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# Ski Resort Closures and Opportunities for Sustainability in North America

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**Abstract:** More than half of the ski resorts in North America have closed since the early building booms—many facing a warming climate and pressures to find water to make artificial snow. Researching and documenting all resorts between 1969–2019, we find that 59% of all resorts in North America have closed since the resort boom of the 1960s and 70s (65% in the United States, 31% in Canada). This shift has left some states or provinces with only one or no resorts remaining. To proactively persevere with a variable climate, less water, and a need for more energy to make snow, we suggest mountains holistically plan for sustainability. Recommendations include third party environmental certification, commitment to sustainability at the management level, communication to customers about sustainability practices and implementing unique models for remaining open and competitive. These practices include resort consolidation, multi-mountain passes, and/or unique ownership models. We believe that ski resorts must focus on positive environmental practices, sustainability planning, and climate change adaptation if they want to remain viable and competitive in the coming decades.

**Keywords:** ski resorts; sustainable skiing; climate change; mountain development; winter tourism



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## 1. Introduction

Snow skiing is a popular winter recreational activity which brings an influx of visitors to rural or remote mountain regions. These resorts often provide an economic stimulus and diversify the regional economies. Colorado, for example, estimates the industry generates USD 4.8 billion in annual economic output, supports 46,000 year-round equivalent jobs, and accounts for 8% of flights into the state's largest airport [1]. While the economic impact is significant, construction, operation and the visitor influx can negatively impact the local environment. In response to these effects and increased concern for the environment, resorts face many new responsibilities and costs which threaten their long-term viability. Resorts must now manage waste, water, wildlife, and soil, while also holding expensive insurance to remain open. These responsibilities have created a very different industry from the 1960s and 1970s during the early resort boom. In addition to environmental regulations, many resorts must now adapt due to climate change and the continuously higher demands from consumers. Climate change has created challenges for many resorts, especially those at lower elevations and latitudes. Furthermore, tourist demands have increased, with visitors expecting longer seasons, excellent snow conditions regardless of the weather, and a standard high quality product. To meet these demands, resorts must have a significant amount of water and energy on reserve to make snow. These factors combined require resorts to produce more man-made snow, adding to the existing economic pressures on the resort.

We identified only one other study, conducted only in New England through 2007, that found that resorts closed for a variety of reasons including: increased insurance costs, defaulting on loan payments, a changing market structure, limited snowmaking, and inconsistent weather patterns associated with climate change [2]. Our hypothesis is that ski

resorts, specifically in North America, must adapt or close down because of environmental regulations, climate change, and consumer expectations. Our research evaluates the literature with respect to the environmental impacts and sustainability of ski resorts and further identifies, quantifies, and maps the resorts that have closed in the United States and Canada since the ski resort boom of the 1960s and 1970s. In addition, this paper discusses some unique models for resorts to continue to operate and remain competitive. These practices include resort consolidation, multi-mountain passes, and/or unique ownership models. We believe that ski resorts should take environmental considerations, sustainability, and climate change adaptation seriously to remain economically viable and competitive in the coming decades.

## 2. Literature Review

### *2.1. History of Skiing and Ski Resorts*

Skiing started and evolved in Scandinavia. Firstly, as a form of transportation as early as 2000 B.C. Next, as a military tool in snow covered areas. Thirdly, Scandinavia was the first to introduce downhill ski racing as a sport, downhill racing, in the late 18th century. As the efficiency and technique of using skis continued to progress, skiing expanded to the rest of the European continent and the world. The first Winter Olympic Games in Chamonix, France, in 1924, gave wide exposure to competitive downhill skiing and started a new era of snowsports [3]. Many more Olympic games and events have followed, which has increased skiing's popularity and led to a significant boom in resort construction, especially in North America.

The Olympic events led to a major increase in the number of skiers and encouraged a rush of technology into the industry. Early improvements included primitive ski lifts, both T-bars and rope tows, and then eventually more advanced chair lifts, which improved efficiency and speed to move skiers from the bottom to the top of the mountain. This revolution started in 1936 at Sun Valley Resort in the United States (US). Subsequently, these technological advancements have created a massive patchwork of resorts offering skiing, dining, lodging, and entertainment at mountain destinations. Following Sun Valley, many more ski resorts were quickly built across the United States and around the world [3]. Between 1960 and 1970, 925 ski resorts were built in the United States (725) and Canada (200) [4]. This resort construction boom peaked and began to decline in the 1980s and 1990s.

More recently, the growth in the ski resort industry has slowed and has declined. By 2021, the industry was left with only 462 resorts in the United States. However, these resorts bring in 10.5 million skiers and snowboarders each year [5], valued at 3.1 billion US dollars [6]. Skiing is an economic engine, especially for rural destinations. The remaining resorts now face new challenges from climate change and from regulations trying to minimize environmental impacts on these semi-wild places. To remain progressive, competitive, and in compliance, many ski mountains now include sustainable development and environmentally friendly operations within their strategic plans and their bottom lines. However, these initiatives are often expensive [7,8] and multi-faceted, thus threatening their continuation. Ski resorts must consider environmental criteria and rules with respect to erosion, water, wildlife, chemicals, energy, vegetation, and climate change if they want to achieve sustainability in their operations.

