

TRACKING SNOWMOBILERS TO UNDERSTAND TRAVEL BEHAVIOR IN AVALANCHE TERRAIN

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ABSTRACT: This paper will present an analysis of snowmobile tracks from the 2015-16 winter season. Avalanche fatality statistics since 2000 shows that an increasing number of snowmobilers are killed in avalanches in the US, and over that period outweigh the number of backcountry ski / riders. This has been attributed to multiple factors including lower levels of avalanche education and awareness, high powered machines able to access increasingly exposed terrain, and a lack of knowledge about travel habits and decision processes. Using a similar approach as successfully employed to collect data from skiers, we collected GPS and survey data from backcountry / off trail snowmobilers.

Preliminary data analysis, and comparison with our backcountry skier data set, shows marked differences with respect to terrain use by backcountry snowmobilers. These differences point to important avalanche education goals for snowmobilers. Typical trip lengths are typically an order of magnitude longer, average speed is higher, and total distance covered is much greater. However, the amount of time spend in avalanche terrain as a function of the total trip is typically less, but the number of avalanche terrain features encountered is typically greater. Unique to the snowmobile community is the added complexity of rider proximity, with many riders being out of sight of their partners for several minutes or more at a time, as well as a tendency to gather in groups at the base of potentially hazardous hillsides. Both practices have been implicated in multiple avalanche accidents involving snowmobilers. Our results provide the first analysis of GPS tracked snowmobilers moving in avalanche terrain.

KEYWORDS: Snowmobiles, GPS tracking, Decision making, Avalanche terrain, Education

1. INTRODUCTION & BACKGROUND

The purpose of this paper is to explore the movement of back country snowmobilers in avalanche terrain as documented through GPS tracking. These users are commonly referred to as “sledders” or “off-trail riders” in North America.

Our previous and ongoing work has examined how backcountry skiers / riders move in the backcountry and the decision making processes therein (Hendriks and Johnson, 2014; Hendriks et al., 2013). This paper is an extension of these ideas, but focusses specifically on snowmobilers.

Avalanche fatality statistics since 2000 shows that an increasing number of snowmobilers are killed in avalanches in the US and Canada. In the USA, over the period 2000-2015 the number of fatalities with a primary activity of “backcountry tourers” was

122 and “side country riders” was 42. When these two groups are combined they are equal to the number of snowmobiler fatalities, 163 over that period. This is in stark contrast to the period 1985-1999 where snowmobiler fatalities were 65, compared with the 76 backcountry tourers and 35 side country riders (111 total) (CAIC, 2016).

The increase in snowmobiler fatalities has been attributed to multiple factors including relatively lower levels of avalanche education and awareness, lack of avalanche rescue equipment and training (Haegeli et al., 2012) (although this has changed in the most recent years e.g. Staples et al., (2014) and Hanke and Savage, (2014)), and high powered machines able to more easily access increasingly exposed avalanche terrain. While significant efforts have been made towards increased training (e.g. Chabot, 2002; Staples et al., 2014; Hanke and Savage, 2014), and there have successful studies using online discrete choice experiments (e.g. Haegeli et al., 2010; Haegeli et al., 2012), the avalanche research community has relatively less knowledge about travel habits and decision processes in the snowmobile community.

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This paper provides preliminary analysis of snowmobile tracks from the 2015/16 winter season in North America. We present two case studies, and explore the differences in snowmobile tracks as contrast to skiers / riders in the backcountry. We also highlight critical differences in the terrain usage, and consider this with respect to avalanche hazard exposure and education.

2. METHODS

Similar to the approach taken by Hendriks and Johnson (2014), we used a crowdsourcing approach to collect observations of terrain used by back country snowmobilers. We launched a snowmobile specific webpage to attract participants (www.montana.edu/snowscience/sleds), and used a smartphone application called SkiTracks to track snowmobilers. We combined this with a smartphone optimized survey tool with snowmobile-specific questions. Using this fully digital, smartphone based approach, we collected almost a hundred tracks from North America – predominantly the Intermountain USA (Montana, Wyoming, Utah, Colorado, Idaho), but also received some tracks from Alaska and Canada. We also augmented this approach with a series of intercept surveys in SW Montana, where we would wait at a trailhead and conduct surveys and hand out GPS units for tracking.

