# Lessons From the Edge

What the mountains teach us about **anticipating mistakes** and **reducing consequences.**




Lessons From the Edge *explores what mountain recreation teaches us about understanding and managing risk in any environment. Drawing from experience in outdoor settings, participants will explore personal and organizational risk tolerance, as well as common habits that lead to incidents. We will connect these lessons to practical tools for decision-making, situational awareness, and improved communication. Participants will leave with transferable insights to reduce consequences and improve performance.*

Luc Mehl | triplepointtraining.com | luc@triplepointtraining.com

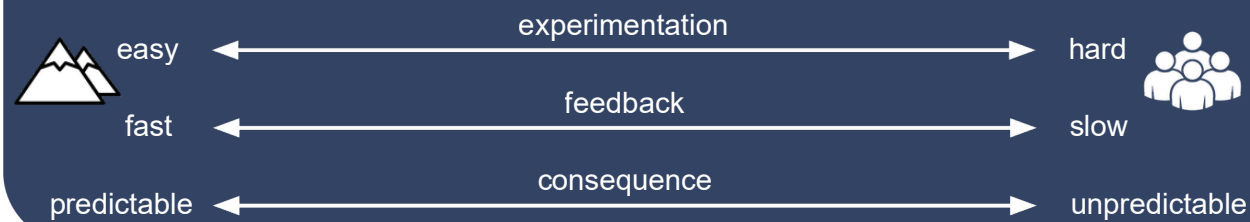
# The Problem:

Why do smart, experienced people die in the mountains?

This is the problem that motivates me to learn more about risk. You likely have other concerns. I think mountain lessons are applicable.

# How Mountain Lessons Can Help

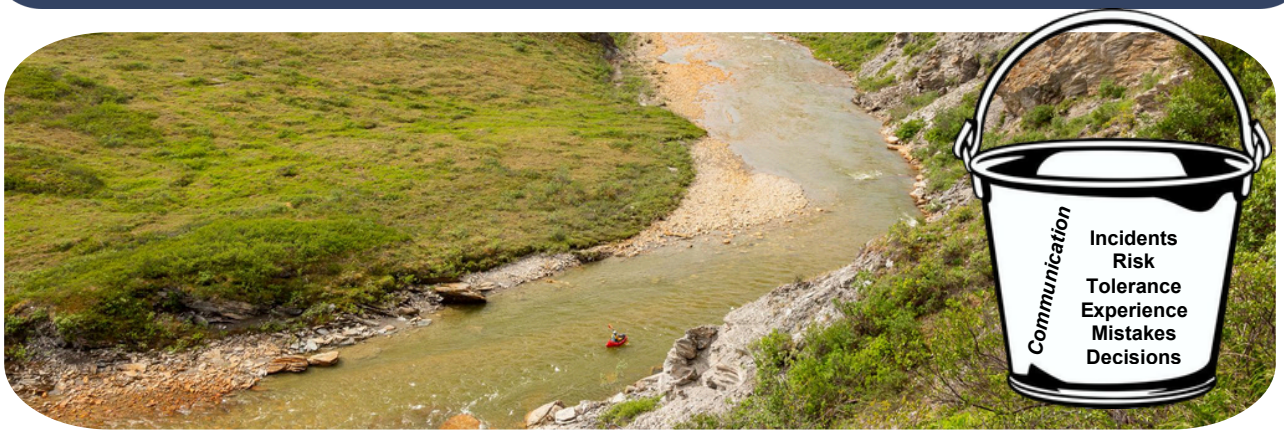
Mountain recreation vs. other **complex systems**




The mountains provide a learning environment with easy experimentation, fast feedback, and predictable consequences.

# Key Takeaways

1. **Risk management = Communication**
2. *Expect* mistakes. Focus on the consequences.
3. Recognize *nearly normal* and adjust the plan.



# 1. Incidents
## Common factors and concepts




**Mount Logan.** An ambition objective: 370 miles, 30 days, unsupported. Many things went wrong: an avalanche, snow-blindness, frostbite, mild hypothermia. We were at the threshold between manageable risk and a major incident.

## Accident Causation Models:
## The Linear Accident Model

Heinrich, 1931

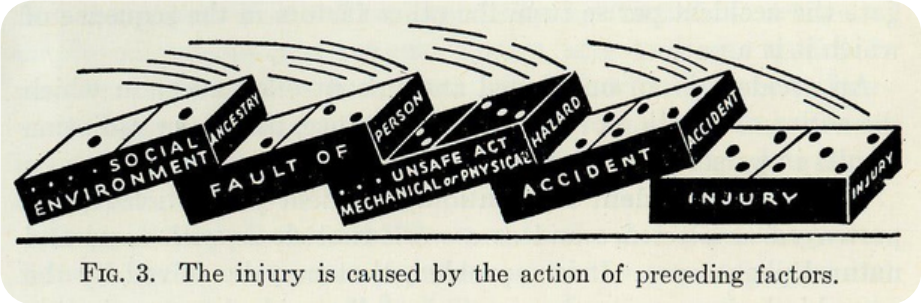



Fig. 3. The injury is caused by the action of preceding factors.

The **Linear Accident Model**: One factor triggers the next, like dominoes.

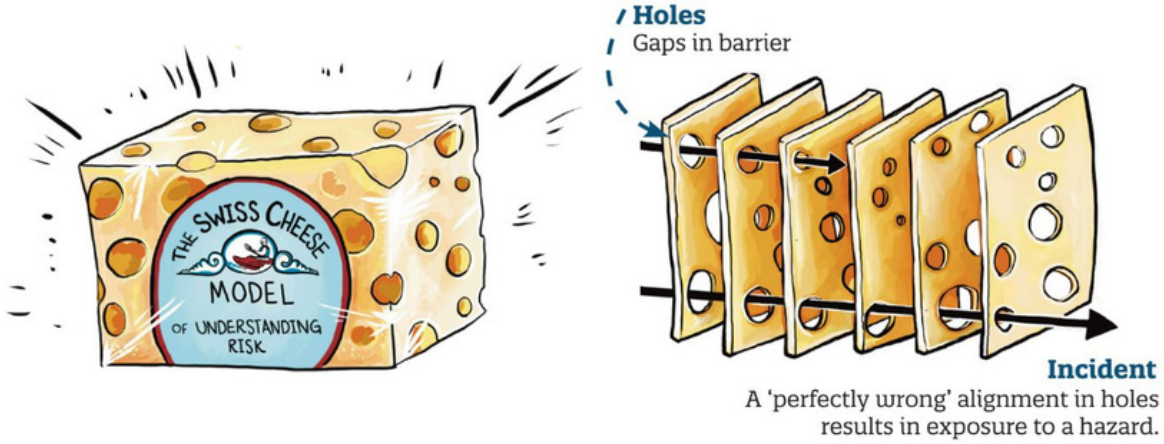
- Environment → Worker's shortcomings → Unsafe act → Accident

For Mount Logan: "Someone messed up." [Probably Josh, statistically.]

The linear model suggests a solution: Pull the Josh domino (fire or discipline the employee). Pulling that domino provides closure but doesn't help prevent the next incident.

