

MTFC Scenario Quest 2023-24

Team Name	Risky Business
Team ID #	16423
Proposal Topic Title*	Whether the Weather is Warm, Whether the Weather is Not, We Have to Put Up With the Weather, Whether We Like It or Not: Mitigating Hikers' Risk While on the Appalachian Trail

*title inspired by an English tongue twister

Mission 1 Ski Resort Prompts

Responses:

- 1.1
 - Any business near the ski resort would be affected and would be at risk in this scenario. If the resort is open for a shorter amount of time, it will attract less people to the area which will bring in less revenue for the business in the surrounding area. This can be especially impactful to small businesses (such as Mom and Pop shops) which depend on the winter ski-rush. Additionally, if the ski resort takes in less revenue, it will have a major impact on its employees. Instructors, maintenance workers, and other employees that help run the resort may lose their job because the ski resort can't afford to pay them.
- 1.2
 - Loss can be quantified as the amount of money lost after a negative event. If the ski season is shorter, there would be less tickets sold and fewer days open. If there is too much snow, there may be fewer trails open because of the risk of an avalanche. Each of these variables (revenue, ski season length, tickets sold, and number of trails open) can be used to quantify a ski resort's loss in a given season.
- 1.3
 - Insurance mitigation would give money back to the resort due to closure in extreme weather conditions and ensure that the ski resort will still maintain a minimum revenue for the year. This protects employees of the ski resort. Behavior change mitigation could mean that the business invests in other programs so that it could be open in the summer (water or alpine slide for the summer) or increase their hours (by investing in stadium lights) to allow for more opportune times in the day (night skiing for example). Another thing the ski resort could do would be to increase ticket prices, but then give rain checks so that if people booked tickets on a day that wasn't snowy, they could move their tickets to another day. This would encourage people to keep coming back to the resort (instead of switching to a different resort with more snow) and offset the revenue lost in the winter. Modifying outcome mitigation could mean investing in more fake snow machines so that people could still ski on the trails that weren't getting that much snow. For heavy snowfall, triggering avalanches before the trails open could reduce the risk of someone being on the trails when the avalanche occurs.

Mission 1 - Team Project Proposal Prompt

- Identify the Topic
 - Our team seeks to model the effect that climate change has on environmental factors (such as weather patterns and animal behaviors) in the mountains on the Appalachian trail and assess the new risks to hikers in the coming years. From there, we will provide recommendations to hikers for what times are the safest to hike certain regions of the Appalachian trail. This is important because it will increase the safety of hikers who use the trail during dangerous conditions caused by climate change, and this topic is especially relevant because of how climate change has affected the earth: extreme weather is becoming more and more common, the animal's behaviors are changing in response to the affected seasonal patterns, and climate change's effect on mountainous hiking trails directly affects the safety of hikers. The consequences of climate change are felt globally, but in this project we want to focus specifically on the Appalachian Trail along the East Coast of the US. Some other areas of impact are the families of the hikers that have to deal with the fallout of an injury and businesses surrounding the trail which may benefit from hiker patrons.
- Identifying Possible Risks
 - The risk for this project mainly encompasses hiker safety and tourism. With the climate warming up, there is a higher risk for avalanches, and the weather is acting strange, causing more adverse weather conditions like severe thunderstorms, tornados, and hurricanes which can reduce tourism because it is dangerous to go hiking in inclement weather. The animals on the mountain are adapting to the strange weather which may cause them to act unpredictably. The best case scenario is that hikers follow the Appalachian Trail in a manner that puts them on certain sections of the trail when they are the safest (example: hikers are not in the south during peak hurricane season), but there is a chance that the hiker will be in the wrong place at the wrong time. In addition, to the affected number of hikers, businesses such as the Appalachian Mountain Club will sustain decreases in revenue as hiking becomes more dangerous.
- Identify Risk Mitigation Strategies
 - For the insurance risk mitigation strategy, an insurance policy could be made that covers a hiker's medical bills if they get injured on the trail. For the behavior change strategy, hikers could be incentivized to travel the trail during the months that are found to be the safest. The dangers in certain regions (weather, animals, trail instability, etc.) could be put on signs and trail posts to encourage the hikers to stay away. For the modifying outcomes strategy, hikers could be given better supplies to make the journey and increase communication between checkpoints. This ensures that the hiker doesn't come underprepared, and it reduces the risk that the hiker gets stranded without any way to call for help.

