GUIDELINES for SNOWMOBILE TRAIL GROOMER OPERATOR TRAINING

A Resource Guide for Trail Grooming Managers and Equipment Operators

Produced by

iasa
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GUIDELINES for SNOWMOBILE TRAIL GROOMER OPERATOR TRAINING

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Special recognition is given to the many companies whose photos and/or materials have been used for demonstration purposes in this project. Sponsors of this project do not endorse products or manufacturers. Trade and manufacturer’s names appear in this document only because they are considered essential to the object of the document.

The purpose of this publication is educational only, with no other intent but to expand snowmobiling and grooming professionals’ knowledge base. It should not be assumed by the reader that all contributors agree with every written word, but are opinions only. The authors, contributors, FHWA, Trails Work Consulting, IASA, ACSA and their members accept no liability resulting from the compliance or noncompliance with the procedures or recommendations given herein, or for the accuracy or completeness of the information contained herein.

Snowmobilers must understand that snowmobile trails are not engineered roadways and therefore will not always be uniformly maintained with every potential hazard removed. Individual snowmobile operators and passengers must take responsibility for their own safe riding behavior, always being mindful that snowmobiling takes place in the unpredictable natural environment, and recognizing the effects of weather on trails.

The intent of publishing this document is to provide entities involved with snowmobile trail grooming a framework to train and certify their equipment operators. However, all decisions on local operator training content, as well as certification requirements, are reserved for implementation by local jurisdictions and local trail grooming managers consistent with local priorities and resources.

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Chapter One:

INTRODUCTION TO TRAIL GROOMING

Purpose of this Resource Guide

The purpose of this resource guide is to provide snowmobiling agencies, associations, and clubs with guidelines that are a resource for:

- grooming recreational snowmobile trails to help improve the quality of trails and the effectiveness of grooming efforts and expenditures;
- training snowmobile trail groomer operators on the proper operation and maintenance of grooming equipment; proper trail grooming objectives, principles, and practices; and trail grooming safety issues; and
- increasing community awareness of snowmobile trail grooming requirements and practices, including the need for the public to allow proper set up time on freshly groomed trails and safe operating procedures for snowmobilers when encountering groomers on the trail.

Photo 1.1 Snowmobile traffic creates rough trails that require trail grooming

A growing number of snowmobiles are operating on snowmobile trails today, which drives an increasing need for smooth trails that can keep traffic moving safely. This makes it necessary to optimize the use of personnel and equipment involved with trail grooming. Increased operational costs have also necessitated tighter controls on grooming operations to maximize the effectiveness of expenditures. Certainly, grooming under conditions that do not allow snowmobile trails to properly set up is not advantageous or effective. This resource guide is intended to help grooming managers and operators recognize various scenarios to help them optimize their effectiveness under as many winter conditions as possible.

Photo 1.2 Smooth, firm trails created by trail grooming

Historically, area decisions regarding grooming scheduling have sometimes been driven by perspectives like “the public demands that we groom during the day so they can see the groomer,” or “the groomer operators are volunteers, so they need to groom fast so they can get back home.” Neither situation tends to produce effective grooming. Scheduling productive and effective grooming operations can be challenging, particularly in areas where there is no “slow time” and snowmobile traffic is heavy every day of the week. Grooming managers are continually challenged to make their grooming resources go further to keep up with the ever increasing demand for smooth trails.

This guide is but one tool to assist with the development and maintenance of safer, smoother snowmobile trails. The materials within are intended as general guidelines that may not apply to every local situation or condition and are not intended to be all encompassing. At the same time, the materials within cover basic yet important grooming fundamentals and principles and also provide valuable tips that can help areas improve the quality, and durability, of their snowmobile trail systems if applied correctly.

Snowmobile trail grooming times, frequencies, and methods can be influenced by many variables including: temperature, type and depth of snow, terrain, snowmobile traffic volume and use patterns, wind, current or incoming storms, and avalanche or water crossing hazards. Decisions as to when to groom and the implements to use should be based upon the informed judgment of the local grooming manager, following guidelines and principles outlined in this guide along with guidance and program-wide stipulations from jurisdictional or governmental program administrators who typically control local funding levels.

The *Groomer Operator Training Core Components Checklist* on the following pages outlines topics that are important for groomer operators to know and understand and provides a snapshot of the topics covered more in-depth by this resource guide.

International Association of Snowmobile Administrators

GROOMER OPERATOR TRAINING

Core Components Checklist

Every Groomer Operator Should Be Able To:

1. **Demonstrate an Understanding of the Basics of Snowmobile Trail Grooming.**
   - ☐ Understand trail grooming's general purpose, objectives, principles, and practices, along with common terms used in trail grooming.
   - ☐ Understand the basic characteristics and mechanics of snow.
   - ☐ Understand the role and importance of grooming managers and schedules.
   - ☐ Understand the source and level of funding for their snowmobile trails.

2. **Know the Grooming Equipment they are Operating and Identify its Key Controls, Components, and Features.**
   - ☐ Know the capabilities, characteristics, and limitations of their grooming tractor and front blade.
   - ☐ Identify key controls and components of their grooming tractor and front blade (steering, throttle, brakes, lights, mirrors, hydraulics, tracks, engine, hitch, etc.)
   - ☐ Know the capabilities, characteristics, and limitations of their grooming implement(s) (drag, tiller, or compactor bar as applicable).
   - ☐ Identify key features of their grooming implements (frame, blades, wheels, tongue, hydraulics, skags, pan, tines, drum, lights, etc. as applicable)

3. **Start, Operate, And Control the Groomer.**
   - ☐ Properly conduct a pre- and post-operation visual inspection.
   - ☐ Operate and understand all in-cab controls, instruments, and gauges.
   - ☐ Start, stop, and park the vehicle.
   - ☐ Back up the vehicle and hook it up to implements.
   - ☐ Operate the vehicle on the right side of the trail.
   - ☐ Demonstrate proper technique to get the vehicle unstuck.
   - ☐ Demonstrate front blade functions and operation.
   - ☐ Demonstrate the function and operation of rear implements.

