



SLIPPERY SLOPES

HOW CLIMATE CHANGE IS THREATENING
THE WINTER OLYMPICS

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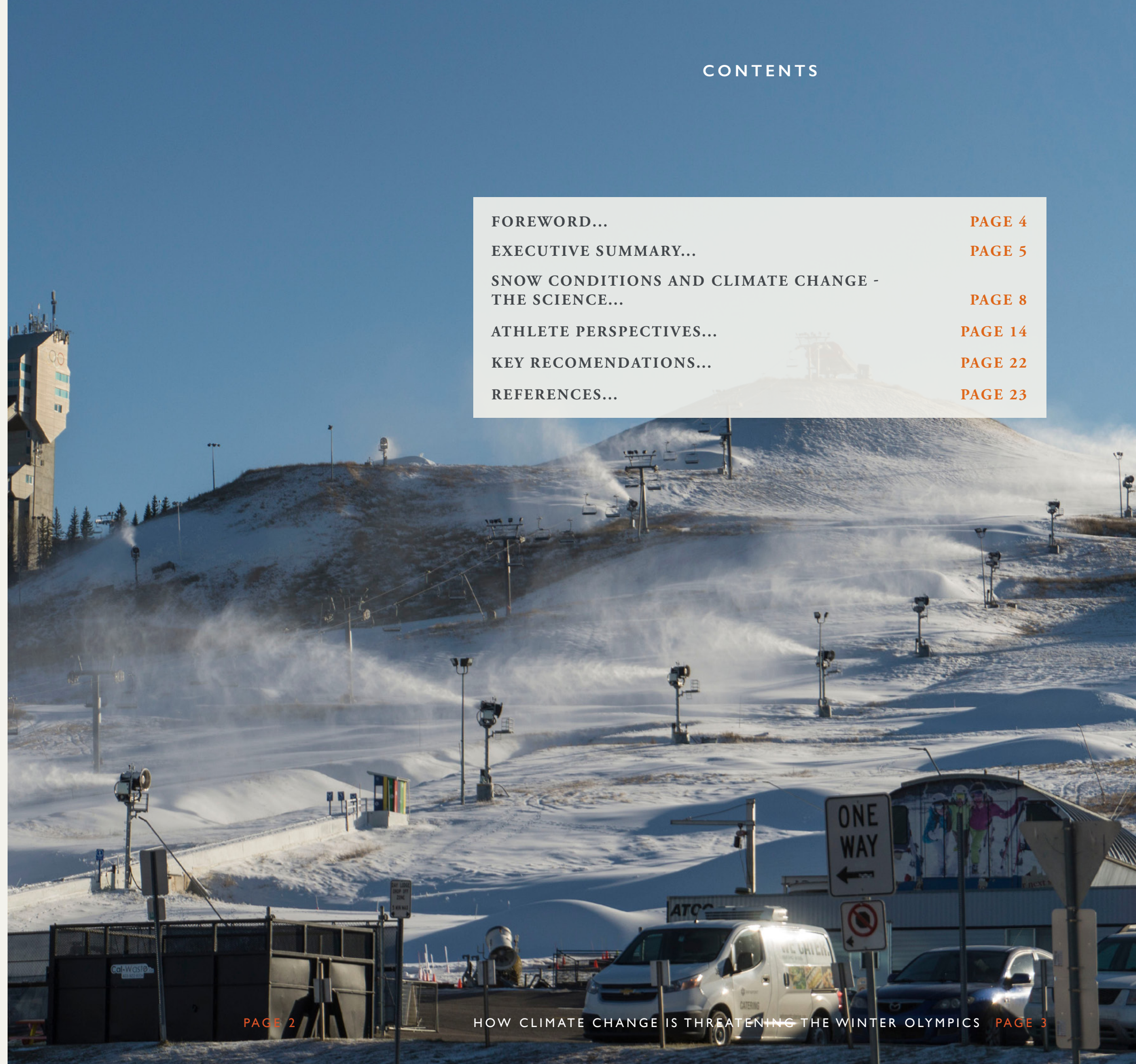
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FOREWORD



BY LESLEY MCKENNA

I have been lucky enough to have worked in many snowy places all over the world in my career as a snowsport athlete and coach and then team manager from the early 1990's until the present day. I have seen huge changes in the snowpack in ski resorts over the winters and especially in glacier cover/condition in those 30 years and the changes are hugely concerning on many levels.

In the context of high performance snowsport and athletes training for the Olympics, the changing snow conditions and weather patterns have made it a lot more difficult to plan ahead and to find consistent high-level training conditions.

