Dick Penniman

Customs and Practices at U.S. Ski Areas for Mitigating Common Hazards through Trail Configuration and Maintenance


ABSTRACT: U.S. ski areas have improved trail systems by following various configuration and maintenance customs and practices. Some of these customs and practices address specific safety issues such as slope gradients and widths, trail intersections, beginner areas, side-hills, abrupt turns, separating divergent ability skiers, surface grooming, and the presence of snow-making machinery and other man-made structures on ski trails. This paper describes these safety issues and categorizes U.S. ski area configuration and maintenance customs and practices that address them according to a known “safety hierarchy.”

KEYWORDS: skier, slope gradient, safety hierarchy, fall line, beginner, trail, side-hill

When downhill skiing was in its infancy, ski trails were nothing more than snow-covered logging roads or natural glades and open slopes. The most common mode of uphill transportation was the rope tow or one’s own climbing skis. A rope tow operator may have provided a maintained path for skiers going up, but virtually everyone was dependent on his or her own resources skiing down [1].

As ski areas have evolved into commercial enterprises competing with each other and with alternative recreation providers, they have adapted to meet the changing demands for recreational skiing and the ever increasing competition for recreation dollars. In light of these factors, the majority of ski area operators no longer risk leaving certain elements of quality and consistency of the ski area environment to the uncertainties and whims of “Mother Nature.”

A goal at most commercial ski areas in the U.S. is to minimize some of the unpredictability of the natural environment and to maximize the consistency and marketability of the recreational skiing experience. Common measures for attaining that goal include the removal of large numbers of trees to create wide, unconfining trails; stumps and boulders are routinely removed and the ground surface graded and reseded with grass so as to extend the skiing season on less snow; man-made snow is commonly produced to expand skiable trail surfaces or augment “Mother Nature’s” own whenever and wherever natural snow is not dependable or ample enough to support commercial skiing; specially designed over-snow vehicles and machinery routinely reshape and recondition the natural or manmade snow surface as weather conditions and/or normal skier use degrade skiing quality and consistency. In recent years

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many ski areas have transformed some selected skiing trails into "terrain parks" with specially built metal rail devices and machine-built snow mounds of various shapes and sizes called "attractions" to satisfy the growing demands of free style snowboarders (and some skiers) who wish to perform aerial maneuvers and other tricks. Some ski areas even maintain entire trails of highly consistent, machine-made moguls to satisfy customers who wish to engage in such skiing.

The impetus to mold and manipulate the skiing environment evolved from a desire to fulfill consumer demand, from normal business competition, from safety concerns, and from other causes. The result has been an increase in the quality, number, and types of services provided to skiers at commercial ski areas. One of these services is to construct and maintain skiing trails within graduated parameters that offer patrons of varying skill levels as consistent an environment as possible commensurate to their abilities. This practice has improved the ease of skiing to the extent that many ski areas cater to individuals for whom skiing would otherwise be very difficult or impossible. These include the very young, the elderly, and individuals who are physically challenged such as the blind, partial paraplegics, amputees, and others. At many ski areas, even the mentally challenged are encouraged to participate in certain supervised activities.

Some of the customs and practices most commonly followed in the configuration and maintenance of commercial skiing trails in the U.S. are presented in this paper. The customs and practices that address certain safety issues are categorized according to an often used "safety hierarchy" as presented by Ralph L. Barnett and Dennis B. Brickman in their paper entitled, "Safety Hierarchy" which was published in the Journal of Safety Research in 1986 [2].

Definition of Terms

"Skiers" are defined as users of skis, snowboards, or other gravity-propelled recreational devices whose design and function allow users a significant degree of control over speed and direction on snow. "Beginning skiers" or "beginners" [3] are defined as those individuals who are using one or another of these devices for the first time, or who possess marginal abilities to turn or stop on slopes with an incline greater than 20%. (The use of 20% as a slope angle limit for beginner skiers will be explained later in this paper.) The term "trail" will be used to describe all slopes, trails, roads, or paths used by skiers. The "fall-line" of a trail is defined as the direction a ball would roll down a slope [4]. On a topographic map, the "fall-line" is represented by a line perpendicular to the tangent of a given contour line at any given point along that line. Trails may have multiple fall-lines along their length. The term "side-hill" will be used to describe a fall-line that slopes across rather than parallel to the designated boundaries of a given trail. A side-hill can also be described as a slant or tilt of the trail that is in a direction other than that defined by the trim line of the vegetation or boundary designators along the sides of the trail.

