IMPROVING BEST PRACTICES FOR TREE WELL PHENOMENA RISK AND INCIDENTS

Research collaboration between Mountain Adventure Skills Training (MAST) program, College of the Rockies - Fernie Campus and CMH Heli-Skiing and Summer Adventures (CMH).

CMH

COLLEGE OF THE ROCKIES


TREE WELL

Tree well fatalities are an ever-present issue in Western Canadian and US ski areas. Up to 20% of fatalities at public ski areas are related to tree well phenomena. There were five tree well related fatalities at Western US and Canadian ski resorts in 2018, and while the perception may exist that such dangers are only encountered in the backcountry, snow science researcher, Paul Baugher notes that "tree well-related deaths and SIS almost always occur inbounds" and that in average years, non-avalanche-related snow immersion deaths (NARSID), including tree well incidents, account for up to 40% of total snowboard fatalities inbounds at US ski areas, and up to 25% total fatalities in BC ski areas inbounds.

This project is the result of a unique partnership between the College of the Rockies (the College) and CMH Heli-Skiing & Summer Adventures (CMH), both of whom share a common goal of advancing snow sport safety research. This project was designed to advance knowledge of extraction techniques for tree well victims while also giving College students an opportunity for experiential learning while conducting this applied research. The research took place both at the Fernie campus of the College, and during a four-day field exercise in Nakusp, BC, on CMH property. This is the first applied research collaboration between the College and CMH.

The research team consisted of eight students from the Mountain Adventure Skills Training (MAST) program, who conducted preliminary and field work; Brian Bell, the program coordinator and instructor, who guided student research and final data analysis; Rob Whelan, Radio Technician for CMH, who was instrumental in building the rescue manikins, orchestrating the team planning and directing the scenarios during the field work; and Gaby Zezulka, Chair of Academic Innovation and Applied Research at College of the Rockies provided administrative and writing support for the project.

GOALS OF THE PROJECT WERE TO:

1. Determine best practices for safely extracting skiers/boarders who have fallen into tree wells
2. Develop safety instruction protocols for CMH staff and guests
3. Understand how to avoid positional asphyxia while in a tree well

Key Questions focused on three main areas:

1. **DIGGING:** where is the best place to start digging? Are there digging techniques that will work better than others?
2. **EQUIPMENT:** Which shovels work best? Does other equipment (sling) help?
3. **EXTRACTION TECHNIQUES:** When is the best point in the rescue to start pulling someone out? Where is the optimal place to stand, and to grab?

It is hoped that by providing guidelines for best extraction techniques for tree well victims, this research will directly benefit CMH, their staff, guests, College of the Rockies, and the larger public. The project created unparalleled experiential learning opportunities for the students.

METHODOLOGY

The project was divided into a classroom-based research component and a practical field study. For the initial research, as most of the students involved had little experience or knowledge of tree wells, they turned to social media and YouTube to get a better sense of tree wells hazards, and typical accident scenarios.

A video research tool was developed to record as much relevant information from available videos as possible. Details that were recorded included:

- Rough estimate of age and gender of victim
- Location of incident
- Whether the incident happened in bounds of a controlled ski area, in the 'slack' country just outside ski area boundaries or in the back country – far away from a ski area.
- Whether any avalanche gear was used in the rescue, and if yes, how it was used
- The number of rescuers
- The time taken to arrive on scene
- Body position (inverted, horizontal, etc.)
- Position of body in relation to the tree (uphill, beside, downhill)
- Visible body parts or equipment
- Depth of victim
- Size of tree well
- Attempt at self-rescue (successful or not)

Next, the partner/rescuer actions were recorded, including:

- Time to locate victim
- Time until rescue started
- Total time of rescue
- Group actions such as digging and pulling
- Whether the digging was organized
- Size of group
- Teamwork

In addition to the video-based research, the students conducted a literature review regarding key topics that would influence tree-well-rescue success. Topics analyzed included:

- NARSID overview
- Shovels for rescue
- Digging techniques
- Airway management practices

After the initial classroom-based work, the research team travelled to the interior BC to complete field work.