4. **Demonstrate Good Operator Safety Procedures.**
   - ☐ Be prepared by carrying tools, safety equipment, and proper clothing.
   - ☐ Ensure grooming equipment is always visible with lights and reflective material.
   - ☐ Always wear seat belts and operate cautiously when using front blade.
   - ☐ File trip plan and stay in communication with dispatch or manager.

- ☐ Safely stop and park grooming equipment when on trail.
- ☐ Safely secure grooming equipment that breaks down on the trail.
- ☐ Avoid ice crossings.
- ☐ Check equipment prior to departure.
- ☐ Carry extra trail signs and replace when missing.

5. Demonstrate Proper Equipment Operation Techniques and Procedures.

- ☐ Understand general grooming operating guidelines, including minimum snow depth, best time to groom, the optimal temperature range for grooming, and grooming procedures for when there is low visibility.
- ☐ Understand grooming basics like: constantly watching the trail behind the groomer; don't leave holes, debris, or back-up piles on the trail; and know your trail so you can anticipate grooming needs and adjustments.
- ☐ Understand proper grooming speed and problems caused by grooming too fast.
- ☐ Understand the proper technique for grooming curves, hills, and bridges.
- ☐ Understand the difference between building and maintaining a trail base.
- ☐ Understand what to do when meeting snowmobiles on the trail.
- ☐ Understand proper grooming width and direction of travel.
- ☐ Understand proper techniques for grooming with a drag.
- ☐ Understand proper techniques for grooming with a tiller.
- ☐ Understand proper techniques for use of a front blade.
- ☐ Understand proper techniques and tips for operating tracked vehicles.
- ☐ Know the Top 10 Operator Abuses

6. Perform Proper Equipment Inspection and Maintenance.

- ☐ Understand the importance of preventative maintenance.
- ☐ Practice the Four Elements of Preventative Maintenance.
- ☐ Refuel and lubricate the equipment.
- ☐ Perform pre-shift inspection and maintenance.
- ☐ Periodically stop to perform walk-around inspection during grooming shift.
- ☐ Perform post-shift inspection and maintenance.
- ☐ Notify grooming manager of equipment maintenance needs.
- ☐ Assist with pre-season, off-season, and regularly scheduled maintenance as requested.

7. Perform Proper Record Keeping.

- ☐ Complete Daily Groomer Operator's Logs and Pre- and Post Operation Checklists.
- ☐ Keep accurate records of equipment use and maintenance.
- ☐ Submit Equipment Maintenance Requests and Corrective Action forms.

8. Know the Local Area and Local Procedures.

- ☐ Know local trail routes and have maps available for snowmobilers.
- ☐ Know local trail signing guidelines.
- ☐ Know local laws and any special closures for sensitive areas.
- ☐ Know local emergency procedures and contact information.

Introduction to Snowmobile Trail Grooming

A snowmobiler's safety and enjoyment is greatly enhanced when a smooth, even layer of snow covers the trail they have chosen to ride.

Photo 1.3 Trail grooming is important to snowmobilers

"Trail grooming" is the activity of producing a smooth surface of snow with a uniform high density through the use of mechanical equipment. Trails become rough primarily through the cumulative effects of snowmobile traffic.

Weather can also have a considerable impact on trail quality, as can the effects of other trail users, water movement, timber operations, etc.

Snowmobile riders are very aware of the importance of trail grooming since it has a very fundamental impact upon the enjoyment of their ride. Consequently, the general interest in good trail grooming is high throughout the snowmobiling community, including businesses that cater to snowmobilers. At the same time, the actions of and the equipment used by snowmobile riders – fast starts or stops, powering through curves, carbide runners, paddle tracks, and powerful engines – can combine to have great impacts upon the conditions of snowmobile trails and can essentially destroy them in a very short period of time.

Photo 1.4 Aggressive riding styles like fast starts and powering through curves impact trails

Trail grooming is typically the single greatest expense facing the operation of a snowmobile trail system, both in terms of capital costs to purchase expensive equipment as well as for the ongoing costs of operating and maintaining that equipment in harsh winter conditions. In many areas, trail grooming is often the main focus of a snowmobile club or association's activities. It can account for as much as 50% to 75% of total expenditures for agency or association operated snowmobile programs. It is big business.

Photo 1.5 Snowmobile grooming tractors share a history with Antarctic travel

Snowmobile trail grooming equipment shares a common history with tracked vehicles originally developed for Antarctic travel and for the alpine ski industry. However, in the mid-1980s a number of changes began to evolve in snowmobile trail grooming tractors and drags that have greatly increased the effectiveness of today's snowmobile grooming equipment. While there is still some crossover today between alpine ski and snowmobile trail grooming equipment, snowmobile trail grooming equipment has evolved to be a specialty product that stands on its own.

Photo 1.6 Typical specialized modern snowmobile trail grooming equipment

The grooming tractor is a heavy-duty, two or four-tracked vehicle whose primary purpose is to provide the power to pull an implement (drag), power a tiller, or carry a compactor bar across the top of the snow. It may also be used to carry a front blade. Some areas also use farm tractors equipped with a track conversion to pull grooming drags.

Photo 1.7 Examples of modern snowmobile trail grooming equipment

The actual work of grooming the snow on the trail bed is performed by a front blade used in conjunction with implements like a drag or tiller that are either towed or carried behind the tractor. While a grooming drag is called a planer or a surfacer by some manufacturers, it will be referred to simply as a drag in this document. Tractors, tillers, drags, and other grooming implements will be discussed in depth in Chapter 2.

TRAIL GROOMING OBJECTIVE

The overall objective of snowmobile trail grooming is to provide smooth trails that are suitable for all levels of rider experience. This can mean many things: establishing a trail base at the beginning of the season, having to reestablish a trail after heavy snowfall and/or winds have obliterated it, or having to work a heavily moguled trail back into a smooth surface (also called “restoring” the trail).