## Accident Causation Models:
## The Swiss Cheese Model

Reason, 1990

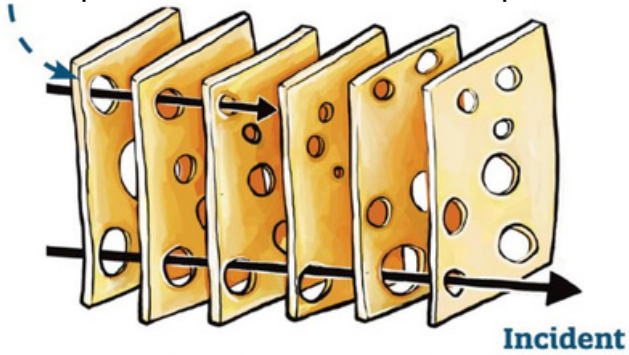


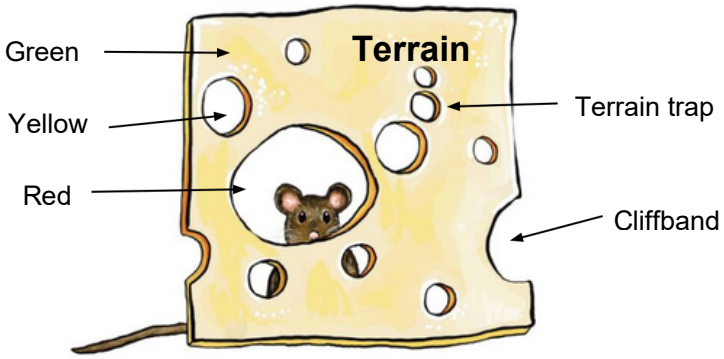

Multiple barriers of protection, but each has gaps.

Applying the Swiss Cheese Model to the Mt. Logan avalanche:



Snowpack, Weather, Terrain, People, Rescue




How our gaps aligned:

- Snowpack: We looked for red flags, but didn't see any
- Terrain: Southern slope
- Weather: Warm afternoon, sun exposure
- Human: After a week of hard, slow, flat travel, we were eager to climb!

The Swiss Cheese Model provides lessons to prevent a similar incident.

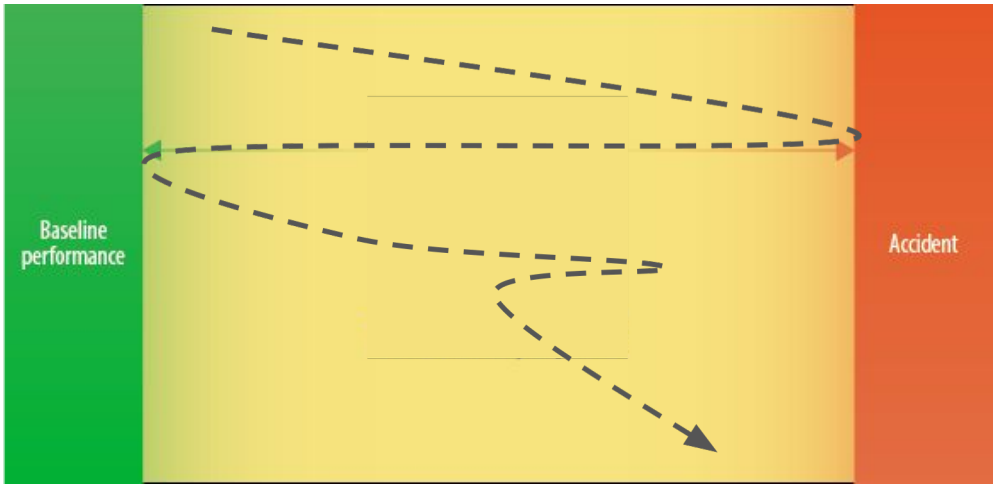
# Accident Causation Models
## Safety Space and Practical Drift




https://flightsafety.org/asw-article/safety-space-practical-drift/

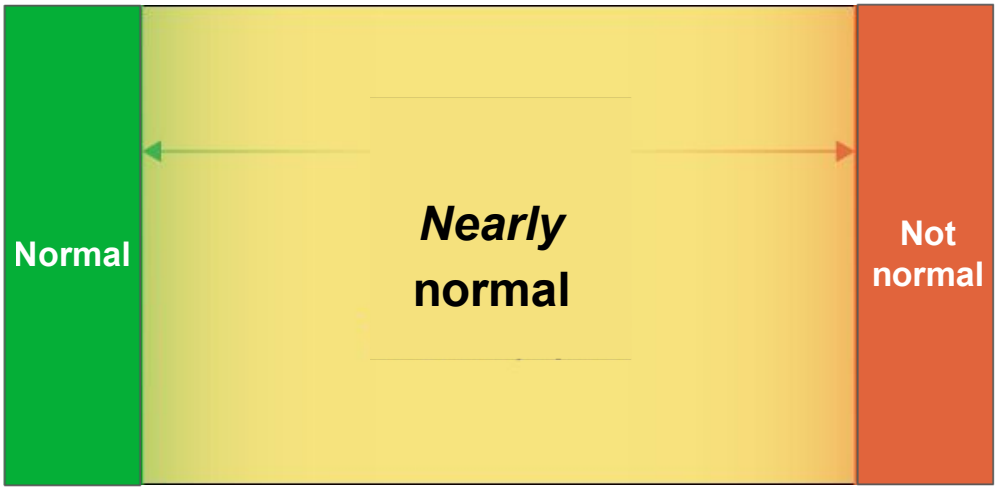
AKA “normalization of deviance” or “safety drift.”

- We are often in the space between perfect performance and an accident.
- This is effectively normalizing the alignment of gaps in our barriers.



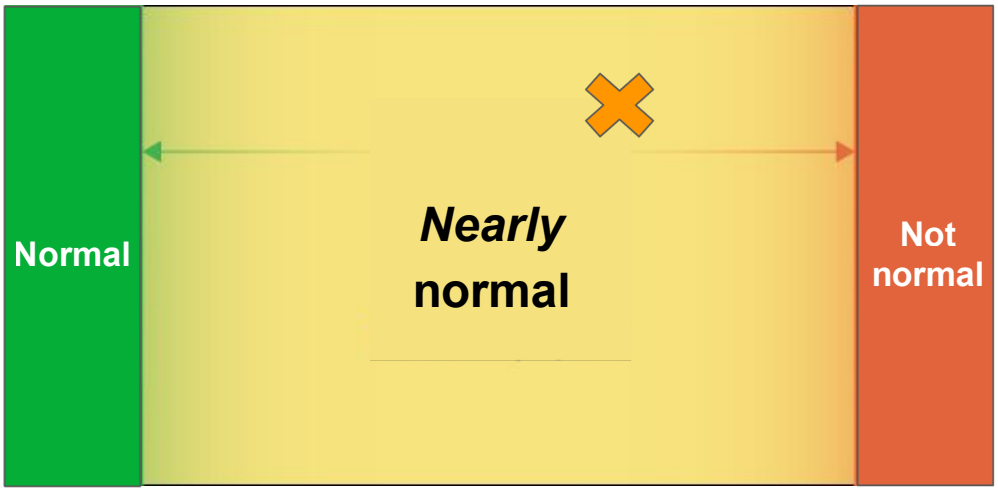

Complacency leads to drift toward an accident, and a quick snap back to the baseline. Close calls, changes in personnel, etc., can change our trajectory.

## Accident Causation Models
*Nearly* normal




The safety space is also the space between ‘normal’ and ‘not normal’ behavior.

- Decisions are **easier** in normal *and* not-normal.
- Decisions are **harder** in the *nearly normal* space




The point isn’t to stop an activity in *nearly normal*. The point is to revise the (risk management) plan.

# Takeaways

1. Many incidents happen when small, reasonable factors lineup wrong.
2. We are usually in the space between baseline performance and an accident.
3. We can learn to recognize *nearly normal* and then revise the pan.

For (3): *Nearly normal* might be a gut feeling. I want to get better at recognizing that space so that it triggers changing the plan.



# *Incidents*

*What is working? What is not?*

Are there common factors in your organization's incidents?

