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ADAPTATION GUIDE FOR QUEBEC'S RECREATIONAL TRAILS TO CLIMATE CHANGE

Photo: Unspash – Dave Hoefler/AI

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TABLE OF CONTENTS

INTRODUCTION

As climate change intensifies, Quebec's recreational trail networks face unprecedented challenges. Erosion, flooding, and soil instability: outdoor infrastructure is bearing the full brunt of a changing climate. This guide is aimed at managers, planners, and volunteers who wish to anticipate these disruptions and adapt their practices to ensure the longevity and resilience of their trails.

TRAIL NETWORKS: A PILLAR OF QUEBEC'S RECREATIONAL TOURISM

Recreational trail networks now occupy a central place in Quebec's recreational tourism landscape. Over the past thirty years, numerous municipalities, organizations, and communities have invested in the development of outdoor infrastructure that serves simultaneously as a major tourist attraction, a regional economic driver, and an accessible leisure space for a diverse clientele. Whether for mountain biking, hiking, trail running, snowshoeing, or other non-motorized activities, Quebec now boasts several hundred recognized destinations known for the quality of their amenities and the vitality of their communities. This enthusiasm reflects a deeper trend: the search for outdoor experiences, closeness to nature, and active lifestyles.

Beyond their sporting or tourism appeal, trail networks generate considerable social and economic returns. They diversify leisure offerings, extend tourist seasons, support commercial vitality, and strengthen local identity. For many communities, trails represent a true lever for sustainable development, mobilizing volunteers, creating jobs, and attracting visitors and residents alike. By promoting access to nature, they also contribute to physical and mental health, stress reduction, and collective well-being. In a context of climate change, preserving and adapting these spaces becomes an essential issue of quality of life and territorial resilience.

INFRASTRUCTURE UNDER CLIMATE PRESSURE

These achievements now face growing pressures related to climate change. Quebec is already experiencing rising average temperatures, an increase in extreme precipitation events, and markeddisruptionstoseasonalcycles(freeze-thaw, spring snowmelt, summer droughts). These phenomena directly affect the durability of outdoor infrastructure: accelerated trail erosion, subsidence, damage to drainage structures, increased soil instability, lost access, and prolonged closures. These impacts translate into higher maintenance costs, safety issues, service interruptions, and fluctuations in visitation.

For a long time, trail design and management relied primarily on technical criteria based on historical conditions. Today, the context demands a more adaptive approach, integrating extreme climate events and future projections from the planning stage and throughout the lifecycle of infrastructure. This transition involves new practices: adapting design and routing, sizing structures to new hydrological standards, choosing more resilient materials, preventive maintenance, temporary closure protocols, and active communication with users. It also requires an evolution in governance models, team training, and collaboration among stakeholders

OBJECTIVES AND SCOPE OF THE GUIDE

It is in this context that this guide was developed. It aims to support managers, planners, volunteers, and outdoor partners in integrating the climate dimension into the planning, development, and operation of non-motorized trail networks. It presents a synthesis of relevant climate knowledge, an analysis of observed and anticipated effects on infrastructure and operations, and a set of concrete solutions promoting resilience. The objective is to provide practical tools to assess vulnerability, plan adaptation, and support sustainable network management.

INTRODUCTION

By situating trail management in the context of climate change, this guide seeks to preserve the quality of the user experience while ensuring the longevity of these infrastructures, true collective assets for Quebec's regions. Adaptation should not be seen as a constraint, but as an opportunity for innovation, collaboration, and recognition of the essential role that outdoor recreation plays in the transition toward more resilient and sustainable territories.

This document is intended as a best practices guide and not a collection of standards. It proposes avenues for adapting the planning, development, and management of recreational trails to climate change, without replacing existing regulatory frameworks.

The recommendations presented are based both on recent climate projections (future scenario models) and on field observations collected from managers and practitioners over recent years. They offer a framework for reflection and concrete examples, intended to evolve as science and practices advance.

Finally, the proposed measures must always be adapted to the specific context of each network: environmental characteristics, development objectives, clientele type, traffic levels, and available resources. The guide invites each manager to use it as inspiration for building their own adaptation approach, in line with their priorities and operational realities.

Understanding Climate Change

Photo: Unsplash – Kelly Sikkema

UNDERSTANDING CLIMATE CHANGE

Quebec's climate is rapidly evolving under the effects of climate change. Observations from recent decades confirm a clear warming trend, accompanied by changes in precipitation patterns, increased variability, and an intensification of extreme events. These transformations, already observable, are expected to intensify throughout the 21st century according to climate projections. For trail managers and mountain bike centres, understanding these parameters is an essential step toward adapting development, maintenance, and operations.

CLIMATE CHANGE MODELLING

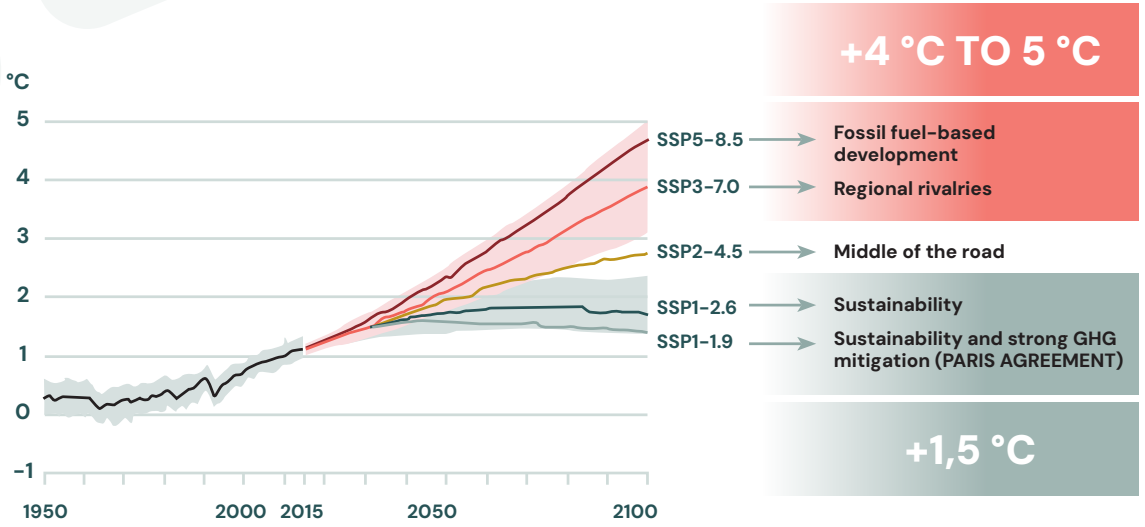
The data used in this guide come from Phase 6 of the Coupled Model Intercomparison Project (CMIP6), a large international initiative that informs the most recent IPCC assessments. This model is based on Shared Socioeconomic Pathways (SSP). These scenarios combine assumptions about the evolution of human societies (growth, urbanization, technologies, governance) and greenhouse gas emission levels. They serve to explore different climate futures based on global emissions reduction efforts.

In the context of this guide, projections are based on the SSP3-7.0 scenario, which describes a world characterized by:

- Persistent regional rivalries
- High population growth
- Limited cooperation on climate issues

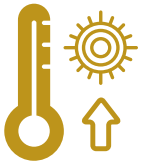
This scenario corresponds to a trajectory where emissions remain high, but without reaching extreme levels. It represents a plausible future if emissions reduction commitments remain insufficient.

GLOBAL SURFACE TEMPERATURE CHANGE RELATIVE TO THE 1850–1900 PERIOD



UNDERSTANDING CLIMATE CHANGE

CONCRETELY, THIS MODEL PREDICTS…



AVERAGE ANNUAL WARMING

+2 TO +4 °C BY 2050 compared to 1981–2010.

+4 TO +8 °C TOWARD END OF CENTURY according to the highest-emission scenarios.

VERY HOT DAYS (≥ 30 °C)

In southern Quebec, typically going from about a dozen days per year to MORE THAN 20 TO 25 DAYS AROUND 2050.

By 2100, several regions could see SEVERAL DOZEN DAYS ≥30°C PER YEAR.

HEAT WAVE

AROUND 8 HEAT WAVE DAYS PER YEAR are projected for a moderate scenario by 2100, UP TO 25 FOR A HIGH SCENARIO; extreme years could exceed 30 TO 50 DAYS.

GROWING SEASON VS FROST SEASON

GROWING SEASON EXTENDED ~20 DAYS by 2050; FROST SEASON RETREATING 20–34 DAYS in the south.

INCREASED PRECIPITATION

TOTAL PRECIPITATION UP ~10% by 2050, up to 20% by end of century, especially in winter and spring,

SHARP INCREASE IN THE FREQUENCY OF INTENSE RAINFALL (events that had a 5% annual probability could reach 10–14% around 2050).

SNOWFALL AND LENGTH OF WINTER

Continuous snow season SHORTENED 15–25 DAYS by mid-century; 40–50 FEWER DAYS BY 2100 in the south

WINTERS WITH LESS SNOW, MORE RAIN-ON-SNOW, with a peak accumulation shifting to shorter periods.

EXTREME COLD ON THE DECLINE

SIGNIFICANT DECLINE IN THE NUMBER OF DAYS WITH TEMPERATURES BELOW -25 °C: a projected median of about 22 days in 2050 and 12 days in 2100 under a moderate scenario, with even more pronounced decreases in the north.

SNOWFALL AND WINTER LENGTH

A DECREASE OF 15 TO 45 CM IN NATURAL SNOWFALL AND A REDUCTION OF 15 TO 25 DAYS OF CONTINUOUS SNOW COVER by 2050 in several regions, with direct impacts on winter activities.

UNDERSTANDING CLIMATE CHANGE

WHY ACT NOW

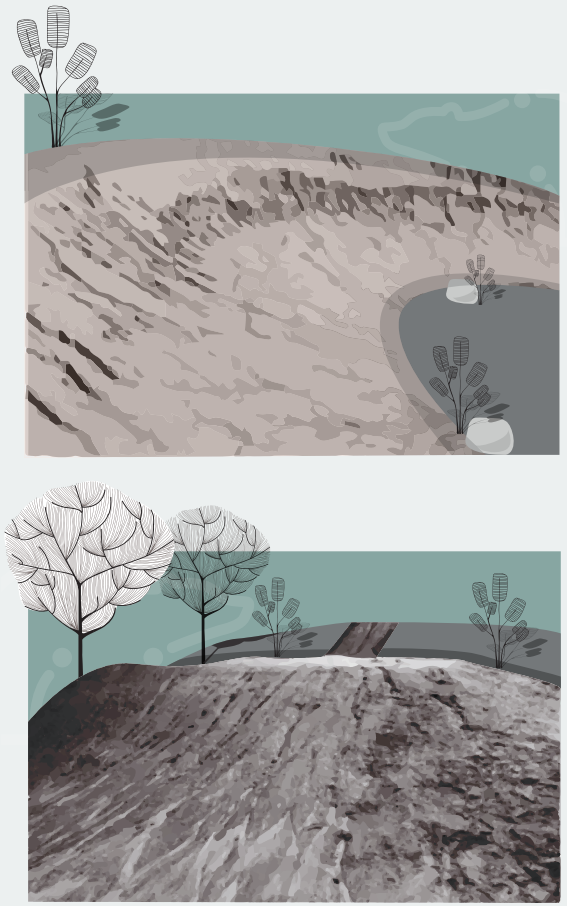
1. Cost of Inaction

- Extreme weather events are strongly increasing insured costs in Quebec: summer 2024 generated $7.1 billion in insured losses in Canada, mainly due to flooding in southern Quebec and Ontario, wildfires, and hail, a 406% increase in claims compared to the 20-year average.
- A pan-Canadian analysis shows that choosing not to adapt public infrastructure leads to estimated average annual climate costs of $15.1 billion by 2100, compared to $5.2 billion with proactive adaptation, nearly $10 billion in savings per year.
- An economic study on Lac Saint-Pierre quantifies losses of nearly $100 million/year in recreational benefits due to climate-induced water level decline, simply from reduced visits and leisure spending.

If we apply this to the context of trails, it is possible to assess the potential for lost day passes, additional repair work, and trail closures.

2. Impacts Already Observed in Quebec

- The Quebec government already documents a marked increase in the frequency and intensity of heat waves, droughts, torrential rains, and floods that are weakening roads, buildings, and recreational infrastructure.
- In 2023, heavy rains caused flooding, evacuations, and the complete closure of sections of national parks, including Parc national de la Jacques-Cartier and the Baie Éternité sector of Parc national du Fjord-du-Saguenay following rockfalls and landslides.
- Municipalities now preventively close their hiking trail networks during the spring thaw to avoid major erosion, explaining that unaddressed damage can take years to recover or become permanent.
- National summaries on outdoor trails already report additional costs related to heat waves, wildfire smoke, storms, and coastal erosion, which reduce opening periods and complicate maintenance.



Cracks caused by severe weather

UNDERSTANDING CLIMATE CHANGE

3. Benefits of Adaptation

- A study on the adaptation of public infrastructure shows that proactive resilience measures (sizing drainage structures, protection against heat and floods, etc.) reduce annual climate costs by approximately two-thirds compared to a scenario without adaptation.
- Economic analyses of Quebec's ski industry indicate that with adaptation measures (strategic artificial snowmaking, trail modifications, season management), resorts can maintain the minimum threshold of 100 skiable days despite a projected 10 to 20-day season shortening by 2050.
- Each dollar invested in trail resilience avoids closures, stabilizes revenues, and provides a competitive advantage.