Each track was brought into a Geographic Information System (GIS) and overlaid on a Digital Elevation Model (DEM) and key terrain metrics were extracted. These were then linked to the pre-season, mainly demographic focused survey, and post-trip, mainly psychographic survey responses.

These methods allow us to obtain a more complete understanding of the person, their group, their decision making practices and their resulting terrain usage during a backcountry snowmobile excursion. We also collect avalanche danger ratings for each track, from each area, for each day.

For this paper we will only examine the terrain associate attributes and will not present any findings from the survey based data. A more in depth discussion of the sampling method, survey design, data processing and analysis methods will be presented in a future journal article.

3. RESULTS

3.1 *Case study 1 = SW Montana*

Our first case study is from SW Montana, near Big Sky. The avalanche forecast prepared by the Gal-

latin National Forrest Avalanche Center (GNFAC) for the day was moderate, with the avalanche problem identified as wind slabs on lee slopes steeper than 30 degrees. Two sets of individual tracks were collected from one group as part of an intercept survey. A section of their track from rider #5 is shown in Figure 1.

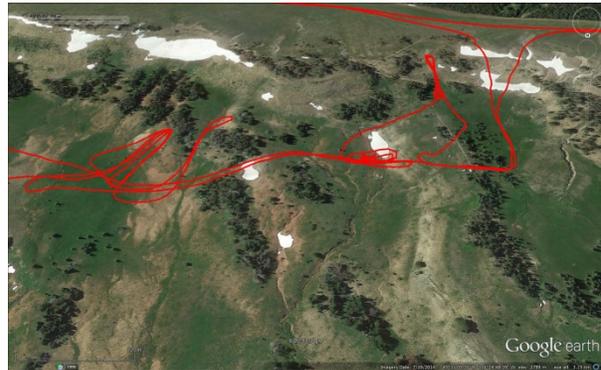


Fig. 1: Section of GPS recorded snowmobile track from SW Montana. This section is an example of the differences in terrain use by snowmobilers vs a skiers/ riders.

Analysis of the terrain metrics within GIS using a 10m digital elevation of these tracks provided the following details:

- Distance = 58.3 km
- Duration = 6 hours, 32 minutes
- Elevation gain / loss = 2088 m
- Maximum speed = 104 km
- Average slope = 4°
- Maximum slope = 32°

When the terrain was analyzed for length of track within avalanche terrain, where slopes are steeper than 30 degrees or where within an alpha angle of 25 degrees, less than 2% of their track was considered within avalanche terrain.

However, when we considered potential avalanche slopes or features, we observed at least 19 unique features with an avalanche potential, with more than 60 encounters total (i.e. some features had multiple passes).

Finally, a viewshed analysis was also conducted on two tracks simultaneously. We examined a point from each track that was recorded at the same time. We then conducted a viewshed analysis – which identifies what terrain is visible from that location. The results can be seen in figure 2.

The green cells are visible cell from the position of rider 5, while the red cells are non-visible for rider