The weather and snow are far less consistent now than they were at the start of my career. It means that plans have to be very flexible if a team is to make it to the best training locations. Everything then becomes more exclusive and more resource-heavy. Opportunities become harder to come by and less accessible.

The fewer ski resorts there are capable of producing the best conditions for training, the fewer kids there are that have the chance of reaching the top level, with the costs of travelling to training and competitions increasing as the weather and snow become less stable. Less accessibility and opportunities for stars of the future; less security in the industry and culture that supports snowsports; a growing threat to the health and vibrancy of the snowsports sector. And all the ensuing performance and environmental impacts. The potential future scenario- in a world without winter sports and host venues as we know them- is a grave one.

I have cherished the last three decades in snowsports. But I harbour mounting fears for where we could be in another 30 years' time.

*Lesley McKenna, Three-time GB Olympian in snowboard halfpipe
(2002, 2006 and 2010 Winter Games), Protect Our Winters UK Ambassador*

EXECUTIVE SUMMARY



Few sporting spectacles are as dramatic and picturesque as the Winter Olympics. Stunning mountain backdrops, glistening slopes, soaring ski jumps and glittering ice rinks rarely fail to deliver a heady dose of speed and excitement.

What viewers of the 2022 Beijing Olympics may miss, as they tune in from home, are the vast array of snow machines and cooling kit that will enable the skiing events to take place.

The Beijing Games will make history as the first Winters on virtually 100% artificial snow. It is a development that scientists believe could become the norm over time as our planet warms, starting with lower altitude slopes and raising pressure and costs on higher resorts.

As this report details, climate change is eroding the ability of snow and ice sports to take place under natural conditions. From the Alps to the Pyrenees, the Rockies to the Andes, snowsports fans are reporting shorter seasons, lower snowfall levels and melting glaciers.

Last year the Tokyo Olympics [Rings of Fire report](#) laid out the deep concerns many athletes had over heat and humidity levels in Japan's capital – fears that were borne out during a [sweltering fortnight](#) last July and August.

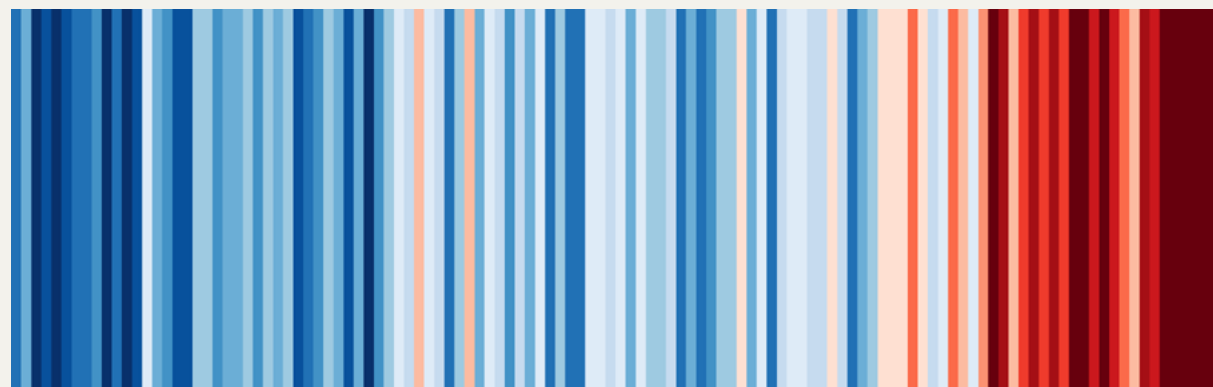
Winter athletes echo those fears here. We hear that the intensive use artificial snow could lead to more injuries, warnings over the environmental damage from pesticides used to keep manmade snow cold, concerns that grassroots opportunities will dry up as ski seasons become more erratic.

Scottish freestyle skier Laura Donaldson warns that if “freestyle super pipes are formed from snow-making machines in a poor [natural snow] season, the walls of the pipe are solid, vertical ice and the pipe floor is solid ice. This is dangerous for athletes, some have died.”

Lauded two-time Canadian Olympian and leading freestyle skier Philippe Marquis tells us of the “scary changes in the basic structure of ice formation and the landscape of glaciers” he has seen in recent years. He details the increase in injuries “caused by the lack of practice on snow.” He explains how the “conditions are definitely more dangerous than what we've seen before” and issues a stark warning of his concern for athletes' safety going forward.

Talented Czech biathlete Jessica Jislová is another competitor worried by the continuing trend of unstable winter weather and the accompanying decline in snow conditions, emphasising how “extreme weather changes can be dangerous for athletes.”