Thus, every dollar invested in trail resilience prevents closures, stabilizes revenue, and provides a competitive advantage.

4. Legal and Insurance Dimensions

- The Quebec government notes that the increase in extreme events poses civil security and liability issues for public organizations managing exposed infrastructure.
- In Canada, legal analyses already recommend integrating climate risk into contracts and insurance policies, as insurers increase premiums or reduce coverage in the face of multiplying extreme events.
- In recreational trail matters, court decisions in other provinces have established municipal liability when known hazards on sections were not adequately corrected or signposted, even when periodic inspections were conducted.
- Failing to account for the new climate reality could ultimately be interpreted as a breach of a manager's duty of care.

Failing to take the new climate reality into account could, in the long run, be interpreted as a breach of a manager's duty of care.

HEALTH AND SAFETY IN A CLIMATE CONTEXT

Climate change directly modifies trail use conditions and poses new health and safety challenges. The increase in heat episodes, smoke, and extreme precipitation exposes users and staff more to physiological and operational risks.

Oppressive Heat Episodes

Oppressive heat episodes can cause a range of disorders: from heat exhaustion to heat stroke, a medical emergency characterized by a very high body temperature, altered consciousness, and which can lead to death without rapid intervention. Studies already show an increase in heat-related health problems among workers in Quebec and project a significant increase in cases by 2050 if no adaptation measures are implemented. For trail networks, this means adapting opening hours, providing shade and water stations, and adjusting the intensity of guided activities during heat waves.

Air Quality

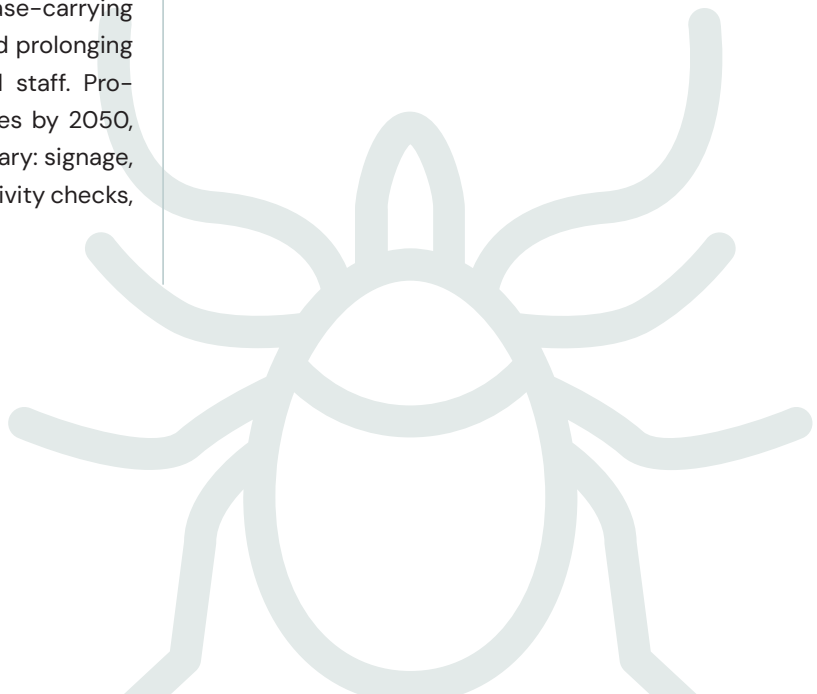
Air quality is also a growing concern. Episodes of wildfire smoke have already led to the cancellation of major sporting events and the closure of outdoor facilities in Quebec, due to air quality indices reaching high health risk levels. Vulnerable people (children, seniors, those with respiratory or cardiac conditions) are particularly at risk, requiring trail managers to integrate air quality forecasts into their opening decisions and public communications.

Vector-borne Diseases

Vector-borne diseases are also gaining ground. Warming and a longer frost-free season are favouring the expansion of Lyme disease-carrying ticks into new regions of Quebec and prolonging the exposure period for users and staff. Projections indicate an increase in cases by 2050, making prevention measures necessary: signage, information on clothing and post-activity checks, protocols in case of tick bites.

First Aid Protocols

In this context, first aid protocols must be adapted to new climate risks. Field teams must be trained to quickly recognize signs of heat stress, heat stroke, respiratory distress from smoke or pollutants, as well as symptoms of tick-borne infections. Continuous staff training, access to appropriate equipment (water, cooling means, protective gear, updated first aid kits), and the integration of these issues into safety plans become essential elements of responsible trail management in a changing climate.



The Impact af Climate on Trails and Trail Network Management

Photo: Unsplash – Matt Palmer

THE IMPACT OF CLIMATE ON TRAILS AND TRAIL NETWORK MANAGEMENT
ON THE TRAILS

THE TRAILS

Outdoor trails, whether for mountain biking, hiking, or other non-motorized activities, are directly exposed to climate hazards. Their performance and durability depend largely on the capacity of designers and managers to anticipate and mitigate the effects of weather conditions. These impacts manifest in several forms:

- INTENSE PRECIPITATION AND EROSION
  Heavy rain generates significant runoff on slopes, causing ruts, erosion of the running surface, and sometimes complete gullying of a section. Poorly positioned or undersized drainage devices worsen this damage.
- FREEZE-THAW CYCLES
  Frequent alternations of freezing and thawing weaken soil structure. Water that infiltrates expands when freezing, causing cracks and heaving, then infiltrates further upon thawing. These cycles accelerate deterioration and require repeated repairs.
- DROUGHTS AND PROLONGED HEAT
  Hot, dry periods dry out fine soils, making them friable and vulnerable to wind or mechanical erosion. They also increase dust production, degrading user experience quality and promoting premature wear.
- STRONG WINDS AND BLOWDOWNS
  Storms cause trees and branches to fall, blocking trails, damaging light infrastructure (footbridges, signage), and creating hazards for users and maintenance staff.
- WINTER CONDITIONS AND SPRING THAW
  Winter thaws and rain-on-snow produce excess water that saturates soils, weakens structures, and promotes rutting and mud in spring.

These combined phenomena lead to faster trail wear, increased maintenance costs, and a reduced optimal period of use. Without adapting design, construction, and maintenance practices, the very durability of trail networks is at risk.

Together, these factors lead to faster trail deterioration, higher maintenance costs, and a shorter optimal period of use. Unless design, construction, and maintenance practices are adapted, the very sustainability of trail networks is at risk.

THE IMPACT OF CLIMATE ON TRAILS AND TRAIL NETWORK MANAGEMENT
ON THE MANAGEMENT OF TRAIL NETWORKS

MANAGEMENT OF TRAIL NETWORKS

Climate change influences both the physical structure of trails and the management of centres and user experiences. These effects manifest in several ways:

- USER AND STAFF SAFETY
  Heat waves increase the risk of heat stroke and dehydration, while windstorms cause tree falls and dangerous obstacles. Heavy rain makes surfaces slippery, increasing fall and accident risks.
- SEASON AND SCHEDULE MANAGEMENT
  Increased climate variability complicates operational planning. Centres must frequently adjust opening and closing periods according to field andweather conditions.
- VISITATION AND REVENU
  Attendance depends heavily on weather. A single rainy day can reduce visitation, while heat waves shift activities toward morning or evening, influencing logistics, catering, and ticketing.
- MAINTENANCE COSTS AND RESOURCES
  Erosion, gullying, or damage to drainage structures require repeated repairs. This leads to increased needs for labour, materials, and funding, which weighs on the already limited budgets of many organizations.
- SOCIAL ACCEPTABILITY AND COMMUNICATION
  Temporary closures, essential for trail protection, can generate dissatisfaction if poorly understood. Transparent and proactive communication is therefore essential to explain the reasons for adaptation measures and maintain public trust.

TRAIL NETWORK MANAGERS THUS FIND THEMSELVES AT THE CROSSROADS OF TWO REALITIES:

Adapting infrastructure to make it more resilient, and adjusting strategic management to ensure safety, quality, and durability of the outdoor experience. Understanding these interactions is the first step toward truly sustainable solutions.

Climate Hazards

Photo : Unsplash – Matt Palmer

Temperature

HIGHLIGHTS

One hazard, a cascade of problems: TRAILS, TREES, AND WINTER CONDITIONS ARE ALL AFFECTED.

Heat waves now necessitate PREVENTIVE CLOSURES, a new reality we can't ignore.

TEMPERATURE

Temperature-related changes are profoundly altering the dynamics of non-motorized recreational trails and the management of the networks that maintain them. Whether they are hiking, cross-country skiing, snowshoeing, mountain biking, or trail running trails, all are subject to increasing pressures linked to rising average temperatures, more frequent heat waves, prolonged droughts, and an increase in freeze-thaw cycles.

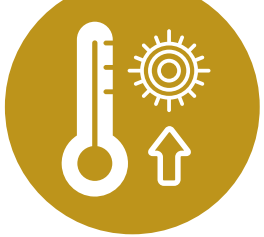
Heat accelerates soil drying, weakens the cohesion of walking and riding surfaces, and increases dust production, affecting both the durability of infrastructure and the quality of the user experience. Prolonged droughts increase the risk of forest fires and accelerate the mortality of trees infested with pathogens, increasing the risk of windthrow across the entire network. Winter thaws disrupt freeze-thaw cycles, destabilize soil structures, and compromise the passability of winter trails, to the detriment of activities such as cross-country skiing and snowshoeing.

For managers, these temperature fluctuations complicate operational planning, extend maintenance periods, increase risks for users and staff, and significantly alter visitor patterns. Heat acts as a multiplier of challenges: it intensifies the strain on teams, influences visitors' perception of safety, and changes expectations regarding the services provided. In this context, heat management becomes an essential component of the daily operation of any recreational trail network.

Climate change increasingly threatens the accessibility, safety, and sustainability of trails. Frequent users of Canadian trails were among the first to notice these changes. A recent survey of guides in the Canadian Rockies revealed that nearly all have observed environmental changes in their operating areas over the course of their careers, including warmer summers and winters, increased winter precipitation, and greater variability in snow cover.

— Lichimo, C. (2025). Outdoor Recreational Trails and Climate Change. ClimateData.ca

Climate Hazards



HEAT

EFFECTS ON TRAILS

Drying of soils and loss of cohesion of walking and running surfaces

Excessive dust formation on dirt trails, diminishing experience quality

Weakening of trail surfaces and appearance of friable and unstable areas

Accelerated degradation of materials exposed to sunlight (wood, structures, signage, bridges)

Thermal discomfort reducing visitation during the hottest hours

EFFECTS ON NETWORK MANAGEMENT AND USERS

Increased risk of dehydration, exhaustion, and heat stroke among users and staff

Shift in visitation to cooler hours (early morning, evening)

Increased pressure on water points, shaded areas, and rest areas along routes

Necessary adaptation of guided activity schedules and programming

Increased need for first aid related to heat stress

DROUGHTS

EFFECTS ON TRAILS

Cracking of silty and clay soils, weakening trail surfaces

Reduction of stabilizing vegetation along trail edges

Increased erosion when rains return on bare soils

Weakening of surrounding forests, increasing blowdown risk

Increased fire risk affecting wooded sections

Drying of wetlands and natural water points frequented by users

EFFECTS ON NETWORK MANAGEMENT AND USERS

Increased dust around welcome buildings, terraces, waiting areas, and parking lots

Decreased user comfort and increased complaints

Pressure on drinking water reserves at sites not connected to the municipal network

Increased fire risks around facilities and wooded corridors

Possible restrictions on certain outdoor activities or services

Photo: Unsplash – Joe Chen

WINTER THAWS AND FREEZE-THAW CYCLES

EFFECTS ON TRAILS

Uplifts and subsidence of the trail surface making it difficult to proceed

Uneven movement of rocks and soil during the thaw, creating unexpected obstacles

Formation of cracks and irregular deformations on stabilized surfacesIncreased instability of slopes and retaining structures

Accelerated deterioration in the spring, a critical period for maintenance

Unpredictable alternation between load-bearing snow and heavy snow, affecting winter passability

Shortening or interruption of cross-country skiing and snowshoeing seasons in southern regions

EFFECTS ON NETWORK MANAGEMENT AND USERS

Icy surfaces around buildings, parking lots, and departure areas, increasing the risk of falls

Frequent closures or adjustments to winter activities, affecting revenue and planning

Increased workload for de-icing, sanding, and safety inspections

Changing conditions complicating staff scheduling and operational planning

Difficulty maintaining adequate snow conditions for cross-country skiing and snowshoeing