Do you share a common language?

How do you recognize *nearly* normal, and what happens next?

# 2. Risk

## How do you talk risk?

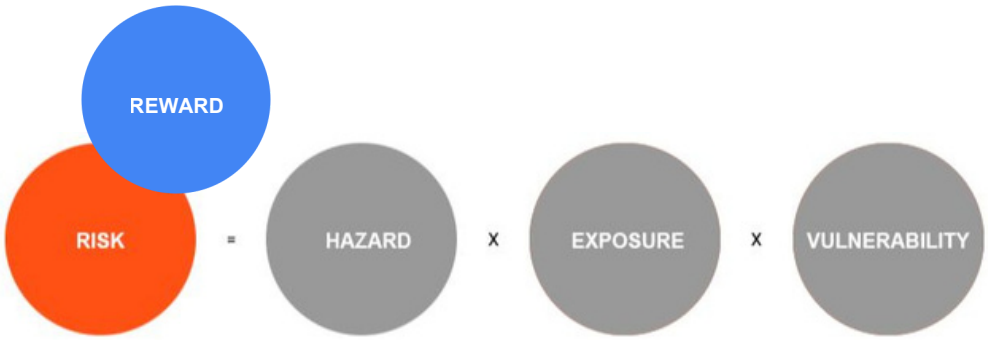


It helps to be on the same page when talking about risk. The terminology means different things to different people:

Risk = Hazard x Exposure
**Risk = Hazard x Exposure x Vulnerability**
Risk = Threat x Vulnerability x Consequence

**Risk = Probability x Consequence**
Risk = Likelihood x Impact
Risk = Severity (of hazard) x Likelihood (of occurrence)
Risk Exposure = Risk Impact x Probability

Risk = Probability x Impact + Time




**Sarah's bee sting.** Sarah had an anaphylactic reaction during a remote hiking trip.

- **Hazard**: Stinging insects
- **Exposure**: Sarah. Or we could be more specific: her face, arms, summer.
- **Vulnerability**: Epi in fanny pack, recent WFR, on the trip with two EMTs.



## Exposure: The stuff that can be harmed







## Vulnerability: How likely? How bad?



Our training, partners, equipment, etc., change our vulnerability.

# Exercise

Tell a risk story narrative and then identify hazards, exposure, and ways you did or could change your vulnerability.

**Hazards**: Things that can do harm that we can't control.

**Exposure**: The people and stuff exposed to the hazards.

**Vulnerability**: The degree of harm due to exposure.

# Takeaways

We should be intentional with our risk vocabulary.

We have little control over hazards, our work is to identify them.

We have the most control over exposure and vulnerability.

# Risk

## Probability & Consequence



**Iliamna Volcano.** Our pre-trip risk assessment included crevasse falls and blisters.

- **Crevasse fall**: Not very likely, big deal.
- **Blisters**: Very likely, not a big deal.

We had a crevasse fall, but we ended up turning around because of a blister! What did we do wrong?

| Likelihood | Negligible 1 | Minor 2 | Moderate 3 | Major 4 | Catastrophic 5 |
|---|---|---|---|---|---|
| 5 Almost certain | Moderate 5 | High 10 | Extreme 15 | Extreme 20 | Extreme 25 |
| 4 Likely | Moderate 4 | High 8 | High 12 | Extreme 16 | Extreme 20 |
| 3 Possible | Low 3 | Moderate 6 | High 9 | High 12 | Extreme 15 |
| 2 Unlikely | Low 2 | Moderate 4 | Moderate 6 | High 8 | High 10 |
| 1 Rare | Low 1 | Low 2 | Low 3 | Moderate 4 | Moderate 5 |

Even though we knew blisters were likely, we never discussed it.

We should have established that “normal” meant taking the time to deal with the small stuff.

Instead, due to my motivation, “normal” meant that we needed to cover a lot of ground.



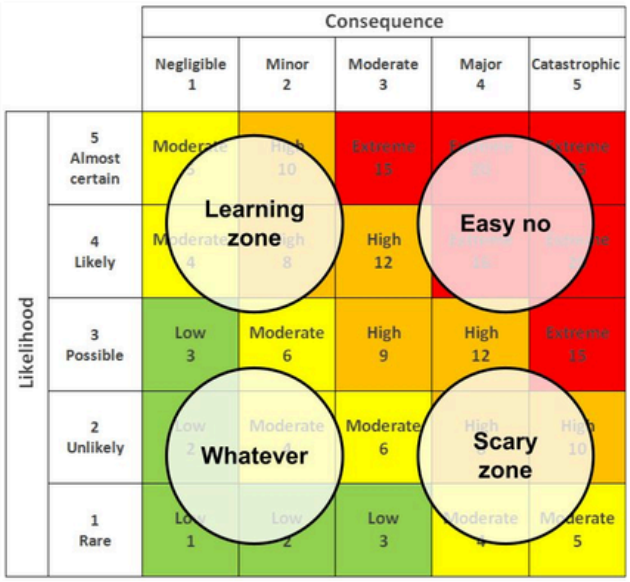
Let’s try to put numbers on the likelihood of a crevasse fall and blister (terms like ‘possible’ are too subjective).

How easy is it to quantify consequences?

**Takeaways:**

- Likelihood is hard to predict.
- Consequence is easier to predict. I like Will Gadd’s three tiers: bumps & brusies, hospital, and death.

There is another problem with risk matrices: the corners can have the same values but are very different situations:



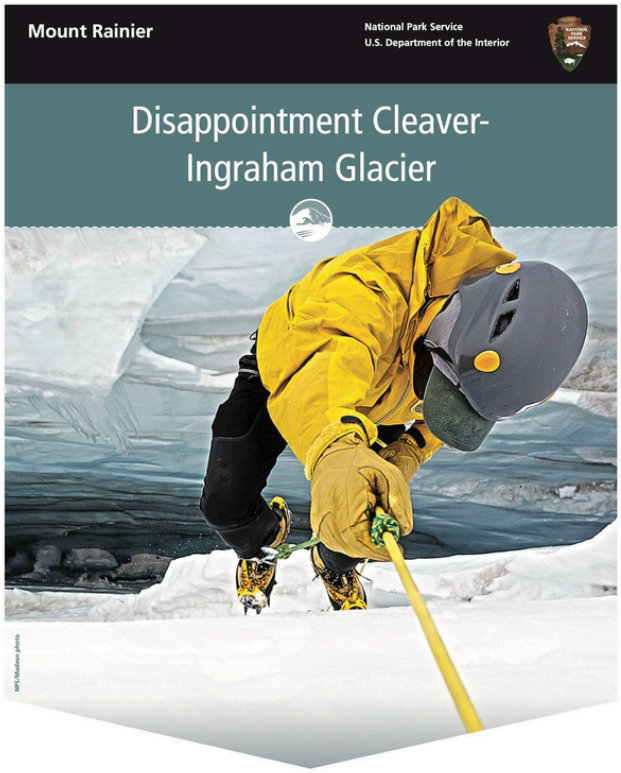
# Exercise

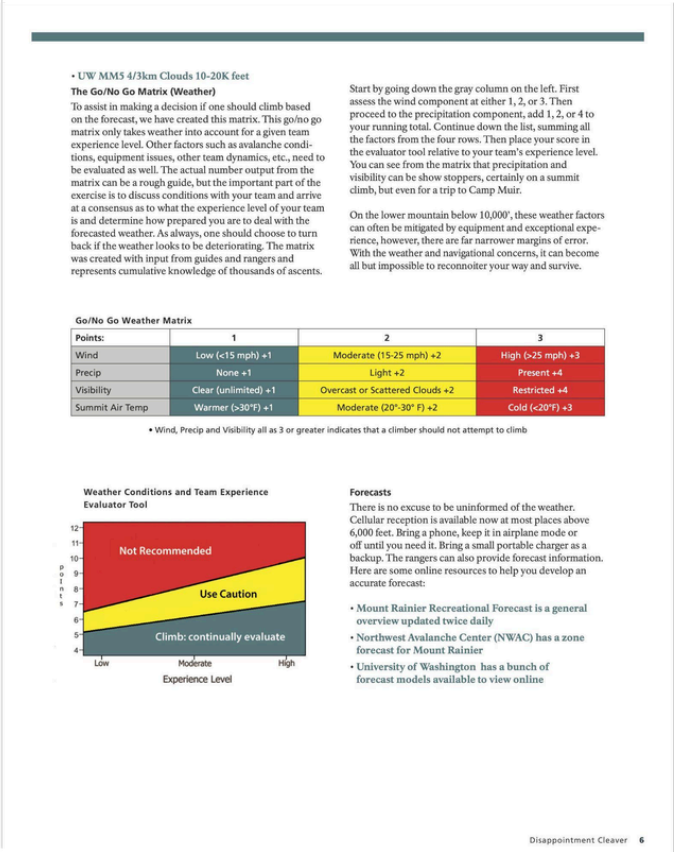
Plot your risk narrative in Probability / Consequence space.

| Likelihood | Consequence: Negligible 1 | Minor 2 | Moderate 3 | Major 4 | Catastrophic 5 |
|---|---|---|---|---|---|
| 5 Almost certain | Moderate 5 | High 10 | Extreme 15 | Extreme 20 | Extreme 25 |
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| 1 Rare | Low 1 | Low 2 | Low 3 | Moderate 4 | Moderate 5 |

**Risk matrices are most useful when they trigger *action* to *reduce* probability or consequence**

## Example 1: NPS Mount Rainier Climbing guide



• UW MM5 4/3km Clouds 10-20K feet

**The Go/No Go Matrix (Weather)**

To assist in making a decision if one should climb based on the forecast, we have created this matrix. This go/no go matrix only takes weather into account for a given team experience level. Other factors such as avalanche conditions, equipment issues, other team dynamics, etc., need to be evaluated as well. The actual number output from the matrix can be a rough guide, but the important part of the exercise is to discuss conditions with your team and arrive at a consensus as to what the experience level of your team is and determine how prepared you are to deal with the forecasted weather. As always, one should choose to turn back if the weather looks to be deteriorating. The matrix was created with input from guides and rangers and represents cumulative knowledge of thousands of ascents.

Start by going down the gray column on the left. First assess the wind component at either 1, 2, or 3. Then proceed to the precipitation component, add 1, 2, or 4 to your running total. Continue down the list, summing all the factors from the four rows. Then place your score in the evaluator tool relative to your team's experience level. You can see from the matrix that precipitation and visibility can be show stoppers, certainly on a summit climb, but even for a trip to Camp Muir.

On the lower mountain below 10,000', these weather factors can often be mitigated by equipment and exceptional experience, however, there are far narrower margins of error. With the weather and navigational concerns, it can become all but impossible to reconnoiter your way and survive.

Go/No Go Weather Matrix

| Points: | 1 | 2 | 3 |
|---|---|---|---|
| Wind | Low (<15 mph) +1 | Moderate (15-25 mph) +2 | High (>25 mph) +3 |
| Precip | None +1 | Light +2 | Present +4 |
| Visibility | Clear (unlimited) +1 | Overcast or Scattered Clouds +2 | Restricted +4 |
| Summit Air Temp | Warmer (>30°F) +1 | Moderate (20°-30° F) +2 | Cold (<20°F) +3 |

• Wind, Precip and Visibility all as 3 or greater indicates that a climber should not attempt to climb

Weather Conditions and Team Experience Evaluator Tool




**Forecasts**

There is no excuse to be uninformed of the weather. Cellular reception is available now at most places above 6,000 feet. Bring a phone, keep it in airplane mode or off until you need it. Bring a small portable charger as a backup. The rangers can also provide forecast information. Here are some online resources to help you develop an accurate forecast:

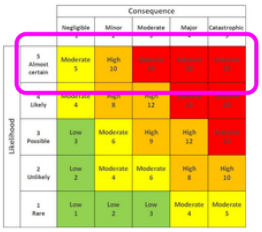
- Mount Rainier Recreational Forecast is a general overview updated twice daily
- Northwest Avalanche Center (NWAC) has a zone forecast for Mount Rainier
- University of Washington has a bunch of forecast models available to view online

Disappointment Cleaver 6

https://www.nps.gov/mora/planyourvisit/upload/Disappointment-Cleaver-Routebrief-2017_FINAL.pdf

This example combines objective and subjective considerations to reduce likelihood.

### Step 1: Objective




- Assume the forecast is “almost certain.”
- Assign points based on exposure to environmental hazards.

Go/No Go Weather Matrix

| Points: | 1 | 2 | 3 |
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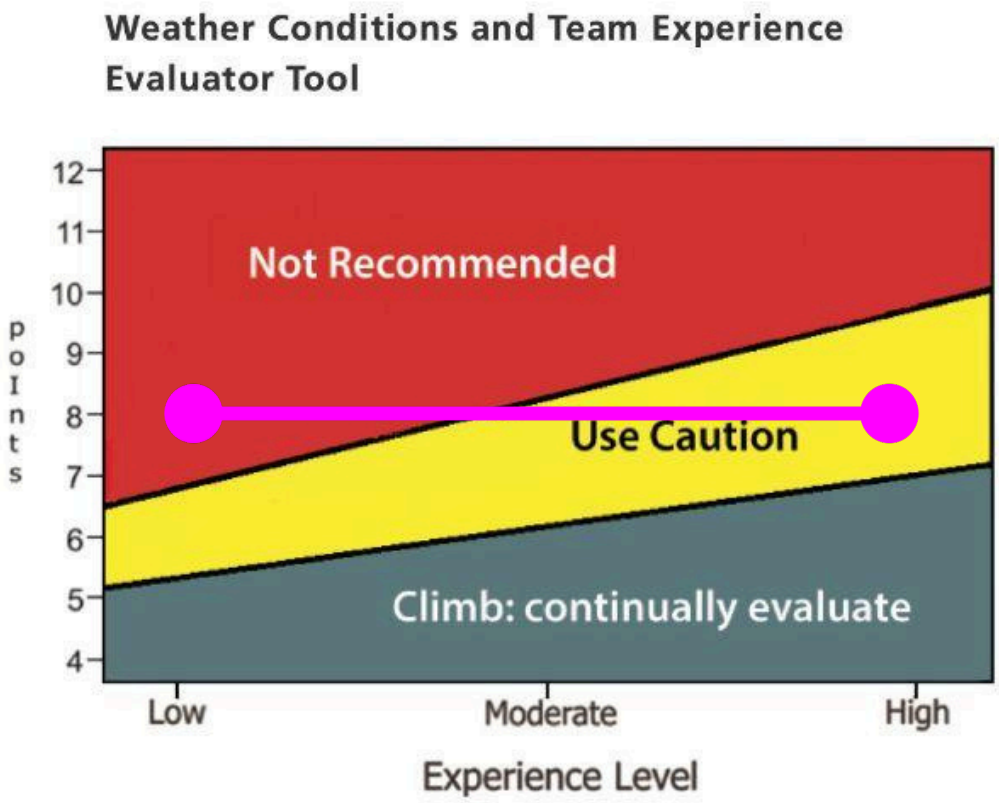
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Let's take values of 2 for each variable → 8 points.