Even track sports like bobsleigh are not immune. Experienced Canadian bobsledder Seyi Smith tells us of the havoc rising temperatures are wreaking on the training and preparation of athletes, as well as outlining the increased risk of concussions and the detrimental impact on competition quality caused by uneven and “erratic ice conditions”.



Temperature changes for China 1901-2020

The most recent UN IPCC report concluded emissions of greenhouse gases from human activities are responsible for approximately 1.1°C of warming since 1850-1900.

Credit: Ed Hawkins, University of Reading

The risk is clear: manmade warming is threatening the long-term future of winter sports³. It is also reducing the number of climatically suitable host venues for the Winter Olympiad, as we detail in this report^{4,5}.

The lack of natural snow at Beijing 2022 is not a surprise. The International Olympic Committee knew the Zhangjiakou and Yanqing Zones outside Beijing had 'minimal snowfall' and would rely on man-made snow to top up natural levels.

In turn this poses tough environmental and economic questions for the sector. The crisp slopes outside Beijing mask an unfortunate truth: they will be the result of an estimated 49 million gallons of chemically-treated water frozen through snow machines,⁸ an energy-intensive process that is costly and potentially damaging in water-stressed areas.

The 2022 Winter Olympics will, no doubt, be an awesome spectacle – watched and enjoyed by millions worldwide. But they should also provoke a debate about the future of snowsports, and the limits of engineering artificial natural environments. Slippery slopes lie ahead.

ON ARTIFICIAL SNOW:

- ✧ Originally invented in a lab in Japan, perfected and finessed into machines in the U.S.
- ✧ First used at the Winter Olympics in Lake Placid 1980
- ✧ It is estimated that 95% of ski resorts globally rely on snowmaking to some extent, either to ensure good quality conditions, prolong the ski season, or both
- ✧ Typically, lower-altitude resorts and those in warmer locations require more snowmaking help
- ✧ Climate change is putting the snow sport industry at risk, both because natural snow is becoming less plentiful in some regions, and because water availability for snowmaking (the current best solution to a lack of snow) is reduced
- ✧ Even if powered by renewables, a huge amount of energy is needed which is both costly and can be a significant drain on water resources
- ✧ There are limitations to the production and maintenance of artificial snow. At low humidity (up to 30%, dry conditions) it can be reliably produced in conditions up to about 3°C (due to additives that help with freezing), but in high humidity (>60%) you need those colder temperatures at freezing or below
- ✧ Beijing 2022 will be the first Winter Olympics to rely almost 100% on artificial snow

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SNOW CONDITIONS AND CLIMATE CHANGE -
THE SCIENCE

SNOW REQUIREMENTS FOR A SELECTION OF WINTER SPORTS

	SPORT	GOVERNING BODY	REQUIREMENTS
	FREESTYLE SKI AND SNOWBOARD	INTERNATIONAL SKI FEDERATION (FIS)	MINIMUM 1M OF PACKED (COMPRESSED) SNOW AS A BASE, BUT IDEALLY MORE IF TEMPERATURES ARE HIGH (IE ABOVE FREEZING) AS THEY MUST EXPECT SOME TO MELT EACH DAY (UP TO 30CM PER DAY DEPENDING ON TEMPERATURE AND EXPOSURE TO SUN AND WIND)
	SKI JUMPING	INTERNATIONAL SKI FEDERATION (FIS)	SNOW COVER FOR PLASTIC-COVERED JUMP HILLS IS MIN. 35CM ABOVE THE PLASTIC MATTING SURFACE; FOR JUMP HILLS WHERE PLASTIC COVERING IS NOT USED, SNOW COVER MUST BE MIN. 30CM
	CROSS-COUNTRY SKI EVENTS	INTERNATIONAL SKI FEDERATION (FIS)	SUFFICIENT BASE COVER REQUIRED ACROSS THE FULL COURSE (SPECIFIC AMOUNT OF SNOW NOT SPECIFIED)
	ALPINE SKI EVENTS	INTERNATIONAL SKI FEDERATION (FIS)	VARIABLE DEPENDING ON ALTITUDE, EXPECTED TEMPERATURES AT THE LOCATIONS AT THE TIME OF COMPETITION ETC. FOR BEIJING 2022 GAMES, AGREED REQUIREMENT OF MIN. 1M MAN-MADE SNOW IN ALL SECTIONS
	BIATHLON	INTERNATIONAL BIATHLON UNION (IBU)	NO SPECIFIC MINIMUMS BUT A REQUIREMENT THAT THERE IS SUFFICIENT BASE SNOW THROUGHOUT THE COURSE AND THAT IT IS EVENLY GROOMED
	NORDIC COMBINE	INTERNATIONAL SKI FEDERATION (FIS)	NO SPECIFIC BASE SNOW MINIMUMS BUT THERE ARE REQUIREMENTS LINKED TO WIND CONTROL