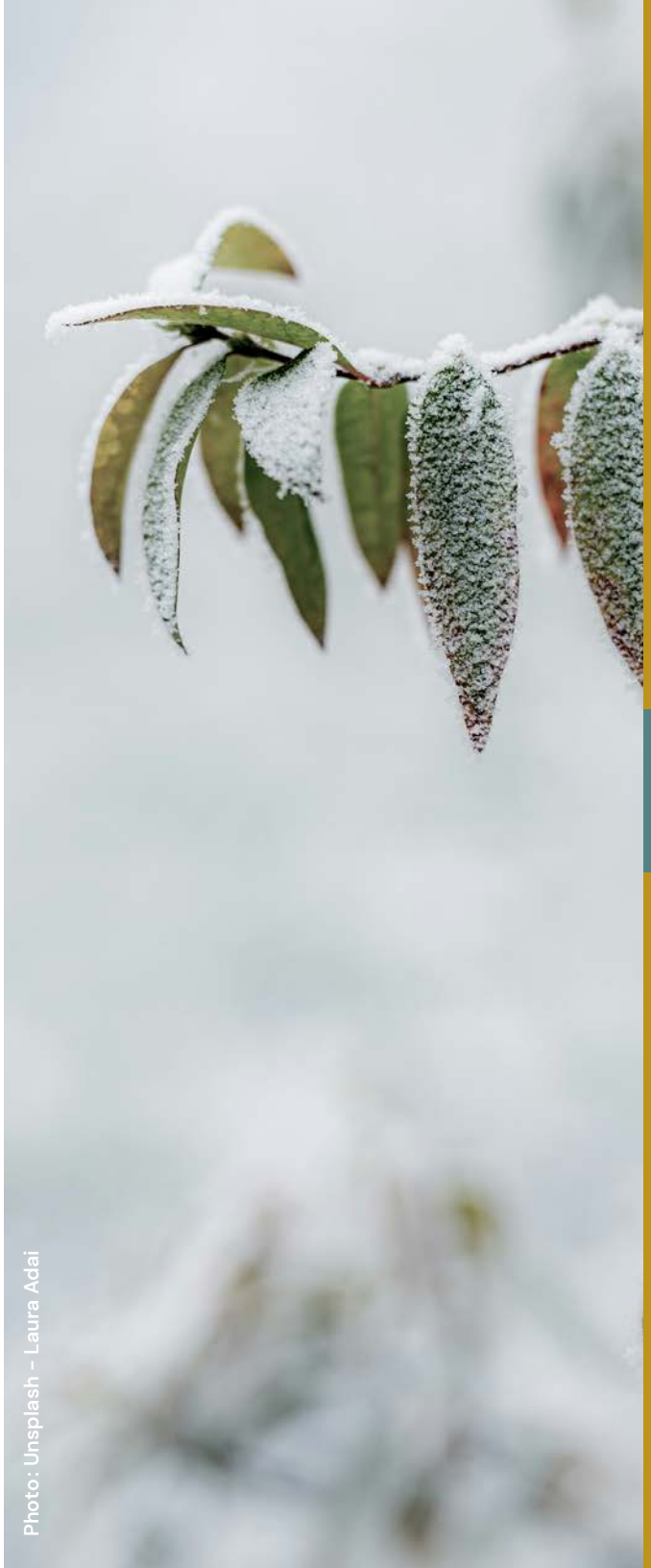


Photo: Unsplash - Laura Adai

INSECTS AND DISEASES

EFFECTS ON TRAILS

Increased tree mortality along trails due to infestations (bark beetles, emerald ash borers, fungi)

Multiplication of blowdowns obstructing trails and creating dangers for users

Woody debris encumbering and damaging trail surfaces and structures

Changes in forest landscapes along networks, affecting route appeal

EFFECTS ON NETWORK MANAGEMENT AND USERS

Expansion of tick distribution and increased health risks for users and employees

Increased need for awareness, signage, and staff training on vector risks

Management of public concerns and increased information requests about health risks

Decreased air quality under dense forest canopy during decomposition periods

Tree mortality increasing blowdown risks near welcome infrastructure

Photo: Unsplash - Erik Karits

WILDFIRES AND AIR QUALITY

EFFECTS ON TRAILS

Destruction of protective vegetation along and on trails

Increased exposure of bare soils to erosion after fires

Aesthetic and ecological degradation of routes crossing burned areas

Extended closures of sections or entire networks during and after fires

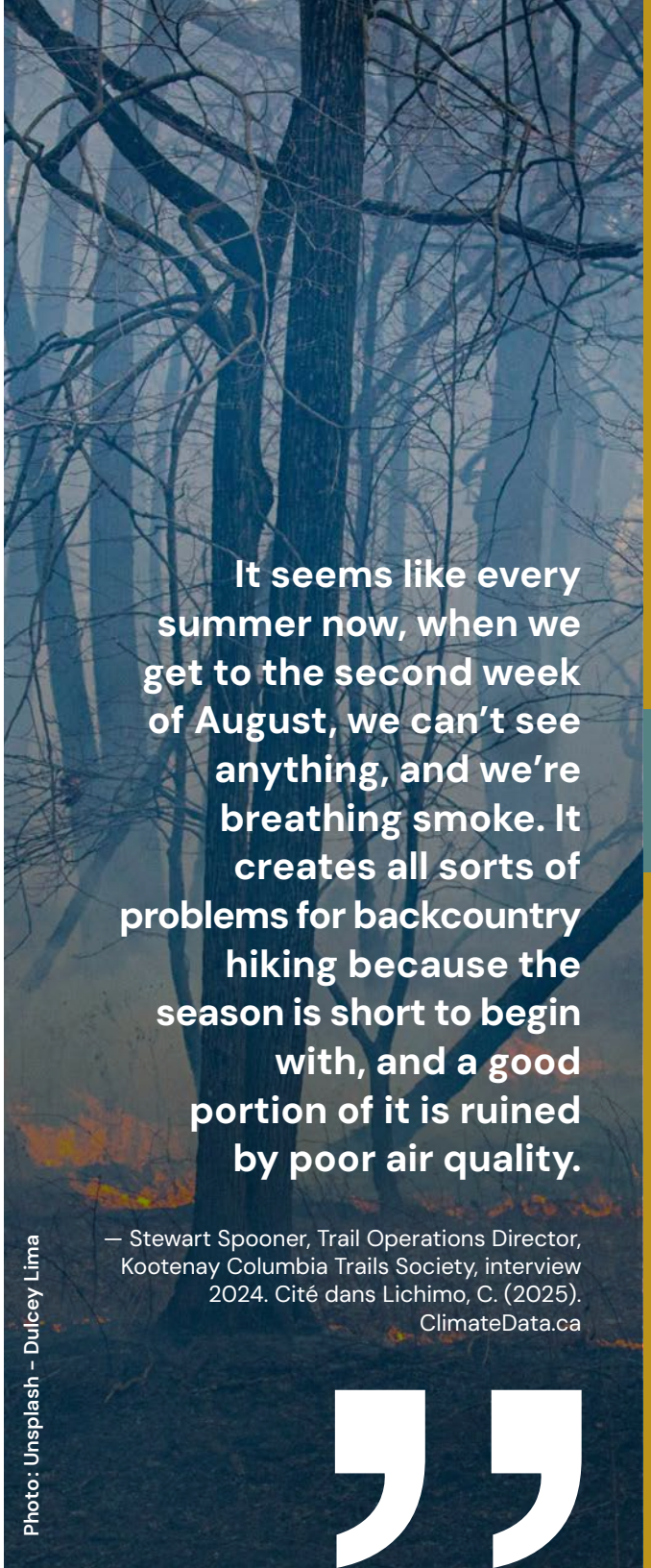
EFFECTS ON NETWORK MANAGEMENT AND USERS

Temporary closures or access restrictions during intense smoke episodes

Respiratory risks for users, particularly vulnerable individuals

Need to monitor the Air Quality Index (AQI) and communicate conditions in real time

Lasting impacts on the attractiveness of networks in affected areas



It seems like every summer now, when we get to the second week of August, we can't see anything, and we're breathing smoke. It creates all sorts of problems for backcountry hiking because the season is short to begin with, and a good portion of it is ruined by poor air quality.

— Stewart Spooner, Trail Operations Director, Kootenay Columbia Trails Society, interview 2024. Cité dans Lichimo, C. (2025). ClimateData.ca

Photo: Unsplash - Dulcey Lima

ADAPTATION MEASURES

DESIGN AND PLANNING

MEASURES TO BE IMPLEMENTED FOR TRAILS

Favour sub-forest and north-facing routes to limit direct sun exposure

Integrate heat-resistant and pathogen-resistant tree species in edge plantings

Plan preventive selective cutting around trails to eliminate trees at risk of infestation

Widen lateral clearance to reduce blowdown blockage risk

Create shaded rest areas along routes, particularly on exposed sections

MEASURES TO BE IMPLEMENTED BY RECREATIONAL TRAIL NETWORK MANAGERS

Install shade structures at start, rest, catering, and waiting areas

Create drinking water stations at key network points (welcome area, mid-trail, parking)

Provide air-conditioned or well-ventilated spaces in welcome buildings during heat waves

Design parking areas with permeable surfaces and shaded areas to reduce heat islands

Assess and remove at-risk trees near buildings, parking areas, and gathering areas

MAINTENANCE AND OPERATIONS

MEASURES TO BE IMPLEMENTED FOR TRAILS

Inspect trees along trails after prolonged periods of drought and before each season

Promptly remove wood debris following windthrow events caused by insects, storms, or wind

Stabilize dried-out sections with wood chips, fine gravel, or aggregate to limit dust and erosion

Monitor areas at risk of fire and remove combustible materials near trails

Prioritize treating or removing infested trees identified during health surveys

Adjust the winter maintenance schedule based on freeze-thaw conditions to protect fragile surfaces

MEASURES TO BE IMPLEMENTED BY RECREATIONAL TRAIL NETWORK MANAGER

Adjust opening hours and event schedules to avoid the hottest times of day during heat waves

Monitor the air quality index (AQI) and adjust operations during periods of smoke

Schedule physical tasks for staff (maintenance, inspections) for the cooler times of day

Regularly water dusty areas (entrances, parking lots, patios) during prolonged droughts

Photo: Unsplash - Heber Davis

RISK MANAGEMENT AND SAFETY

MEASURES TO BE IMPLEMENTED FOR TRAILS

Establish preventive closure protocols during extreme heat waves (humidex > 40°C)

Define temperature and fire risk index thresholds triggering network access restrictions

Map at-risk stands (vulnerable species, high mortality rates) to target priority removals

Signpost exposed, unsheltered sections to inform users of heat risks

MEASURES TO BE IMPLEMENTED BY RECREATIONAL TRAIL NETWORK MANAGER

Establish a heat protocol with trigger thresholds (e.g., humidex > 38°C) to adapt operations

Train staff to recognize signs of heat stroke and administer first aid for hyperthermia

Place thermal stress first aid kits at strategic network points

Implement access controls during intense smoke episodes (AQI > 100) for vulnerable users

Train teams on tick prevention (post-activity inspection, signage, appropriate clothing)

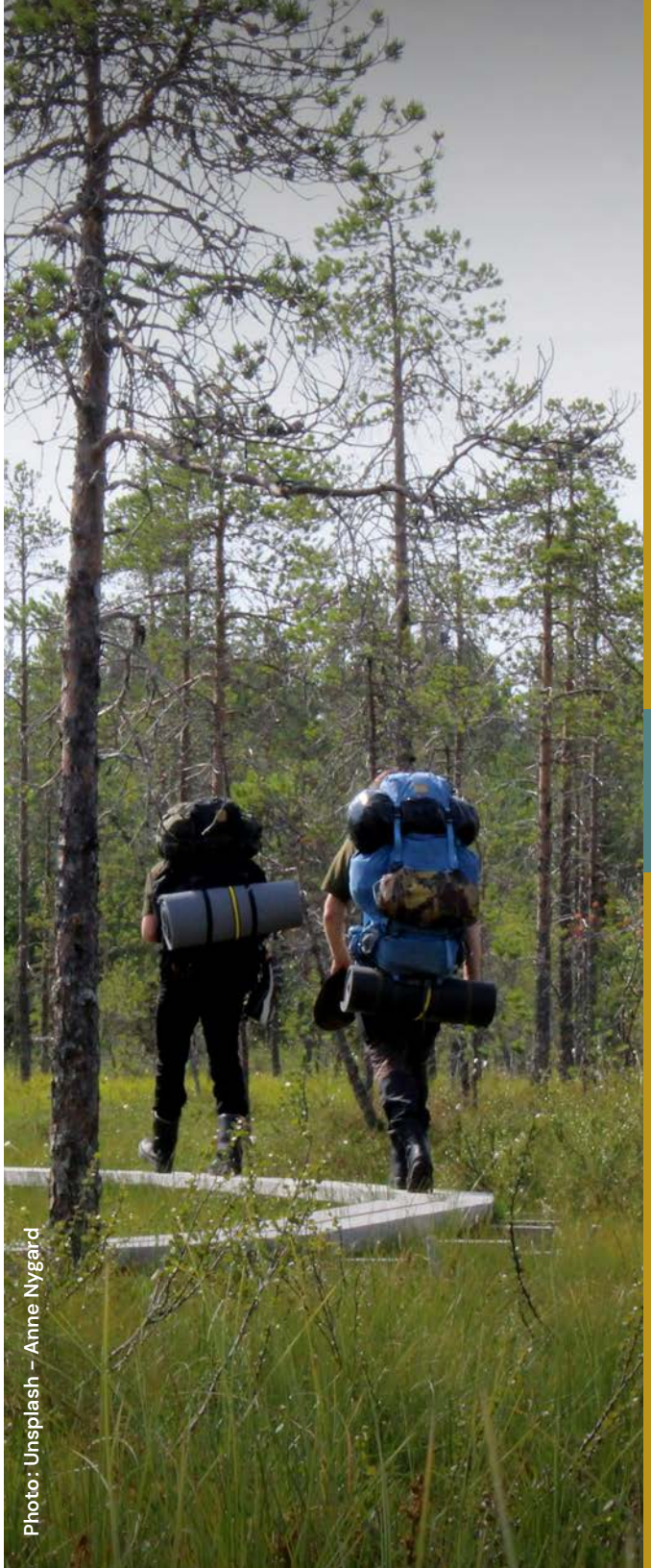


Photo: Unsplash - Anne Nygard

GOVERNANCE AND COMMUNICATION

MEASURES TO BE IMPLEMENTED FOR TRAILS

Document heat, blowdown, and fire episodes to feed adaptive network management

Inform users of closures and risks via social media, app, and website in real time

Train staff on identifying infested or at-risk trees (bark beetles, fungi, abnormal tilt)

Collaborate with foresters and entomologists to develop stand health management plans

MEASURES TO BE IMPLEMENTED BY RECREATIONAL TRAIL NETWORK MANAGER

Proactively communicate conditions and heat-related closures on all available platforms

Integrate a heat management plan into the organization's health and safety policy

Document the impacts of heat waves on visitation and revenue to guide financial planning

Raise user awareness of heat risks (hydration, sun protection, recommended schedules) before departure

Photo: Unsplash - Bernd Dittrich

Precipitations

HIGHLIGHTS

Heavy rains: MAJOR DAMAGE in just a few hours, IMMEDIATE LOSS OF REVENUE.