**Step 2: Subjective**

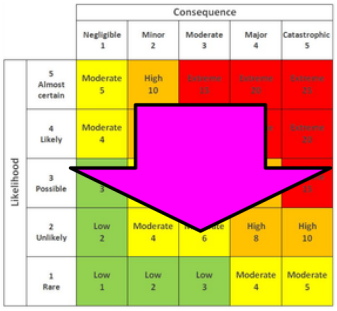
- A go / no-go decision depends on experience.




This approach **reduces the likelihood** that less experienced climbers will go.

**Applying this elsewhere: We can make go / no-go decisions through:**

- Environmental cut-offs
- Changing venues
- Increase leadership ratio



**Example 2: Stanford University Environmental Health & Science.**

Additional controls are needed/recommended depending on matrix rating.

**Step 1:** Evaluate probability vs. consequence.

**Step 2**: Use Action table to assess controls (reduce consequence)

**Assign a risk rating to the experiment.** Based on your procedure outline and the what if analysis, determine the risk rating for the experiment or procedure.

**Risk Rating:** _____

| | | Severity of Consequences - Personnel Safety | | | |
|---|---|---|---|---|---|
| | | No Injuries | Minor | Moderate to life impacting | Life threatening from single exposure |
| Likelihood of Occurrence | (Almost) Certain | Low | High* | Unacceptable* | Unacceptable* |
| | Likely | Low | Medium | High* | Unacceptable* |
| | Possible | Low | Medium | High* | High* |
| | Rare | Low | Low | Medium | High* |

[1]The Risk Rating is subjective. The primary goal is for researchers to pause, think about risk, and differentiate unacceptable and high-level risk steps from those with a lower level risk. This will help drive additional consultation and control measures where needed.

**Revise plan if the risk rating is too high.** Are these risks acceptable? Use the table below to determine the action to take based on the risk rating. What are the highest risk steps? What more can you do to control the risks? Return to planning and use the hierarchy of controls to design a safer experiment.

**Risk Rating Action Table**

| Hazard Risk Rating | Action |
|---|---|
| Unacceptable* | STOP! Additional controls needed to reduce risk. **Consult with PI and EH&S** (650-723-0448). |
| High* | Additional controls recommended to reduce risk. **Consult with PI and EH&S** (650-723-0448). |
| Medium | Ensure you are following best practices. Consult with peers, PI, or EH&S, as needed. |
| Low | Perform work within controls. |

**PI/Supervisor Approval:** _____

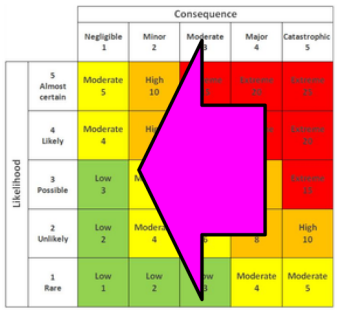
*Signature required for High risk ratings.

NOTE: Unacceptable risk rating experiments **may not proceed**. Introduce further controls to reduce risk.

https://ehs.stanford.edu/wp-content/uploads/Laboratory-Risk-Assessment-Tool.pdf

## Applying this elsewhere: If we are still going to do it, what controls will reduce consequences?

- PPE
- Redundancy
- Egress routes
- Medical training
- Leadership ratio



# Takeaways

Prob vs. Conseq should trigger action to reduce Prob or Conseq.

Consequence is easier to assess than probability.

Assigning numbers is hard, but better than words.



# *Risk*

*What is working? What is not?*

How do you talk risk?

What tools do you use to manage risk?

# 3. Tolerance

Risk tolerance determines if the reward is worth the risk.



**Ice skating in Montana**. I joined a group of people I didn't know to skate a reservoir. I was unfamiliar with the location and the warm/thin conditions.

I felt 'nearly normal,' and less comfortable than the others. I had a red flag observation, and then a second. Finally, I announced that I was past my comfort level and that I was going to turn around.

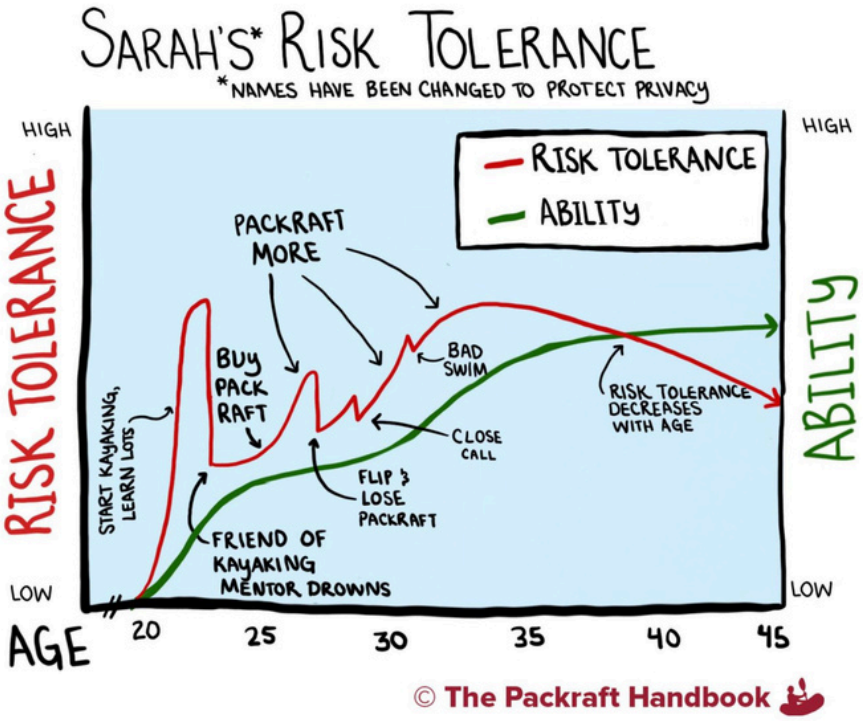
# Risk Tolerance

## Personal

My normal / not-normal ice skating space might look something like this:

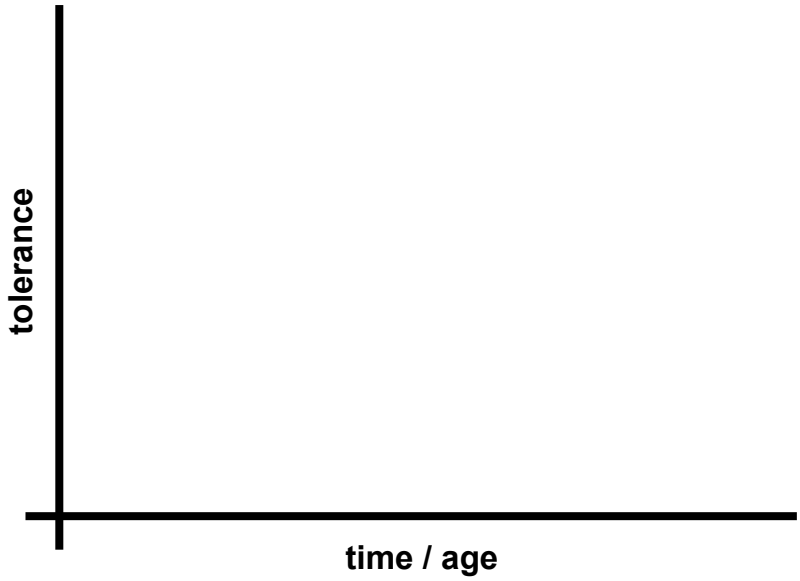
| Variable | Normal (easy yes) | Not normal (easy no) |
|---|---|---|
| **Ice thickness** | 4+ inches | 2 or less |
| **Air temp** | cold (morning) | warm (afternoon) |
| **Group** | Everyone has rescue equipment | I'm the only one with rescue equipment |
| **Egress** | Known exit | Unknown exit |
| **Strike tests** | 2+ strikes | 1 strike |
| **Knee flex** | Can't get cracks | Circumferential cracks |

Our **personal** willingness for things to go wrong changes with time:



## Exercise

Plot the evolution of your personal risk tolerance




If you want more: add experience to your plot.