BEIJING 2022 HISTORICAL WEATHER DATA

There are three potential climate hazards to consider for large mega-events: air quality, temperatures, and precipitation. All three potential climate impacts are forecasted for the Beijing 2022 Winter Olympic Games: lack of precipitation, poor air quality, and insufficiently cold enough temperatures for natural snow. As Beijing and its neighboring regions of Yanqing and Zhangjiakou lie in naturally arid climates, precipitation levels are projected to be insufficient to produce natural snow during these events. The other two climate impacts vary across the three major host zones for these Winter Games: Beijing, Yanqing, and Zhangjiakou.

Air quality is an important measure to consider for the safety of athletes, officials, spectators, and other event-related personnel. Within the main hosting zone of Beijing, over the previous six years (2015-2020) in February there have been a total of 74 days with air quality in the range of unhealthy, very unhealthy, and hazardous from the World

AQI. Yanqing experienced far fewer days (37) while Zhangjiakou experienced an even smaller number of days with poor air quality (18).

Insufficiently cold temperatures do vary across the host sites, but it is important to note that most outdoor events (e.g. ski-based, snowboard-based, bobsleigh, luge, and skeleton) will take place in the Yanqing and Zhangjiakou zones, with the exception of big air snowboarding and freestyle skiing, which will take place in Beijing. Based on historical temperature data for Beijing, nearly all days in February for the past thirty years have been above the freezing level for water.

Outside of Beijing, the Yanqing Zone suffers from a similar problem, which will require the use of artificial snow. The final host zone, Zhangjiakou, has a monthly average temperature in February below the freezing point of water with the average high only slightly above freezing (approximately 1.5°C).

APPROACHES TO SNOWMAKING AND SNOW MAINTENANCE

Over time, winter sport event organizers have become increasingly reliant upon climatic adaptations to deliver safe and fair conditions for competitors and spectators. Nearly all events in the earliest Olympic Winter Games took place outdoors, but by the 1980s, sports like ice hockey, figure skating, speed skating, and curling had moved to indoor, refrigerated ice rinks¹³.

For the sports remaining outdoors, a longstanding adaptation to the lack of natural snowfall has been the practice of artificial snowmaking, technology that dates back to the 1950s and is mandated for Olympic Games competition sites since

first being implemented at Lake Placid in 1980¹⁴. This technology requires snowmaking infrastructure (e.g., water pumps and compressors, air plants, piping, snow guns), access to water (e.g., captured snowmelt, natural water bodies, wastewater), electricity to operate pumps and compressors, and favourable water conditions¹⁵. To enhance the quality of artificial snow, organizers may add chemical or biological additives to the water¹⁶, such as when a pesticide was used at the 2010 Games in Vancouver to allow the water to freeze at higher temperatures¹⁷. So-called “snow hardeners” like salt and fertilizer may also be used to improve snow quality on cross-country skiing trails¹⁸.

In addition to snowmaking, event organizers may transport snow from other sites (by land vehicle or helicopter) and/or stockpile snow in the lead-up to the event¹⁹; for the 2014 Games in Sochi, snow stockpiling took place

a full year ahead of competition²⁰. These adaptations may be combined with strategies like the use of snow fences to capture moving snow and the planting of (or retaining of existing) trees to shade ski runs from the sun²¹.

FUTURE VIABILITY AROUND HOST GAMES LOCATIONS

As we look ahead to how continuing weather trends may affect the numbers of climactically reliable locations capable of hosting major winter events, in recent years leading studies have highlighted how event organizers could be faced with a shrinking pool^{22, 23, 24}.

Consequently, they may have to resort to smaller, more remote venues, potentially resulting in a myriad of logistical hurdles, such as insufficient infrastructure, a lack of tourist amenities and lower levels of accessibility²⁵.

The table below from [Scott et al. \(2014\)](#) projects how, using two indicators (probability of a minimum temperature of ≤08C, and probability of a snow depth of ≥30 centimetres with advanced snowmaking), climate change will affect the reliability of previous Winter Games venues to host future

outdoor competitions. By the 2080s in a high emission scenario, only six out of the 19 would remain reliable. That compares to all 19 having suitable climate conditions from the past hosting period represented (1981-2010)²⁶.

Applying the same criteria, Beijing would also fall into the ‘Not Reliable’ category in 2050 and 2080.