At CMH Nakusp between January 16-18, 2018 over 50 tree wells were investigated and 22 mock rescues were performed with two different rescue manikins. Both were life sized and were clothed in durable ski clothing. One, 'Woody,' weighed 220lbs including ski boots, and the other 'Colani' weighed approx. 70 lbs. No humans were placed in tree wells.

The research team was dropped off on top of a run called Fractured Fairy Tales, with an elevation of 1800 M. Over two days, the two manikins were placed into and extracted from 22 different tree wells, and were transported slowly downhill utilizing a rescue toboggan.

Initially the students dug one full profile across the fall line and one with the fall line of tree wells to fully explore the snowpack and look at snow densities around a smaller tree. This was a labour intensive process but gave the students a good insight into sizes and more importantly shapes of tree wells.

Several rescue strategies were performed utilizing different shovels, different group sizes and utilizing different aids in pulling the manikins out of the tree wells. The rescues were documented and filmed. As the main objective of the research was to test digging and rescue

techniques rather than searching techniques, each 'rescue' began with rescuers fully geared up in downhill ski mode, with avalanche gear, and adjacent to the victim in the tree well.

Besides the rescue digging research, 28 separate tree wells in the vicinity were surveyed to determine well depth, shape, and orientation around the tree trunk.

VIDEO STUDY RESULTS

The below data shows an outline of some of the details found in the videos. The students also got a sense of the real dangers of tree wells and what successful, although often unorganized, rescues can look like. None of the videos analyzed showed fatalities.

VICTIMS

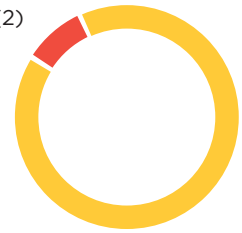
- Male (22)
- Female (2)

SHOWED TEAM WORK

- Yes (8)
- No (16)

HAD RESCUE EQUIPMENT

- Yes: Shovels (2)
- No (22)



VICTIM BODY POSITION

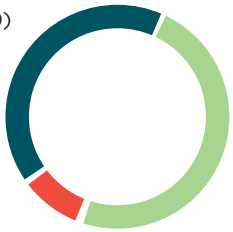
- Upright (10)
- Horizontal (2)
- V-Shaped/ Bend Body (3)
- Head First (9)

TYPE OF RESCUE

- Self (15)
- Assisted (9)

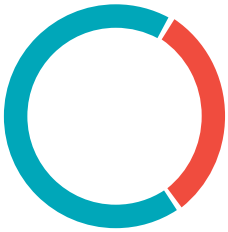
RIDER TYPES

- Snowboarders (10)
- Skiers (12)
- Snowmobilers (2)



SHOWED SENSE OF PANIC AND STRUGGLE

- Did (16)
- Did Not (8)



VIDEO STUDY DISCUSSION

There is a strong correlation between the position of the tree well victim in their ability to self-recue. While 4 out of 9 riders (44%) who went into tree wells head-first were able to self-rescue, 8 of 10 riders (80%) who went in feet-first were able to self-rescue.

The time for total rescues ranged widely, from less than a minute, to almost one hour. There is no obvious correlation between time of rescue and any other factor (equally random rescue times for skiers and snowboarders, for positions of victim, for those who struggled or did not, etc.) Timing seems to be more directly correlated with whether or not the victim had a buddy close by.

While there wasn't a clear indication in the videos that carrying a shovel dramatically increased the speed of the rescue, the 2 videos in which rescuers had a shovel show a more organized approach in the rescue. There is an opportunity for rider education about carrying shovels if riding in gladed areas, as less than 1% of the videos showed evidence of riders carrying these tools.

LITERATURE REVIEW RESULTS

The highest-frequency timing for tree well incidents is during or immediately after a storm, when the snow has not yet consolidated. The soft consistency of the snow creates added danger as it offers no resistance to the rider, either as they fall into the well, or when they are attempting to gain traction or purchase to get out.