Throughout the season, the key to successful trail grooming is for the groomer to build a solid base of snow “pavement” for snowmobiles and grooming equipment to operate upon. The groomed trail base will be packed solid from the ground up while the snow off to the side of the trail will generally be soft and may be several feet deep. This means that both snowmobiles and the grooming equipment can become stuck should they venture off the packed trail base in deep snow areas. As a groomer operator, the trail is your friend – know where it is and stay on it!

It is important to understand the minimum level “grooming frequency” or “grooming standard” that is established for trails in an area. It is always driven by the available budget and results in priorities needing to be set. As a result, it is likely that all trails in an area may not receive the same minimum level of weekly grooming repetitions. Some areas categorize their trails as Level 1, 2, or 3. In this example, Level 1 or “Minimum” trails have no commitments for grooming. Level 2 or “Preferred” trails are fully “restored” at least once every 5 days. Level 3 or “Comprehensive” trails are fully restored at least once every 3 days. If categories like these are used, it is important that, 1) equipment operators and snowmobilers in the area understand the expectations, and 2) the grooming program and operators follow through with the expected commitment.

Photo 1.8 Trail grooming builds a solid, compacted base

THE PHYSICS of SNOW and SNOW SURFACE PREPARATION

It is useful for grooming managers and grooming equipment operators to have a basic understanding of the properties of snow in order to produce and maintain a durable trail. Because snow (or ice) on the Earth's surface exists so close to its melting temperature, it is unlike soils or other construction materials used to build or surface trails. This section presents a general overview of how snow forms in the atmosphere, its response to environment, and external loads that are important to snowmobile trail grooming.

Formation of Snow

The basic structure of snow, or ice, is a hexagonal (six-sided) crystal within Earth's atmospheric pressures and temperatures (see Figure 1.1). Three a-axes are perpendicular to the c-axis at 60^{o} to each other. The direction of crystal growth along the c-axis or a-axes depends on temperature. This temperature dependence of crystal growth produces the wide variety in the geometric forms of snow, such as stellar crystals, plates, dendrites, needles, columns, etc. Prolonged rotation of a snow crystal in the atmosphere produces more irregularly shaped aggregations of crystals such as snow pellets or sleet.

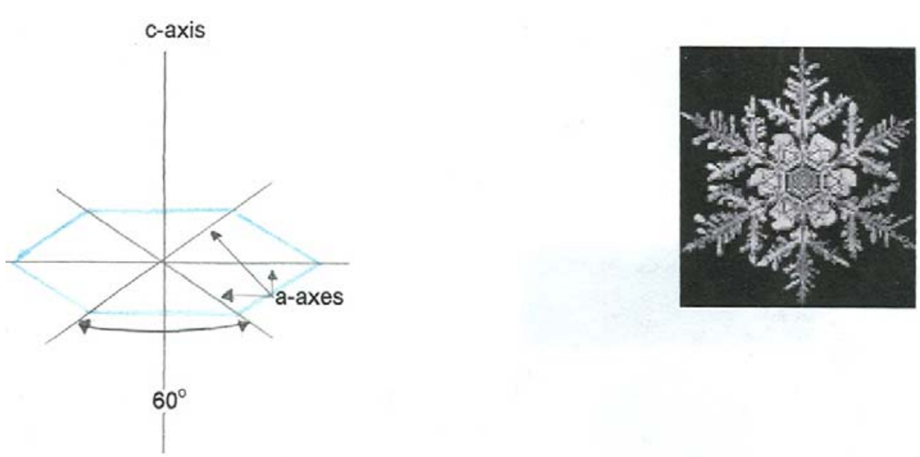


Figure 1.1 The basic structure of snow formed in the atmosphere is a hexagonal crystal. A-axes growth produces a stellar crystal or "snowflake".

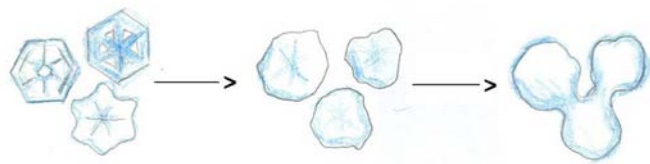
The Snowpack and How It Changes

Once snow has been deposited on the ground, it begins to change, or metamorphose. Gravity causes natural compaction and motion (or creep) to occur. Water vapor moves from areas of higher temperature or higher pressure areas to lower temperature or lower pressure areas. Free water may be present in the snowpack and solar radiation can cause a change in the snow surface.

Three basic types of changes in the snowpack, i.e. snow metamorphism, are important for the groomer operator to understand. These changes depend mostly on the snow temperatures, allowing water vapor to flow within the snowpack, or the migration of free water in the snowpack. It is important to note that the temperature of the snow, even at or near the snow surface, is not typically the same as the ambient air temperature.

Equi-temperature (ET) metamorphism occurs in regions where an "equal" or uniform temperature is present within the snowpack. This produces a high degree of sintering (neck growth and bonding) which yields a higher strength snow. The snow crystals grow, become rounded, and bond at the expense of more faceted forms due to the transport of water vapor.

Under equal temperature conditions, the transportation of water vapor is a pressure dominated process (see Figure 1.2). Higher vapor pressures are present over convex surfaces. Lower vapor pressures exist within concave surfaces. The water vapor at high pressure moves to the low pressure regions, condenses, and forms necks and bonds. This is the desired condition for producing a stronger, more durable snow surface.



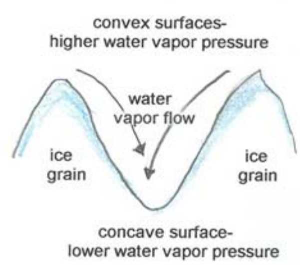


Figure 1.2 Equi-temperature metamorphism. Snow grains become rounded and bond to each other, producing a higher strength snow.

