**Inter-Party Avalanche Involvements: a model and a conversation**

By Charlie Hagedorn

Inter-party avalanche involvements: Do they happen? What can we learn about them?

First: Yes. Inter-party involvements happen. Since 2001, at least six-to-eight people have died in North American avalanches triggered by another party.

Second: A simple model for inter-party involvements suggests that the rate of inter-party involvements may grow like the density of parties squared and that the inter-party involvement rate is proportional to avalanche size. As a rule-of-thumb, inter-party incidents have happened when there was more than one party per twenty avalanche-areas. See definitions below.

A possible inter-party incident in December 2015 drew me deep into this subject. As the number of people entering the winter backcountry of the Cascades continues to grow, I wondered how the rate of inter-party incidents might grow. That exploration led to a paper: *Inter-Party Avalanche Involvements May Increase Quadratically With Party Density*. The paper is written for you – this article is the movie-trailer to pique your interest in reading the real thing.

**A model:**

The paper constructs a simple model as a foundation for conversation about inter-party incidents. Two quick definitions: For this article, an avalanche “involvement” is when a party and an avalanche touch. An “incident” is an event in which at least one involvement occurs.

The model has the simplest of beginnings – the assumption that the rate (*R*single-party) at which parties trigger avalanches is proportional to the number of parties (*N*parties) in an area *A*.

It is convenient (trust me) to switch to a notion of party densities, where :

An inter-party involvement requires two events: First, a single party must trigger an avalanche and second, at least one other party must be unlucky enough to be within the avalanche, with area *A*avalanche . We’ve handled the first with *R*single-party. If we assume parties are equally-likely to be anywhere in our area, then the expected number of parties struck by an avalanche is , so

For simplicity (the qualitative conclusions are the same), we’ll approximate as *N*parties and switch to densities again.

This is a key result. The model suggests that the rate of inter-party involvements grows like the square of the density of parties. If there are twice as many parties, there will be *four* times as many inter-party involvements. Furthermore, the inter-party avalanche involvement rate should grow when the day’s avalanches are larger. These conclusions are not earth-shattering, but they help to make discussion of inter-party incidents more precise.

There is a second question we can ask, and it has an actionable answer: “For this model, at what party-density will inter-party involvements become a meaningful fraction of all involvements?”

First we need the overall involvement rate:

Simple enough, right? Using our results from before, this can be suggestively-arranged as

This has a useful interpretation for forecasters, land-use planners, and backcountry travelers: The model suggests that when approaches one, a party is as likely to be involved in an inter-party incident as it is to trigger an own avalanche, as seen in Figure 1. Indeed, as we will see shortly, every inter-party avalanche incident examined in the paper had , and most were closer to 0.1 . Forecasters will note that this observation sidesteps the hard part of forecasting – determining . On a day when only D1 slides are likely, inter-party incidents are, outside of constrained terrain, *much* less likely than on days with D2.5+ avalanches.

Figure 1: Illustrative plots showing the model’s prediction: quadratic growth in inter-party involvements surpassing linear growth in single-party incidents when . For an 0.2 km2 avalanche, as in this example, this occurs at  parties/km2. The vertical axis in these plots varies *greatly* from day to day with snowpack properties, but the ratio of single-party involvement rate to that of inter-party involvements does not.

Figure 2: Upper panel: Approximate fraction of inter-party avalanche involvements as a function of party-density, measured in units of avalanche-area. Lower panel: Approximate values of as discerned from the historical record of inter-party avalanche incidents and near-misses. All but three incidents occurred with near 0.1.

**Discussion:**

With this model in hand, we can consider its implications for travel practices. In particular, it focuses our attention on party density and avalanche size.

Terrain, access, and timing tend to focus parties into small areas. In a narrow couloir, two parties alone can have urban density. On a deep storm day, arduous trailbreaking means that parties can pile up into a paceline on a single skintrack – when those clumped parties begin to ski, they will be close to each other. In a large bowl, multiple snowmobile parties can choose to high-mark or rest in terrain with overlapping avalanche paths. On an optimal-conditions day in the big mountains, parties can queue up at constrictions on big routes – in April 2019, reportedly 16 people attempted to ski the Grand Teton on a single morning. On both small scales and large, we must not become too crowded, lest we begin to harm ourselves.