This year, another study led by the University of Waterloo concluded that out of the 21 cities to have hosted the Winter Olympics up to 2022, only Sapporo in Japan would have the necessary conditions to host them again in a safe and fair way by the end of the 21st century if there is not a drastic reduction in greenhouse gases²⁷.

SUSTAINABILITY: A VIEW FROM BEIJING 2022

“Beijing 2022 has implemented carbon reduction measures throughout the Games planning period. In the Beijing zone, four competition venues, one non-competition zone and one training venue are the legacies of the Beijing 2008 Games, thereby avoiding additional construction; natural carbon dioxide refrigerant is used at four ice sports venues.

"It is the first time this low climate impact technology has been used in China and at the Olympic Winter Games; all venues are powered by renewable energy; and energy-saving and clean-energy vehicles such as electric vehicles and hydrogen-fueled vehicles will account for 100% of all passenger cars and 84.9% of all vehicles at Games-time.

"Furthermore, carbon sinks generated by afforestation projects in Beijing and Zhangjiakou, together with certified emission reductions sponsored by official domestic partners of Beijing 2022, including PetroChina, the State Grid Corporation of China and the China Three Gorges Corporation, will compensate all residual emissions and ensure a carbon-neutral Games."

Mr. Li Sen

Director General of the Planning Department of the Beijing Planning Committee

CLIMATE SUITABILITY RATING TABLE OF HOST CITIES/REGIONS FOR FUTURE WINTER GAMES [FROM SCOTT ET AL. (2014)]

		2050s		2080s	
	HOST CITY	RCP 2.6 LOW EMISSION	RCP 8.5 HIGH EMISSION	RCP 2.6 LOW EMISSION	RCP 8.5 HIGH EMISSION
	ALBERTVILLE	RELIABLE	RELIABLE	RELIABLE	RELIABLE
	CALGARY	RELIABLE	RELIABLE	RELIABLE	RELIABLE
	CHAMONIX	MARGINAL HIGH RISK	MARGINAL HIGH RISK	MARGINAL HIGH RISK	NON-RELIABLE
	CORTINA D'AMPEZZO	RELIABLE	RELIABLE	RELIABLE	RELIABLE
	GARMISCH-PARTENKIRCHEN	NON-RELIABLE	NON-RELIABLE	NON-RELIABLE	NON-RELIABLE
	GRENOBLE	MARGINAL HIGH RISK	MARGINAL HIGH RISK	MARGINAL HIGH RISK	NON-RELIABLE
	INNSBRUCK	RELIABLE	MARGINAL HIGH RISK	MARGINAL HIGH RISK	NON-RELIABLE
	LAKE PLACID	RELIABLE	RELIABLE	RELIABLE	MARGINAL HIGH RISK
	LILLEHAMMER	RELIABLE	RELIABLE	RELIABLE	MARGINAL HIGH RISK
	NAGANO	RELIABLE	RELIABLE	RELIABLE	NON-RELIABLE
	OSLO	MARGINAL HIGH RISK	MARGINAL HIGH RISK	MARGINAL HIGH RISK	NON-RELIABLE
	SALT LAKE CITY	RELIABLE	RELIABLE	RELIABLE	RELIABLE
	SAPPORO	RELIABLE	RELIABLE	RELIABLE	RELIABLE
	SARAJEVO	MARGINAL HIGH RISK	MARGINAL HIGH RISK	MARGINAL HIGH RISK	NON-RELIABLE
	SOCHI	NON-RELIABLE	NON-RELIABLE	NON-RELIABLE	NON-RELIABLE
	SQUAW VALLEY	MARGINAL HIGH RISK	NON-RELIABLE	NON-RELIABLE	NON-RELIABLE
	ST.MORITZ	RELIABLE	RELIABLE	RELIABLE	RELIABLE
	TURIN	RELIABLE	RELIABLE	RELIABLE	NON-RELIABLE
	VANCOVER	MARGINAL HIGH RISK	NON-RELIABLE	NON-RELIABLE	NON-RELIABLE

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The Paralympic Games, which traditionally occur in the month following the Olympic Games, face even more challenging conditions: the month of March in the Northern hemisphere is fraught with more uneven temperature patterns compared to February.