Slope Gradient Criteria

Ski area planners have written criteria for slope gradients that they have determined are appropriate for beginner, intermediate, and advanced and/or expert skiers. While not all such criteria are presented in this paper, representative examples are presented in Table 1 through Table 3. These planners are well known in the U.S. ski area industry and were chosen from widely divergent geographical areas so as not to favor a particular type of ski area or region. Erickson Associates, Inc. is a New England company, Mel Borgersen and Associates, Ltd. is a Far West company, and Gaylor and Rombold are located in the Midwest.
TABLE 1—Erickson: “Usual Trail Lingo,” 1992, [5].

<table>
<thead>
<tr>
<th>Trail Code</th>
<th>Skier Ability</th>
<th>Grade Max²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easier</td>
<td>Basic beginner</td>
<td>15% (8.5°)²</td>
</tr>
<tr>
<td>More Difficult</td>
<td>Basic intermediate</td>
<td>24% (13.5°)</td>
</tr>
<tr>
<td>Most Difficult</td>
<td>(No description)</td>
<td>50% (26.5°)</td>
</tr>
<tr>
<td>Extreme</td>
<td>(No description)</td>
<td>(no value)</td>
</tr>
</tbody>
</table>

¹ Possible values.
² Beginner skiers prefer less than a 12% (7°) slope gradient. Erickson has given sworn testimony that gradients for novice skiers may be as high as 20% (11.5°).


<table>
<thead>
<tr>
<th>Trail Code</th>
<th>Skier Ability</th>
<th>Grade Max</th>
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</thead>
<tbody>
<tr>
<td>(No code)</td>
<td>Beginner</td>
<td>20% (11.5°)</td>
</tr>
<tr>
<td>(No code)</td>
<td>Intermediate</td>
<td>35% (19°)</td>
</tr>
<tr>
<td>(No code)</td>
<td>Advanced</td>
<td>55% (29°)</td>
</tr>
<tr>
<td>(No code)</td>
<td>Expert</td>
<td>80% (39°)</td>
</tr>
</tbody>
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TABLE 3—Gaylor & Rombold: “Handbook for Ski Slope Development,” 1964, [7].

<table>
<thead>
<tr>
<th>Trail Code</th>
<th>Skier Ability</th>
<th>Grade Max</th>
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<tbody>
<tr>
<td>(No code)</td>
<td>Novice</td>
<td>20% (11.5°)</td>
</tr>
<tr>
<td>(No code)</td>
<td>Intermediate</td>
<td>34% (18°)</td>
</tr>
<tr>
<td>(No code)</td>
<td>Expert</td>
<td>&gt;35% (&gt;19°)</td>
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If it is assumed that Gaylor and Rombold equate their term “novice” with “beginner” and their term “expert” with “advanced,” all three planners are fairly consistent in the maximum slope gradients they assign for various types of trails. For “intermediate” trails there is only a 1% difference between Borgersen and Gaylor/Rombold, while Erickson assigns a 9 to 10% lower grade for “intermediate” trails. Taking the maximum slope angles for each category in these three tables, consensus values for maximum standard trail gradients in each category can be derived. “Beginner” (Gaylor/Rombold “novice”) trails do not exceed 20%, “intermediate” (Erickson “basic intermediate”) trails do not exceed 35%, and “advanced” (Gaylor/Rombold “expert”) trails do not exceed 55%.

A Safety Hierarchy as Applied to Configuration and Maintenance Customs and Practice for Ski Trails

Safety hierarchies have evolved within the safety engineering and standards communities to prioritize hazard and risk mitigation measures in order of their proven and/or presumed effectiveness. One safety hierarchy that combines many of these is shown in Table 4.

As this hierarchy applies to certain configuration and maintenance customs and practices for ski trails, the “First Priority” category implies the complete removal of all unnecessary hazards. The “Second Priority” category suggests, where appropriate, the use of controlling or guarding devices such as hazard marking (bamboo and/or rope barricades), traffic controls

<table>
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<th>Priority</th>
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<tr>
<td>First Priority: Eliminate the hazard and/or risk</td>
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<tr>
<td>Second Priority: Apply safeguarding technology</td>
</tr>
<tr>
<td>Third Priority: Use warning signs</td>
</tr>
<tr>
<td>Fourth Priority: Train and instruct</td>
</tr>
<tr>
<td>Fifth Priority: Prescribe personal protection</td>
</tr>
</tbody>
</table>

(mazes and wing fences), and impact mitigation devices (padding, shields, and screens) [2]. Warning and direction signs such as “Trails Merge” and “Caution” fall under the “Third Priority” category [8], while skier safety education is indicated under the “Fourth Priority” category. Finally, personal protection devices such as helmets, wrist braces and thumb protectors come within the “Fifth Priority” category. The last two priority categories will not be discussed because they do not concern trail configuration and maintenance issues and, therefore, are outside the scope of this paper.