**Until we can control the weather, avalanche size is largely out of our control, but as avalanche size grows, we must be increasingly attentive to those above and below us.** When slides are sufficiently large, they can propagate (and run) to or from locations that are out of sight. Simultaneously, a larger slide is more-likely to find (or be triggered by) another party.

**Incidents:**

The paper examines thirteen inter-party incidents and near-misses in North America. The fatal incidents are enumerated in the sidebar. The twelve events amenable to quantitative study are shown in Table 1.

There are commonalities among these incidents. As we can see from both Table 1 and Figure 2, the inter-party incidents occurred with , and most near 0.1, in qualitative agreement with the model’s prediction that values approaching 1 should be significant. Furthermore, after Krause’s suggestion to include avalanche character, it became clear that all but one of the incidents involved a slab avalanche. The reason isn’t known, but it is a clear signal in the small sample of incidents.

**Fatal Inter-Party Incidents: (sidebar)**

Lizard Range, Fernie, BC (2001): A party of skiers in poor visibility ski-cut the top of a drainage. The resulting slide ran out of sight around a corner; the party opted not to ski the route. The slide struck a party of thirteen. Two fatalities.

Empress Lake , Monashees, BC (2004): A snowmobiling party jumped a cornice onto a slope, disabling a machine mid-slope. A second party crossed above, triggering a slab. One fatality.

Boulder/Turbo Mountain, Revelstoke, BC (2010): A snowmobile festival of roughly two hundred people was struck by a D3 slide triggered by a high-marking participant. Up to forty were buried. Two fatalities.

Eagle Pass, Revelstoke, BC (2010 – possible): A party of snowmobilers may have triggered a D3.5 slide above two parties comprising nineteen people. One fatality.

Kendall Peak, Snoqualmie Pass, WA (2015 – possible): A solo skier disappeared on a stormy day, recovered six months later. Injuries were consistent with avalanche. Investigation found that two parties had triggered slides uphill of the burial location on the disappearance-day. The cause of the accident remains uncertain.

Temptation Path, Bear Creek, CO (2019): A party of snowboarders triggered a slab in constrained permanently-closed terrain adjoining a ski resort. The slide crossed a popular trail, and the party beacon-searched the debris. A beacon-less solo skier was discovered by probe-line the following day. One fatality.

**Mitigation:**

As the number of people in the backcountry continues to grow, it will be useful to have strategies in-hand to limit inter-party incidents. Here are suggestions to spur that conversation:

**Awareness:** The most direct approach is to raise awareness of the potential hazard. Nobody wants to trigger nor be impacted by an inter-party avalanche. If parties are aware of the hazard, they can make choices to protect themselves and others.

**Density reduction**: If we spread out, we won’t hurt one another. There are still lonely places left to travel, even if they are harder to get to. Inter-party hazard can also be a selling point for those interested in expanding wintertime access for all forms of winter recreation.

**Travel practices:** We can practice “defensive routefinding” – choosing routes where we cannot be impacted from above, avoiding large-path terrain traps when human-triggering is likely, choosing truly safe spots to linger, and entering avalanche terrain only when we “must”. In some situations, active measures may be appropriate – attempting to make contact by voice with out-of-sight parties in constrained terrain. Choosing not to descend nor ski-cut otherwise-attractive routes where people may be below may be an unpleasant choice in the moment, but it is an easy choice to live with.

**Regional travel standards**: When densities are high enough that nearby parties are a perpetual concern, predictable movement is important. Common run-lists may improve communication between parties. Terrain-specific traditions – up-only and down-only routes may minimize the risk for slow-moving ascending parties. A trailhead “run board”, akin to a public flight-plan register, could enable the coordination of parties who may have never meet.

