Research Studies Related to Snowmobiling Impacts

SNOW AND TRAIL CONDITIONS

Having adequate snow cover is essential to limiting impacts from snowmobiles to the natural environment – as well as preventing damage to snowmobiles and personal injuries to riders. Therefore the 'season of use' often enters into discussions regarding appropriate time periods and snow cover for snowmobiling access.

While snowfall can be sporadic from year to year in some areas based upon local weather patterns, one good planning indicator for snow cover is SNOTEL data compiled in western States by the National Resources Conservation Service (NRCS), a U.S. Department of Agriculture agency. This data includes historic snow depths and snow water equivalent information for their extensive snow course network and is extremely helpful to determine accurate long-term snow patterns for an area. This data is available at www.wcc.nrcs.usda.gov/snow/ . Other sources of historic snowfall planning information include the United States Snow Climatology data provided by the National Oceanic and Atmospheric Administration's (NOAA) National Climate Data Center at www.ncdc.noaa.gov/ussc/mainpage.html and the National Snow Analyses provided by the National Weather Service's National Operational Hydrologic Remote Sensing Center (also a division of NOAA) at www.nohrsc.noaa.gov/ .

While scientific studies on this topic are almost nonexistent, the study listed below was completed in 2005 for the Yellowstone National Park Winter Use Plan and is a good example as to how local areas could similarly be analyzed if there is a need for a scientific look at this issue.

1. **Historical Snow Water Equivalent and Temperature Data for Oversnow Vehicle Travel Areas in Grand Teton and Yellowstone National Parks.** Farnes, P.E. & Hansen, K. (2005) Montana State University – Department of Earth Sciences.

Executive Summary: The objective of this report is to quantify the historic snow water equivalent and temperatures for stations in Grand Teton and Yellowstone National Parks, compare snow water equivalent with opening and closing dates of oversnow vehicle travel, and provide estimated opening and closing dates that would have been possible over the historic period of record.

Snowpack and climate data have been collected at many locations in Grand Teton and Yellowstone National Parks. Measurements of climatic variables have been taken since the late 1800s at Mammoth. Other stations were started in the early 1900s up to the late 1970s. Snow courses have been measured since the mid 1930s and SNOTEL (SNOw survey TELemetry) stations were generally started in the early 1980s. Four telemetered weather stations were installed in the upper Snake River drainage in the early 1990s.

Daily data from these stations have been analyzed for their period of record to determine the coldest temperature for each winter, when the snowpack starts to accumulate, maximum snow water equivalent (SWE) and date of maximum SWE, date snowpack melts, and various threshold values of SWE needed to sustain oversnow vehicle travel. Monthly average maximum, minimum, and average temperature and monthly precipitation have been summarized and are available on the data CD (see page 3).

There is considerable variability in how the snowpack develops and melts over the span of many years. In order to establish realistic opening and closing dates for use of oversnow vehicles on park roads, it is important to understand this variability. Using historical snow and climate measurements at locations along these travel routes can provide an insight to this variability and to the dates that OSV travel would have been possible over this historic record.

Recently, the criteria for opening the roads to the public for over snow vehicle (OSV) travel has been to open them on the Wednesday before the weekend before Christmas, usually around December 15 (thereafter, the targeted opening date). Closure typically occurred no later than the first Monday in March for the Mammoth to Norris, Norris to Madison, and Norris to Canyon roads (hereafter, generally considered to be March 4). The National Park Service closes the remaining roads on the second Monday in March (hereafter, March 11).

By comparing historical opening dates with SWE on those dates, about 25mm or 1 inch of SWE (about 250 – 300 mm or 10-12 inches accumulated snow depth) was needed for administrative OSV travel and 1.5 inches SWE was needed to open the roads to the public. This amounts to about 380 – 460 mm or 15 to 18 inches of cumulative snowfall needed for opening to the public. The threshold levels at Mammoth are less than for other areas as the point for starting oversnow travel is at higher elevation than the Mammoth (Yellowstone Park) weather station. Historically, administrative travel south from Mammoth to Norris has occurred when the SWE at Mammoth reached about 12 mm or one-half inch SWE and public travel was permitted when SWE reached about 25 mm or one inch SWE.

Some areas of the park road system accumulate less snow than others and are more critical to opening the park roads to OSV's. For example, snowpack at Madison Junction dictates when the road can be opened between West Yellowstone and Old Faithful and West Yellowstone, Norris Junction and Canyon. Snow accumulation at Old Faithful and Lake dictate when traffic can be permitted from the South Entrance to those areas. The freeze-up of Yellowstone Lake determines when Mary Bay becomes safe for visitor travel (although the NPS often opens it before freeze-up, in part because relatively few visitors travel this route). Mammoth must have adequate snowpack to access the interior of the park from the North Entrance via Norris Junction. Moran 5 WNW at Jackson Dam and Glade Creek are critical in determining when OSV's can use local roads in Grand Teton National Park and the road from Flagg Ranch into Idaho via Grassy Lake.