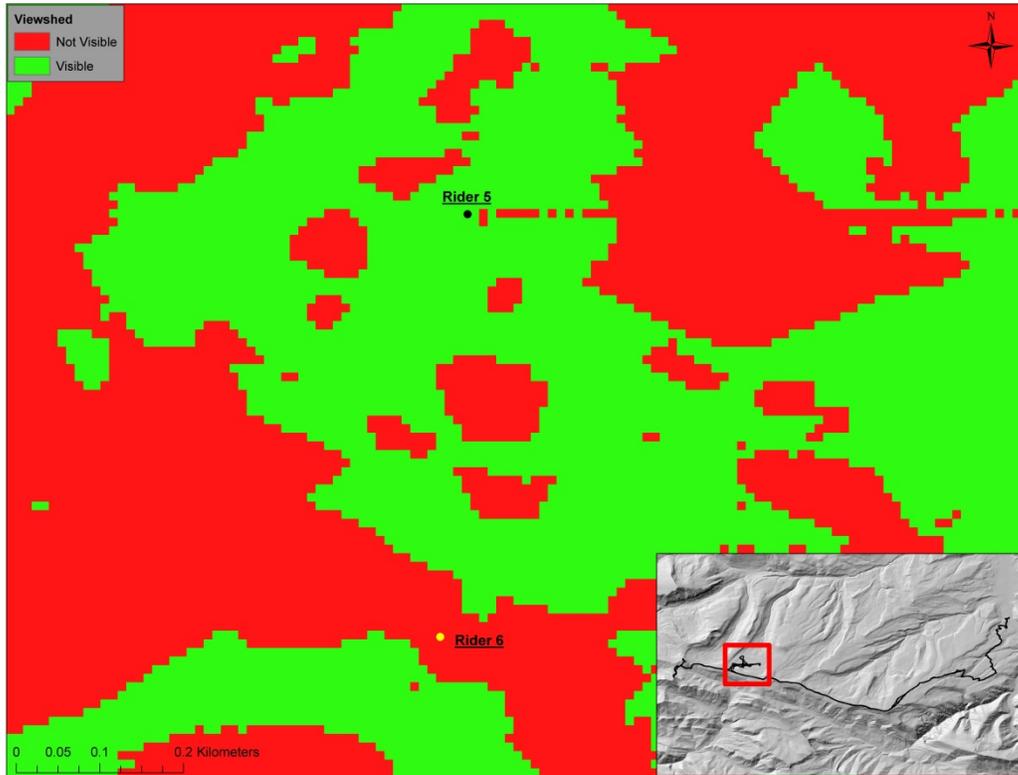


Fig. 2: Viewshed analysis for two snowmobile tracks in SW Montana. The green cells are visible cell from the position of rider 5, while the red cells are non-visible for rider 5. It shows that rider 6 is not visible to rider 5 at that point in time. Inset map shows entire track and viewed area.

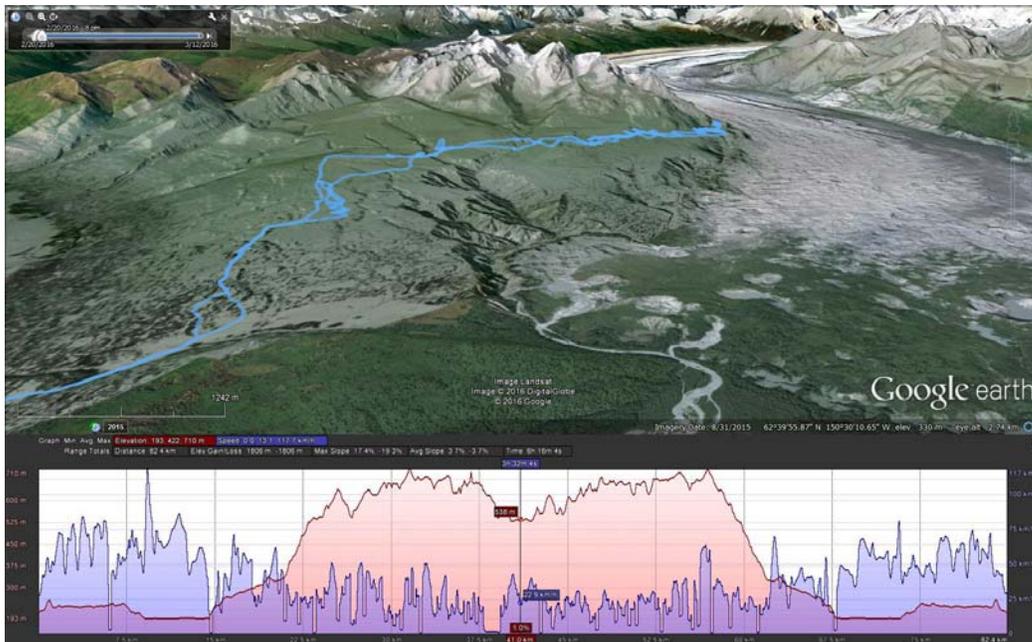


Fig. 3: Example of a recorded snowmobile track from Alaska. The GPS track is shown in Google Earth, with an inset of the terrain profile (in pink), and speed profile (blue) shown below. This track is typical of snowmobile tracks submitted, and provides an example of the differences in terrain use by snowmobilers vs a skiers/ riders.

5. It shows that rider 6 is not visible to rider 5 at that point in time. We then repeated this analysis for multiple time steps, and noted the length of time that riders were out of view from one another. These time periods ranged from a few seconds, to a maximum of 6 minutes.

Case study 2 = South central Alaska

Our second case study is from South Central Alaska, north of Anchorage. There was no avalanche forecast provided for this area at the time, but reviewing the observations made by the snowmobiler, it would likely have been low. One track was submitted for this trip, and it was noted there were two people in the group. The track and associated elevation and speed profile is shown on Google Earth for visualization purposes in Figure 3.

