United States Department of Agriculture

Lolo Peak Fire Tree-Strike Fatality

Field Report

August 2017

Forest Service

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Lolo Peak Fire Tree-Strike Fatality
Lolo National Forest, Montana – August 2, 2017
Field Report

This field report focuses specifically on the felling operation aspect of the Lolo Peak Fire Tree-Strike Fatality event and the conditions that influenced it. The details of Brent's story are derived from witness statements and a careful examination of the stump, tree, and associated aspects of the felling operation.

Saw Operations Analysis

The following synopsis of the tree felling operation from tree size-up to escape route has been reconstructed to the Learning Review team's best ability. The cutting sequence is portrayed in chronological order and is based on witness interviews and accident site analysis. It is important to understand that once Brent began the cutting sequence, he was by himself at the base of the tree, leaving the exact order of procedures unknown. We ask readers to please keep this in mind when reading through the analysis of the cutting sequence.

> **Note:** During the Learning Review process it became evident that a diverse set of terminology to describe the same technique, action, or object exists within the Sawyer community. To ensure consistency in terminology within this report, a glossary of terms and definitions is included in Appendix B.

Tree Size-Up

The strike tree was a standing dead whitebark pine (*Pinus albicaulus*) approximately 15 inches in diameter at breast height (DBH) and 50 feet tall. The bole of the snag curved (see Figure 1) and forked several times, resulting in multiple tops (see Figure 2). Brent and his saw partner sized up the tree and looked for any defects, going so far as to scrape the bark from the trunk. From the perspective of the witnesses, including Brent's saw partner, the strike tree's canopy was free from obstructions, and the

Figure 1: Photo of the felled strike tree illustrating the curved bole.

lean was deemed relatively straight up-and-down. Brent and his saw partner discussed how the lean was such that it would allow the tree to be felled in any direction.

Brent was cutting within his qualifications as a USDA Forest Service B-Sawyer—Felling and Bucking. This qualification is equivalent to the National Wildfire Coordinating Group (NWCG) Intermediate Faller (FAL2) qualification.

Figure 2: Photo of the strike tree showing the multiple tops (reconstructed post-incident).

Undercut

After assessing the tree for lean and integrity, Brent decided to fall the tree into an opening slightly downhill. Brent began the falling process by constructing an undercut that would direct the tree into the opening (see Figure 3).

The Learning Review team recovered the undercut piece of the tree. The sloping angle of the undercut piece measured 45 degrees (see Figure 4).

Figure 3: Photo showing the strike-tree stump looking towards the direction of the intended lay.

Figure 4: Photos showing the angle of the undercut (top) and a close-up of the compass illustrating the 45-degree angle of the undercut (bottom).

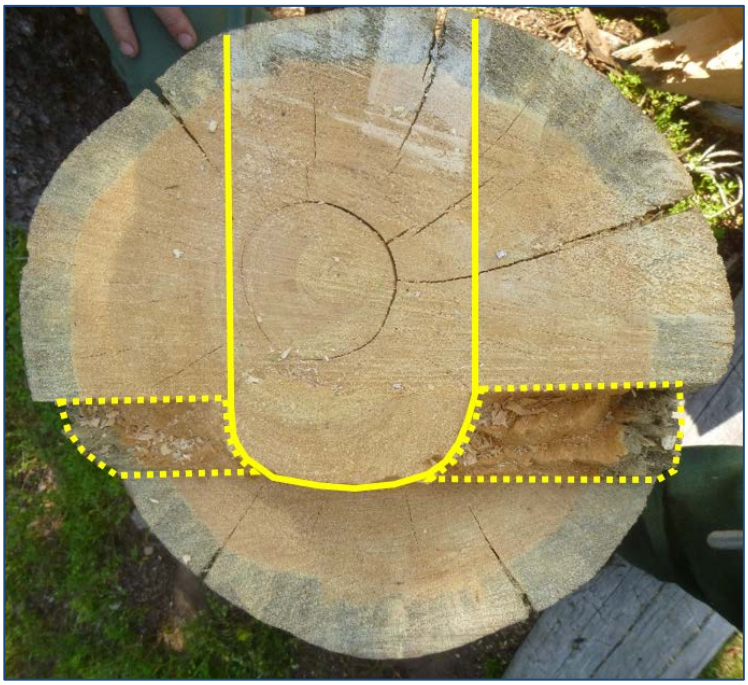


Figure 5: Photo of the strike tree stump showing the bred-out center section of the hinge wood (solid yellow line) and the hinge wood (dotted yello line w).

Hinge Wood Construction – Boring Cut

After completing the undercut, Brent repositioned himself at the back of the tree. He then used the chain saw to bore out the center of the hinge wood, also known as holding wood (see Figure 5). This practice is used to reduce the amount of hinge wood and is sometimes referred to as "boring the guts" or a "keyhole cut" (see Figure 6).