The following sections describe some existing U.S. customs and practices for trail configuration and maintenance that are circumscribed by the first three priorities of the “Safety Hierarchy.”

Intersections

Reducing skier to skier collisions is a primary consideration at trail intersections [8]. Standard human reaction time [9] dictates that skiers must be able to see and anticipate the movements of other skiers well before there is a need to take action to avoid them. Visibility can be obscured temporarily by weather conditions or permanently by terrain features and vegetation. A limited reaction time requires that skiers be able to approach intersections at appropriate speeds, especially where more advanced or faster moving skiers merge with less skilled or slower skiers.

Configuring trail intersections so that skiers have ample visibility of on-coming traffic and so that they merge at low angles of incidence and at slow speeds are customs and practices that fall within the “First Priority” category. If dense trees obscure the view of approaching skiers on intersecting trails, it is customary to thin or limb the trees to create adequate visibility. Where appropriate, slope gradients are reduced, and trail boundaries are widened above the intersection to allow skiers more opportunity to observe other skiers, maneuver away from them, and slow down if necessary. Minimizing the approach angles of intersecting trails is also done to automatically allow skiers to merge parallel to each other.

If, after trail construction, visibility of merging skiers remains obscured by unremovable obstacles or merging angles are less than ideal for skiers to approach each other in a relatively parallel fashion, several “Second Priority” category customs and practices for intersections include wing fences, speed mazes, and/or posted guards [2]. Wing fences allow unimpaired visibility from all directions and discourage skiers from merging at too obtuse an angle. Speed mazes are also used to control skier speeds and directions before an intersection. On heavily used egress trails and at particularly busy times of the day, posted patrollers may also be employed to advise skiers to slow down at strategic locations above potentially dangerous intersections.

Trail signs such as “Merge” and “Slow” fall within the “Third Priority” category for intersections [2]. They are generally placed before and within view of the intersection to help warn approaching skiers from both directions. “Slow” is a relative term and in some
cases it may not convey the desired message to skiers. Where appropriate, signs with a more specific message are posted.

*Beginner Trails*

Beginning skiers, by definition, have minimal control over their speed and direction \[4\]. They are usually unable to recognize subtle variations in slope and terrain and, in any event, may be incapable of compensating for them. Narrow trails, turns in trails, and steep drops or embankments on the sides of trails can intimidate beginners or require skills they do not yet have, compromising whatever ability they do have to stop or turn.

Configuring a slope to maximize trail width and to minimize surface irregularities, obstacles, slope steepness, side drop-offs, and side-hills are some of the U.S. ski area configuration and maintenance customs and practices that fall within the "First Priority" category for beginner trails. Narrow and/or winding roads are generally not considered suitable beginner trails because of the higher level of skier control required. Ideal beginner terrain is a very gentle slope that ends on a flat section, or better still, has a "counter slope" to stop the skier \[3\]. Short, slightly steeper sections in beginner trails are appropriate if they are obvious to beginners approaching from above and if beginners have the option of easily maneuvering around these sections on lower slope angles to one or both sides.

It has been the experience of many U.S. ski areas that obstacles within the designated boundaries of beginner trails sooner or later are likely to cause problems for beginning skiers. When it is impractical to remove obstacles such as lift towers, light poles, and buildings from beginner trails, it is the custom and practice to install appropriate padding and shielding devices. These procedures are in the "Second Priority" category for beginner trails. In special circumstances, where appropriate, potentially hazardous obstacles beyond the designated trail boundaries are also padded and/or shielded \[10\].

Many collisions with fixed obstacles have resulted from a slide after a fall. Sliding skiers of any ability may choose to prepare themselves for impact with a padded obstacle rather than attempt to arrest their speed. If the pad does not function adequately, severe injury may result \[10\]. Many commercially available padding products are only designed to mitigate injuries from low-speed impacts of from five to seven miles per hour \[2\]. If higher speed impacts can be anticipated, several layers of these devices are often added on top of another to provide the appropriate level of impact mitigation.