ARTIFICIAL SNOW ON THE SLOPES AT 2022 GAMES:

- ❖ The host committee estimates it will need around 49 million gallons of water to create snow conditions for Alpine events
- ❖ Beijing one of the world's most water scarce cities
- ❖ Artificial snow planned for use on competition area of around 800,000 square metres, with around 1.2 million cubic metres of snow required
- ❖ Eight water cooling towers required
- ❖ Installation of 130 fan-driven snow generators
- ❖ Use of around 300 snowmaking guns
- ❖ Three pumping stations at different altitudes will feed the snow guns
- ❖ Economic costs of artificial snow (estimates at other sites include \$3 for every cubic metre of snow)
- ❖ IOC bid evaluation document warned that the Yangqing and Zhangjiakou venues “have minimal annual snowfall and for the Games would rely completely on artificial snow”; this differs from previous Games where snowmaking was used to supplement existing natural snow
- ❖ According to bid document, there are no nearby high-altitude locations from which to source artificial snow
- ❖ Alpine ski site is adjacent to the 4,600 hectare Songshan National Nature Reserve, a protected forest ecosystem
- ❖ China hopes to achieve a target of getting 300 million nationals involved in winter sports in the coming years in a 1 trillion yuan (approx. \$157 billion) industry. This would only be feasible if artificial snow use was harnessed across whole seasons and different resorts, dwarfing the use across one event such as the 2022 Games

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SUSTAINABILITY AND THE IOC

- ❖ *The IOC built its Olympic 2020 Agenda on the three pillars of Credibility, Sustainability and Youth.*
- ❖ *A stated objective announced before the UN Climate Conference in Glasgow is to become 'climate positive' (ie saving more greenhouse gas emissions than are being generated) in 2024.*
- ❖ *Starting in 2030, Olympic host venues will be obliged to be climate positive.*

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As well as the implications for federations, ski resorts, spectators, broadcasters and organizers, those who are most affected by the sustainability of snow-based events are of course the participants themselves- from young enthusiasts being coached by their parents to elite athletes vying for Olympic glory.

At the very highest level, more and more athletes are expressing their concerns²⁷ at the increasingly alarming consequences of deteriorating snow conditions.



Philippe Marquis is a two-time Winter Olympian and top freestyle skier. He told this report of his direct experiences of climate change in the mountains.

“All around the world, the snow pack has become more and more unpredictable. The temperature patterns and weather fluctuations have made for inconsistent snow conditions with some intensified gaps.

“When we used to be able to look back at previous years to anticipate snow conditions, it now seems like it's a week-to-week affair. Some weeks are dry, some are wet, sometimes we see abnormally warm temperatures, next thing you know, it's plunging again. All those variations make for general deterioration in the average snow conditions.

“The biggest concerns are around the melting glaciers all around the world. I'm only in my early thirties and I've seen some scary changes in the basic structure of ice formation and the landscape of glaciers. We see more slides (rock, ice, snow), new crevasses, the skiable terrain becomes smaller, and the viable window to ski on those high-altitude glaciers is becoming shorter.

“At resorts, we are highly dependent on artificial snow making. Ice has become more prevalent in places where it had never been a problem. But, most importantly, we are experiencing more drought than ever before. It impacts our water supplies on a much bigger scale.”

For Marquis, the effects of these changes are multiple and manifest themselves in a variety of ways- from the practical (“Finding reliable training and competition facilities has become a real puzzle. Athletes have to be more adaptable than ever before, trying to manage the variable conditions”) to the perilous.

“I've noticed an increase in mental health issues around snow sport athletes. We also see more injuries caused by the lack of practice on snow and the added pressure to perform when there is a window of opportunities. Athletes feel the urge to push their limits even if the conditions are suboptimal.

“The conditions are definitely more dangerous than what we've seen before. From an environmental standpoint, the amount of water required to produce substantial amounts of [artificial] snow to ensure early season venues is mind-blowing. Yes, we've always needed a push from artificial snow making, but we've come to an irreversible crossroad where artificial snow making is now carrying a heavy load. Where will we be in five years? Ten years? Fifty years?

“I am certainly concerned about the athletes' safety down the pipeline. Outside the Winter Games or major events, athletes at a regional or national level don't always have good conditions to work with. That's where I fear the most for some athletes' safety. Not only do younger athletes not have the experience nor the physical abilities to manage deteriorating conditions but they are put in environments that are constantly changing with limited resources. In the long run, with the snow conditions patterns that we are now seeing unfolding in front of us, this is a recipe for increasing dangers.”



Laura Donaldson competed at the Salt Lake City Winter Olympics in 2002. The Scottish freestyle skier told this report of the changes she had witnessed over the decades.

“In my experience, snow conditions have deteriorated in the last few years. I have memories of Scottish winters as a child, sledging on the roads when they were completely covered in a good few centimetres of snow. Nowadays, it is a freak storm like 'the Beast from the East' that might bring those good few centimetres of snow. We used to ski in Scotland regularly at weekends. Nowadays, the snow cannot be relied upon. There are now many more seasons of inadequate snow than there ever used to be in this country.