Temperature gradient (TG) metamorphism causes the formation of a poorly bonded, faceted TG crystal, commonly know as "depth hoar." It is typically seen at the base of the snowpack or underneath an ice crust layer. The formation of a TG layer typically occurs in a shallow snowpack during cold, clear nights. The heat loss of the snow surface to the atmosphere through radiation creates a strong temperature gradient, or temperature difference, within the snowpack. The ground temperature will be warmer than the snow surface temperature. A weak, hollow layer will be formed and will persist at the base of the snow.

Under temperature gradient conditions, water vapor transport is dominated by temperature (see Figure 1.3 on the next page). Water vapor at the higher ground temperature moves upward to the lower snow surface temperature, or more simply, hot moves to cold. When the net vapor transport is toward the snow surface, faceted cohesionless crystals rapidly form due to the excess vapor density. It is important for the groomer operator to note a weather pattern of cold, clear nights with a shallow snowpack early in the season, particularly in mountainous regions, since the presence of a TG layer at the base of the snowpack can eventually produce an avalanche cycle.

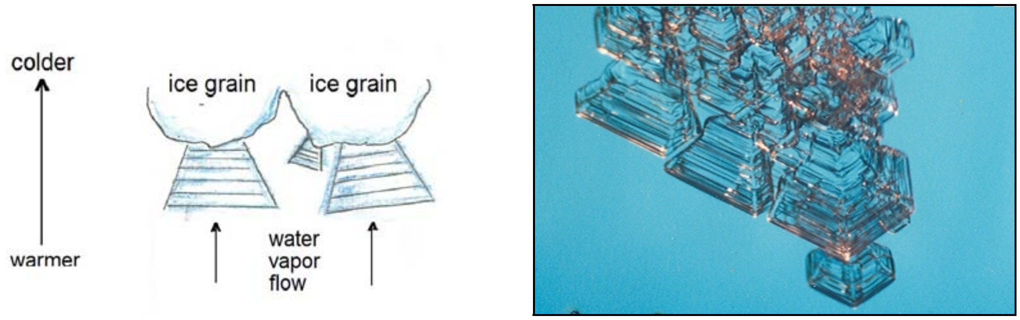


Figure 1.3 Temperature gradient metamorphism – the flow of water vapor towards the colder snow surface causes the weak "depth hoar" to grow.

Cold, clear nights following the passage of a front can also cause changes on the snow surface. The development of surface hoar occurs when a temperature gradient, or difference, between the atmosphere and the snow surface develops. Again, hot moves to cold, so water vapor is driven from the atmosphere to the cooling snow surface, forming the cohesionless faceted surface hoar crystals (see Figure 1.4). Again, these crystals are very stable within the snowpack, and a layer of these weak crystals can persist over the entire winter season.

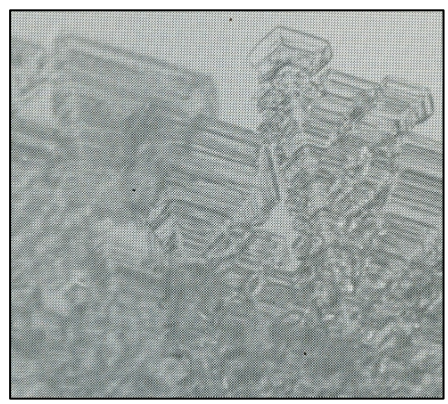


Figure 1.4 Surface hoar crystals form on the snow surface during cold, clear nights.

Melt-freeze (MF) metamorphism occurs whenever free water is present within the snowpack. Free water may be present due to a rain event or surface melting by solar radiation. Free water will percolate slowly through the snow and freeze within a colder region of the snowpack. Near the snow surface, smaller grains will melt and the melt water will be retained by the surface tension of the larger grains. Refreezing forms larger, polygranular clusters. The snow strength becomes increasingly dependent upon the degree of refreezing that occurs. Melt-freeze snow can become solid ice or completely de-bonded, depending on its temperature.

Grooming Snow, Physical Properties, and Metamorphism

Regional and seasonal differences in snow quality (i.e. physical properties of snow such as particle size, wetness, density, temperature, etc.) will influence the ideal method for trail preparation. In general, the goal of trail grooming is to reduce the snow particle size and produce some different particle sizes in order to maximize the number of bonding, or sintering, sites within the snow. Mixing a layer of snow should also temporarily produce an equal temperature layer, to some extent. In other words, the goal is to prepare a layer of the snow to maximize equi-temperature metamorphism within that layer, and allow sufficient time for bonds to form between the snow grains, i.e. “set-up.” Therefore, the overall quality, or physical properties, of the snow prior to and post-grooming are of some importance.

For grooming, the most important indicator properties of the snow are particle size, temperature, wetness, and the final snow hardness, or strength. Snow density, or the mass per unit volume of the snow, is not necessarily a good indicator property of snow strength since very wet, unbonded, melt-freeze snow can be of very high density but have very low strength.

The particle size and sorting can be determined by simply examining the snow prior to grooming. A particle size range from 1/32 in. to 3/16 in. (0.5 mm to 4.5 mm) is ideal. Large particles or clumps that have developed perhaps due to melt-freeze changes (MF metamorphism), may require a more aggressive grooming technique, such as tilling the snow. In many regions, the snowfall consists of relatively low density, small particulate snow and the snowpack remains dry. In such areas, a multi-blade drag can provide sufficient remixing of the snow surface. It is important for the groomer operator to become familiar with the variations in snow particle sizes for his/her specific region and snow conditions in order to determine the appropriate grooming technique.

For bonding to occur, the snow temperature must be below freezing, i.e., less than 32^{o}F or 0^{o}C. Again, equi-temperature metamorphism is a water vapor pressure dominated process, so water vapor is probably more available for vapor transport in warmer snow. This only implies that bonding may occur at a more rapid rate when the processed snow is only a few degrees below freezing. Well-bonded snow can be achieved at very cold temperatures (less than -40^{o}F or -40^{o}C). The critical factor is allowing sufficient time for the snow to sinter, or “set up.” It is highly recommended that grooming occur post-sunset, as the snow surface does absorb some solar radiation during the day which will increase the snow surface temperature. An equi-temperature metamorphism condition, and therefore better conditions for trail set up, is more easily achieved after sunset.