## Risk Tolerance

Organizational

At the **organizational** level:

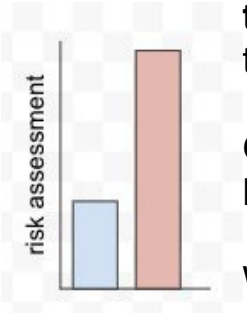
- Leadership decides the organization's risk tolerance and communicates it to staff.
- Leadership empowers and trusts staff to make their own decisions.

But there is a problem ... risk tolerance is only useful as a planning tool if our risk assessment is accurate.

## Risk Tolerance

Depends on assessment!






I'm still trying to wrap my head around this. But young Luc **didn't think activities were risky**, and therefore it didn't take much tolerance to do them.

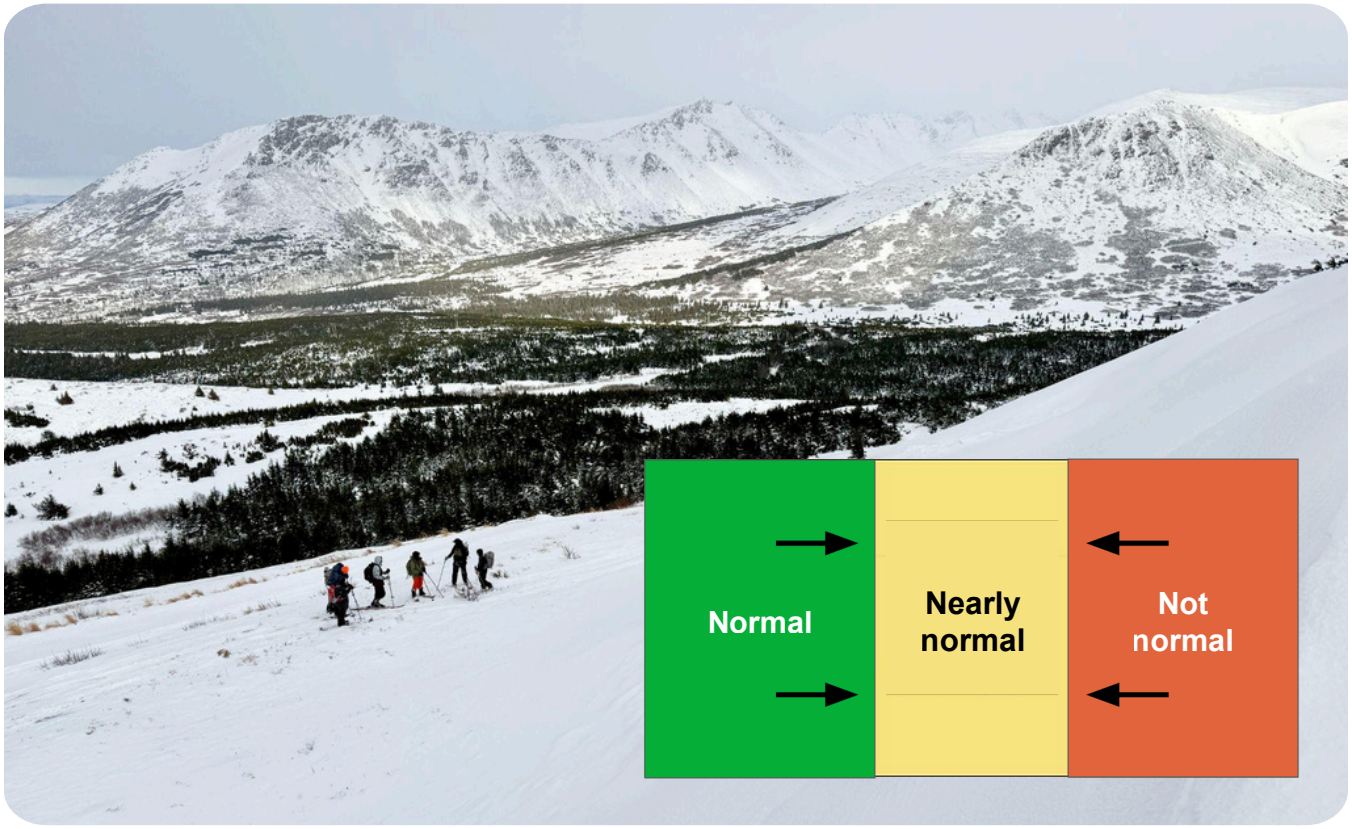
Old Luc sees more risk everywhere. If I still choose to go, I have a **higher tolerance** for things to go wrong.

We get better at assessment through relevant experience.

# Takeaways

Communicating tolerance only works if our assessment is accurate.

Well-communicated tolerance shrinks the *nearly normal* space.




# *Tolerance*

*What is working? What is not?*

Is your organization's risk tolerance clearly communicated from above? How?

How do you manage different personal risk tolerances in peer outings?

# 4. Experience

How does experience influence our decisions?



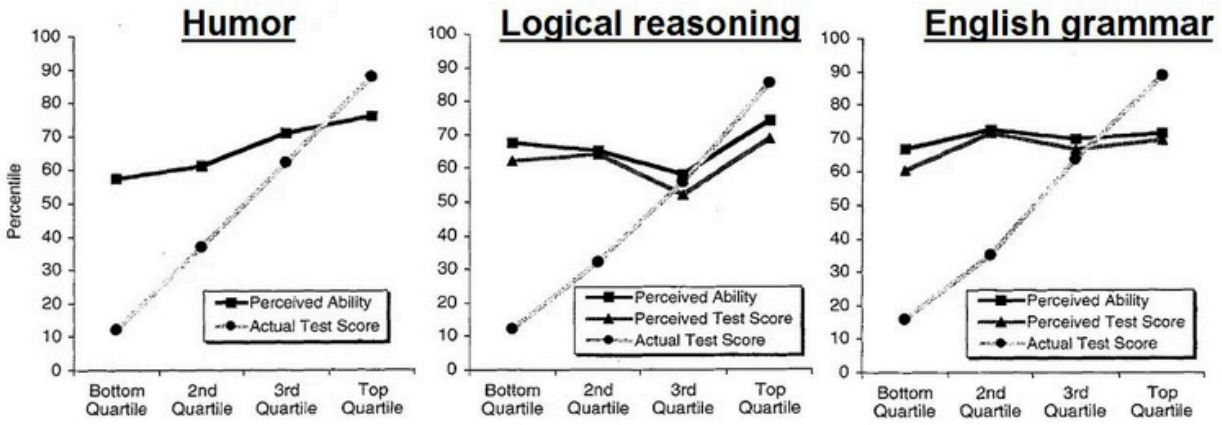

**Sea kayaking and icebergs.** Who is in the best position to gauge how safe we can get? The person with the most kayaking experience? The person who has spent the most time around ice bergs?

What kind of experience make us better decision-makers?