FIELD STUDY RESULTS

It was found that there were three overall shapes of tree wells, which are aligned with the relative size and/or species of the tree.

1. **VERTICAL TUBE:** Smaller tree wells generally presented a vertical tube shaped tree well which presented the greatest possibility of the rider becoming fully vertically pinned against the tree in an inverted position, and the most hazardous potential for a victim. As most vertical tubes were associated with smaller trees, it was evident that the victim was easier to spot when in a tree with fewer and shorter branches close to the ground.
2. **FUNNELS:** Larger trees tend to give rise to funnel-shaped tree wells as their larger branch canopy shelters a larger void. These can present an easier rescue than vertical tubes as the hauling angles are less acute and allow for faster initial pulling and overall faster rescue times.
3. **CLUMPS:** Depending on tree density in gladed areas, there may occur situations where trees are close enough that multiple tree wells will merge, forming 'clumps' of tree wells that can be hazardous to rescuers and slow the rescue drastically.

Through the 22 mock rescues the students began with their knowledge of standard avalanche-rescue digging technique, using the V-conveyor system whereby rescuers pinpoint the victim's location, and dig a V-shaped trench with the victim at the apex. The students gradually developed systems that allowed for more efficiency. Under the direction of Rob Whelan, a "T Rescue" system evolved and proved that the most effective rescue actions tested were a combination of:

1. **Digging the V-shaped trench as deep as the victim's waist, on the downhill side of the tree well.**

2. **Platform preparation (digging a flat area on either side of the victim from which to pull).**

3. **Pulling the victim onto the receiving platform (the excavated V-shaped trench).**

The average tree well depth was 2.3 meters and height of snow ranged from 210 to 250 cm.

Fastest rescue time:	1.47
Slowest rescue time:	17.45
Average rescue time:	5.19

FIELD STUDY DISCUSSION

Although the search phase of a rescue was not part of our research it became obvious that larger trees with longer and more branches close to the ground could hide all signs of a victim in the tree well.

Through a methodical survey of tree wells within the study site it was found that due to snow creep the tree wells were small to non-existent on the uphill side of the tree trunk. The shape of the canopy of branches does affect the width of the tree well but not necessarily the depth. In fact, it was found that many seemingly small trees (minimal overall diameter including branches) had very deep tree wells that can be as dangerous or more dangerous because of the tight space (and therefore little room for the victim to wriggle around into a better self-rescue position).

Many of the tree wells utilized in this project were quite vertical with acute angles and firm snow around the lip of the tree well. This necessitated quite a bit of digging to get to the victim's waist as it proved literally impossible to pull victims straight up and over the lip. In post-storm conditions the snow would likely be much less dense and angles of the tree well lip much less acute. Therefore, it may be possible to pull victims out on the downhill side with minimal digging. More research in variable conditions is needed in this regard.

The variables that affected rescue times ranged from number of rescuers, depth of buried manikin, different shovel types, overall strength of rescuers, and snow crusts along the lip of some of the tree wells slowing digging.

With respect to digging equipment, when used in the rear positions of the V-conveyor digging system, shovels with a hoe mode were superior. The smaller and more portable 'client' shovels were utilized in one rescue scenario. They were found to be significantly inferior in moving snow efficiently.

This type of shovel allows the digger to re-attach the shovel blade perpendicularly to the handle. Shovels that incorporated a hoe mode proved to be the favourite; its D-shaped handle and the angles of the blade and handle made for ergonomic efficiency. This finding is supported by Schindelwig et al in their 2017 study "Does Avalanche Shovel Shape Affect Excavation Time: A Pilot Study," which noted that shovels with deeper sides and that have a hoe mode offer improved ergonomics and can move more snow.

The students found that using a well organized V-conveyor digging system on the downhill side of the victim proved to be the fastest overall way to excavate snow to reach the victim's waist. Unless the victim is clearly being held up by the skis or snowboard, the equipment should be removed and set aside as quickly as possible so as not to impede the shoveling process Initiating organized digging quickly, and digging to the victim's waist before trying to pull created the best scenario for success.