Relatively inexpensive rapid response digital thermometers are commercially available for snow temperature measurements. Infrared temperature sensors are not recommended since solar radiation, the reflection of the snow surface, and the exhaust from the grooming vehicle can produce an inaccurate temperature measurement.

The free water content of the snow, or wetness of the snow, can influence the selection of the best method for processing the snow. This property is best determined by measuring the snow temperature. The groomer operator should examine the snow, by trying to make a snowball, for example. Very warm, wet, or saturated, snow will not be cohesive. However, if the temperature is dropping wet snow may refreeze overnight. Also, freshly fallen, cold, dry snow will not readily stick together. However, grooming and compacting this type of snow will enhance its ability to form bonds or “setup.”

Snow hardness is the best indicator property for snow strength. There are many available methods for testing hardness, such as cone penetrometers, ram penetrometers, drop tests, etc. For the groomer operator, simply walking or stomping on the snow with a simple "boot test" (see Photo 1.9) is probably sufficient to give an indication of the compressive strength of the snow. When boots make a deep imprint, the snow is soft. A light imprint indicates a medium strength snow. When it is difficult to imprint the snow at all, the trail can be considered hard and grooming is working well. Another simple means for the groomer operator to get an indication of strength from within the cab of the tractor is to watch the ski imprint of the last snowmobile traveling the trail. If the body of the ski is sinking into the surface, the trail is soft. If the skag is riding on the surface, it is hard.

Post-grooming, sufficient time must be allowed for the snow to sinter or "setup," preferably overnight.

Photo 1.9 Example of a "boot test" that indicates a soft trail

Additional References on Snow Physics and Metamorphism

For more detailed information regarding Snow Physics, refer to:

International Classification for Seasonal Snow on the Ground; COLBECK, S.C., ET AL. *Int. Commission on Snow and ice of the Int. Assn. of Sci. Hydrology 37 pp.* 1990.
www.crrel.usace.army.mil/techpub/ CRREL_Reports/reports/Seasonal_Snow.pdf.

Snow Roads and Runways; ABELE, G. *CRREL monograph 90-3, 100 p.* 1990.

Processing Snow for High Strength Roads and Runways; LANG, R.M., BLAISDELL, G.L., D'URSO C., REINEMER, G., LESHER, M. *Cold Regions Sci. & Tech., Vol. 25, Issue 1, pp 17-31.* 1997.

For a more detailed discussion of snow metamorphism, refer to: The Avalanche Handbook; MCCLUNG, D.M. AND SCHEARER, P. *The Mountaineers, 266 pp.* 1993.

TRAIL GROOMING PRINCIPLES

It is important that the basic principles of snowmobile trail grooming are understood in order to properly operate trail grooming equipment and achieve the desired result of smooth, firm trails. Working a heavily moguled trail back into a smooth surface, that will last, is probably the most difficult aspect of trail grooming. To accomplish this successfully, it is important to understand the characteristics of moguls.

Mogul Formation

The primary reason snowmobile trail grooming is necessary is the continuous formation of moguls by passing snowmobile traffic. Moguls are patterns of mounds and dips formed in the trail's snow surface perpendicular to the direction of snowmobile travel.

Moguls in snowmobile trails are caused by passing snowmobiles just as "washboards" are created in gravel roads by passing vehicles. Gravel roads have to regularly be graded. Similarly, snowmobile trails must be regularly groomed. Moguls are as undesirable to snowmobilers as washboards are to motorists.

Figure 1.5 demonstrates how moguls are formed. In the top view, a small rut is created in the trail by a snowmobile that has either braked suddenly or accelerated too quickly. Views 2, 3, and 4 show how the rut develops into a run of moguls as the suspensions of many successive snowmobiles react to the uneven trail surface, each one compounding the other, as each snowmobile passes.

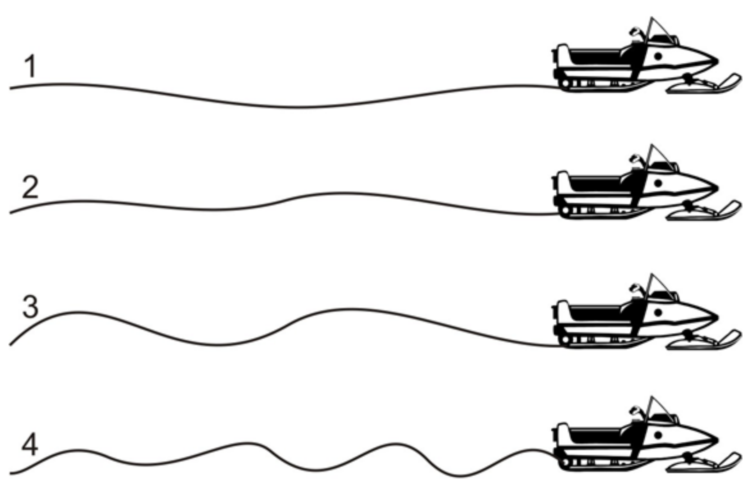


Figure 1.5 Mogul formation

Today’s modern snowmobile, with its carbide runners that cut the snow surface and up to two-inch deep track lugs that dig out the snow, is an unintentionally effective digging machine. As a result, snowmobile riders innocently destroy the surface they desire to be smooth. Moguls tend to form wherever snowmobiles accelerate quickly or slow down abruptly. This can include before and after curves, approaching and leaving stop signs, before and after bridges, or on steep hills. These areas all require extra attention by the groomer operator.