SPRING has become the MOST CRITICAL TIME for trail integrity.

PRECIPITATIONS

Precipitation is one of the most determining factors for the performance, durability, and usability of non-motorized recreational trails. Heavy rain, snow, freezing rain, and spring snowmelt put significant pressure on trail surfaces, drainage structures, vegetation, and welcome infrastructure. These hazards affect all types of trails: hiking and running trails are particularly vulnerable to erosion and ruts, mountain bike trails to hydraulic overloads and subsidence, and cross-country skiing and snowshoeing trails to snow cover variations and winter rain episodes.

For recreational trail network managers, precipitation introduces significant variability in daily planning. It affects not only the trails, but also access, welcome areas, parking, internal logistics, and user communication. The multiplication of extreme episodes requires clear protocols, rapid adaptation capacity, and an organizational culture oriented toward resilience.

Extreme rains and summer thunderstorms fuelled by violent deep convection above mountain areas will increase the risk of damage to trails themselves. Intensification of the water cycle leads to more erosion, which requires increased trail maintenance and the funds needed to carry out this work.

— Pacific Crest Trail Association (2022). A Changing PCT: Climate Change is Already Altering the Trail Experience. PCTA.org

EFFECTS OF PRECIPITATION

SHORT-DURATION INTENSE RAINFALL (less than a day)

EFFECTS ON TRAILS

Concentrated runoff on slopes, accelerating trail surface erosion

Formation of deep ruts within hours on dirt trails

Gullying of steep surfaces, particularly on bike and hiking trails

Local flooding cutting sections in low-lying or hydromorphic zones

Overflow of undersized culverts and drainage structures

Erosion of edges, ditches, and embankments weakening trail structure

EFFECTS ON NETWORK MANAGEMENT AND USERS

Rapid trail closures causing unforeseen operational reorganizations

Immediate drop in visitation, followed by peaks at reopenings

Increased sliding and accident risks in welcome areas and parking lots

Pressure on teams for post-event inspections before reopening

Adaptation of services and guided activities based on network conditions

Extended trail closures due to impassability and user risk

LONG-DURATION INTENSE RAINFALL (several days)

EFFECTS ON TRAILS

Progressive soil saturation reducing load-bearing capacity

Loss of bearing capacity and subsidence on fine or organic soil sections

Embankment slides in unstable or steep-slope areas

Prolonged flooding isolating certain network sections

Extended trail closures requiring major rehabilitation work

EFFECTS ON NETWORK MANAGEMENT AND USERS

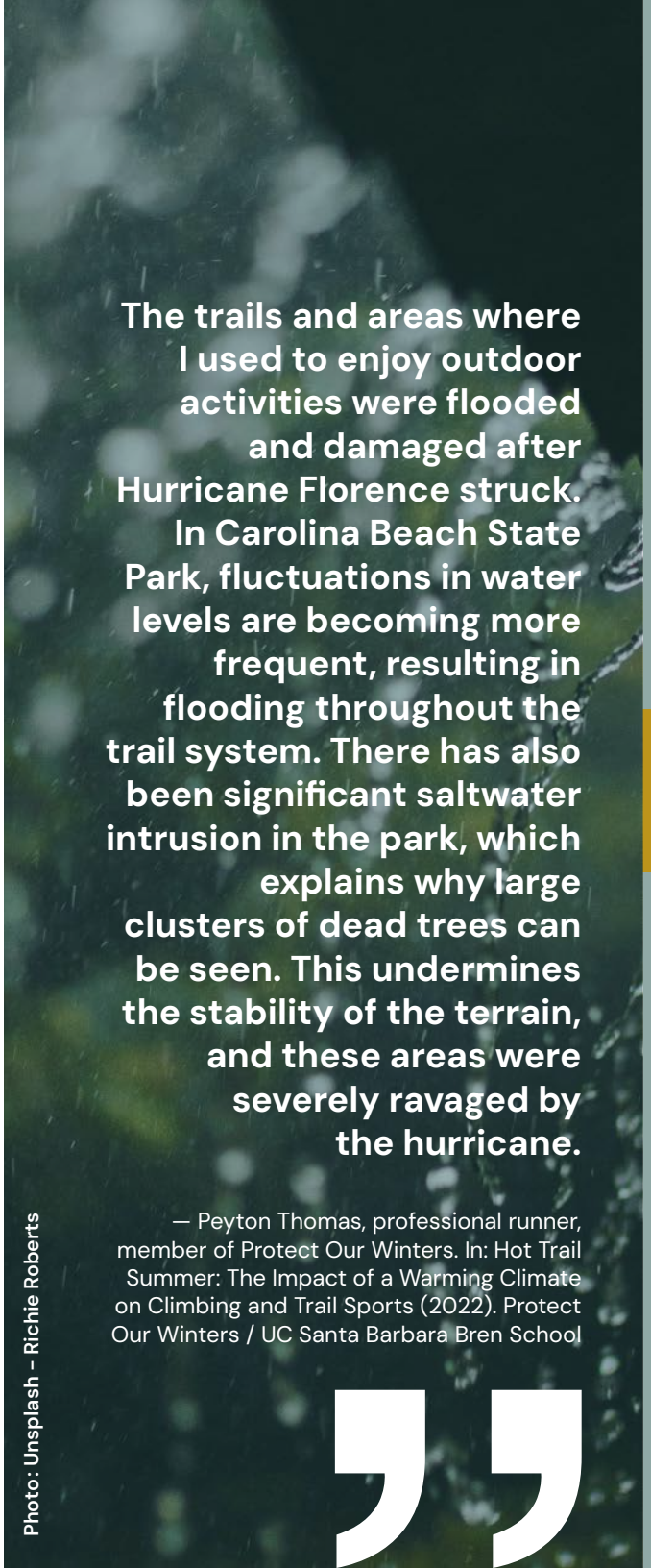
Extended closures significantly reducing revenue and visitation

Reduced visitation even in covered welcome areas

Saturation of parking areas and access roads making access difficult

Increased maintenance and water management costs around buildings

Need for increased and proactive communication to manage user expectations



The trails and areas where I used to enjoy outdoor activities were flooded and damaged after Hurricane Florence struck. In Carolina Beach State Park, fluctuations in water levels are becoming more frequent, resulting in flooding throughout the trail system. There has also been significant saltwater intrusion in the park, which explains why large clusters of dead trees can be seen. This undermines the stability of the terrain, and these areas were severely ravaged by the hurricane.

— Peyton Thomas, professional runner, member of Protect Our Winters. In: Hot Trail Summer: The Impact of a Warming Climate on Climbing and Trail Sports (2022). Protect Our Winters / UC Santa Barbara Bren School

Photo: Unsplash - Richie Roberts

PRECIPITATIONS

SNOW

EFFECTS ON TRAILS

Reduced accumulations in the south, shortening cross-country skiing and snowshoeing seasons

Rapid melt combined with rain causing accelerated spring runoff and erosion

Increased loads on structures (bridges, footbridges, culverts, shelters) in snowier regions

Growing unpredictability of winter usability windows for all activities

EFFECTS ON NETWORK MANAGEMENT AND USERS

Reduction of the winter season in southern regions, affecting activities and revenue

Increased loads on roofs and light structures of welcome buildings in snowier regions

Growing difficulty in planning and marketing winter activities over stable windows

Photo : Unsplash - Annie Spratt

FREEZING RAIN

EFFECTS ON TRAILS

Broken branches and fallen trees causing widespread windthrow across the entire network

Trails blocked by heavy and dangerous wood debris

Surfaces made extremely slippery and dangerous for all types of users

Increase in accidents and the risk of serious injury on unmarked or unclosed trails

Potential damage to lightweight structures under the weight of accumulated ice

EFFECTS ON NETWORK MANAGEMENT AND USERS

High risks to users and staff in pedestrian areas and access points

Temporary closures of all outdoor facilities for safety reasons

Falling trees or branches near buildings and parking lots, increasing the risk of damage

Power outages affecting essential services (reception, communications, lighting)

Photo: Unsplash - Sabrina Loftus

ADAPTATION MEASURES

DESIGN AND PLANNING

MEASURES TO BE IMPLEMENTED FOR TRAILS

Design culverts and drainage structures based on IDF curves adjusted for climate change

Increase the number of lateral outfalls to prevent runoff from concentrating on slopes

Avoid or raise sections in hydromorphic areas and at the bottom of slopes at risk of flooding

Reinforce bridge and footbridge structures to withstand more frequent flooding and snow loads

Establish riparian vegetation buffer zones to stabilize riverbanks along watercourses

Prioritize permeable and erosion-resistant surface materials on exposed sections

MEASURES TO BE IMPLEMENTED BY RECREATIONAL TRAIL NETWORK MANAGER

Provide covered areas at reception, ticket, and waiting zones to maintain services during inclement weather

Improve drainage in parking lots and access areas to prevent water accumulation and rutting

Install non-slip surfaces on outdoor pedestrian walkways exposed to rain and ice

Secure lightweight structures (tents, patios, shelters) against snow loads and wet winds

MAINTENANCE AND OPERATIONS

MEASURES TO BE IMPLEMENTED FOR TRAILS

Clean and clear culverts, ditches, and drains before the rainy season and after each heavy rainfall event.

Inspect vulnerable sections within 24 hours of any heavy rainfall event.

Temporarily stabilize eroded areas with geotextile or fascines pending rehabilitation

Increase monitoring in the spring during snowmelt combined with rain

Regularly maintain drainage structures to prevent them from becoming clogged

MEASURES TO BE IMPLEMENTED BY RECREATIONAL TRAIL NETWORK MANAGER

Implement a protocol for quickly closing trails once rainfall thresholds are exceeded

Reorganize internal operations on closure days to maintain services and revenue

Plan alternative activities for inclement weather to keep visitors on-site

Inspect access roads and buildings after every significant episode of rain, snow, or ice

Manage salt and abrasives responsibly in winter to limit impacts on soil and vegetation

Photo: Unsplash - Joerg Alves

RISK MANAGEMENT AND SAFETY

MEASURES TO BE IMPLEMENTED FOR TRAILS

Close trails when precipitation thresholds are exceeded (e.g., >25 mm in 1 hour)

Establish objective reopening criteria (no saturation, no deep ruts, complete inspection)

Map at-risk sections (steep slopes, fine soils, wetlands) to guide priority inspections

Keep emergency repair materials (granulars, geotextile) in strategic caches on the network

Clearly signpost dangerous areas during extreme events

MEASURES TO BE IMPLEMENTED BY RECREATIONAL TRAIL NETWORK MANAGER

Establish clear and documented trail closure and reopening criteria

Signpost slippery surfaces and at-risk areas in outdoor pedestrian spaces in icy conditions

Have sufficient de-icing materials on hand before the winter season

Manage visitation at post-rain reopenings to avoid overuse of still-fragile trails

Photo: Unsplash - Athithan Vignakaran

GOVERNANCE AND COMMUNICATION

MEASURES TO BE IMPLEMENTED FOR TRAILS

Keep a record of closures and reopenings with associated precipitation conditions to calibrate thresholds

Broadcast trail conditions in real time on all platforms (app, website, social media)

Integrate intense precipitation projections into long-term network rehabilitation plans

Collaborate with hydrology services to share runoff data and climate projections

Train staff in rapid post-precipitation damage assessment and closure protocol activation

MEASURES TO BE IMPLEMENTED BY RECREATIONAL TRAIL NETWORK MANAGER

Disseminate trail conditions and closure decisions transparently and proactively

Document precipitation impacts on visitation and revenue to adjust financial planning

Train staff in closure, inspection, and communication protocols for extreme events