Avalanche rescue shovels that incorporated a hoe mode emerged as the most ergonomic to use and moved the most snow.

Every rescue is different and no set of rules will guarantee to make the rescue any more efficient. However, a few guidelines should help rescuers be more efficient and therefore successful.

GUIDELINES FOR SUCCESSFUL RESCUE

Initial speedy assessment of airway and responsiveness through verbal contact is key, let the victim know they are being rescued and prompt them to stay calm.
Try to communicate with victim without getting too close to tree well, being careful not to knock further snow down on top of victim.

If verbal communication is possible and the victim and rescuer can coordinate their movements without knocking more snow down onto the victim, using an 8m webbing to stabilize the victim may be a good idea. Or if the snow density is soft near the lip of the tree well, it might be possible to get the webbing girth hitched around the waist or legs of the victim and then extricate (pull) the victim out with minimal digging.

If the victim is unconscious digging at least to the victim's waist is likely necessary before any pulling should take place, unless there is an obvious egress available. The density / consistency of the snow is the primary factor in determining whether an extrication of an unconscious victim is possible without first digging to their waist.

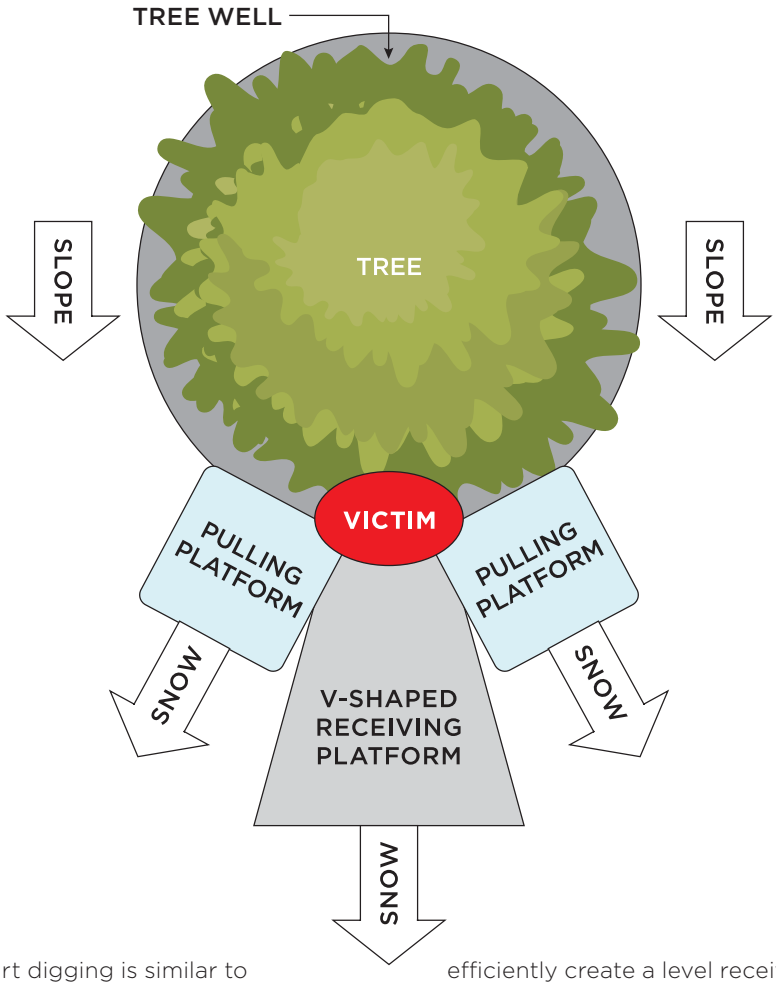
In our multiple extrication scenarios we found that trying to pull the victim out too soon often

proved extremely difficult and resulted in lost time and energy. This time and energy may be better spent digging quickly.