Photo 1.10 Curves and areas where snowmobiles cut onto trails require special attention

Moguls also tend to form in long, coherent stretches or runs on relatively flat, open sections of trail. Each passing snowmobile, as the suspension extends and contracts, causes the mounds to get higher and the dips to get deeper the same distance apart from one another in a constant, unchanging rhythm that pounds both machine and rider and makes the ride most unpleasant. And the greater the speed, the more suspensions will expand and contract. In these locations, it can be important that a drag, with its length and planer effect, is used to level the trail versus trying to “groom” with the front tractor blade, which can often further accentuate the rhythm of this type of moguling.

Photo 1.11 A snowmobile’s skis, track, and suspension all contribute to mogul formation

Moguls can also be caused by “natural formation” in situations where there is warm ground or creeks under the snow, as well as by the alternating effects of sun and shade.

THE FOUR STEPS OF TRAIL GROOMING

The primary purpose of grooming is to remove moguls and compact the trail base. This is not simply a matter of knocking off part of one mound and pushing the displaced snow into the adjacent dip. A “cut-and-fill” grooming operation produces an uneven snow density that can result in a poor riding experience. Even though the trail may initially look smooth, the trail will most likely quickly revert back to moguls as the soft snow is pounded out of the filled dips by passing snowmobiles.

Four basic operations are required to produce a well groomed trail that is durable. They include: Step 1 – Removal of Moguls, Step 2 – Processing the Snow, Step 3 – Compression of the Processed Snow, and Step 4 – Trail Set Up. In most cases, grooming with a multi-blade drag will produce results superior to grooming with a single blade drag or a tiller since a multi-blade drag generally does a good job of accomplishing all four steps while a single blade drag or tiller accomplishes some steps better than others. For this reason, a multi-blade drag has been chosen to demonstrate the four grooming steps.

Step 1 – Removal of Moguls

Ideally, moguls should be completely cut away from the snow that forms the trail base. Beware that if the top is simply cut off a mound and dropped into the depression of the adjacent dip, it can result in the same mogul returning in no time at all. By completely removing the mound, all the way down to the bottom of the adjacent dip, the profile of the mogul is eliminated from the trail.

However, also beware to not cut into the layer of snow that forms the compressed trail base below the bottom of a mogul’s dip. The mogul should be removed, but not the solid trail base below it, so care must be given to cutting no deeper than the bottom of the dips that form the moguls. This requires that the cutting depth must be continually monitored and adjusted by the Groomer Operator.

There may be limitations to successfully removing the entire mogul: 1) if there is bare ground showing at the bottom of the dips in the moguls, do not attempt to cut the whole mound off since it could damage the equipment and result in destroying whatever hardened trail base there is; 2) if using a single blade drag and the moguls are deep, it is likely that snow could be lost out the sides of the drag when cutting deep enough with the blade to successfully remove the entire mogul. In this situation it is better to “save” the snow on the trail base rather than spilling it out the side where it may be “lost” for the purposes of grooming; 3) if using a tiller, the front blade on the tractor is the most effective tool for mogul removal prior to processing the snow with the tiller. However this has limitations since it cannot duplicate the planer effect of a drag; and 4) if using a multi-blade drag, it will not cut any deeper than the depth that the planer blades extend below the bottom of the side rails of the drag when it is fully lowered. If the trail bed is soft, the side rails may cut into the trail bed. But if the trail bed is hard, the rails will typically ride on top and limit the cutting depth. In all cases, the goal should be to remove all, or as much of the mogul as is reasonably possible, to produce a trail that will stand up better to snowmobiling traffic. Oftentimes, multiple grooming passes may be required to achieve this.

Multi-blade drags accomplish mogul removal by using multiple sets of planer blades angled to cut *into* the moguls. As shown in Figure 1.6, the preset cutting depth of the planer blades are typically stepped slightly lower from the front to the rear of the drag, which results in the deepest cutting depth when the drag is fully lowered so it rides flat on the side rails. Again, if the depth of the moguls exceeds the depth of the drag blades, multiple passes may be required to accomplish complete mogul removal.

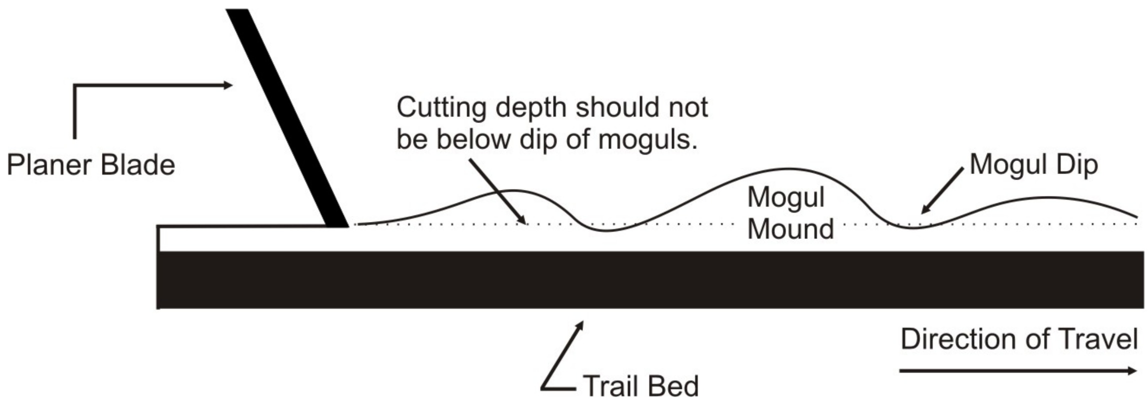


Figure 1.6 Step 1: Removal of moguls. The planer blade cutting depth should cut to the bottom of the mogul's dip, but not into the compacted trail bed.

When deep, fresh snowfall covers moguls on the trail, it may not always be possible or practical to completely remove the moguls. In such a case, it is critical that extra attention is given to Steps 2, 3, and 4 outlined below since a new, hardened trail base must be created to cover the profile of old moguls below the new layer of snow.