Hinge Wood Construction – Back Cut

After boring out the center of the hinge wood, Brent initiated the back cut from the same position at the back of the tree. Brent cut from the back of the tree towards the undercut to continue hinge wood construction (see Figure 7).

Figure 6: Photo of the bole of the strike tree (after it fell) showing the bored-out center section of the hinge wood (indicated by yellow bracket).

Figure 7: Photo of the strike tree stump showing the thickness of the hinge wood.

Wedging

When satisfied with the construction of the hinge wood, Brent inserted a five and a half inch-long pocket wedge into the back cut. Brent used a five-pound falling axe to drive the pocket wedge deeper into the back cut, pounding it in until the wedge was flush with the back of tree. Brent then inserted a ten-inch long hard-head wedge next to the pocket wedge in the back cut. A third wedge was found at the scene, but based on post-accident assessment of the stump, it is unclear whether Brent had used it (see Figure 8).

Figure 8: Photo of the stump of the strike tree showing the estimated placement of the wedges in the back cut.

As Brent struck the hard-head wedge with the falling axe, a loud pop was heard, and the tree began to fall. Brent turned away from the tree and began his escape. He was struck approximately 28 feet from where he had been cutting (see Figure 9) as the snag fell 100 degrees off of its intended lay (see Figure 10).

Figure 9: Photo of the strike tree (pieced back together post-accident) showing the location where the strike tree impacted the firefighter (marked with black X).

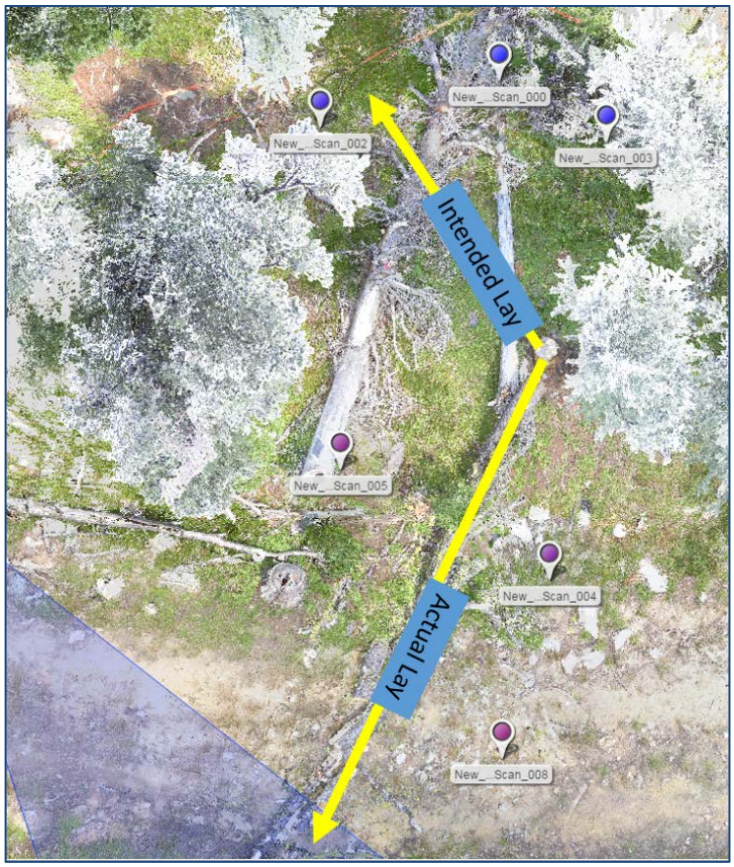


Figure 10: Birds-eye view of the accident location showing the intended lay of the strike tree and its actual lay.

Conditions of Influence

The conditions described in the following section provide opportunities for the reader to reflect, ask questions, and derive both personal and organizational learning. These conditions of influence emerged from discussions between the Learning Review team and focus group members. The validity of the conditions of influence were vetted with subject-matter experts in the Sawyer community before being highlighted in this report.

We ask the reader to remember that no one tree is the same, and that a broader look at tree felling operations beyond the context of this event is important. Throughout this section, questions will be posed to spur thought and dialogue regarding how these conditions of influence play into a Sawyer's every day, normal work environment.

Condition of Influence: Cutting Sequence and Techniques

The hinge wood is an important part of the felling process as it directs where the tree will fall and is intended to prevent tree separation from the stump until it is committed to the intended lay. Understanding how much hinge wood to leave is critical to maintaining control of the tree. Too much hinge wood may prevent a tree from falling. Too little hinge wood can result in the loss of control of a falling tree before it has committed to the intended lay.

1. How do you determine what hinge wood dimensions are needed?
2. Has your hinge wood ever broken before the tree was committed to the intended lay? What happened?