Mission 2 Ski Resort Prompts

Responses:

- 2.1

There are five main questions that need to be taken into consideration in order to characterize the risks to ski resorts. Question 1: How much money do ski resorts lose when there is too much or too little snow? Question 2: what is the current typical ski ticket price ? Question 3: When do ticket prices become too expensive? Question 4: How does a reduction in the number of days at the ski resort impact the surrounding businesses? Question 5: What is the amount of snow needed?

- 2.2

In this dataset, historical trends are clearly identified. The data is also able to somewhat accurately present the frequency of potential outcomes and separates potential outcomes. Additional data that would be helpful to include when doing a risk mitigation study would include the measurement of snow, the amount of fake snow needed, and how the surrounding businesses fared financially.

- 2.3

By identifying the data size and the values of each point, we can create a linear regression model that will help us to predict future snowfall and profit. By looking at the center of values, we can find the mean and median, and then by comparing the two, we can find the impact outliers have on the data. By looking at the spread, we can create a box and whisker plot which will help us find the variability of the data and therefore how reliably we can predict the future outcome.

Visual representations are important because they show the spread of data, and in doing so, give us two things: 1, where the outliers in the data lie, and 2, the variation in the data. If the median and mean differ, it usually has something to do with outliers, and having a visual representation of the data shows us where the outliers are quickly.

In order to fully characterize the risks to the ski resorts, additional data on the history of the resorts would be helpful. Otherwise, additional data in the specific quantity of snowfall and profits in surrounding businesses would also be helpful.

Mission 2 - Team Project Proposal Prompt

Identify Driving Research Questions for Your Topic

There are four research questions that drive our topic fourth. Question 1: What temperature, altitudes, and air pressure would result in freezing temperatures yielding ice? Question 2: How could animal behavior change as a result of their changing environment in order to impact the safety of people on the Appalachian Trail? Question 3: What effect would these changes in weather conditions have on weathering and erosion, contributing to overall trail safety? Question 4: What are the greatest weather related risks that hikers on the Appalachian trail face? How will climate change increase these risk factors?

Identify the Type of Data You Hope to Find:

We hope to find data on temperatures, (freezing), trail quality, animal sightings, amount of check in spots on trail and frequency and value of hiker insurance if available. This data would be given to us in number, frequency, and dates if applicable-and any direct correlation to humans.

Additionally, data on the weather events that lead to the most human deaths and injuries on the Appalachian Trail would help us to determine which weather events are the most risky for hikers. Then, data that will help predict the frequency of extreme weather events in the Appalachian Mountain Range will help us to see which risks will increase in the future. This data would include the frequency of weather related deaths on the Appalachian Trail. It will also include data for the predictions of the frequency of future extreme weather events.

Identify Potential Data Sources for Your Topic

1. Data Source 1: [MyNasaData](#)

This is a very credible source that originates from the MTFC website. This resource falls under the category of climate data. With this set of data, we are able to connect climate change and air temperatures to hurricanes, prominently with the patterns observed by El Niño. While this data set gives a bar graph representing average temperatures of hurricanes, it doesn't provide the information it used to find these averages.

2. Data Source 2: <https://activesafe.ca/wp-content/uploads/2018/04/Hiking.pdf>

This source is credible, originating from the BC Injury Research and Prevention Unit. This source of data falls under the category of Hiker Risks. We are able to link different contributing factors to hiker safety, linking that to the overall safety of hikers. This data mostly entails proportions of certain incidents occurring, then they conduct significance tests based on these proportions. A limitation would be the required assumptions made instead of having statistics for certain aspects of the report.

3. Data Source 3: <https://www.sciencedirect.com/science/article/pii/S0379073820301146>

This source is a very credible peer reviewed article, talking about the causes of death for hikers at different altitudes from 2003-2018. This data source falls under the category of Hiker safety, specifically due to altitude. This source helps us to quantify the issue we are trying to mitigate, we could graph the number of hikers that died, and connect these to certain conditions allowing us to adjust our model based on these conditions, and their severity. A limitation to this data set is it is relatively small, only taking statistics from hikers in Switzerland.