Step 2 – Processing the Snow

At any given time, there may be several types of snow on a snowmobile trail – hard packed snow, soft snow, wet snow, dry snow, ice, freshly fallen snow, wind blown snow that is typically small granules and some of the hardest snow, or snow that has been pounded by snowmobiles and worked so hard by groomers that there is little consistency left in it. It is critical that all types of snow be "processed" to achieve proper trail compression and set up.

As shown in Figure 1.7, snow processing is accomplished by the establishment of a rolling or churning action in front of the blades as they move forward at a correct and constant speed. In many drag designs, the multiple blades are angled so the snow moves from side to side further mixing and homogenizing it. While the snow is being mixed, it is also de-aerated (air space between snow particles is removed to make it denser). When using a single blade drag, it is critical that this rolling action is achieved since there is only one blade/one shot at properly processing the snow. While a tiller does an excellent job of processing snow, it can be limited by the depth of its tines.

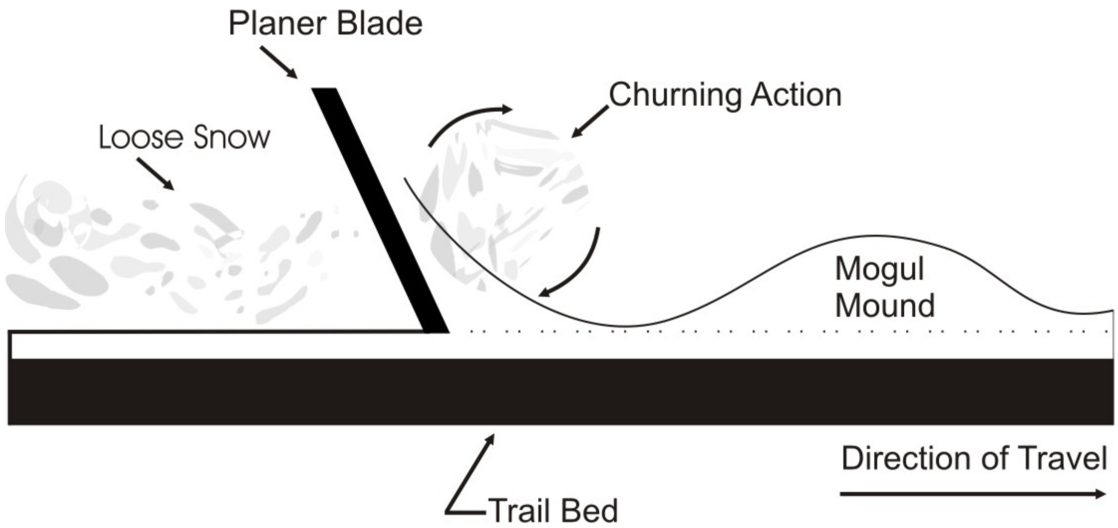


Figure 1.7 Step 2: Processing the snow. A churning action should be created in front of the planer blade to help process the compacted snow from the mogul into granules of various sizes.

This churning, tumbling, or milling action removes air from the snow and, at the same time, breaks up the compacted snow from which moguls are formed into smaller granules of various sizes. It also breaks away points from individual snow flakes so they can be compressed more tightly.

The mechanical action of the churning and tumbling has another important purpose in that it can sometimes introduce moisture into the snow mix due to friction. This friction causes the temperature of the snow to actually rise, be it a very small fraction of a degree, which can create a small amount of moisture in the processed snow. This is especially valuable when snow is very dry. Introducing this moisture into the processed snow is also very important to the success of Step 4, achieving good trail “set up.”

It is critical that the rolling or churning action is achieved. If snow is allowed to ball up or plow along in front of the blades without this rolling action, the snow is not being properly processed (doesn’t de-aerate, doesn’t mix and break points, doesn’t produce friction). This can be caused by the tractor traveling too fast (not enough time for the snow to properly roll and process), grooming conditions being too warm or too wet, or improper drag blade height (set too deep if “plowing” or too shallow if no snow in blade).

The height of the drag’s blade(s) is critical to proper processing of the snow. If the trail is fairly smooth or only slightly moguled, only a minimum of snow will need to be processed since it isn’t desirable to disturb any more of the trail base than what is needed to remove the moguls. In such cases, there may only be a need to have snow churning in the rear sets of blades on a multi-blade or only a partial blade full on a single blade. If the trail is heavily moguled or if there is lots of new snow, more blades on the multi or greater depth on the single blade will likely be required. Remember – process only as much as is needed to remove the moguls, but no more.

Proper ground speed is also critical to proper processing of the snow. Too slow and the proper churning, rolling, and mixing to produce the friction that is needed to improve trail set up is not achieved. Too fast and several factors work against effective grooming, particularly with multi-blade drags. First, too high of a ground speed results in the angled blades spraying snow out the sides of the drag where it is lost and wasted for the purposes of grooming. Snow is precious to the grooming operation and most areas can ill afford to deliberately throw it off the trail. Second, the rolling and churning action is partially dependant upon forces of gravity, so proper time must be allowed for the snow to roll, churn, and fall out. Third, going too fast can sometimes, in effect, over-process the snow and prematurely wear it out. Processing snow can be similar to using a blender – low to mid speeds can achieve good mixing and blending, but setting the speed too high can actually start to change the consistency and even liquefy what's being processed. The same can be true with grooming in that the quality of the snow can actually be adversely affected by going too fast. And fourth, regardless if using a single blade, multi-blade, or tiller to groom, too high of a ground speed results in a side-to-side rocking that produces a rough versus smooth finished trail. Irrespective of the type of groomer, the best quality trails, in terms of both smoothness and durability, result from grooming at speeds between 5 and 7 miles per hour (8 and 11 kilometers per hour).

After the processed snow passes through the last set of blades or the tiller, there should be an even blend of loose particles ready for compression.

Step 3 – Compression of the Processed Snow

The moist, loose snow created by the processing step must be "compressed" into an even covering of uniform density with a smooth surface. This process further de-aerates the snow and provides for a denser trail surface. As shown in Figure 1.8, this step is accomplished by a flat packing/compression pan at the rear of the drag.