“Meanwhile, in the Swiss Alps I experienced seasons with inadequate snow like never before. In these seasons, the snow arrived late - perhaps sometime in January. Because there weren't enough layers of snow laid down in early winter, the base never forms properly and a painfully short season follows. As there is no real base of solid ice, the snow that falls later in the season (around Easter) won't stay on the ground for long. Therefore, everything melts early.”

Donaldson has also seen the limitations of relying on man-made snow to resolve the issue in the long-term.

“Some ski resorts have the ability to make snow using machines, but those require low enough temperatures in order to work. Also, the artificial snowflakes they generate have cylindrical structures (unlike the far more intricate structure of natural flakes) which mould together to form

bulletproof ice conditions. While this isn't a perfect situation, it can help to form the solid base of ice the resort needs to support the high numbers of visiting skiers. These poor snow seasons won't last longer than 3 months - from January until the end of March or perhaps mid-April at the latest. In a more typical winter in the Alps (in the 80s-early 90s), the season lasted for 5 months. The first snow would arrive in November, then continue through December and it would last until May. The snow always stays on the glaciers, but the resorts with those are few and the glaciers are decreasing.”

Donaldson too shares concerns around the possible consequences for athlete safety.

“In a poor snow season (of which there are many more) the snow is of noticeably poorer quality underfoot. These conditions can represent a greater danger for athletes, since poor snow quality determines how the athlete skis. It is less stable under the skis and it may not fully cover rocks and plants.

“Jump take-offs can be excessively icy and slippery, bad take-offs directly contribute to bad landings. It is dangerous for an athlete if take-offs and landings are formed from sheets of ice. The ice comes about when there's less snow heating up during the day and melting followed by overnight freezing. If Freestyle super pipes are formed from snow-making machines in a poor season, the walls of the pipe are solid, vertical ice and the pipe floor is solid ice. This is dangerous for athletes, some have died.”



British freestyle champion and Winter Olympian **Peter Speight** told this report that he has experienced “much more frequent warm spells in the middle of winter, with temperatures rising well above freezing in places such as the Alps in Europe and the Rocky Mountains in North America. This not only affects snow conditions, but also shows the direct impact warming temperatures is already having on the most extreme environments.

“There is definite evidence of melting glaciers, such as the glacier in Saas Fee Switzerland. This can not only affect the ability of skiers to use the

glacier, but glaciers are also large holders of water that, when melting, will contribute to sea level rises. Warm spells also create inconsistent snow conditions and unpredictable melting.”

He too explained how excessive reliance on artificial snow is not sustainable.

“It's helpful for creating physical snow for people to use, but it uses large amounts of water and energy and does not help solve climate change. We need to solve climate change at the source (reduce greenhouse gas emissions), rather than rely on mitigation focused solutions.”



And it is not just skiers who are being impacted. **Seyi Smith** is a vastly experienced athlete who has the rare distinction of having competed at both Summer and Winter Olympics, first at the London 2012 Games as part of the Canadian 4x100m relay team before making the switch to bobsleigh. His four-man crew finished 6th at the PyeongChang Games in 2018. Smith has the added insights of working in sustainability as the founder of Race to Zero YYC, an IOC-sponsored project through the Young Leaders program.

Smith told this report that although snow conditions do not directly affect bobsleigh, he too has noticed how changing weather conditions are having an increasing impact on issues such as competition scheduling and preparation. For example, *“The start of the sliding season [being] pushed later into the year due to warmer than normal temperatures in the fall”* and *“More reliance on artificial measures to create and maintain good quality ice for training/competitions”*.

According to Smith, warmer weather can undermine the quality of a track, which in turn can also take a toll on athlete welfare as *“Exceptionally bumpy ice surfaces do increase the*

risk of concussions (not acute but from repetitive runs down poorly maintained surfaces)”.

Additionally, *“Erratic ice conditions impact the quality of competition as facility crews must constantly adjust to maintain good quality ice surfaces”*.

As someone who has straddled both winter and summer sport at the highest level, Smith is acutely aware of what is at stake as a result of warmer weather. For, as well as the absorbing pursuit of excellence, sport is about sharing experiences and harvesting memories. He cites the case of the natural bob track in St. Moritz, Switzerland, as an example of what might be lost to future generations of bobsledders.

“As temperatures rise, it is unlikely races will continue at that location indefinitely unless they switch to an artificial surface, which is highly unlikely. All athletes agree that sliding on the St. Moritz track is beautiful compared to artificial tracks - so in the bobsledding world, the use of artificial ice conditions is not the remedy as it comes with its own issues. Poor quality sliding, the use of refrigerants; I see it as bad for the athlete experience and obviously bad for the environment.”