Adapt refund policies during unforeseen closures to maintain user trust

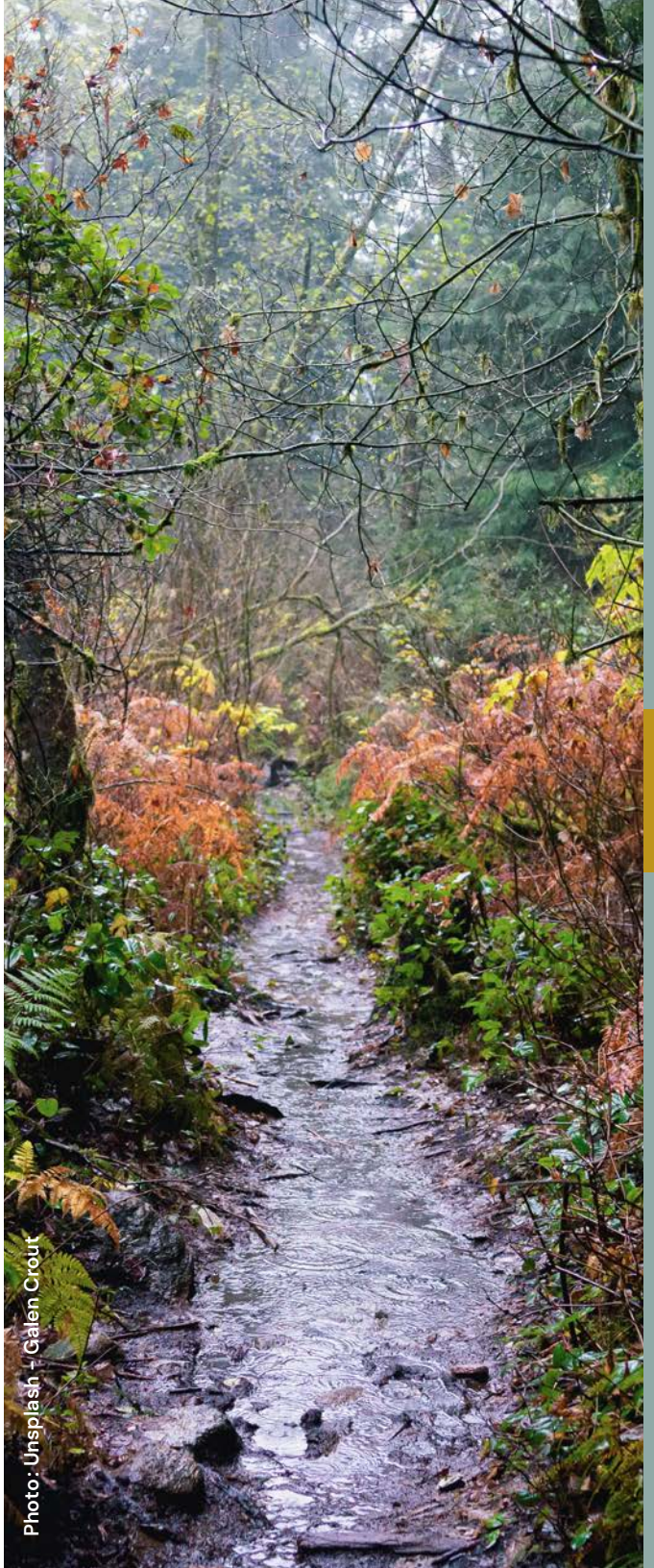


Photo: Unsplash - Galen Crout

Winds and Storms

HIGHLIGHTS

Entire corridors can become blocked in a matter of minutes. WITHOUT AN EMERGENCY PROTOCOL, THE ORGANIZATION IS OVERWHELMED.

THE WIND SILENTLY WEAKENS THE FOREST: inventories of at-risk trees are no longer optional.

WINDS AND STORMS

Strong winds and extreme storms pose both a sudden and a structural threat to the entire network of non-motorized recreational trails. Unlike other weather hazards that develop gradually, extreme winds can cause considerable damage in a matter of hours, blocking entire corridors, damaging infrastructure, and endangering users on the network, whether they are hiking, mountain biking, cross-country skiing, or trail running.

Wind has a cumulative effect on the health of forest stands bordering trails, gradually weakening trees and increasing the risk of them falling. During extreme events, massive windthrow can block entire sections within minutes, requiring rapid and costly interventions. Storms often combine wind, rain, and freezing rain, amplifying the damage and complicating maintenance teams' response efforts.

For recreational trail network managers, these events require a high degree of responsiveness, well-established emergency protocols, and an internal organization capable of rapidly mobilizing teams. Communication with users, on-site safety management, and the ability to resume operations as quickly as possible are major challenges in a context where these events are becoming more frequent and intense.

Many trails are found in riparian and coastal corridors, in forests or on slopes, making them vulnerable to flooding, fires, erosion, and landslides. Climate change has obvious repercussions on weather patterns and landscapes, causing flooding, extreme heat, droughts, and wildfires. These phenomena are expected to intensify over time, calling for mitigation and adaptation measures at all scales and for all types of infrastructure.

— Rails-to-Trails Conservancy (2023).
Trails and Climate Resilience. RailstoTrails.org.

EFFECTS OF WINDS AND STORMS

SUSTAINED WINDS

EFFECTS ON TRAILS

Progressive weakening of the forest canopy bordering the trails

Increase in the number of trees at risk of falling on or near trail corridors

Increased exposure of sections located on ridges, at forest edges, and in natural wind corridors

Cumulative mechanical stress on lightweight structures (footbridges, shelters, signage)

Accelerated wind erosion on bare, exposed sections

EFFECTS ON NETWORK MANAGEMENT AND USERS

A gradual increase in the number of hazardous trees near visitor facilities

Mechanical stress on lightweight structures (tents, decks, signage)

Increased risks for staff working in forests or at exposed sites

Cumulative mechanical stress on light structures (footbridges, shelters, signage)

EXTREME WINDS AND STORMS

EFFECTS ON TRAILS

Massive blowdowns obstructing trails and making progression impossible and dangerous

Damage to or destruction of light structures (trail footbridges, trail shelters, signage)

Rapid blockage of sections and isolation of certain network areas

Combined impacts with rain and ice, accentuating damage to surfaces and structures

High costs and significant delays for restoration after major events

EFFECTS ON NETWORK MANAGEMENT AND USERS

Immediate closures and rapid evacuations for safety reasons

Blowdowns near buildings, parking areas, and gathering zones increasing user risks

Damage to light welcome infrastructure (shelters, terraces, directional signage)

Power outages disrupting essential services (reception, communication, lighting)

Need for emergency interventions and thorough inspections before any reopening

Forest fires, erosion, extreme heat, rising sea levels, and tree die-off are all climate change-related impacts that are affecting our trail networks. As global temperatures continue to rise, these five factors pose an increasing threat to deprive trail enthusiasts of the places they love.

— Protect Our Winters / UC Santa Barbara Bren School (2022). Hot Trail Summer: The Impact of a Warming Climate on Climbing and Trail Sports

Photo: Unsplash - Richie Roberts

ADAPTATION MEASURES

DESIGN AND PLANNING

MEASURES TO BE IMPLEMENTED FOR TRAILS

Avoid routing on exposed ridges and natural wind corridors during planning

Favour stable forest stands (deep-rooted hardwoods) as buffer zones along trails

Design light structures (footbridges, shelters) with anchoring resistant to significant gusts

Maintain sufficient lateral clearance width to reduce blowdown blockage risk

Integrate clearance corridors in identified high-risk blowdown areas

MEASURES TO BE IMPLEMENTED BY RECREATIONAL TRAIL NETWORK MANAGER

Reinforce light welcome structures (tents, terraces, shelters, signage) with appropriate anchoring

Create natural windbreaks (hedges, dense tree stands) around buildings and welcome areas

Secure mobile equipment against wind displacement

Assess and remove at-risk trees near buildings, parking areas, and gathering zones

MAINTENANCE AND OPERATIONS

MEASURES TO BE IMPLEMENTED FOR TRAILS

Conduct annual at-risk tree inventories (large diameter, tilt, broken crown) before each season

Clear blowdowns within hours following a storm to allow rapid trail reopening

Perform preventive pruning of branches overhanging trails in high-traffic areas

Check the condition of light structures and anchoring after each significant wind event

MEASURES TO BE IMPLEMENTED BY RECREATIONAL TRAIL NETWORK MANAGER

Inspect buildings, light structures, and nearby trees after each significant wind event

Store and secure movable outdoor equipment as soon as a high-wind advisory is issued

Regularly check the condition of electrical systems and backup generators before storm season

Plan reserve staff for days with high risk of weather disruptions

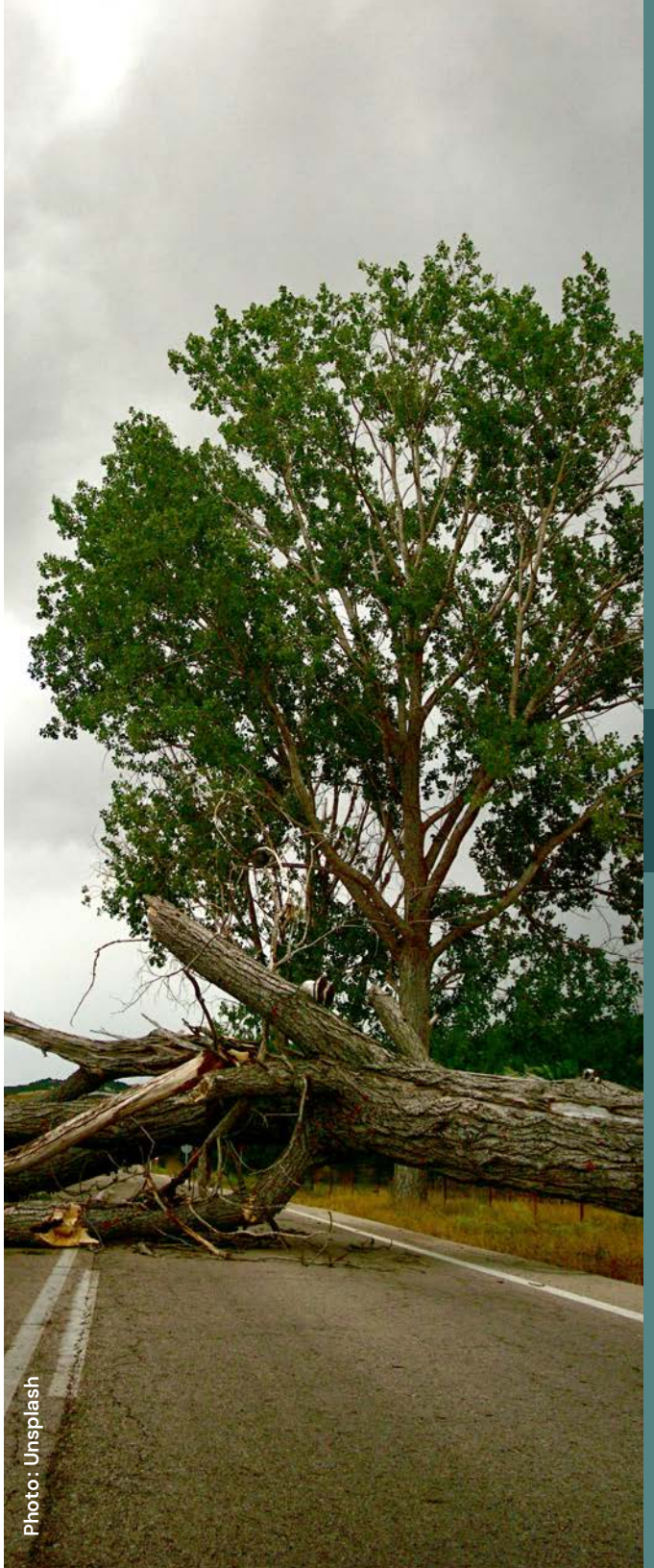


Photo: Unsplash

RISK MANAGEMENT AND SAFETY

MEASURES TO BE IMPLEMENTED FOR TRAILS

Preventively close wooded sections during high-wind advisories (gusts >70 km/h) before the event

Establish a systematic inspection protocol before any reopening after a significant storm

Map historical blowdown corridors to target inspections and intervention priorities

Keep chainsaw and clearing equipment available at all times during the season

MEASURES TO BE IMPLEMENTED BY RECREATIONAL TRAIL NETWORK MANAGER

Establish a rapid evacuation protocol and user alert for sudden storms

Define wind trigger thresholds (e.g., gusts >70–80 km/h) for closing outdoor areas

Train staff in emergency procedures (evacuation, first aid, power outages) in storm context

Have a backup generator to maintain essential operations during power outages

Establish a list of contractors available quickly for emergency repairs after storms