**Radios**: Radios are already a powerful tool for intra-party communication – they can also connect parties. Some regions, Telluride’s Bear Creek in particular, have begun to define FRS/GMRS community radio channels for coordination between parties. From afar, the effort appears encouraging. There may be an opportunity for backcountry radio manufacturers to add second channel-monitoring functionality to avoid cluttering inter-party communication with intra-party chatter.

**Conclusion:**

As more people enter the wintertime mountain environment, we must find ways to play well together. If the model presented above is correct, we will need to limit our *density* and give greater consideration to neighboring parties as avalanche *size* grows. A combination of mitigation strategies is likely to be needed, with awareness of inter-party hazard chief among them.

If this subject has caught your interest, please check out the full-length paper. You can find it on the arXiv at <https://arxiv.org/abs/1910.10668> or at [www.kendallpeak.org](http://www.kendallpeak.org/).

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Charlie Hagedorn is a physicist and backcountry skier from Seattle, WA. He wants you think about parties above you and below you this winter.

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| **Incident** | **Avalanche Type** | ***A*** (km2) | ***N*parties** | ***n*party**(parties/km2) | ***A*avalanche**(km2 ) | ***n*party*A*avalanche** |
| Lizard Range | Wind Slab, cross-loading | 2-4.5 | 3+ | 0.7-1.5 | ~0.1 | 0.04-0.3 |
| Empress Lake | Dry Slab | ~1.2 | 2 | 1.6 | ~0.05 | 0.05-0.1 |
| Nisqually/Wilson | Slab | ~1.3 | 3+ | ≥ 2.3 | ~0.02 | 0.03-0.08 |
| Boulder/Turbo Mountain | Persistent Slab | 1-2 | 30-100 | 15-100 | ~0.2 | 3-20 |
| Eagle Pass (possible) | Slab | 1-2 | 2-3 | 0.5-3 | >0.3 | 0.15-3 |
| Taylor Mountain | Hard Slab | ~0.8 |  |  | >0.3 |  |
| Kendall Peak (possible) | Slab | 0.2-1.0 | 3-9 | 9-15 | 0.003-0.01 | 0.03-0.15 |
| Avalanche Crest/Rogers | Slab | 2-5 | 5+ | 1-5 |  |  |
| Grandfather Couloir | Loose snow | ~0.16 | 2 | ~12.5 | 0.02-0.08 | 0.3-1 |
| Mount Herman | Wind Slab | 0.4-1.2 | 2+ | >2-5 |  |  |
| Hawkins Mountain | Soft Slab | 0.6-1 | 2-3 | 2-5 | 0.03-0.05 | 0.06-0.25 |
| Temptation, Bear Creek | Soft Slab | 0.3-1.3 | 2+ | 1.5-7 | ~0.03 | 0.05-0.2 |

**Table 1:**  Measurements from selected inter-party incidents. Estimating *A*, the area of connected terrain, is subjective and uncertain. The model predicts that inter-party involvements become likely as *n*party*A*avalanche approaches 1. Eleven out of twelve incidents involved slab avalanches.

**Photo Captions (abbreviated captions for the CAIC Temptation photos)**

**Figure 3:** Start zone and upper portion of the fatal February 2019 inter-party avalanche in Bear Creek, outside of Telluride, Colorado. The dashed red line indicates the triggering rider’s path of travel. The blue line is the initial avalanche crown. The red circle highlights the location of two party members at the time of the avalanche, and the dashed blue arrow is the Temptation avalanche path. The boundary of Telluride Ski Resort is along the ridge. (Image courtesy CAIC)

**Figure 4:** View of the avalanche debris at the bottom of the Temptation avalanche path. The dashed blue arrow marks the avalanche path. The blue line outlines the debris. The red circle denotes the solo-skier’s fatal-burial location. The dashed yellow line is the approximate location of the Bear Creek Trail. (Image courtesy CAIC)

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Further references may be found within the full paper:

C. Hagedorn. “Inter-Party Avalanche Involvements May Increase Quadratically With Party Density”. arXiv:1910.10668. (2019).