Using SWE data and estimated road openings from 1949-2005, it appears that roads would have been opened to the public about 7 days after they were opened to administrative travel for the West Yellowstone-Old Faithful-Lake-Canyon-Norris-West Yellowstone loop (hereafter the "Lower Loop and West Entrance Road"). In 8 of the 57 years, roads would not have been open to administrative travel by December 15. In 16 years out of 57, public access would have been delayed until after the current opening date of December 15.

Spring closure dates closely match the date at which snowpack becomes isothermal (same temperature throughout the snowpack), which is the beginning of spring melt. Road closures due to snowmelt in the spring would have occurred earlier than March 4 in about 7 of those 57 years. Madison Junction is again a critical point for snowmobile travel on the Lower Loop and West Entrance Road; snowmelt starts there about 18 days before it begins at West Yellowstone.

For the road between East Entrance and Lake, Yellowstone Lake needs to be frozen before snow starts to accumulate in the Mary Bay area (Pers. Comm. M. Yochim). This is typically about a month after there is adequate snow on other portions of the road based on the SWE accumulation at the Lake Yellowstone station. Based on SWE and estimated road openings from 1949-2005, administrative travel would have been possible by December 15 on 55 of the past 57 years. Public travel would have been possible by Dec. 15 on 50 of the past 57 years. For the past 57 years, snowmelt has always started after March 11.

The Mammoth to Norris section would have been open to administrative travel on 34 of the 57 years (based on 12 mm SWE at Mammoth) by December 15 while only 14 out of 57 years would have been open to public travel by December 15 (based on 25 mm SWE at Mammoth). Melt would close the roads before March 4 in 24 of the 57 years.

Access from the South Entrance (Snake River Station) to Grant Village would have been open to administrative travel by December 15 in all but 3 years over the past 57 years based on criteria shown above. Public access would have been possible in 49 of the past 57 years by December 15. Melt would have closed the roads by March 4 in only one of the past 57 years.

At Madison Junction, there is neither a weather station or snow course. However, winter maximum and minimum daily temperatures and daily snow depths and snowfall have been recorded for the majority of days between the time the snow starts to accumulate and when it melts. SWE was estimated on the first of the month using snow depths from Madison Junction and densities from West Yellowstone, Old Faithful and Norris Basin snow courses. Daily data were extrapolated using daily SWE from the West Yellowstone snow pillow (a device that measures snow water equivalent by measuring the weight of accumulated snow). Norris Basin has only a snow course. The daily SWE for the Norris Basin location was estimated using the Canyon snow pillow data to estimate the SWE distribution between the monthly measurements.

Mid-winter melt can be a problem for maintaining snow on the roadways. Days between December 15 and March 1 when daily minimum temperatures remained at or above 0 degrees C or 32 degrees F and whether or not precipitation was observed, were analyzed for all sites. Some mid-winter melt occurs almost every year. In over one-half of the cases, rain was recorded. The events were fairly well distributed across the period indicating that warm minimum temperatures with or without rain can occur at most anytime during the winter. Lower elevation sites, such as Mammoth, have more frequent occurrences of mid-winter melt and rain-on-snow events than do higher elevations sites.

2. **Snowmobile Trail Bump Formation Analysis, Prediction and Modeling.** Alger, R., Gruenberg, S. and Gwaltney, G. (2000) Michigan Technological University for Yellowstone National Park

Executive Summary: The study of the formation and geometry of snowmobile generated bumps has been of interest to snowmobile designers, groomer operators and manufacturers, and snow scientists for years. Numerous small studies have been undertaken to model this formation and to determine the mechanisms involved in mogul growth, but prior to this major study the hypotheses were mostly unproven. This report and the work that leads to it, is a start to models to predict mogul formation and geometry.

It is well known that where there are snowmobiles traveling, there will eventually be moguls. The development of these moguls is extremely important when trying to design suspensions, and also in determining the best means to groom the snow roads to minimize roughness. To complicate matters further, it appears that the suspension characteristics of snowmobiles are a major contributing factor to generation, and any alterations to the suspension, change the bumps formed. This study looks at formation in connection to weather parameters such as snow temperature, free water content, new snow, etc. It investigates present grooming practices and the differences between certain vehicles. How the snow moves and where the bumps come from is studied. How fast do the bumps form, how many snowmobiles make the snow road unbearable, along with other hypotheses made prior to the start of this test, and some that came up as it went along, are investigated.

This study is a major measurement and data analysis undertaking with the outcome being a qualitative as well as quantitative model of how bumps form. Some generalizations are as follows: 1. Bumps formed very rapidly under all weather conditions tested. 2. Bumps formed in the same locations, even over the long test period. 3. Early winter weather can have a major effect on the groomed snow roads for the entire winter. 4. Snow coaches deteriorate the snow roads differently than snowmobiles.