Another factor that plays into deciding how much hinge wood a Sawyer should leave is the condition of the wood fibers. Hinge wood fibers in living trees react differently than hinge wood fibers in dead trees. Trees that contain rotten wood fibers may not have the strength and integrity required to function as a hinge.

1. Does dead wood fiber require the same hinge wood dimensions as live wood fiber?

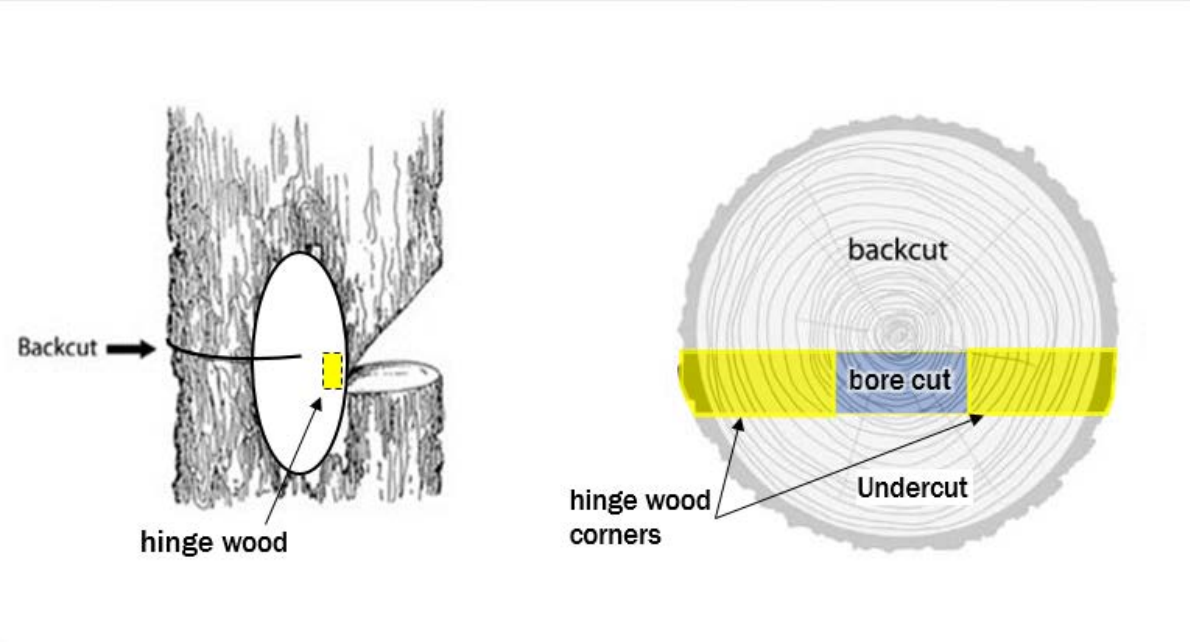
While working along Carlton Ridge Road on August 2, Vista Grande IHC Sawyers continually encountered the issue of their wedges contacting the hinge wood (bottoming out) before the tree could fall. To remedy this issue, Vista Grande IHC Sawyers began to bore out the center portion of the hinge wood, a technique that is sometimes used to adjust the dimensions of the hinge wood. By cutting out the center of the hinge wood, a Sawyer is able to provide additional depth for wedges to be inserted into the back cut. This way, the wedges do not bottom out before tipping the tree enough to get it to fall.

While this technique is not formally taught in USDA Forest Service or National Wildfire Coordinating Group (NWCG) curriculum, a focus group of subject-matter experts provided multiple perspectives regarding this technique and considered it to be a valid option for hinge wood construction. This is a common practice within the wildland fire system. Chain saw operators and trainers often supplement their Agency saw experience and knowledge base with external information and techniques. This can lead to non-standardized training programs that vary widely across the Agency, resulting in mixed interpretations of techniques and the loss of critical information.

1. Outside of the current minimum standards of training, how does a Sawyer gain different tools without looking at external influences?

2. Is the current training system meeting the needs of today's Sawyer community?

Maintaining Stability of the Hinge Wood When Utilizing a Boring Cut



A graphic illustrating the profile view of a conventional undercut, hinge wood, and back cut (left) and a cross section of the stump showing the undercut, hinge wood corners, bore cut, and the back cut (right).

During tree felling operations, a bore cut may sometimes be used to create additional space for wedges to be inserted into the back cut, allowing for additional lift. Removing the center of the hinge wood, as is done with a bore cut, reduces the amount of hinge wood present, inherently reducing the hinge wood's strength. Although removing the center of the hinge wood reduces the strength, maintaining *both* corners provides a stable pivot point, preventing the tree from spinning and directing the tree to its intended lay. Therefore it is critical to ensure that the corners of the hinge wood are composed of solid wood fibers to maintain the directional control of the tree.