Jessica Jislová is a talented Czech biathlete who made her Olympic debut at the 2018 Games in South Korea. As a competitor in a sport in which cross-country skiing plays a pivotal role, she told this report that she had noticed a pattern of unstable winter weather and the accompanying decline in snow conditions in recent years.

“I feel like winters are more unpredictable now. It is difficult to estimate where and when good snow conditions for training camps will

be, especially at the beginning of November. A lot more competitions are on artificial snow. And also I think the weather changes are a little bit more extreme.

“The extreme weather changes can be dangerous for athletes. When one week you are racing in -20°C and next week in +5°C, your body is under a lot of pressure trying to adapt. In my opinion, athletes can be more prone to illness, colds or flu.”



Andrew Kurka is one of the world’s finest para-alpine skiers, having won the gold medal in the downhill event at the 2018 Paralympic Winter Games. He has also noticed the impact of significant weather changes in a variety of regions, telling this report that he feels snow conditions have been diminished *“mostly due to the oddly inclement weather in different locations”*.

“It’s always been difficult to get consistent conditions but as I’ve been racing it seems more difficult with less snow coming later

in the year, less consistently. It seems to me that the increased importance of man-made snow, especially in early season training, has become exceedingly more prevalent in my sport. Glaciers are melting and snow seems to typically come later in the season.

“It seems that more and more competitions are getting cancelled regularly. Which is extraordinarily tough for me, because I’m a speed skier and being a speed skier but not having speed races is difficult.”



Zoë Gillings-Brier is the only British snowboarder to have competed at four Winter Olympics. Her experiences in qualifying for and participating at consecutive Games from 2006 to 2018 give her a special insight into the deteriorating conditions, as she told this report that the situation had worsened in the past two decades.

“There is less snow fall than there was 20 years ago and more competitions are cancelled due to lack of snow”, with “smaller glaciers to train on” and “less training in the Summer”.

As well as underlining the requirements for the creation of fake snow (“You can only make artificial snow if it’s cold enough to do so”), Gillings-Brier also added that, *“Artificial snow is less forgiving if you fall”*.

Ultimately, her key message was aimed at politicians around the globe.

“Governments from all countries in the world have to make real changes to use more green energy. Now.”



THE RISKS OF ARTIFICIAL SNOW:

- * Artificial snow can create a faster surface
- * Artificial snow fashions a harder surface, creating a risk of more severe injuries when falls do occur
- * Artificial snow is almost 30% ice and 70% air, compared to natural snow which is closer to 10% ice and 90% air thereby creating a grittier snowpack
- * The chemical composition of artificial snow can decrease biodiversity and disrupt vegetation
- * Artificial snow remains on the ground longer in the melting season, delaying plant growth underneath the snowpack
- * The production of artificial snow can increase runoff in the melting season, which can lead to higher peak flows (with potential for flooding) and disruption in watersheds
- * The noise of snow cannons at night can be harmful to local wildlife

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KEY RECOMMENDATIONS

From grassroots to the highest levels of competition, the winter sport community is a global one, encompassing local clubs, national federations and international organising committees.

With warmer temperatures forging an entrenched long-term pattern, winter athletes and the dedicated followers of snowsports around the world will continue to witness first-hand how the effects of snow deterioration can create a blizzard of disruption, danger and environmental damage. The future of winter sports and the most cherished and prestigious competitions are at risk²⁸.

As the number of climactically suitable host venues for high-profile events dwindles over the coming decades²⁹, education and action must be undertaken by winter sport stakeholders now if the efforts to highlight and counteract the fast retreat of snow, ice and traditional winter conditions are to garner success.

Measures recommended by scientists, athletes and experts include:

- ✱ Further sharing of resources, education and information around snow conditions and training/competition environments.
 - ✱ Detailed and transparent assessments undertaken of the ecological and economical effects of using artificial snow on a mass scale.
 - ✱ A greater level of discussion and dialogue around the suitability of different host locations in order to maximise event sustainability and safety.
 - ✱ Increased climate consideration and planning by event organizing committees.
- ✱ Further research undertaken into the potential impacts of mass artificial snow use on athlete welfare.
 - ✱ Sports incentivised to explore ways of reducing carbon footprint.
 - ✱ Even greater scrutiny and assessment of sustainability credentials as part of host venue bidding process.
 - ✱ Further development of post-event systems to monitor and evaluate the success of the implementation of sustainability plans for longer periods to ensure the environmental legacy is maintained.

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