Because beginners are often unable to plan their actions far enough in advance to avoid even obvious obstacles, hazard markings, warnings, and signs may be of limited use on beginner trails. Pads, shields, or screens are usually more appropriate for beginner trails in situations where warnings would suffice for intermediate or advanced level trails.

It can be anticipated that beginner skiers will unwittingly ski, slide, or fall outside the boundaries of the trail. Therefore, on beginner trails, the configuration of side and end boundaries is a primary consideration. Where appropriate, trail debris such as uprooted stumps, limbs, and loose rocks are cleared well back into the trees so that skiers that go off course will not hit such objects that may be hidden in softer, ungroomed snow just below the surface. At some locations, snow berms and catch fences are used to prevent errant skiers from being injured by going off beginner trails \[2\].

"Third Priority" category customs and practices for beginner trails include directional signs that help skiers find trails to the bottom of the lift, the base lodge, or some other destination. Difficulty rating signs are customarily used to tell skiers which trails may be appropriate for their ability. This subject will be discussed in more detail later in this paper.
Side-Hills

Gravity is obviously the propelling force in alpine skiing, and skiers must constantly work against this force to control their speed. Most trails are constructed parallel to the fall-line because it is natural for skiers to move in the direction that gravity pulls them. When skiers fall on such trails, gravity pulls them directly downhill, parallel to the trail boundary, and, hopefully, out of harm’s way. Side-hill trails, on the other hand, are trails where trees or other boundary obstacles angle down and across the true fall line of the slope. These types of trails can be hazardous in hard snow conditions because gravity will tend to pull fallen, sliding skiers across the designated trail and into the trees and other objects along the trail boundary. The hazard created by side-hill trails can be compounded because skiers tend to look in the direction they are traveling and may not notice the potential for collision with certain objects at the sides of the trail if they were to fall and slide. These types of trails are generally not suitable for beginner skiers. Such trails are not to be confused with road cuts that create a flat sloping ramp across a slope. Road cuts provide an artificial fall line that does reduce the gradient of the slope being traversed so long as the skier stays on the flat, horizontal portion of the road.

Configuring trails that flow in the direction of the fall-line or create their own fall-line is a custom and practice that falls within the “First Priority” category for eliminating side-hills. Trails with existing side-hills may be corrected in the summer by moving earth and/or in the winter by moving snow. A “cut and fill” technique is normally used to accomplish this. Cut and fill is the process of excavating away earth or snow from the uphill side of the slope and using the excavated material to build a platform on the downhill side. A drawback to this technique is that a steep drop is created off the downhill edge of the fill platform. Skiers are often unaware of this short but extreme slope because it is out of their line of site. If skiers fall near the edge and their momentum carries them onto this drop-off, it acts as a “zone of acceleration” where their speed will increase quickly and unexpectedly before impacting the tree line or trail boundary. Catch fences and other customs and practices within the “Second Priority” category are usually used to guard against such drop-offs.

“Second-Priority” category customs and practices for minimizing potential problems with side-hill trails include screening devices such as catch fences, snow berms, and waterproofed hay bales, which are used to catch errant skiers headed for obstacles on the trail, in the tree line, or beyond the trail boundary. Screening materials normally used in these applications are strong enough to stop skiers at expected speeds for the trail, but not so rigid as to cause severe injury on impact. A “zone of deceleration” to reduce impact injury as much as is practical is designed into some commercially available screening and shielding products.

There are no known “Third Priority” category customs and practices that adequately address hazardous side-hill trails.

Abrupt Turns

Any trail that forces skiers to change direction dramatically at a specific location can predictably result in skiers overrunning the turn [10]. A common example of such a turn is a fall-line trail that terminates at a traverse road.

Within the “First Priority” category of U.S. ski area customs and practices for dealing with abrupt turns is configuring the bottom portion of the trail so that it allows skiers to merge with the return road at an acute angle. This is accomplished by shaping the vegetation trim line or trail boundary so that it angles away from the fall-line in the direction of the road. If this measure creates a potential side-hill problem, a shallow-sloped, wide-open de-
celeration area is often added below the turn where trees and other obstacles have been removed. Building an embankment on the outside of the turn by elevating the outside with earth or snow is also done to counteract the centrifugal forces that tend to force skiers off the trail. This configuration follows the same principle as banking a turn on a road to keep cars from going off the outside of the turn. Widening the turn and/or reducing skier speeds by decreasing the slope angle also helps to lessen the potential for skiers to overrun the turn.