The ability to utilize a wedge to its maximum potential can be an important part of the felling process. In tree felling operations, wedges allow the Sawyer to prevent the tree from settling backwards and pinching the chain saw guide bar. Wedges are also used to pivot trees past their center of gravity in the felling process. A one-inch thick wedge that is fully inserted into the back cut provides one inch of lift at the base of the tree, creating a fulcrum.[1] As the wedge lifts the tree vertically, the hinge wood provides a pivot point, and the tree pivots at that point towards the intended lay. For the Sawyer to maintain control of the tree during the wedging process it is critical for the hinge wood to remain intact until the tree has committed to its intended lay.

[1] The point on which a lever rests or is supported and on which it pivots. The Oxford Living Dictionary. https://en.oxforddictionaries.com/definition/fulcrum.

1. How do you determine if wedging will lift the tree enough to direct it where you would like it to go?

As Brent began conducting wedging procedures on the strike tree, other crewmembers described watching the tree top move towards the intended lay. The next thing they described was hearing a loud "pop" and watching the tree fall away from the intended lay. Accident site visits and stump analysis revealed that the hinge wood was broken and was most likely the source of the loud "pop" sound.

It is clear that the hinge wood did provide a certain amount of pivot as the witnesses watched the top move. However, it is also clear that the hinge wood reached the limits of its ability to act as a pivot, breaking before the tree committed to the intended lay.

1. Are there other techniques or tools outside of wedging that would allow you to directionally fall a tree?
2. How do you determine when the wedging procedure is getting close to breaking hinge wood fibers?

Condition of Influence: Escape Routes and Safety Zones

Recommended Direction of Escape

Regarding escape routes, the *Wildland Fire Chain Saws* workbook advises that "escape routes and safety zones should be at least 20 feet from the stump and 45 degrees to the sides and back from the direction of the fall.[2] " The workbook goes on to counsel new Sawyers to "not choose a path directly behind the desired felling direction of the tree. It is best to prepare two escape routes in case you are forced to switch your location on the final cut. However, ensure you select one as the primary escape route and do everything possible to work from that side of the tree…Ensure you are not exiting behind the tree or crossing behind it.[3]"

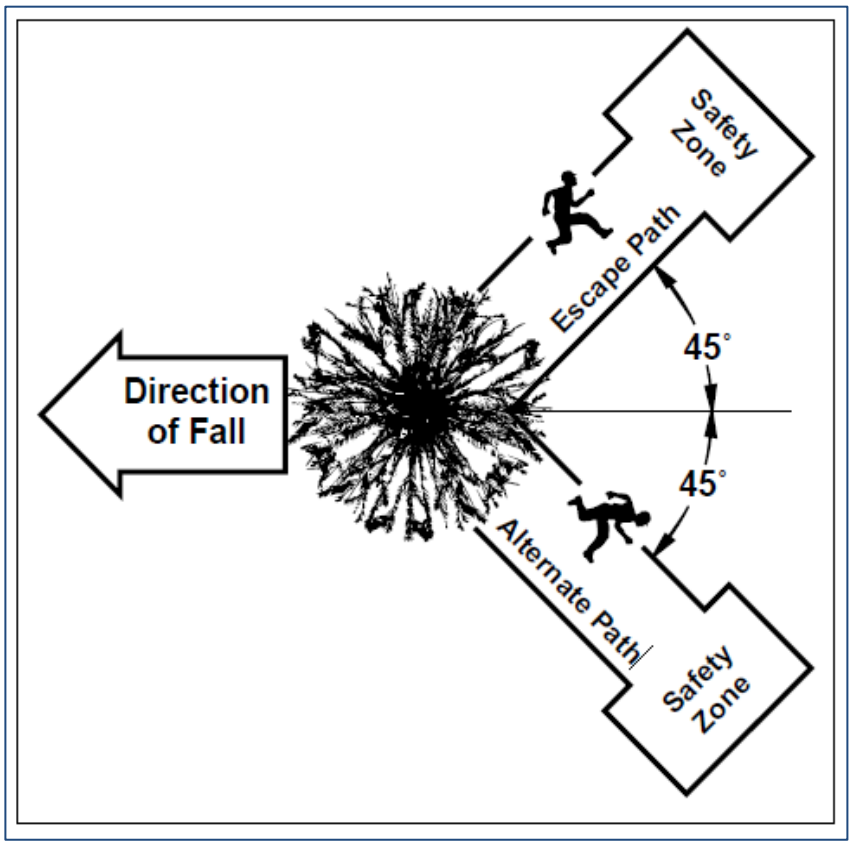


Figure 11: A figure taken from the Health and Safety Code Handbook FSH-6709.11 illustrating the recommended escape routes and safety zones during felling operations (pg. 20-53).