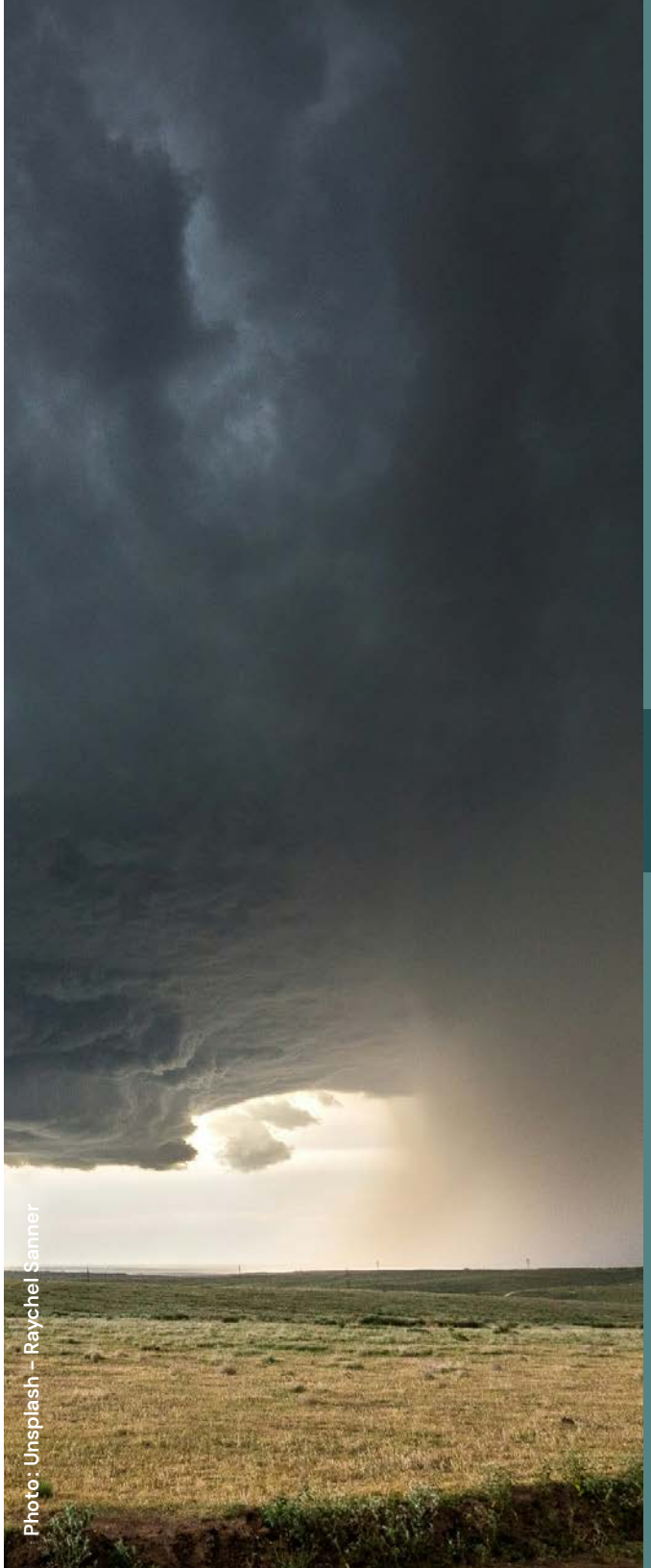


Photo: Unsplash - Raychel Sanner

GOVERNANCE AND COMMUNICATION

MEASURES TO BE IMPLEMENTED FOR TRAILS

Document blowdowns (location, species, size) to identify vulnerable stands and guide interventions

Integrate real-time weather monitoring (winds, thunderstorms) into daily network management tools

Train staff in rapid risk assessment related to blowdowns and closure decision-making

Raise user awareness of wind risks and the need to leave trails during storm advisories

Collaborate with forestry specialists to plan preventive selective cutting in at-risk areas

MEASURES TO BE IMPLEMENTED BY RECREATIONAL TRAIL NETWORK MANAGER

Broadcast real-time alerts to users (app, social media, website) in case of emergency closures

Document wind-related incidents (damage, blowdowns, closures) to calibrate future protocols

Integrate weather monitoring into daily management tools and team training

Communicate transparently about safety measures taken during extreme events

Photo: Unsplash - Adarsh Kumar

Concrete adaptation Strategies for Trail Managers

Climate change adaptation does not rely solely on technical or operational measures. To be truly effective, it must be part of a structured, continuous, and integrated approach across all management practices. The previous sections presented a wide range of measures applicable to trails and trail network management. This section aims to transform these measures into coherent action strategies, enabling managers to move from analysis to implementation

CONCRETE ADAPTATION STRATEGIES FOR TRAIL MANAGERS

This section therefore proposes a methodological framework that combines both strategic principles and practical tools. It is aimed at managers, planners, municipalities, and organizations responsible for the planning, maintenance, and operation of trail networks. The objective is to provide a clear approach to:

- ASSESS climate risks in a structured manner
- PRIORITIZE interventions based on the vulnerability of infrastructure and the adaptation capacity of the centre
- DEFINE realistic action plans, adapted to available resources
- INTEGRATE adaptive management into current practices
- MOBILIZE teams and partners around a shared vision of resilience
- EFFECTIVELY USE existing tools to support decision-making

This section adopts a mixed approach :

- CONCEPTUAL – presenting the fundamental principles of risk analysis, adaptive management, and risk tolerance
- OPERATIONAL – proposing concrete steps, simple methods, decision frameworks, and tools directly applicable in the field

By combining these two dimensions, this section offers managers a practical guide to structuring their adaptation approach, optimizing resources, and strengthening the resilience of their infrastructure and operations in the face of a transforming climate.

RISK ASSESSMENTS > ADAPTATION PLAN > ACTION PLAN

Climate adaptation for a mountain biking center does not begin with on-site work, but with a process of understanding, planning, and structuring. Climate hazards are numerous, their effects vary from one site to another, and available resources (human, financial, and material) are often limited. In this context, it is essential to have an approach that allows for prioritizing, organizing, and planning interventions.

Three complementary tools play a central role in this process: risk analysis, the adaptation plan, and the action plan. Together, they form a solid foundation for initiating climate adaptation in a gradual, realistic, and sustainable manner. They enable managers to move from a general understanding of the issues to an operational strategy integrated into the center's daily practices.

1. Risk analysis: Understanding vulnerabilities

Risk analysis is the first structuring step. It aims to identify climate hazards likely to affect the centre, assess their probability and intensity, and understand their potential impacts on infrastructure, operations, staff, and users.

For a trail network, this analysis must be contextual: it must take into account topography, visitation, type of infrastructure, forest cover, activity seasonality, and the operational capacity of the centre. Two centres located a few kilometres apart can present very different vulnerabilities.

On the next page, you'll find the self-assessment tool.

CONCRETE ADAPTATION STRATEGIES FOR TRAIL MANAGERS

VULNERABILITY SELF-ASSESSMENT TOOL

For each box, you must assess the likelihood of an event in that column occurring at your facility. Next, you must assess the severity of such an incident at your facility. Scores range from 1 (low) to 5 (very high). The result is then obtained by multiplying the two indicators. A score of 5 or lower requires monitoring. A score of 6 to 12 indicates an issue that requires medium-term attention. A score of 13 or higher indicates a high-risk factor and should be prioritized in your action plan.

P	S
R	

P = Probability (1-5)
S = Severity (1-5)
R = Result S x G

1–5 : Monitor
6–12 : Plan
13–25 : Adaptation priority

RISK ANALYSIS - VULNERABILITIES OF THE CENTER	Heat / Heat Waves		Heavy Rainfall		Strong Winds / Storms / Windfall		Freezing Rain / Heavy Snow		Forest Fires / Smoke		Droughts		Winter Thaws / Freeze-Thaw Cycles	
Buildings, reception areas, gathering areas														
Parking lots, pedestrian zones, queues														
Daily operations (ticketing, food service, events)														
Staff (safety, workload, exposure)														
Visitors (safety, comfort, experience)														
Equipment, machinery, communications														
Internal logistics (access, traffic flow, flow management)														

CONCRETE ADAPTATION STRATEGIES FOR TRAIL MANAGERS

HERE IS AN EXAMPLE OF A COMPLETED RISK ASSESSMENT TABLE.

It shows that this destination has good control over its reception area, but that workers and visitors are at risk, particularly when operations are affected by limited operational capacity. The action plan would therefore be based on these priorities.

P	S
R	

P = Probability (1-5)
S = Severity (1-5)
R = Result S x G

1–5 : Monitor
6–12 : Plan
13–25 : Adaptation priority

RISK ANALYSIS - VULNERABILITIES OF THE CENTER	Heat / Heat Waves		Heavy Rainfall		Strong Winds / Storms / Windfall		Freezing Rain / Heavy Snow		Forest Fires / Smoke		Droughts		Winter Thaws / Freeze-Thaw Cycles	
Buildings, reception areas, gathering areas	4	2	4	1	3	3	2	3	2	2	2	1	2	1
	8		4		9		6		4		2		2	
Parking lots, pedestrian zones, queues	4	3	4	4	3	3	4	3	2	2	2	2	3	2
	12		16		9		12		4		4		6	
Daily operations (ticketing, food service, events)	3	3	4	4	4	5	5	5	2	4	2	2	3	3
	9		16		20		25		8		4		9	
Staff (safety, workload, exposure)	3	4	3	4	3	5	3	5	2	5	2	3	2	3
	12		12		15		15		10		6		6	
Visitors (safety, comfort, experience)	4	4	4	4	3	5	3	3	3	4	3	3	3	2
	16		16		15		9		12		9		6	
Equipment, machinery, communications	4	2	4	3	4	4	2	3	1	3	2	2	2	1
	8		12		16		6		3		4		2	
Internal logistics (access, traffic flow, flow management)	2	2	3	4	3	3	3	2	2	2	2	3	2	3
	4		12		9		6		4		6		6	

CONCRETE ADAPTATION STRATEGIES FOR TRAIL MANAGERS

2-Adaptation plan: From analysis to action

The adaptation plan serves as a framework for moving from reactive to proactive management of climate risks. It translates risk analysis into concrete, prioritized, and achievable actions integrated into the centre's current operations.

1. VISION AND OBJECTIVES

First, define what the centre wants to protect and improve. For example:

- Ensure the safety of users and staff.
- Maintain the quality of the trail experience.
- Limit service disruptions and closures.
- Strengthen the resilience of infrastructure and operations.

Improve communication before, during, and after extreme weather events.

2. RISK PRIORITIZATION

Using the risk matrix:

- Classify each risk into three categories:
  - CRITICAL: immediate or very short-term intervention required.
  - MODERATE: intervention planned over the coming years.
  - LOW: monitoring, occasional adjustments.
- Focus efforts on a limited number of critical risks to avoid spreading resources too thin.

This process yields a «Top 5» priority issues to address first.

3. SELECTION OF ADAPTATION MEASURES

For each priority risk, define concrete measures by combining:

- Operational measures: closure protocols, schedule adjustments, emergency plans, visitor flow management.
- Human measures: staff training (heat, smoke, first aid), clarification of roles during alert situations.
- Physical measures: improvements around buildings, drainage upgrades, access protection, trail rerouting.
- Communication measures: template messages, alert channels, pre-visit information for users.

Each measure should be framed as a simple statement: «What – Where – Who – When.»

4. IMPLEMENTATION TIMELINE

Organize measures over time:

- SHORT TERM (0–1 year): low-cost, high-impact actions (protocols, basic training, initial fixes at the most vulnerable points).
- MEDIUM TERM (2–5 years): planned works and targeted investments.
- LONG TERM (5+ years): major projects or those dependent on partnerships.

A simple «Measure – Deadline – Responsible Party» table is sufficient to make the plan operational.

CONCRETE ADAPTATION STRATEGIES FOR TRAIL MANAGERS

5. RESOURCES AND PARTNERSHIPS

For each action block, specify:

- Estimated budget.
- Labour required (internal team, volunteers, contractors).
- Necessary equipment.
- Potential partners (municipality, regional county municipality, watershed organization, associations, experts).

The goal is not to have a perfect budget, but a ballpark estimate to support planning.

6. MONITORING AND UPDATES

The plan must remain a living document:

- ANNUAL REVIEW:
  assessment of completed actions, updated priorities.
- ADJUSTMENTS AFTER EACH EXTREME EVENT:
  what worked and what didn't, lessons learned.
- INTEGRATION WITH EXISTING TOOLS:
  maintenance plan, safety procedures, trail master plan.

In practice, the adaptation plan becomes a simple dashboard linking: priority risks, selected measures, timeline, responsible parties, and progress status.

Photo: Unsplash – Sean Benesh

CONCRETE ADAPTATION STRATEGIES FOR TRAIL MANAGERS

3-Action plan: Translating strategy into concrete steps

The action plan is the operational breakdown of the adaptation plan. It answers a simple question: 'What do we do, when, how, and with what resources?' It must be short, clear, and usable by the entire team, both in meetings and in the field context.

A good action plan includes, for each measure:

1. A Precise and Measurable Action

Framed concretely, for example:

- Install a shaded shelter at the departure area
- Establish a closure protocol during thunderstorms
- Train staff in heat and smoke management
- Improve drainage around buildings and key access points
- Create a covered waiting area near the ticket office

2. A Designated Responsible Party

- Each action must have a clearly identified «owner» (person or role) to avoid grey areas and facilitate follow-up.

3. A Realistic Timeline

- A target completion date
- Where applicable, a frequency (monthly inspection, annual protocol update, etc.)

4. Required Resources

- Estimated budget
- Required materials
- Labour (internal team, volunteers, contractors)

5. A Simple Progress Indicator

- Action completed
- Action in progress
- Action deferred
- Action to be revised or discontinued

Presented as a table, the action plan bridges intention and implementation, ensuring that each adaptation measure is clearly defined, assigned, scheduled, and tracked over time.

A PROGRESSIVE, ACCESSIBLE, AND STRUCTURED APPROACH

For outdoor destinations, the risk analysis, adaptation plan, and action plan together form a progressive, accessible, and scalable process. They make it possible to:

- Structure the adaptation process
- Prioritize interventions
- Mobilize teams
- Facilitate decision-making
- Demonstrate proactive management
- Support funding applications
- Improve the overall resilience of the centre

They represent the essential first step toward initiating climate adaptation in a sustainable, coherent, and effective manner.

