Fire Control Burn Program

Guardian Airwaves' **Burning Bear**™ program is a virtual reality simulation training for fire control burn. It integrates a 3D virtual environment with its characteristic vegetation as the fuel model. The program offers preset environmental conditions and also user or instructor inputs. The variables are wind speed, wind direction, relative humidity (RH), and temperature. A trainee can run multiple sessions on the same map area under varying conditions. Its prototype was tested in 2019 by 125 wildland firefighters. Guardian Airwaves' prototype provided a basis to develop the **Burning Bear**™ fire control burn program for single or multiple trainees.

Our modules are repeatable, measurable, and not injurious to its trainees. Fires, natural disasters, and threats come unexpectedly and we want our firefighters to be prepared and safe.

Guardian Airwaves' future research includes deep learning to compare and/or surpass human-level performance with data sets gathered. Also, we would like to explore if environmental science predictions can be relayed in virtual environments.

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