[2] NWCG 2012. Wildland Fire Chain Saws workbook. Pg. 4C.9.
[3] NWCG 2012. Wildland Fire Chain Saws workbook, Pg. 4C.10-11.

The Health and Safety Code Handbook FSH-6709.11, Chapter 22.48e, also teaches Sawyers to establish two escape routes at 45-degree angles from the intended lay of the tree and emphasizes the danger zone directly behind the tree as an area that should be avoided for escape[4] (see Figure 11).

Witnesses described Brent's response to the snag falling as a clear pause and then movement to escape in a direction approximately 45 degrees from where he stood. As Brent ran up his escape route, fellow crewmembers of Vista Grande IHC that stood nearby began shouting to Brent to run the other way. They were watching his activities from a distance and were generally in line with the route Brent used in his attempt to escape.

While we will never know what Brent was thinking at the time, the pause he took suggests that what was occurring was unanticipated and that he was trying to make sense of it all.

Based on the current training guidance that emphasizes two escape routes at 45-degree angles, it is plausible that Brent had identified two such routes. From the position that Brent stood at the time the snag began falling, one of his escape routes would have required him to move through the danger zone behind the stump (Figure 12). The other escape route, which Brent utilized, kept him out of that danger zone but inadvertently placed him in the same path as the falling snag.

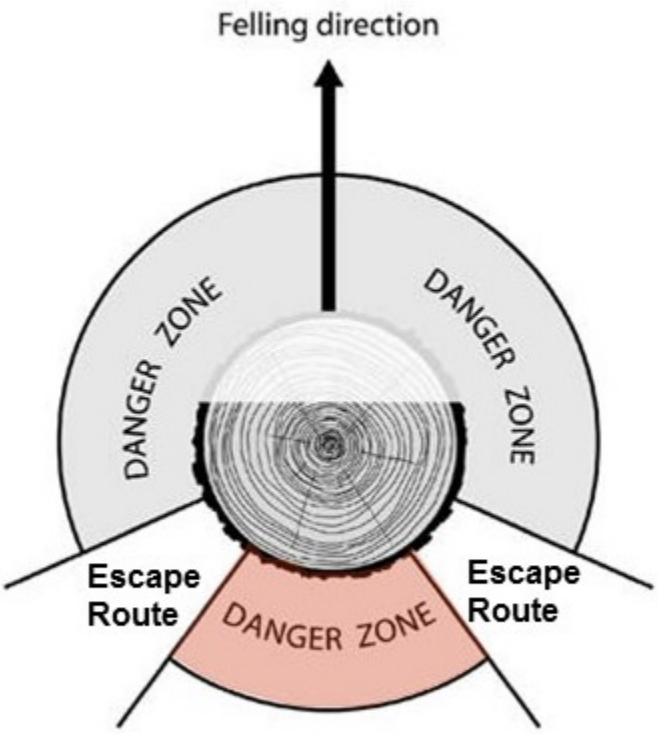


Figure 12: A graphic illustrating the danger zones typical in tree felling operations. The red section represents the danger zone at the rear of the tree.

The practice of utilizing 45-degree escape routes was developed under the assumption that everything goes according to the plan, allowing a Sawyer to safely move away from a tree and avoid any kickback that might occur. However, if a tree fails to fall in the intended direction, it is falling in an unpredicted manner, making it almost impossible to pre-plan a suitable escape route.

In focus group discussions with subject-matter experts, it was recognized that it is not always in a Sawyer's best interest to limit themselves to these two escape routes. Limiting the number of escape routes may reduce the margin for success. The reality is, tree felling is dynamic and ultimately requires more flexibility to escape a falling tree than two escape routes afford.

1. Is it a possibility that the accepted strategy of defining two escape routes at 45-degree angles from a Sawyer's location provides a false sense of security to the Sawyer?
2. Have you ever had to use something other than your planned escape route(s)? Why?

Sawyers are also taught that to exit the tree safely, one should: "Keep your eye on the top of the tree. *Do not hesitate at the stump*; take a few quick steps down your escape route with a quick glance over

[4] USDA Forest Service 1999. Health and Safety Code Handbook FSH-6709.11, Pg. 20—53.

your shoulder to ensure the tree is committed and that nothing is coming back at you. Then exit the entire length of your escape route."[5] Discussions within the focus groups resulted in the suggestion that perhaps it would benefit Sawyers more to ensure the tree is committed *first*, before proceeding down their pre-planned escape route.

1. Do you watch the tree as it begins to fall to verify the direction it is falling?
2. What cutting situations cause you to pay extra attention? Does a particular size, shape, or type of tree give you more pause than others? Why?