Risk Tolerance Principles and Adaptive Management

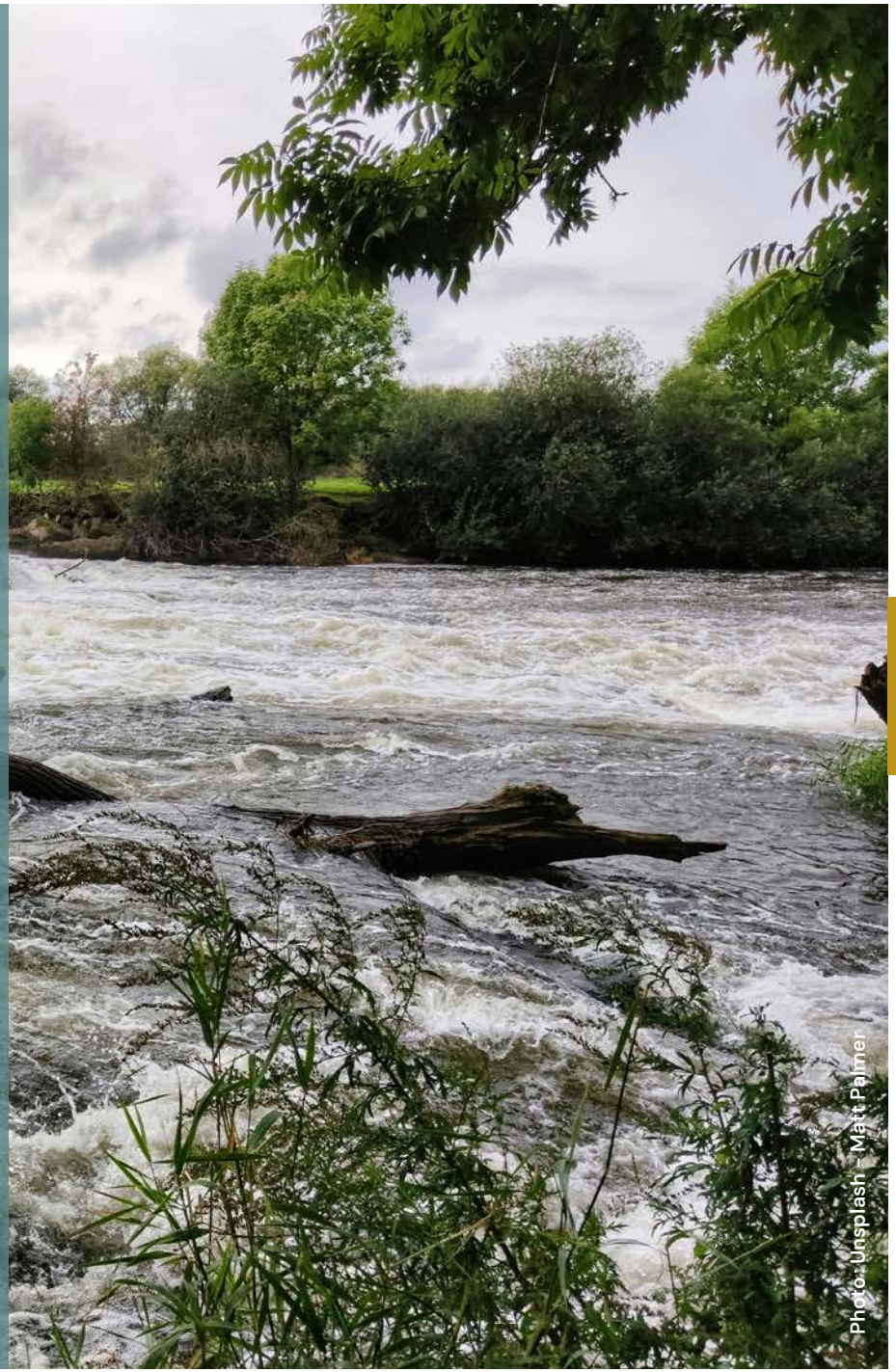


Photo: Unsplash – Matt Palmer

RISK TOLERANCE PRINCIPLES AND ADAPTIVE MANAGEMENT

Climate change adaptation does not only consist of reducing risks: it also involves determining which risks a centre is prepared to accept and which require immediate intervention. This distinction is essential, as resources (financial, human, material) are limited, and centres must arbitrate between several priorities.

Risk tolerance thus enables focusing efforts on the most effective measures, taking into account the centre's investment capacity, visitation, the ecological sensitivity of the site, and the nature of activities offered. Combined with an adaptive management approach, it enables adjusting decisions over time, according to evolving climate conditions and field observations.

RISK TOLERANCE: DISTINGUISHING THE ESSENTIAL FROM THE ACCEPTABLE

Risk tolerance corresponds to the level of risk that a centre considers acceptable, given its objectives, resources, and operational context.

Elle repose sur une distinction fondamentale entre :

Risks That MUST BE ELIMINATED OR SIGNIFICANTLY REDUCED

These are risks that threaten:

- The safety of users (e.g., windfall trees, thunderstorms, freezing rain, extreme heat)
- The safety of staff
- The integrity of critical infrastructure
- Operational continuity (e.g., blocked access, damaged buildings)
- The centre's reputation in the event of a serious incident

These risks require immediate or priority action, as they can lead to major consequences.

ACCEPTABLE OR TOLERABLE Risks

These are risks that are:

- Low in frequency
- Minor in impact
- Reversible in effect
- Non-threatening to safety
- Manageable through simple operational adjustments

Examples :

- Increased dust during drought periods
- Minor inconveniences for users
- Minor service disruptions
- Limited impact on the overall experience

These risks do not require major investment, but should be monitored.

FACTORS INFLUENCING RISK TOLERANCE

Risk tolerance is not uniform, it varies according to the characteristics of the centre

Three factors play a determining role:

1. INVESTMENT CAPACITY

A centre with limited resources will need to focus its efforts on:

- Critical risks
- High-impact interventions
- Low-cost but effective measures

Conversely, a better-funded centre will be able to target a broader reduction of risks.

2. VISITOR VOLUME AND USER PROFILE

A heavily visited centre, or one welcoming a diverse public (families, beginners), will have a lower risk tolerance, particularly regarding:

- Safety-related risks
- Extreme weather conditions
- Reception infrastructure

A more specialized centre, frequented by experienced users, may tolerate certain minor risks.

3. BIODIVERSITY AND ECOLOGICAL SENSITIVITY OF THE SITE

Sites located in ecologically sensitive environments must incorporate:

- Habitat protection
- Management of cumulative impacts
- Preservation of soils and vegetation

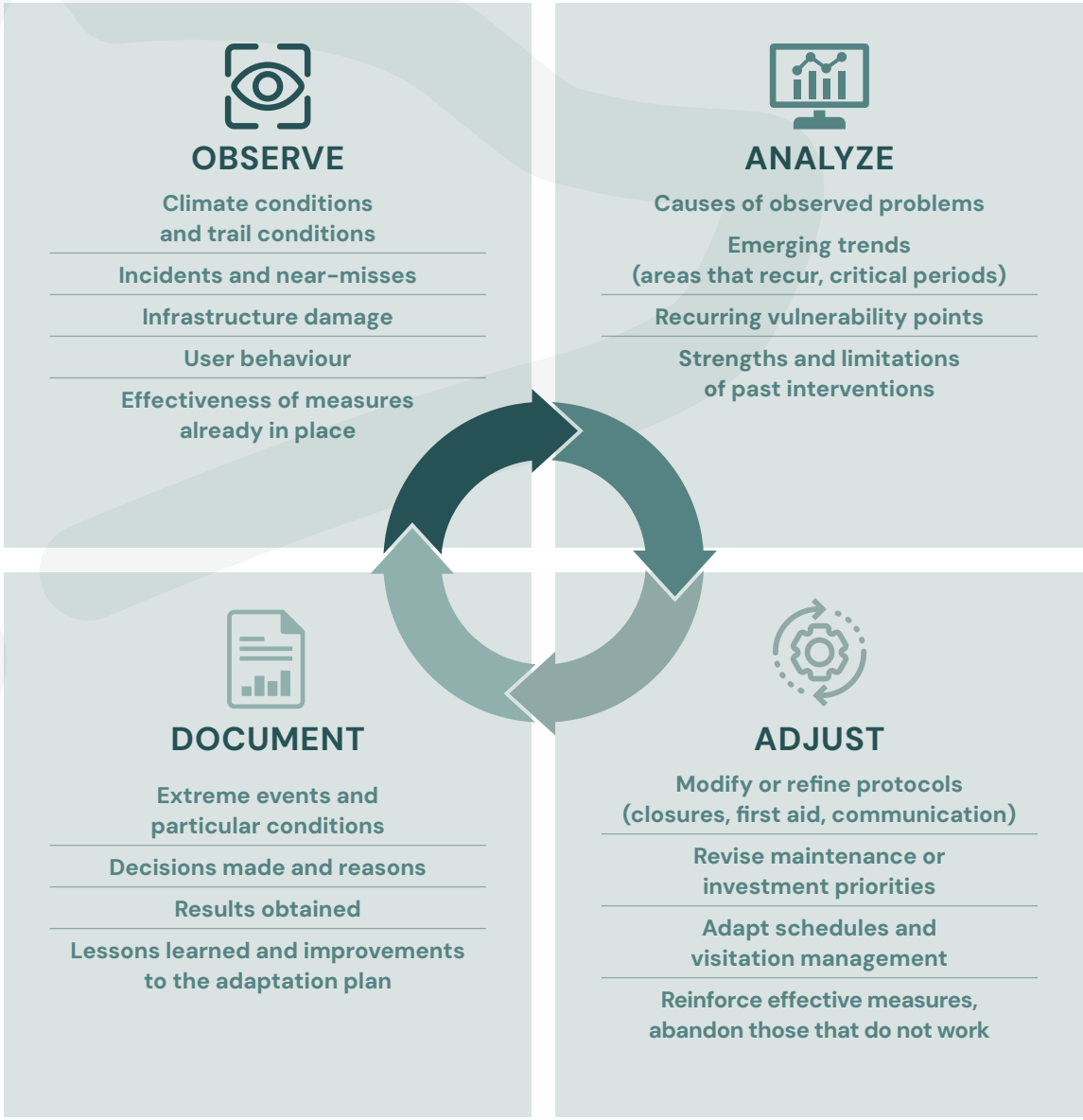
Risk tolerance must therefore include environmental considerations, not only operational ones.

ADAPTIVE MANAGEMENT: ADJUSTING TO CONDITIONS

Adaptive management is a dynamic approach that recognizes that climate conditions, impacts, and resources evolve over time. It aims to continuously adjust the way the centre is managed, based on what is actually observed in the field.

It relies on a simple cycle:

This cycle allows the centre to respond quickly, learn year over year, and optimize its resources rather than starting from scratch after each event.



RISK TOLERANCE PRINCIPLES AND ADAPTIVE MANAGEMENT

WHY COMBINE RISK TOLERANCE AND ADAPTIVE MANAGEMENT?

Adaptive management becomes particularly effective when combined with clear reflection on the centre's risk tolerance (to what extent is a certain level of risk or discomfort acceptable before intervening?).

This combination enables:

- Avoiding heavy investments where the risk is low or acceptable
- Concentrating efforts on risks that are truly critical for safety and operations
- Adjusting decisions based on real conditions, rather than theoretical scenarios
- Maintaining a good level of safety without unnecessarily multiplying closures
- Better protecting both infrastructure, natural environments, and user experience

In practice, this framework offers the manager a flexible and realistic means of navigating a transforming climate, making the centre gradually evolve rather than in fits and starts.

Tools for Managers

Photo: Unsplash – Giorgio Trovato

TOOLS FOR MANAGERS

Implementing climate adaptation relies not only on technical and organizational measures, but also on access to reliable, accessible, and manager-appropriate tools. These tools enable better understanding of climate hazards, assessing risks, planning interventions, monitoring evolving conditions, and supporting decision-making.

Outdoor centres, whether small or large, can benefit from a variety of resources: climate platforms, technical guides, risk management tools, planning models, alert systems, and communication tools.

The following table presents a selection of priority tools to integrate into the toolkit of any trail manager in Quebec.

TOOL / RESOURCE	PRIMARY USE	WEBSITE
MétéoMédia / Environment Canada	Alerts, closures, planning	meteo.gc.ca
Ouranos	Regional climate projections	ouranos.ca
ClimateData.ca	Historical and projected data	climatedata.ca
SOPFEU	Fire danger, air quality	sopfeu.qc.ca
Alerte Québec (app)	Official real-time alerts	securitepublique.gouv.qc.ca
Trailforks	Trail status, user communication	trailforks.com
MELCCFP – PCM-2	Climate adaptation funding	environnement.gouv.qc.ca
Canadian Red Cross	Outdoor first aid training	croixrouge.ca

CLIMATE AND METEOROLOGICAL TOOLS

These tools enable monitoring current conditions, anticipating extreme events, and understanding long-term climate trends. They are essential for planning daily operations and feeding risk analysis.

EXAMPLES OF USEFUL TOOLS

- PROFESSIONAL METEOROLOGICAL PLATFORMS: detailed forecasts, thunderstorm alerts, heat indices, extreme winds
- WILDFIRE MONITORING TOOLS: interactive maps, danger indices, air quality
- REGIONAL CLIMATE PORTALS: climate projections, warming scenarios, trend analyses
- LOCAL WEATHER STATIONS: real-time data, useful for operational decisions

USEFULNESS FOR CENTRES

- Anticipating temporary closures
- Adjusting opening hours
- Planning maintenance operations
- Monitoring emerging risks (heat, smoke, winds)
- Documenting extreme events for annual tracking

RISK ANALYSIS AND PLANNING TOOLS

These tools support conducting a structured risk analysis and preparing an adaptation plan or action plan. They enable prioritizing interventions and organizing resources.