Mission 3 Ski Resort Prompts

Responses:

- 3.1:
 - [\(Climate Change and Ski Tourism Sustainability: An Integrated Model of the Adaptive Dynamics between Ski Area Operations and Skier Demand., 2020\)](#)
 - [\(Vulnerability of ski tourism towards internal climate variability and climate change in the Swiss Alps, 2021\)](#)
 - These papers include models simulating skiing tourism and how it will likely change as a result of climate change. Keywords include climate risk, ski tourism, sustainable tourism, adaptive dynamics, tourism demand, internal climate variability, large-ensemble, snow modeling, and snow indices. Both of these included charts, tables, diagrams, statistical tests, as well as means. These papers included partial pseudocode demonstrating how their model came to their conclusions, while not going into detail. These models were helpful in showing the data they found and how they looked at it and dealt with lack of data at certain points. There were some math concepts that were beyond our current ability.

- 3.2.1
 - The probability of it being a typical year is 70%, a heavy year is 10%, and a light year is 20%.

- 3.2.2
 - All values are given in thousands of dollars and are rounded to one decimal place.

Snowfall Type	Alpine Arena	Mountain Meadows	White Haven
Typical	786.1	885.9	798.5
Heavy	1116.0	945.0	645.0
Light	450.5	386.0	504.8
Average	784.2	739.0	649.4

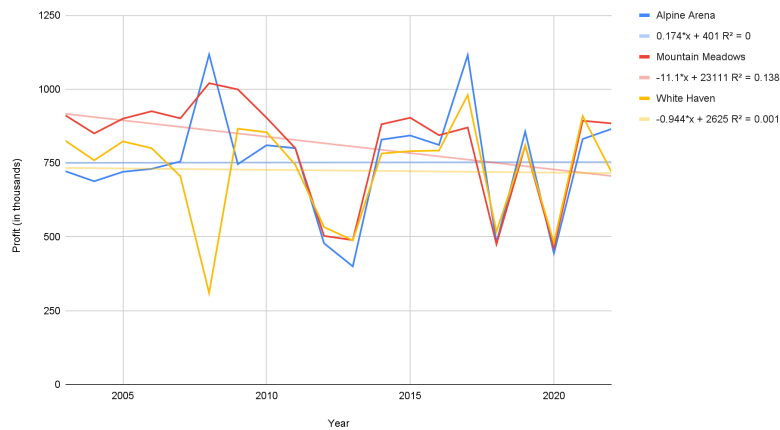
- There was less profit in light snowfall years for all resorts.

- 3.2.3
 - Expected profit for each ski resort in thousands of dollars, rounded to two decimal places.

Alpine Arena	Mountain Meadows	White Haven
751.97	791.83	724.41

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- 3.3.1
 - Least Squares Linear Regression Model for the 3 resorts. Unfortunately, the correlation coefficients were not available. Alternatively, the team provided the r^2 value which is the square of the correlation coefficient.

Linear Regression of Ski Resorts (3.3)



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- Mountain Meadows is more “in trouble” than the other resorts. This is because it has the most negative slope of -11.1, meaning that each year, the average profit falls by over \$11,000. Visually looking at the graph, you can also determine that the Mountain Meadows trendline has the most significant negative slope and also becomes the most negative in 2022.
- Based on the linear regression model we can assume that during light snowfall years, the corresponding resort profit is lower on average, while during heavy snowfall years the opposite is true. However during a typical snowfall year, the profit is average. This makes sense, since the majority of the years have typical weather.