If abrupt turns are unavoidable, “Second Priority” category customs and practices include installing catch fences and/or constructing snow berms [2]. Catch fences may take the form of either temporary or permanent structures. Similar considerations in constructing fences are followed as described in the Side-Hills section. A berm of snow is sometimes used on the outside of the turn to act as a guard rail for the turn. These are normally constructed to avoid an abrupt wall of compacted snow for skiers to impact, but not beveled so much that they create a launching ramp into the woods or off the trail. Speed mazes are also used to slow skier speeds just before abrupt turns. Where hard snow conditions warrant, or where blunt impact can be anticipated, waterproofed hay bales are sometimes used to line the berm, creating a softer impact.

“Third Priority” category customs and practices for abrupt turns include “Slow” and “Caution” signs. The same considerations for “Slow” signs as described in previous sections apply. Large signs that display an arrow curving in the appropriate direction in a position above the turn are also used. Where direct supervision is required, posted guards are stationed above the turn to verbally advise skiers to enter the turn at appropriate speeds.

Separating Divergent Ability Skiers

A safety consideration in the over-all layout of ski trails is the placement of trails so as to minimize the mix of faster, advanced-ability skiers with slower, lower-ability skiers. Mixing such skiers on the same trail creates the potential for skier to skier collisions. Access trails to bottom lift terminals and heavily used egress routes are particular areas where such collisions are common.

The U.S. ski area custom and practice of providing divided and/or separate trails is within the “First Priority” category for separating divergent ability skiers. Most advanced skiers tend to stay on slopes that suit their ability and will usually go to beginner level slopes only if there is a need to do so. Therefore, laying out trails and placing lift terminals so as to eliminate the need for advanced skiers to use lower level trails effectively acts to separate divergent ability skiers.

Where such lift placement and trail separation is not practical, “Second Priority” category customs and practices include preventative measures to decrease skier speeds and to keep divergent skier ability levels separated. These include speed mazes and wing fences whose construction methods were described in previous sections. Where appropriate, speed mazes help reduce advanced skier speeds, and wing fences divide shared trails down the fall-line.

The custom and practice of installing “Slow Area” and “Family Area” signs are within the “Third Priority” category for separating divergent ability skiers. However, what is “Slow” for one skier may not be “Slow” for another. And “Family Area” does not necessarily tell the skier what specific behavior is required. Additional written, explicit warnings or expectations of skier behavior often accompany these signs where necessary. When appropriate, a staff presence is also added to advise skiers and to promote compliance with the intended purpose of the posted signs.
Surface Grooming

The use of over-snow vehicles to recondition the skiing surface of a trail is commonly referred to as trail “grooming.” This process usually occurs during the night when the trails are closed. Grooming may be possible while a trail is open if skiers are warned of the presence of vehicles before they enter the trail, and adequate precautions are taken to eliminate the possibility of skiers coming into contact with the vehicles. Grooming normally improves the skiing experience, providing a more consistent and, therefore, safer skiing surface. But it may do quite the opposite. It is possible to over-groom certain types of trails, thereby increasing skier speeds to dangerous levels. Drivers may also make mistakes, and/or grooming implements and techniques may not suit snow conditions, leaving hazardous surface features. Regardless of the reason, improperly groomed skiing surfaces can cause skiers to lose control and fall or collide with obstacles or other skiers. Thin snow cover may also cause a trail to be too dangerous or simply impractical to open to recreational skiers. A poorly groomed skiing surface or thin snow cover and bare spots may be especially dangerous if new snow fall obscures them from view and is not yet deep enough to completely prevent skiers from hitting obstacles that lie just below the new snow surface.

If, for all practical purposes, trail conditions are unskiable, “First Priority” category customs and practices at U.S. ski areas for dealing with poor surface conditions usually include preventing skier access by closing entire trails (or portions thereof) until repairs can be made. Adding man-made snow and/or hauling in stockpiled snow is also done to repair unskiable surface conditions.

Where it is impossible, impractical, or undesirable to repair unskiable spots, but the trail is otherwise viable, “Second Priority” category customs and practices include isolating specific danger areas. Barrier and shielding devices installed around such areas are used as described in previous sections.