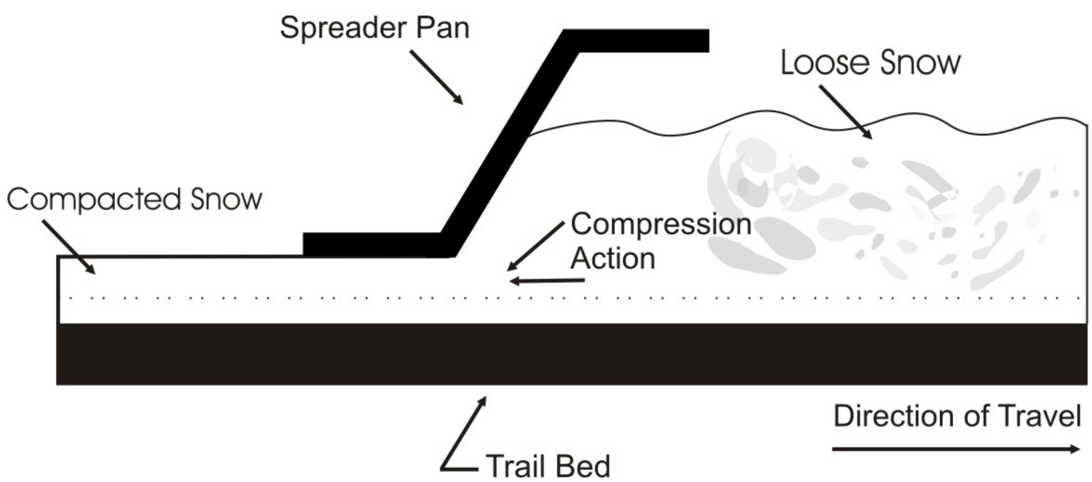


Figure 1.8 Step 3: Compression of the processed snow. The loose snow created by the cutting and churning action of the blades is distributed by the spreader pan, then compressed into a new layer of compacted snow on the trail bed.

On a multi-blade drag, the front of the pan is angled so loose snow that is contained by the side rails is captured and pulled under the spreader pan where it is then compressed by the weight of the moving drag. Since single blade drags typically do not have side rails, the snow must pass under the single blade of the unit and then be compressed by the drag's pan. If too much snow is carried in the single blade, it spills out the sides. This difference means that the multi-blade typically increases the finished snow depth/base of the trail with each pass, while the single blade increases trail depth only when there is an accumulation of new snow on the trail. While a tiller can apply down pressure when processing the snow, there is typically very little compression and generally is only from the unit's plastic comb.

Step 4 – Trail Set Up

Set up is simply allowing the snow that has been disturbed by cutting, processing, and compressing the proper time required to refreeze. Generally, the longer the set up time that is allowed, the more durable the trail will be and the longer the newly created smooth surface will last.

Photo 1.12 A freshly groomed trail that requires set up.

Once the drag or tiller has passed, the snow from the moguls should have been fully removed, processed, and redistributed as a new layer of denser, smoother "snow pavement."

The last step in the grooming operation allows the moisture that was created during the processing step to refreeze. This binds the individual granules of tightly packed snow firmly together, creating a hard surface that will withstand passing traffic much better.

The length of time needed for a trail to set up correctly can vary from two to six or even more than ten hours, depending upon the temperature and moisture content of the snow. Trail set up can be similar to freezing a tray of ice cubes – after a short time there may be a crust but the cube isn't entirely solid and it generally takes a few hours for it to become fully firm. A snowmobile trail is no different. Therefore, it is vital that the trail remain as undisturbed as possible during this set up period for firmer, better quality trails that will stand up longer to snowmobiling traffic.

Ideally a snowmobile trail would be closed during set up time, but that isn't practical. Consequently, the best time to groom is generally at night when traffic levels are typically lower and air temperatures are generally colder.

Photo 1.13 Try to groom at times when snowmobiles will not follow the groomer for best trail set up

For the best set up, it is strongly recommended that grooming occur at night after snowmobile traffic subsides. This also provides for the safer operation of both groomers and snowmobiles since it is easier to see oncoming lights and beacons. Most importantly, night grooming provides for more effective grooming since there is typically more time for the trail pavement to freeze solid before traffic resumes, maximizing the effectiveness of the area's grooming dollars.

It is recommended that daytime grooming be done in areas only if there is little or no daytime snowmobile use on the trail being grooming. Other exceptions would include special circumstances such as when daylight would aid operator visibility for initial early season trail set up and establishment or for trail reestablishment of the trail after big storms, extremely heavy snowfalls, and/or significant wind events.

CHAPTER QUIZ

1. Snowmobile trail grooming is:
   a) the single largest expense of a snowmobile trail program
   b) using mechanical equipment to produce a high density snow surface
   c) very demanding work that requires your undivided attention at all times
   d) all of the above

2. Moguls are:
   a) similar to washboards on a gravel road
   b) patterns of mounds and dips formed in the trail's snow surface perpendicular to the direction of a snowmobile's travel
   c) fun to ride
   d) undesirable to snowmobilers
   e) a, b, and d above
   f) all of the above

3. Moguls should be:
   a) cut off at the top and filled in the bottom
   b) completely cut away
   c) enhanced with the front blade
   d) all of the above

4. The four basic operations of trail grooming include removing the mogul, processing and compressing the snow, and set-up. True False

5. Snow must roll or churn to be processed with a grooming drag. True False

6. Trail set up can be similar to freezing a tray of ice cubes – after an hour you may have a crust on the surface of the ice cube but the center isn't frozen, so you have to wait a few more hours for the ice cubes or the trail to fully freeze solid. True False

7. It generally takes a couple of hours or more of being undisturbed for snow to bond and reach full strength. True False

8. The length of time needed for a trail to set-up correctly can vary from two to six or even more than ten hours, depending upon the temperature and moisture content of the snow. True False