Mission 3 - Team Project Proposal Prompt

- Articles produced by the Literature Search

- [\(An Exploration of Hiking Risk Perception: Dimensions and Antecedent Factors, 2019\)](#)
- [\(TrailBuddy: Using AI to Create a Predictive Trail Conditions App, 2020\)](#)
- [\(Application of airborne LiDAR and GIS in modeling trail erosion along the Appalachian Trail in New Hampshire, USA, 2020\)](#)
- [\(How Cold is Too Cold to Hike?, 2022\)](#)
- [\(How Windy is Too Windy To Hike?, 2021\)](#)
- [\(A Platform for Difficulty Assessment and Recommendation of Hiking Trails, 2021\)](#)
- [\(NOAA Weather Models, 2017\)](#)

Searches for “math models” of “hiking risks” resulted in a variety of papers. One paper, “TrailBuddy: Using AI to Create a Predictive Train Conditions App”, talked about an app that performed the same function as the model we are trying to create by predicting dangerous hiking conditions. Most of the other papers we found gave us mathematical equations, data for risks we plan to analyze, such as weather and murders, and mentioned how a decrease in hiking would affect tourism. The papers on the apps were unhelpful because they didn’t provide any data we could incorporate into our app, but they did give us an idea for how to get data. One weather model we found from the National Weather Service gave us a Quasigeostrophic Omega Equation, which was beyond our area of knowledge.

Based on the online research, the team has determined that following paths may be fruitful mathematical models to pursue. One path is to investigate weather conditions along segments of the Appalachian Trail over the course of a year. We will apply mathematical methods to determine the likelihood of severe weather events over the course of the year. Then, make recommendations for when the safest times are for hikers to attempt

each segment of the trail. Alternatively, we may investigate the risk analysis of checkpoints along the Appalachian Trail. This would be split up into multiple graphs to properly analyze this over the course of a year. We could create 1 graph per season to properly account for the seasonal change. Then, we would make recommendations on what part of the trail is safest per season. These proposed models are supported by the studies linked above. In particular, our approach is very similar to that of TrailBuddy, as we wish to be able to analyze the risks hikers will face across all seasons.

We hope that our mathematical model would be able to characterize the danger level and frequency of high risk events on segments of the Appalachian trail over the course of a year. Then, we can make recommendations to help hikers determine when they should segment hike each portion of the trail. This would constitute a change in behavior in the hikers.

Mission 4 Ski Resort Prompts

Responses:

- 4.1: There were no outliers present in the light snowfall years for Mountain Meadow, however, the profits are trending down for light snowfall years at a rate of -4.35 thousand dollars a year for years after 2012. This is due to the fact that the amount of customers during light snow year are kept at a constant, with little to no factors such as danger associated with the weather causing outliers. Since there were only 2 heavy snowfall years, an outlier cannot be determined. However, when compared to the heavy snowfall years of other Alpine Arena, Mountain Meadow's profit of \$870 thousand in 2017 was \$245 thousand dollars less.
- 4.2
 - 4.2.1: These results provide the frequency of each of the losses for the 3 resorts. It is revealed that there is a 70% of typical snowfall, a 10% chance of heavy snowfall, and a 20% chance of light snowfall each year. Each of these correlates with a projected income, which directly correlates to the frequency of loss (typical snowfall is average profit, heavy snowfall is above-average profit, and light snowfall is low profit). This overall tells us that the distribution of risks is uneven as shown through the percentages listed and the fact that it is determined by weather patterns that fluctuate constantly.
 - 4.2.2: The mean profits provide the severity of the loss for Mountain Meadows. This is because it shows the average profit over all weather types, which can be extended to mean the severity of the loss.
 - 4.2.3: A measure of loss would have to compare the profit to a "standard," or in this case, the average expected profit over all weather types. Loss would be defined as a profit that is below this average expected profit, and while it may still be positive, it is lower than expected and shows decreased profit overall.

Mission 4 - Team Project Proposal Prompt

Audiences & Risk Mitigation Viability

The most viable risk mitigation strategy of the three: modifying outcomes, insurance, and behavior change. Behavior change is the optimal risk mitigation strategy. This is due to the fact that insurance won't prevent these hikes from getting into dangerous situations. There is no way to modify the outcome because the weather, and animal and human actions cannot be changed, all of which can impact the safety of the hiker. Therefore the best strategy is to advise the hikers on which path is the safest and when, allowing them to make safer decisions. The perspective on the audience isn't adjusted due to this risk mitigation strategy, as the intended audience are hikers who want to segment hike the Appalachian Trail. Our strategy involves advising them on the dangers of each segment of the trail at different times of the year, making it so implementing behavior change doesn't affect our perspective on the audience for approach.