Analysis of the terrain metrics within GIS using a 10m digital elevation of these tracks provided the following details:

- Distance = 82.3 km
- Duration = 6 hours, 15 minutes
- Elevation gain / loss = 1806 m
- Maximum speed = 118 km
- Average slope = 3°
- Maximum slope = 26°

When the terrain was analyzed for length of track within avalanche terrain, where slopes are steeper than 30 degrees or where within an alpha angle of 25 degrees, a little over 1% of their track was considered within avalanche terrain.

However, when we considered potential avalanche slopes or features, we observed at least 11 unique features with an avalanche potential, with 37 encounters total (i.e. some features had multiple passes).

4. DISCUSSION

The two case studies presented are representative of the tracks that we have obtained for this study, in that they illustrate terrain use that could be considered typical for the snowmobilers that submitted tracks to our study. It should be pointed out that this convenient sample is not representative of the entire snowmobile population. We likely did not see tracks from very “extreme” users, or beginners mainly riding trails, and therefore any inference for the entire snowmobile population should be done with caution.

Having analyzed both skier / riders tracks and snowmobile tracks as recorded by GPS there is a

clear visual difference upon review of submitted tracks. Snowmobile tracks often look like “spaghetti” on the landscape, representing multiple laps in deep snowy meadows, or multiple attempts at terrain features like steep slopes, cornices, or rib like features for jumps. Ski tracks by contrast tend to have less repeated terrain use, and commonly don’t have a high level of repeat use (i.e dozens) in the same area. This visual difference, combined with average and maximum speeds, has been critical in identifying tracks that have been inadvertently submitted to the incorrect crowd-sourced data collection platform (e.g. snowmobile track submitted to the “tracks” project for skiers / riders).

Furthermore, when we compare the skier / riders tracks to those submitted by snowmobilers, we see that the typical trip lengths are much longer for snowmobilers, their average and maximum speed is higher, and total distance covered is much greater.

However, the amount of time spend in avalanche terrain as a function of the total trip is typically less for snowmobilers, as often much their approach is on a relatively low angled trail / summer road, and they can recreate in low angled meadows. When we consider the number of avalanche terrain features encountered however, we see that this is often greater for snowmobilers. We consider that this is a critical difference, and it has implications for regional spatial variability as well as the incidence and nature of snowmobile related accidents. A skier / rider may only expose themselves to 5-10 unique slopes in a day (with different aspects / slopes etc.), and these are typically within a 5-10km radius. A snowmobiler might expose themselves to a 50 or 100 individual features within 50km radius. Therefore, we might expect a greater probability of finding greater variability in snowpack stability over this greater distance.

The viewshed analysis also highlights a problem that is likely more prevalent in the snowmobile community than in the ski community. This is the issue of rider proximity, and rider visibility. In the scenario where riders are out of sight of their partners for several minutes or more at a time any potential avalanche incident and subsequent burial becomes a more serious situation. Skiers / riders tend to travel in groups that are in close proximity, and may only loose visual contact for brief moments on the decent. Our analysis shows that these moments of loss of view between riders is often in the order of several minutes as they play in undulating meadows, in trees, and around ter-

rain features. While not explicitly shown here, in the few cases where we received multiple tracks from the same group, gathering of the group at the base of a hillside, or avalanche feature was observed. Likewise, it is common practice for snowmobilers to help dig out stuck machines thus exposing multiple people to on slope hazard.

Future work will examine the demographic and psychographic data in more detail and also combine the terrain metrics with these factors and the avalanche hazard. In this way we will be able to compare our field based results more directly with the results from online surveys (e.g. Haegeli et al., 2010; Haegeli et al., 2012) regarding terrain choices by snowmobilers

5. CONCLUSIONS

Our results provide the first, albeit preliminary, analysis of GPS tracked snowmobilers moving in avalanche terrain. We highlight that the terrain use is substantially different to back country skiers / rider and that analysis of the terrain metrics supports this. We also note that while the percentage of time that a typical snowmobiler spends in avalanche terrain is commonly less than backcountry skiers / riders, the number of individual features is likely greater. This combined with loss of visual contact between riders, and grouping at the base of features has implications for avalanche hazard exposure and future avalanche education for snowmobilers. We think that analysis of the similarities and differences among the two user groups may provide additional insights to snowmobile related accidents and prevention/education.

ACKNOWLEDGEMENTS

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