EXAMPLES OF USEFUL TOOLS

- RISK MATRICES: probability X severity, adapted for outdoor centres
- VULNERABILITY ASSESSMENT GRIDS: infrastructure, operations, staff, users
- ADAPTATION PLAN MODELS: structure, prioritization, schedule, resources
- MAPPING TOOLS: identification of sensitive areas, access routes, critical infrastructure
- CLIMATE INCIDENT RECORDS: tracking damage, closures, and interventions

USEFULNESS FOR CENTRES

- Structuring risk analysis
- Prioritizing adaptation measures
- Planning investments
- Documenting decisions
- Facilitating internal communication

OPERATIONAL AND SAFETY MANAGEMENT TOOLS

These tools support the daily management of the centre, particularly during extreme climate events. They ensure the safety of staff and users and improve the centre's responsiveness.

EXAMPLES OF USEFUL TOOLS

- ALERT AND NOTIFICATION SYSTEMS: thunderstorms, winds, heat, air quality
- CLOSURE PROTOCOLS: guides, checklists, standardized procedures
- STAFF MANAGEMENT TOOLS: team planning, schedule management in extreme conditions
- INTERNAL COMMUNICATION SYSTEMS: radios, mobile applications, coordination platforms
- EVENT MANAGEMENT TOOLS: procedures for competitions, gatherings, special activities

USEFULNESS FOR CENTRES

- Improving decision speed
- Ensuring clear and uniform communication
- Reducing staff risks
- Standardizing interventions
- Strengthening overall site safety

INFORMATION AND USER COMMUNICATION TOOLS

Communication is a key element of adaptation. Users must be informed of conditions, closures, risks, and operational adjustments. Digital tools facilitate this communication.

EXAMPLES OF USEFUL TOOLS

- WEBSITES AND INFORMATION PLATFORMS:
  trail conditions, notices, updates
- MOBILE APPLICATIONS:
  alerts, interactive maps, notifications
- SOCIAL MEDIA:
  rapid communication during extreme events
- DYNAMIC PANELS OR TEMPORARY SIGNAGE:
  on-site, to inform users
- ONLINE TICKETING SYSTEMS:
  visitation management, schedule adjustments

USEFULNESS FOR CENTRES

- Informing users quickly
- Reducing risks related to misinformation
- Improving the client experience
- Managing expectations in difficult conditions
- Strengthening transparency and trust

TRAINING AND CAPACITY BUILDING TOOLS

Climate adaptation also relies on staff capacity to understand risks, apply protocols, and intervene effectively. Training tools play an essential role.

EXAMPLES OF USEFUL TOOLS

- Training modules on climate risks
- Technical guides for operations in extreme conditions
- Workshops on safety, communication, and emergency management
- First aid training adapted to outdoor environments
- Resources on adaptive management and decision-making under uncertainty

USEFULNESS FOR CENTRES

- Strengthening staff skills
- Improving intervention consistency
- Reducing error risks
- Supporting adaptive management
- Fostering a proactive organizational culture

COLLABORATION AND PARTNERSHIP TOOLS

Climate adaptation is a collective effort. Centres can benefit from collaborations with municipalities, environmental organizations, experts, or other centres.

EXAMPLES OF USEFUL TOOLS

- Information-sharing networks
- Regional working groups
- Partnerships with municipal services (civil security, environment, forestry)
- Collaboration with climate, hydrology, or forestry experts
- Funding or technical support programs

USEFULNESS FOR CENTRES

- Accessing specialized resources
- Sharing best practices
- Pooling costs
- Improving regional coherence of adaptation

AN EVOLVING TOOLKIT

The tools presented in this section do not constitute an exhaustive list. They must be adapted to the context, resources, and priorities of each centre. What matters is developing an evolving toolkit that grows richer over time, through experience and collaboration.

By combining these tools with technical measures, organizational measures, and strategic principles, mountain biking centres have a solid foundation for strengthening their resilience in the face of climate change.

Conclusion

Climate change is rapidly transforming the context in which recreational trail centres and networks in Quebec operate. Extreme heat, heavy rain, violent winds, freezing rain, wildfires, and freeze-thaw cycles are no longer anomalies, but recurring realities that influence safety, maintenance, planning, and user experience. In this context, adaptation is no longer optional: it becomes an essential component of the sustainable management of outdoor infrastructure and the natural environments that support them.

This guide proposes a structured approach to support managers in this transition. The sections dedicated to climate hazards and their impacts draw a clear picture of the vulnerabilities specific to trails and centres. The adaptation measures are then organized into major categories of intervention (design and planning, maintenance and operations, risk and safety management, governance and communication) to distinguish the needs of physical infrastructure (trails, buildings, access routes) from those related to human and organizational dimensions (teams, services, reception), while highlighting their complementarity.

The strategic approach presented at the end of the guide (risk analysis, adaptation plan, action plan) provides a concrete basis for prioritizing issues, planning interventions, and optimizing resource use. The notions of risk tolerance and adaptive management remind us that adaptation is not a state to be achieved once and for all, but a continuous process: observe, analyze, adjust, and document, season after season. The proposed tools, whether climate-related, operational, or organizational, aim to support this work on a daily basis, drawing on practices already in place in the outdoor sector.

At the heart of this guide lies a simple idea: climate adaptation is a progressive and accessible approach, even for organizations with limited resources. It relies as much on concrete actions (better observing the terrain, adjusting protocols, adapting schedules, communicating more clearly) as on more significant technical interventions. It requires a detailed understanding of local realities, an ability to make choices, and a willingness to integrate climate into the management culture.

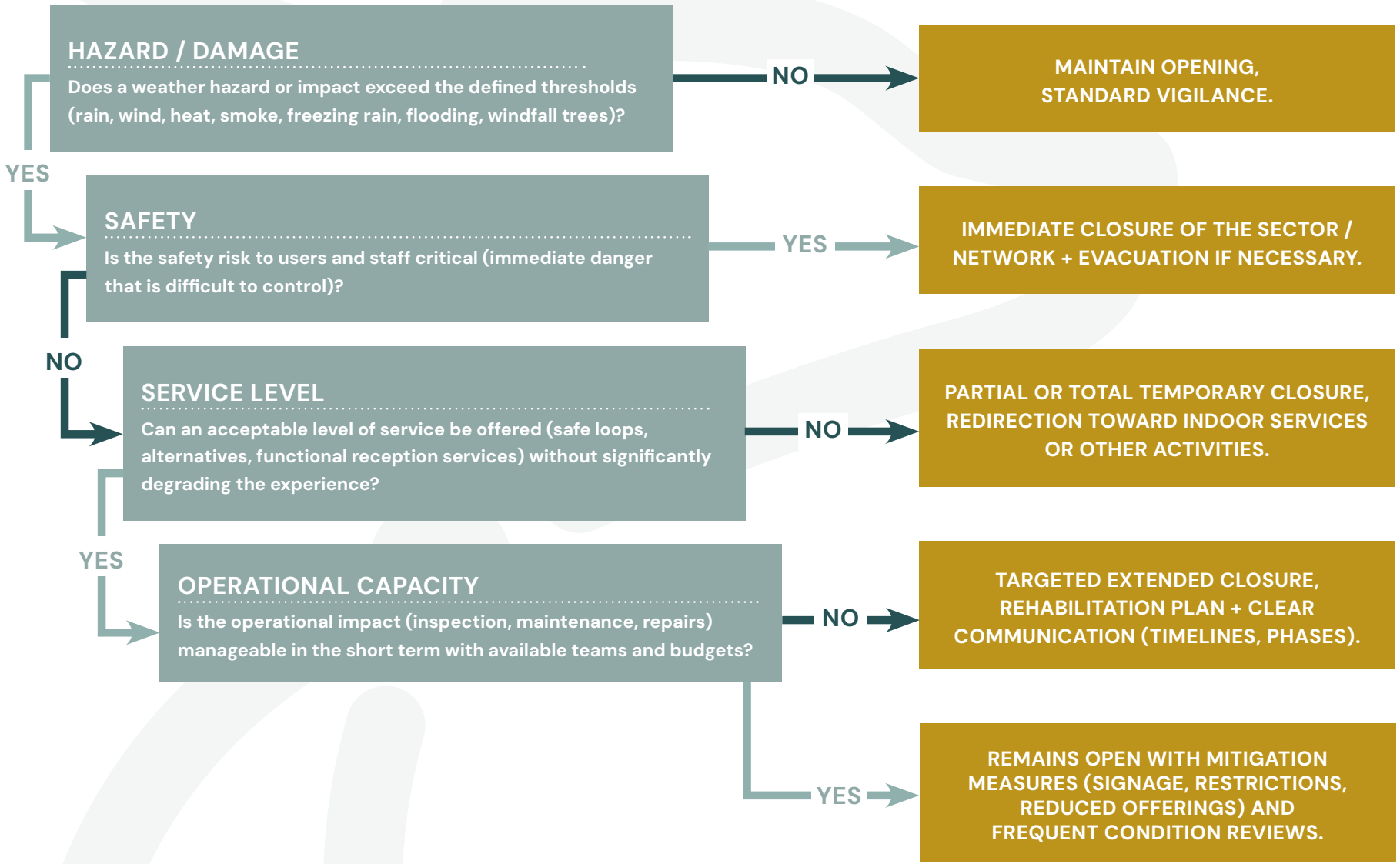
Trail centres contribute to health, well-being, local economy, and the vitality of communities, while showcasing often fragile natural environments. By strengthening their resilience to climate change, they protect their infrastructure and operations, but also the user experience, staff safety, and the sustainability of the surrounding ecosystems. Adaptation is not an additional burden: it is an opportunity to enhance the quality of amenities, professionalize management, and strengthen collaboration among territorial stakeholders.

This guide is intended as a support point for initiating, structuring, and nurturing this approach. It proposes a framework and avenues, but it is up to each centre, each network, and each team to translate them according to their realities, resources, and ambitions. By adopting a proactive, structured, and collaborative approach, managers can not only face climate challenges, but also become references in sustainable management, innovation, and resilience. The climate is changing and practices are evolving; the rest will be written in the field, through the seasons, by those who bring these trails to life.

Acronyms

GHG	**Greenhouse gases**
GIEC	**Intergovernmental Panel on Climate Change**
CMIP6	**Coupled Model Intercomparison Project Phase 6 (climate model)**
SSP	**Socioeconomic and emissions scenarios (SSP1 2.6, SSP3 7.0, etc.)**
ECCC	**Environment and Climate Change Canada**
MELCCFP	**Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (Quebec)**

DECISION CHARTER | MANAGEMENT OF ONE-OFF HAZARDS



GLOSSARY

CLIMATE ADAPTATION
A set of measures aimed at reducing the negative impacts of climate change or taking advantage of its positive effects on a territory, infrastructure, or communities.

CLIMATE HAZARD
A potentially damaging weather or climate phenomenon (heat wave, intense rain, freezing rain, storm, wildfire, drought, etc.). The hazard becomes a risk when it encounters a vulnerable element.

CLIMATE CHANGE
A lasting modification of average climate and the frequency of extremes, mainly due to the increase in greenhouse gases of human origin.

FREEZE-THAW CYCLE
Repeated alternation of temperatures above and below 0°C, which causes the expansion and contraction of water in soil and materials, weakening trails and structures.

EXTREME EPISODE / EXTREME EVENT
An unusual weather event by its intensity or duration (torrential rain, heat wave, windstorm, rain-on-snow, etc.), exceeding conditions normally observed in a region.

GREENHOUSE GAS (GHG)
Gases present in the atmosphere (CO2, methane, nitrous oxide, etc.) that retain part of the heat emitted by the Earth's surface and contribute to global warming.

AIR QUALITY INDEX (AQI)
An indicator that synthesizes the concentration of several atmospheric pollutants (ozone, fine particles, etc.) to assess health risk, notably in the presence of wildfire smoke.

INTENSE PRECIPITATION
Rain (or rain-on-snow) falling in large quantities over a short period, exceeding normal thresholds for a given site and greatly increasing runoff, erosion, and flooding.

CLIMATE PROJECTIONS
Estimates of future climate conditions based on numerical models and GHG emission scenarios (e.g., CMIP6, SSP3-7.0). They are not point forecasts, but probabilistic portraits of possible futures.

RESILIENCE
The capacity of a system (trail, centre, community) to withstand a climate shock, recover quickly, and adapt to be better prepared for future events.

CLIMATE RISK
A combination of a climate hazard, the vulnerability of exposed elements (trails, buildings, users, staff), and their level of exposure. The same hazard can generate little or much risk depending on the context.

RUNOFF
The flow of rainwater or meltwater on the soil surface. On a trail, poorly controlled runoff causes surface erosion, rut formation, and gullying.

DROUGHT
A prolonged period with precipitation well below normal, causing a water deficit in soil and vegetation, an increase in dust, and an increased risk of fire.

VULNERABILITY
The degree of sensitivity of an element (trail, building, natural environment, user group) to climate hazards, based on its physical, social, or organizational characteristics.

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