Goals for Mitigation Strategy

If no interventions are made, the risk of hikers walking into a dangerous situation where they can be murdered or become a casualty of a natural disaster will remain the same (and potentially increase as climate change brings about more inclement weather). The goal and hope for the impact of the risk mitigation strategy would be to decrease the overall risk of hikers getting hurt on the trail, and helping them be aware of the safety risks at certain points and at certain times on the Appalachian Trail.

Mission 5 Ski Resort Prompts

Responses:

- 5.1
 - If there is no intervention in Mountain Meadows, the resort will lose an average of \$11,100 per year, regardless of the amount of snow. This includes data from the past 20 years and is a trend of all snowfall levels as seen in the linear regression model created in Mission 3.
- 5.2
 - Behavior change:
 - Ideas
 - Give tickets back if they were booked for a day with no snow and allow the person to rebook at a later date.
 - Make a mascot (polar bear) and say customers can save the polar bears by supporting the resort.
 - Learn how to snowboard/ski for free in light snow years.
 - While a lot of these behavior changes are designed to increase the number of customers at the resort, there is also an increased chance that the resort will have lower average profits per person due to changes in ticket rebooking policies and revenue lost from free lessons and marketing expenditures. However, allowing people to rebook their tickets increases the chance that they will stay with the resort and not travel to other resorts instead. Free lessons may initially result in a loss of revenue, but it is an incentive for more people to buy tickets and for them to return in later years.
 - Modifying outcomes:
 - Including more activities (like tubing, ice skating, and fire pits) to increase revenue during years when snowfall is light
 - They can also introduce more summer time activities such as mountain biking, camp fires, and a mountain coaster or alpine slides.
 - Invest in more fake snow machines so that more people can ski in light snow years.
 - Insurance:
 - During the light years specifically, little profit usually comes with it, as there is no reason to go skiing. An insurance policy will enable Mountain Meadows to gain a higher profit specifically for light years and decrease the overall profit loss average. This will also increase the weighted mean profit for the resort over all weather types.

- 5.3

	Mean Profit With Insurance (Thousands of Dollars)	Mean Profit Without Insurance (Thousands of Dollars)	Standard Deviation (Thousands of Dollars)	Probability
Light	552.5	482.5	17.3108829	0.2
Typical	855.929	885.929	49.905	0.1
Heavy	915.000	945.00	106.066	0.7

- The standard deviation of the profits is the same for each weather type regardless if Mountain Meadows gets the insurance policy. This is because they were just shifted down for typical and heavy years and up for light years. For the typical and heavy years with insurance, the mean profit is 30 thousand dollars less per year than without the policy, but for light years, the mean profit is greater by 70 thousand dollars. However, when a weighted average is taken of all weather types,

the standard deviation is smaller with insurance when compared to the standard deviation without insurance.

- The insurance policy addresses Mountain Meadow's risk of losing profit during light snow years by giving them \$100,000 during light snow years. This helps them keep a more steady flow of profit when they need it most.

Mission 5 - Team Project Proposal Prompt

- 5.1
 - We are trying to reduce the number of casualties that occur while hiking on the Appalachian trail, and the best risk mitigation strategy for this would be a behavior change. A recommendation based on this strategy would be an infographic to tell the hikers when the best times to hike are (and where the most dangerous places are to hike). The metrics we would use would include lives saved as well as a "danger level" of a specific time of hiking.
- 5.2
 - While our proposal is designed to increase safety of hikers and profits of nearby businesses, there are some issues that could be presented. If a smaller number of routes is traveled more often, it is possible that these routes could become overcrowded and could cause negative environmental factors due to possible overuse.
- 5.3
 - In a best case scenario, our recommendations would effectively convey information to hikers in order to ensure their safety. This will remove any ignorance in hikers, making them aware of dangers of some parts of the trail, and reducing the risk (provided that they take our recommendations). As knowledge is power, people would be able to avoid possible dangers if they know they exist.