# Experience

## Self-assessment: Perceived ability

Kruger & Dunning, 1999




**Takeaway: We are bad at self-assessment. If we don't know the answer, then we don't know how to assess our ability.**

# Experience

## Kind and wicked learning environments

Hogarth, Soyer, *The Myth of Experience*



**Kind**: Frequent, reliable, relevant feedback.

- Chess
- Tennis
- Golf




**Wicked**: Missing or misleading feedback.

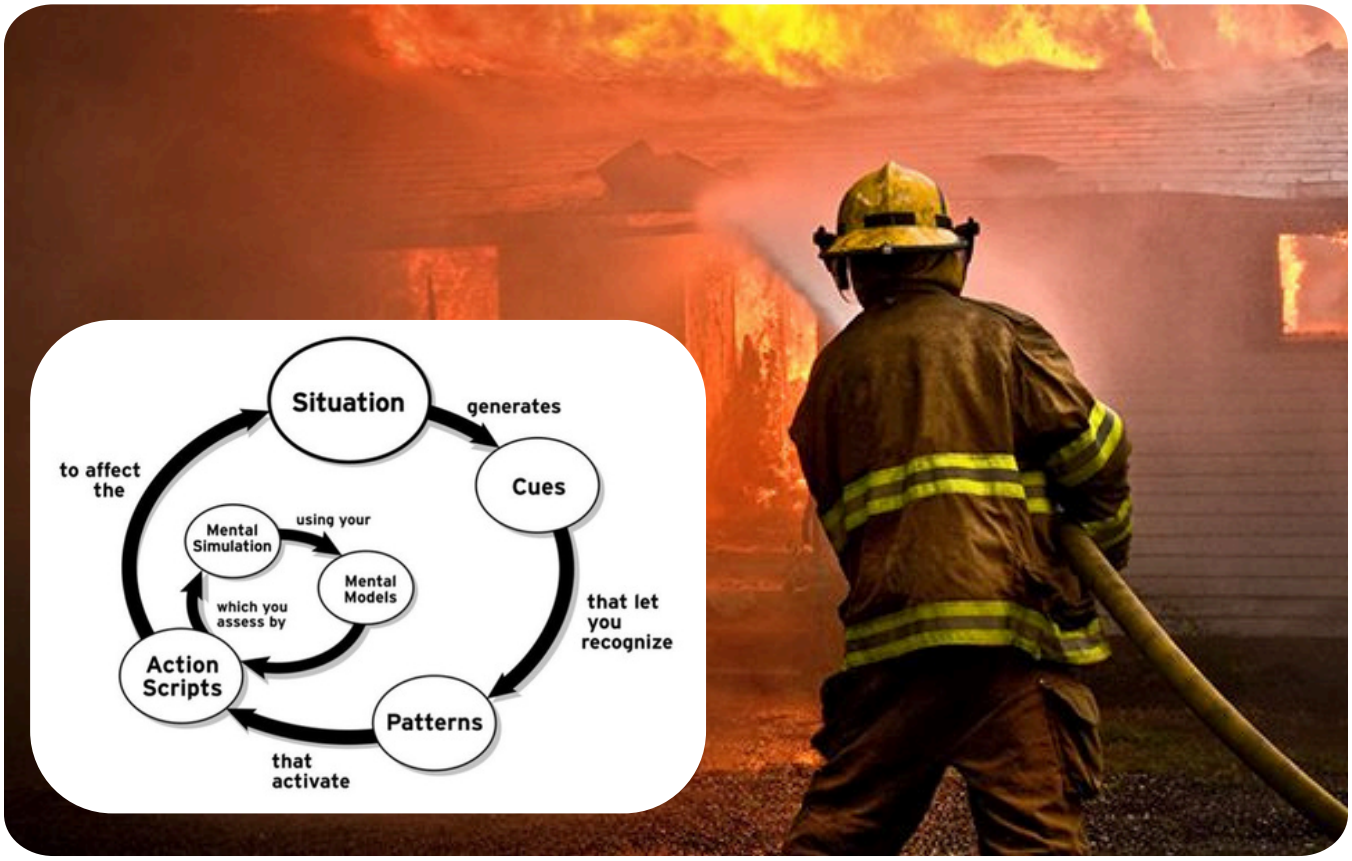
- Poker
- Avalanche terrain
- The stock market

**Takeaway: Experience only works toward better decisions if it is in a kind learning environment.**

# Experience

## Intuition: Recognition-primed Decision Model

Klein, *Sources of Power*




Klein's study of firefighters:

- Critical decision is not pros and cons assessment of options A, B, C.
- Critical decision is intuitive, based on experience.

1. Perceive cues (sounds, smells, environmental conditions)
2. Pattern recognition based on experience
3. Action plan
4. Mental model

I really want to get better at the cues part… noticing changes in the weather, mood, etc. In other words, situational awareness.

**Takeaway: we need to gain experience.**

# Situational Awareness

Mica Endsley




Put another way: What? So what? Now what?

## Takeaways

Experience only helps if we receive abundant and accurate feedback.

Experience builds situational awareness.

Experience informs critical decisions.

## *Experience*

*What is working? What is not?*

What aspects of your learning environments are kind vs. wicked?

How do you learn from experience?

How do you share what you've learned?

# 5. Mistakes

Expect mistakes. Plan for consequences.



**Rob's drowning.** Rob Kehrer drowned during a 200-mile adventure race. The Tana River has a Class IV canyon (technical), with big, pushy, glacial water. Rob was afraid of water and only paddled what he needed to finish these events. He portaged the Class IV section and put back on the river in a Class II section.

*He did good risk assessment and made good decisions.*

Capsizing was likely … that's why he portaged. But he could have done more to prepare for the consequence: equipment, practice.

## Human and Organizational Performance

## 1. Error is normal

Todd Conklin: *The 5 Principles of Human Behavior*



**We are going to make mistakes.**

We need a shift from “fail-safe” to “safe to fail.”

- The point isn’t “don’t capsize.”
- The point is: add more buoyancy and train for the event: practice getting back in your boat, practice swimming to shore, etc.

## 2. Blame fixes nothing

**“You can either learn from a mistake or blame. Not both.”**

We don’t intentionally choose the bad option.

## 3. Context drives behavior

**“Why did it make sense to them at that time?”**

## 4. Learning is essential

**“Growth mindset” — Learning involves making mistakes.**

Don’t forget to learn from the successes too, not just the near misses.

## 5. How we respond matters

Leadership response shapes future outcomes.




What happened May 17th? How comfortable did the employee feel speaking up?

Red Dog Mine: Very few spills reported when reports were linked to bonuses.

# Takeaways

Mistakes will happen, and are learning opportunities.

How you / your org. responds to mistakes determines whether future incidents will be prevented.



# *Mistakes*

*What is working? What is not?*

How can we create a culture of reporting mistakes?

How can we reduce consequences?

# 6. Decisions

## How do we make better decisions?

Annie Duke, all of her books are excellent



There are two timeframes for decision-making:

- Before-action (“deliberative”)
- During-action (“real-time”)

## **Ulysses Contract | Pre-commitment | Kill Criteria**
(before action)

**Anticipating failure before it happens.**

- Pre-define cut-off values and go / no-go decisions.