As for the distance in which Sawyers should travel away from the stump, the *Wildland Fire Chain Saws* workbook (S-212) stipulates "at least 20 feet from the stump"[6] while the Health and Safety Handbook recommends "generally not less than 20 feet (6 m).[7]" Some Sawyers are taught on-the-job that "plenty plus more equals safe enough." Others maintain that most accidents occur within ten feet of the stump.

The variety of recommended distances to travel along an escape route were debated at length within focus group discussions with subject-matter experts, highlighting distinctly different approaches in practice within the Sawyer community. Considering these differences, the subject-matter experts agreed that stipulating an exact distance may not be an appropriate solution.

Instead, a more useful approach may be to train and practice moving a Sawyer's attention upward—to focus on the tree and other aerial hazards at the moment the tree begins to fall with the intent of maintaining awareness of, and flexibility in, their escape options. This would require a conscious effort to assess the direction the tree is actually falling before moving away from the tree. This conscious effort may be challenging as it is counterintuitive to the instinctive "flight" response humans often have in times of stress or perceived danger and will likely require frequent and repeated practice.

Habitual training influences action taken during a "fight or flight" response such that people often resort to the training practices they have received or practiced most frequently. In most cases, that training will yield successful outcomes, reinforcing its use the next time. However, there will be times in a Sawyer's experience where their training does not match the situation being faced.

1. What are the trade-offs of training people to engage in routine behavior vs. training them to assess things in the moment (pre-planned escape routes vs. assessing the tree's falling direction before deciding on an escape route)?
2. Do you conduct scenario-based training that is outside of your crew's direct experience?
3. Does your cutting operation change when you are being observed?

Condition of Influence: Current Saw Training Curriculum

During discussions about the boring cut technique used by Vista Grande IHC Sawyers, it was acknowledged that sometimes the complexity of a tree remains ill-defined *until* it is cut. Focus group discussions that included Sawyers from current and former interagency Hotshot crews, USDA Forest Service National Saw Technical Advisory Group (TAG) representatives, and chain saw trainers revealed many experiences where saw operations did not go as expected.

As such, these current and former Sawyers recognized the value of learning new techniques outside the scope of what is currently taught in formal training. They emphasized the importance of putting

[5] NWCG 2012. Wildland Fire Chain Saws workbook, Pg. 4C.10-17
[6] NWCG 2012. Wildland Fire Chain Saws workbook, Pg. 4C.9.
[7] USDA Forest Service 1999. Health and Safety Code Handbook FSH-6709.11, Pg. 20-52.

concerted effort into continually learning and refining skills throughout one's felling career. Additionally, they deemed it vital to share those learnings with other Sawyers to expand each individual Sawyer's knowledge base and to build consistency across the Sawyer community.

1. Should the focus and techniques currently taught in formal USDA Forest Service Saw curriculum be expanded?
2. How does our current Saw Training System allow for incorporating other techniques and how do they get standardized nationally?

During the discussions regarding cutting techniques, subject-matter experts also identified a lack of consistency within the Sawyer community regarding terminology, instruction, training, cutting techniques, and interpretation of policy. This highlighted a disparity that exists across Regions, states, and local Districts. As every tree is different and every situation has its own unique risks and challenges, these demands, coupled with the highlighted inconsistencies in tree felling operations, have the potential to create issues. In order to help our Sawyers manage these different scenarios, we need to provide a more robust Saw program curriculum that is aligned to the dynamic nature of the work that will showcase a variety of techniques, skills, and knowledge that will increase flexibility, adaptability, and ultimately, survivability. See the Safety Action Plan document for a detailed recommendation addressing current saw curriculum.

1. In what ways do you see terminology, instruction, and training differ between Regions, states, and local Districts?
2. Does this lack of consistency reflect a broader disparity in the implementation of the saw operations curriculum?
3. How can you address this lack of consistency on your unit?

Condition of Influence: Personal Protective Equipment Review

Eyewitness accounts stated that the tree struck Brent from behind, knocking him to the ground and dislodging his helmet. The distance from where he was impacted and where the helmet landed on the ground was approximately 10 to 12 feet. While Brent's helmet met the current wildland firefighting requirements for Type I helmets, a helmet can only provide the highest level of head protection when it remains on the head.

Other helmet designs exist that provide additional head protection properties, such as retention devices and a reduction of impact forces from the side and top of the head. However, these features may require tradeoffs in other features such as weight, electrical protection, chemical resistance, and thermoregulation. Despite any additional head protection properties, the extreme forces involved in the Lolo Peak Fire Tree Strike make it unlikely that another type of helmet would have prevented this fatality.