If isolated surface spots on the trail are skiable, but are significantly different from what skiers have been exposed to, as previously mentioned, warning markers and signs are employed as “Third Priority” category measures [2]. Where necessary, posted guards are also used to verbally warn skiers of poor surface or other dangerous conditions on trails. Where certain surface conditions increase the difficulty level of the trail from its normal rating, signs and/or staff members are posted to advise and inform skiers of the specific conditions on the trail.

Snow-Making Machinery and Man-Made Structures

Placing snow-making machinery and other man-made structures such as steel culverts and small out-buildings on or near designated skiing trails is often necessary for the operating viability of U.S. ski areas. While at a glance, these objects may seem to present no more significant hazard than surrounding exposed earth or natural objects such as rocks and forest vegetation, the magnitude of the hazard they present is, in fact, often far greater. For example, a three-inch-diameter steel hydrant standpipe is far more rigid than the same diameter branch or sapling. The potential injury that a skier may suffer upon impact with such a steel standpipe with its associated nozzles and valve handles is clearly more significant than a collision with a similarly sized sapling. Yet, at a glance to the passing recreational skier, a steel standpipe may be indistinguishable from a similarly sized sapling.

The appearance of being in and among natural elements of the outdoor environment is part of the appeal of recreational skiing. Trees and natural terrain features are considered desirable to the ambiance of the skiing experience, while metal pipes, utility buildings, and other operational structures are not.
The removal of man-made obstacles or unnecessary structures from the recreational skiing environment falls within the "First Priority" category of U.S. ski area customs and practices for mitigating potential skier injury from impact. Snow-making supply pipes and hydrants and erosion control devices such as metal culverts can be buried or may be naturally screened by placing them far enough back into dense boundary vegetation so as not to pose a potential for skier impact.

The custom and practice of screening or padding manmade objects that are difficult or impractical to remove falls within the "Second Priority" category. Brightly colored fences and pads also help alert skiers to the potential hazard presented by these objects and can be considered as "Third Priority" category enhancements of these measures. Closure of trails where snowmaking is taking place or where temporary equipment and structures may be located is also a "Second Priority" option.

"Third Priority" category customs and practices include signs and warnings of snowmaking equipment in use or other objects and equipment that present a hazard to skiers. To offer skiers the option to avoid the area where such objects are located, signs and warnings are placed above the objects at a location to allow skiers to choose a completely different trail or a route that eliminates any potential for encountering the hazard.

Discussion

Mitigation of trail configuration problems is commonly accompanied by observations by the ski area to determine if the effort has been effective. Clearly, as in any endeavor, attempts to solve a problem may not be effective or may create another completely unexpected one. Follow-up observations usually help such situations to be corrected before injury results.

Even if there appear to be no configuration problems on a given ski trail subsequent to early observations after industry custom and practice procedures are put in place, observations of skier traffic over time may indicate a pattern of injuries, collisions, and/or near misses. Observations of traffic patterns and skier behavior over time often help determine how skiers react and interact along the trail in crowded versus uncrowded conditions, in fair versus foul weather, and with ideal versus marginal snow surface conditions. Recording observations on videotape for analysis of any future changes can also prove useful. Computer databases and pin maps can also be useful in identifying trends in accident locations and concentrations.

Conclusion

Downhill skiing has evolved from its early days of being a somewhat daring, wilderness adventure into what is now a family-oriented recreational activity in a professionally managed and maintained environment. From the removal of forests, to the reconfiguration of the ground surface, to the manufacture of artificial snow, to the reconditioning of the snow surface, almost all elements of the ski area environment are routinely reconfigured and controlled in some way. From both their appearance and their apparent function, modern ski areas attempt to provide an environment where skiers feel as though they are in natural surroundings, but where unnecessary hazards that detract from an enjoyable recreational environment have been mitigated. Most of the hazard mitigation customs and practices utilized by U.S. ski areas in the configuration and maintenance of ski trails may be categorized according to the "safety hierarchy" presented by Barnett and Brickman. In so doing, a clearer picture of which current U.S. ski area customs and practices may be more effective for certain situations emerges. No matter what safety measures are incorporated into trail configuration and maintenance, however, there are some hazards that are inherent to skiing that
either cannot or should not be removed. Skiers must still act responsibly and moderate their speed and direction in a reasonable manner. As modern U.S. ski areas are operated today, the responsibility for creating and maintaining a reasonably safe and enjoyable recreational environment is shared by both skier and ski area.

References