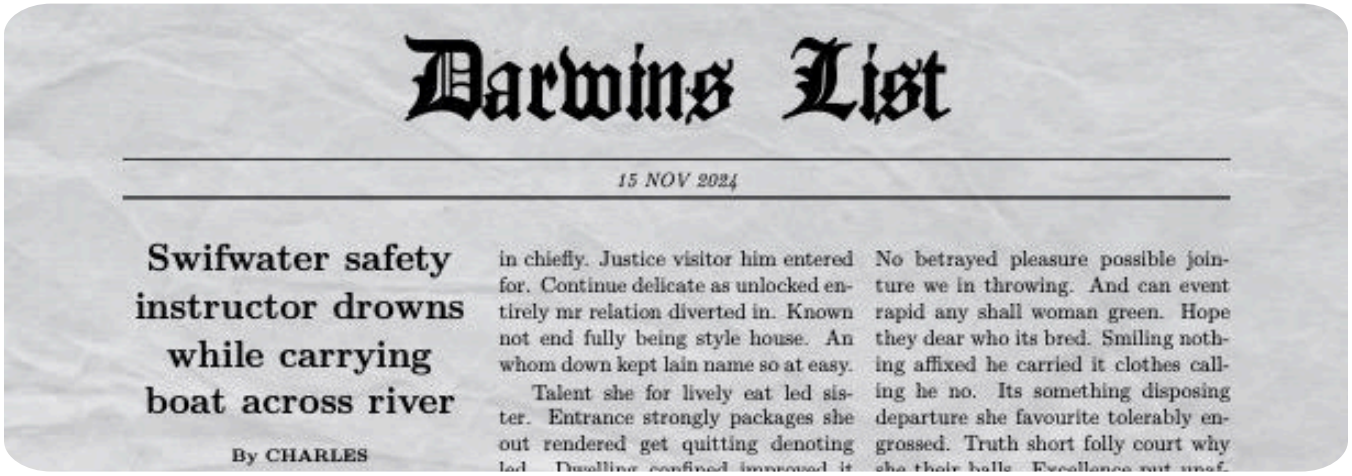
Examples:

- Ulysses and the sirens.
- Sarah says I can’t go boating solo.
- I have high water cut-off values for my river courses.

**What environmental or other cut-offs do you use? Is there a formal list?**

## Pre-mortem
(before action)

Gary Klein, *Sources of Power*



Darwins List

15 NOV 2024

**Swifwater safety instructor drowns while carrying boat across river**

By CHARLES

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**Anticipating failure before it happens.**

- Pre-mortem. Doc's meet to discuss why a patient [project] died [failed] before it happens.
- What would the headline say?
- Like a time machine to identify failure
- AKA "Reverse engineering"

Examples: Sarah and I waded across several rivers in the Alaska Range because we didn't want to bother to unpack and repack our boats. But the crossings got challenging!

Is anyone actually doing this? I like the idea but it has been hard to implement.



## Checklists

Atul Gawande, *The Checklist Manifesto*



Checklists can be used before or during action.

Checklists **support judgement** when time is limited. Our brains are bad at coming up with new solutions on the fly. Routines can help.

Examples:

- Aviation
- Medicine
- Avalanche Ed
  - Is it avalanche terrain?
  - Is the current avalanche problem a factor?
  - Do we need to adjust our travel technique?
  - Did we miss anything?

It helps to have triggers that prompt the use of checklists or routines:

- “Safety zone”
- “Pause Point”

Sounds great ... but it is easy to get complacent.

# Heuristics and Personal Disaster Flags
(during / after action)

Daniel Kahneman / Ian McCammon




## Heuristics and biases

We rely on mental shortcuts, but they sometimes mislead us.

We can improve awareness of these mental errors, but they are reflexive … hard to change behavior.

Examples:

- Expert Halo
- Familiarity
- Scarcity
- Commitment
- Confirmation bias
- Sunken cost bias

Instead of expecting to change reflexive behavior, let's try front-loading patterns of behavior:

## Personal Disaster Flags

1. Through self-assessment, identify our personal traps.

2. Share our traps with our partners and ask them to call us out.



# Takeaways

Decision-making tools can help us avoid consequential mistakes.

Before: Identify the consequences that matter.
During: Catch mental-shortcuts. Maybe. Default to routines.



# *Decisions*

*What is working? What is not?*

Which tools do you already use?

What cutoff criteria do you already in place?

Where can these tools be applied to your personal/professional outings?

# Communication

Putting it all together



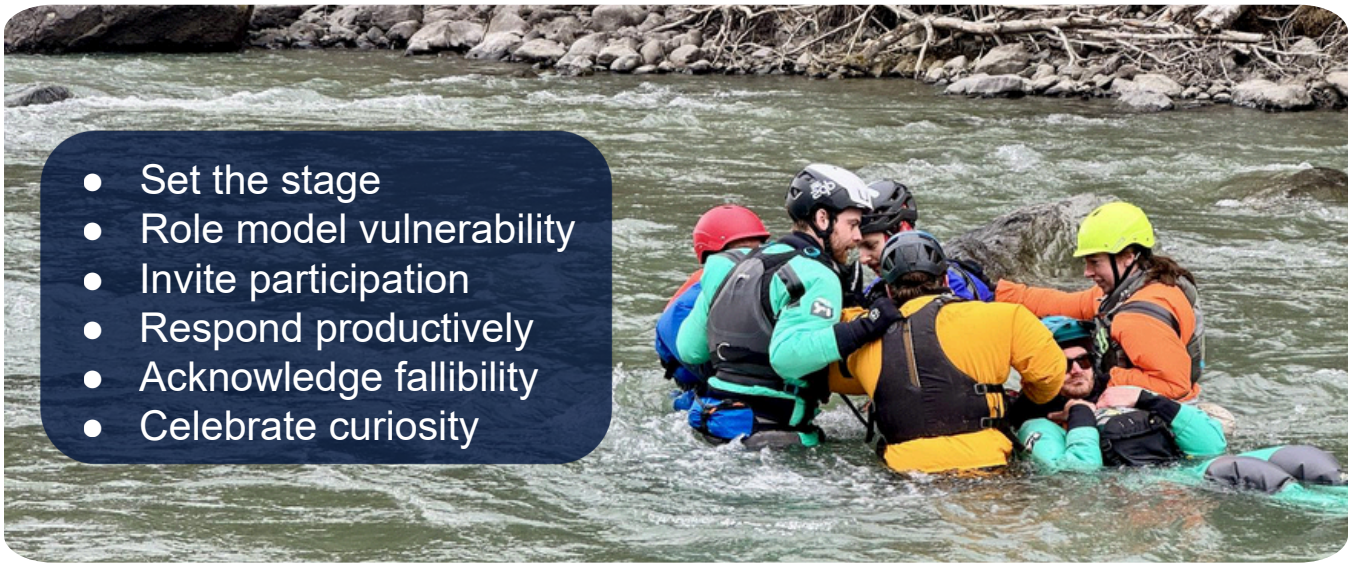
**Eagle River Drunk Fisherman.** I had my back to the river while instructing a group. A drunk fisherman in the rocks was yammering on and I was trying not to get distracted. Then I realized he was saying, “Hey, there’s wood coming down the river!”

I use this story to ask course participants to speak up when they have concerns.

# How do we get better at communication?

## Psychological Safety

Amy Edmondson, *The Fearless Organiization*




**Communication = our best risk management tool.**

1. Set the stage: Growth mindset, not just completing tasks.
2. Role model vulnerability
3. Invite participation
4. Respond productively: “We can blame or learn.”
5. Acknowledge fallibility: “We are going to make mistakes.”
6. Celebrate curiosity: Challenges and different perspectives are appreciated.

How I do this in my river courses:

- Real talk about risk: I can’t guarantee safety.
- Use the drunk fisherman story to signal that I need their help looking for hazards, speaking up.
- Pause and bring full group in for discussion when a concern is raised. This conveys that I appreciate the observation and take it seriously.
- Defer to the other instructors or offer to look something up when I don’t know the answer.
- Run the course as a series of experiments: “I don’t know, let’s try it!”

# Lessons From the Edge

1. **Risk management = Communication**
2. **E*xpect* mistakes. Focus on the consequences.**
3. **Recognize *nearly normal* and adjust the plan.**

**Feedback please!**

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