1. Do you understand the limitations of your personal protective equipment (PPE)?

The Lolo Peak Fire fatality is not the first of its kind. Other tree-strike incidents have occurred with similar impacts to the helmet. These incidents, including the 2016 Strawberry Fire Fatality, have highlighted the need to examine the design, standards, and policy regarding wildland firefighting helmets. The Strawberry Fire Fatality Learning Review[8] Safety Action Plan (SAP) Recommendation Topic Number 2

[8] Strawberry Fire Fatality Learning Review Report, Appendix C, https://www.wildfirelessons.net/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=a50ca4eb-43e5-7fe3-feb3-52abecbb4606&forceDialog=0.

went so far as to direct the USFS Deputy Chief of the National Forest Systems to initiate a comprehensive review of the wildland firefighting helmet—design, standards, and policy.

For a detailed helmet report, including injuries and additional PPE information, refer to Appendix A, U.S. Department of Agriculture, Forest Service, National Technology and Development Program, Helmet Report: Lolo Peak Fire Tree-Strike.

Appendix A: USDA Forest Service, National Technology and Development Program, Helmet Report: Lolo Peak Fire Tree-Strike

This report is based on interviews, site visits, and visual examinations of equipment.

On August 2, 2017, a falling snag struck and killed a wildland Firefighter chain saw operator while he performed tree felling duties on the Lolo Peak Fire (Lolo and Bitterroot national Forests, Montana). The Sawyer died from multiple blunt force injuries, including severe head trauma.

The Sawyer was a member of the 20-person Vista Grande Interagency Hotshot Crew, based out of the San Bernardino National Forest in California.

The Lolo Peak Fire Fatality Tree-Strike Learning Review team conducted site visits on August 4 and August 6, 2017. USDA Forest Service National Technology and Development Program (NTDP) Equipment Specialists conducted a visual examination of the helmet on August 5, 2017. The team conducted witness interviews on August 7 and August 13, 2017.

Witnesses stated that the tree struck the Sawyer on the top of his helmet from behind as he attempted to escape the tree. The impact dislodged his helmet and knocked him to the ground.

Wildland Firefighting Helmet

Make—Bullard Wildfire Series Fire Helmet

Model—FH911H/911H

Date of manufacture—February 2015

Date put into service—May 2015

Certifications—National Fire Protection Association (NFPA) 1977 Standard on Protective Clothing and Equipment for Wildland Firefighting, 2011 edition; ANSI/ISEA Z89.1-2009, Type I, Class E&G.

Helmet shell/outer surface condition — The shell has numerous scratches (see Figure 1). The center rib has a 1½-inch scuffmark (see Figure 2). The left side goggle clip is broken (see Figure 3).The rear brim edge has a 2-inch by 2-inch scuffmark next to a ¼-inch crack (see Figure 4). The retroreflective markings are missing from the helmet shell. The chinstrap is stowed on the front brim of the helmet (see Figure 1).

Figure 1: Top view of the helmet showing numerous scratches and the stowed chinstrap.

Figure 2: Top view of the helmet. The oval along the center rib highlights fresh scuffmarks.

Figure 3: Side view of the helmet with an arrow pointing to the broken left side goggle clip.

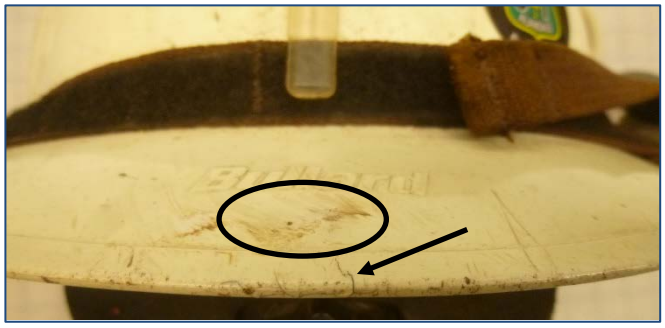


Figure 4: Rear view of the helmet with the oval highlighting fresh scuffmarks and an arrow pointing to a 1/4-inch crack on the brim edge.

Figure 5: View of the inside of the helmet showing the left-front suspension key detached from the suspension key slot.

Helmet suspension condition — The helmet has six suspension keys that connect to their respective six suspension key slots. The left front suspension key is detached from its suspension key slot (see Figure 5). The remaining suspension components appear to be intact and functional.

Helmet analysis — The numerous scratches on the outer surface of the helmet shell are consistent with a helmet that has been in service for two years. The scuffmarks along the center rib and rear brim areas appear to be fresh and likely resulted from the tree impact. The ¼-inch crack on the rear brim edge of the helmet appears to have existed prior to the accident. The goggle clip may have been broken during the impact, but this could not be determined with certainty. The retroreflective markings were removed from the helmet shell before this accident. Like many accidents that involve an object striking a helmet, the helmet dislodged from the Sawyer's head. It is not clear if the scratches, scuffmarks, and other anomalies on the shell occurred when the tree struck the helmet or when the helmet contacted the ground.