As the manikins were generally in the tree wells head-first and vertical, it was tempting to attempt to clear snow around the airway first, before proper digging is done to establish the receiving platform. This proved ineffective unless the victim was not buried deeply or was in a funnel shaped well with more room to move around. The tighter the confines of the tree well, the higher the risk was of knocking more loose snow onto the victim, or even compacting the snow around the victim's face, which made going for the airway early too risky. Instead, recommended best practice is to utilize the V conveyor organized digging system in a downhill orientation from the victim's location. Start digging 1-2 meters downhill of victim.

Shovels with hoe mode should be used in the rear positions of the V conveyor. When rescuers rotate in V conveyor the shovels should be left in place while rescuers move positions.

T - RESCUE



- Best place to start digging is similar to the V-conveyor system – start digging just below victim.
- Minimum of three rescuers works best.
- Two rescuers focus on digging “pulling platforms” (1 m square platforms at the lip of the tree well on each side of victim).
- Unless the victim is clearly being held up by the skis or snowboard, the equipment should be removed and set aside as quickly as possible so as not to impede the shoveling process.
- Third rescuer digs “receiving platform” (similar to v-shaped conveyor on the downhill side of victim). Coordinate digging energy to efficiently create a level receiving platform at the same time as the two pulling platforms.
- Additional rescuers can be added to the back of the receiving platform ramp.
- Platform diggers can carefully remove skis as soon as possible. In our scenarios it was found that the victim did not sink deeper without skis.
- Dig until receiving platform is level, wide enough for rescuers to attend to victim once pulled out, and reaches just below victim’s waist.
- Shovels in ‘hoe’ mode work very well and worked best at the back of the V-conveyor

- Shovels that incorporate a hoe mode are best used at the back of the line of digging rescuers.
- Organization of gear and positioning of diggers prior to rescue (and during) is key to smooth rescue.
- Don't pull too early – pulling too soon is generally ineffective until 'receiving platform' reaches just below the waist.
- When the 'pulling platforms', which are adjacent to lip of tree well and to the receiving platform, are ready rescuers coordinate pulling.
- The bottom hem of the jacket proved to be the ideal grasping point for the following reasons:
    1. Easily reached by both rescuers.
    2. Usually strong enough to take the forces involved.
    3. Pulls on the victim's torso instead of stretching the ski pants without much actual pull.
- Pull victim out onto Receiving Platform and assess airway.

RECEIVING PLATFORM

1. Should be large enough for rescuers to perform CPR once victim is out.
2. Without a proper platform there is inadequate access to the victim to initiate CPR.
3. The receiving platform should be as level as possible – not sloping down to victim = too hard to pull up hill.
4. Once the 'receiving platform' and 'pulling platforms' have reached the victim's waist the rescuers should endeavor to facilitate pulling.
5. The use of a sling seems intuitive but we found that it was not as effective as pulling on the hem of the coat, and that it was often tempting to put the sling on too soon and start pulling too soon to be very effective.

CONCLUSION

Although there were few controls and a true 'scientific approach' to this project was difficult the main findings are clear. Tree wells are extremely dangerous. With five fatalities during the 2017/2018 Winter it is evident that self-extrication cannot be counted on. Therefore, any true successful rescue needs to be extremely rapid. This can only occur if a ski partner is close by and can initiate the rescue.

Our research was about figuring out the safest fastest way to pull someone out once they are found. But it seems the true success in surviving a headfirst fall into a deep tree well lies in the search phase of the rescue and more education and research should be focused on this element.

Rob Whelan will utilize these findings to further develop safety instruction protocols for CMH staff and guests.

The goal of "How to avoid positional asphyxia while in a tree well" was not explored as no humans were put into tree wells. The search phase of a rescue also was not part of this study.

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i https://mpora.com/action/skiing/tree-well-survival-guide/

ii https://globalnews.ca/news/4076022/tree-well-deaths-mountains/

iii https://www.powder.com/stories/the-safe-zone/how-to-prevent-snow-immersion-suffocation/

iv http://arc.lib.montana.edu/snow-science/item.php?id=129