The adjustable ratchet appears normal and is functional. The left front suspension key is detached from the suspension key slot. The detached suspension key and corresponding suspension key slot appear to be undamaged and are functional. In general, a detached suspension key is a sign of significant impact.

Head protection limitations—Acceptable helmets for fireline use are certified according to the NFPA 1977 "Standard on Protective Clothing and Equipment for Wildland Fire Fighting." Helmets certified to NFPA 1977 also meet the American National Standards Institute (ANSI) Z89.1 requirements for Type I, Class G head protection. Type I helmets are intended to reduce the force of impact resulting from a blow to the top of the head. Class G helmets are intended to reduce the danger of contact with low-voltage electrical conductors. Helmets that meet the NFPA 1977 and ANSI Z89.1 standards must pass a battery of tests, including the Force Transmission Test.

The Force Transmission Test — The standard Force Transmission Test delivers 54 joules of energy to a test helmet mounted on a head form. The head form contains a load cell that measures the energy transmitted to the spine. This test is roughly equivalent to the energy delivered by a brick falling one story (10 feet). Energy in excess of 54 joules is believed to cause vertebral damage. Additionally, energy greater than the standard test requirement may result in varying degrees of helmet suspension damage. Even with the standard Force Transmission Test, a suspension key may detach from the suspension key slot. However, a detached key does not always constitute a failure of the test helmet. An average value

that does not exceed 3780 Newtons (850 pounds) at the load cell is the pass/fail criteria for the Force Transmission Test.

Helmet discussion — We do not know the exact amount of energy released by the falling tree in this accident. Using the USDA Forest Service Management Center Volume Estimator Equation for whitebark pine, we estimated the impact energy of the tree strike at 11,390 joules, or 211 times the Force Transmission Test.

This helmet meets the current wildland firefighting requirements for Type I helmets. A helmet provides the highest level of head protection when it remains on the head. Other helmet designs exist that provide additional head protection properties, such as retention devices and a reduction of impact forces from the side and top of the head. However, these features may require tradeoffs in the weight, electrical protection, chemical resistance, and thermoregulation of the helmet, to name a few. Because of the extreme forces involved in this accident, it is unlikely that another type of helmet would have prevented this fatality. However, the question remains: would another type or class of head protection have increased the likelihood of survival in this case?

Additional helmet information — Helmet components include an outer shell, suspension components, and chinstrap. Helmets require periodic inspection and maintenance. NFPA 1977 compliance ensures that protective items used in wildland firefighting meet minimum design, performance, testing, and certification requirements.

Helmet replacement parts reminder — Be sure that helmet replacement parts are compatible with the helmet you use. Find information about Bullard helmets and replacement parts at <http://www.bullard.com/>.

Appendix B: Glossary of Terms[9]

B Sawyer—Felling and Bucking – (not applied in the Fire Management context) An intermediate Sawyer who may independently fell, buck, and limb any size material in moderately complex situations. This person may saw at the next higher level under the immediate supervision of a Sawyer qualified to supervise the work (FSM 2358.1, ex. 02). This person may also conduct classroom and field training for A and B Sawyers with prior written approval from the Saw Program Coordinator.

Back Cut – The final cut in a felling operation.

Boring – Method of using the bottom half of the guide bar tip to saw into the tree while felling or bucking.

Escape Route – A predetermined route of exit used by Sawyers when felling or bucking. The essential components of an escape route are selection of the desired direction and distance, prior to felling or bucking, and a well cleared route through which to escape to a safe area.

Hinge Wood/ Holding Wood – Section of wood located between the undercut (face) and the back cut that directs where the tree will fall. The hinge wood is intended to prevent the tree from separating from the stump until it is committed to the lay.

Kerf – Space resulting from a saw cut.

Lay – Refers to either the position in which a felled tree is lying or the intended falling place of a standing tree

Lean – Refers to the directional tilt of a tree away from its vertical position in relation to the intended lay of the tree. Many times two lean forces may be in play in the same tree. Lean is described as head lean, back lean and side lean.

Stump Analysis – The process of examining the stump of a tree to determine how the tree was cut.

Stump Shot – The height difference between the horizontal cut of the undercut (face, or notch) and the back cut. The difference in height establishes an anti-kick-back step that will prevent a tree from jumping back over the stump toward the Faller.

Undercut – A notch cut in a tree to guide the direction of fall.

Wedge – A plastic or metal tool used to assist the Sawyer to prevent a tree from falling backwards, lift the tree to redistribute its weight, or to prevent the bar from pinching while bucking.

[9] All definitions were taken from the USDA Forest Service Saw Operations Guide or the Occupational Safety and Health Administration (OSHA) Logging eTool Glossary.