### *2.2. Snow Resort Impacts on the Environment*

Ski resorts have significant negative impacts on the environment. Many mountains must mechanically alter the landscape of their local environment. These efforts create manicured ski slopes, which can then offer a longer ski season and allows the resorts to profit from natural or artificial snowfalls [9]. Developing new ski pistes (trails) can seriously degrade soil, kill vegetation and negatively impact wildlife habitat [10]. The Institute for Snow and Avalanche Research found that machine grading contributed to an increase in soil density by 30% [11] to 50%, an increase in pH, and a decrease in total nitrogen [12]. The combined effect of tree clearing, road construction, snowmaking and machine grading

leads to compaction and subsequently a cycle of runoff and sedimentation. Any water that cannot infiltrate into the soil becomes surface runoff and takes loose soil with it [13], often into local pristine waterways. Suspended sediment yield has been found to be two and a half times greater from ski resort development [14]. This erosion undercuts banks, deposits sediment into natural streams and increases the velocity of existing and new stream channels [15]. Furthermore, the construction of ski runs reduces the water holding capacity, organic carbon and total nitrogen in soils [16] and has the potential to pollute lakes in boreal and alpine regions [17].

Over time, the soil loss and machine grading of slopes negatively affects vegetation. Normally, plants act as a wind trap and root stabilizer; however, the degradation of the undergrowth precipitates even more damage [18]. Grading inhibits additional re-vegetation in the area [19]. Of course, best management practices for piste creation are possible. These include water bars directing water off the piste, seeding the disturbed area immediately, spreading hay, which can prevent splash erosion from heavy rain events, and minimizing machine grading and fertilization during the construction or maintenance of pistes [20,21]. Many pistes can be constructed by clearing and cutting and avoiding the impacts of leveling the soil with heavy equipment, also known as machine grading [22]. Limiting the width of trails and promoting more natural glade skiing will help prevent habitat fragmentation and maintain the health of vegetation and wildlife [23]. Resorts can use mulching, different types of sediment mats, especially those made from jute or coco. The overall goal is to minimize erosion and maintain as much plant cover as possible [24]. If negative effects are already significant, restoration measures have been proven to stop degradation and rehabilitate the appearance and function of the landscape [25].

Vegetation is also impacted by artificial snow. Human-made snow is denser than natural snow and can cause the melting process to be delayed by two [26] to four weeks [27], thereby affecting the timing of plant growth [28]. This delay in plant growth affects the wildlife that relies on this early growth for food. The human-made snow can lead to frost damage, oxygen deficiency, infection by pathogens or bacteria, a delay in plant development, increased $CO_2$ levels, and damage to the tissue of plants. Artificial snowpack affects plant species with a 5% reduction in oxygen levels, an 8% increase in $CO_2$ and thermal conductivity twice as high as natural snow. This creates heat below the snowpack and greater rates of runoff, erosion and loss of vegetation [29]. Humans add to this late melt and impact the plant life with more skiers and their desire for a longer skiing season.

With more skiers and artificial snow, the vegetation (plants and trees) is reduced, and this negatively impacts the species that rely on this for food and shelter. There is often an edge effect for the vegetation along the piste, further creating land fragmentation [23,30] and damage to the alpine and sub-alpine ecosystem. This sensitive environment is home to many plants and endemic species [31]. Studies have found that fragmenting, through the alteration to create ski pistes, has a negative impact on arthropods, small mammals, and endangered species [32,33]. In addition, expansion of ski pistes can have a negative direct effect on alpine birds [34], beetles, insects [35], and reptiles [36]. Many resorts try to mitigate this impact. Some will voluntarily protect migratory species in their wintering grounds by raising funds and protecting lands [37], or through year-round monitoring programs [31]. Aside from these on-site impacts, there are considerable effects from the water and energy required to keep these large resorts running.

### *2.3. Snowmaking, Energy, and Waste Management—Problems and Solutions*

Resorts can no longer rely exclusively on natural snow. There are environmental drains when resorts must make snow, harness more energy, and remove waste. Because of the longer season and increased use of snowmaking, resorts have begun to counteract these problems by implementing small-scale sustainable solutions. Of particular importance is the ability to produce human-made snow and capturing water on or near the resort. Today, almost all ski areas in the United States use snowmaking to some extent. Manmade snow cover on skiable terrain ranges from 62% in the Northeast to 98% in the Midwest.

An average-sized ski area can use 10,000 gallons of water every minute when it needs to achieve good coverage on the mountain [38]. This water is usually withdrawn from local water bodies and can impact the ecological health of a lake or river.

Some localities and states have set standards for mean water flows, forcing creative technical solutions by mountain managers. In Vermont, the Okemo ski resort constructed a reservoir to store water during the summer and spring months to be used when local water bodies drop below the critical level. In New South Wales, Australia, a new cloud seeding initiative attempted to increase snowfall by 10%. Unfortunately, the year the government financed the program, with an AUD 15 million investment, the project failed. In fact, there was a 1% per year decrease in snowfall that year. As climate change precipitates, the mountains will see warming temperatures, greater snowmelt, and more severe runoff [39]. The changing climate will require more snowmaking, and this will also result in more energy usage to power these snowmaking machines [40]. However, snowmaking will not be able to solve the climate problem for all ski resorts. After a climate change of +2 °C, snowmaking cannot be the only strategy [41].

Resorts need to focus on all aspects of energy usage in addition to snowmaking. Ski resorts need energy not only for snow production, but also lighting, powering lifts, and for all accommodation, retail, and restaurant needs. However, the most energy is used to power compressors for snowmaking [42]. Snowmaking accounts for approximately 67% of all use [43]. Researchers estimated that between 2007 and 2020, given climate conditions, an additional 11–27% of snowmaking capability was needed to offset the loss of natural snow [44]. Though different types of snow guns can reduce the amount of energy used, the added pressure to make more snow still places added economic stress upon resorts [42]. Focusing on solutions, by improving systems and through strong leadership, resorts can reduce the financial stress and become more sustainable.

Mountains can replace incandescent bulbs with LEDs and upgrading light ballasts can improve building energy efficiency by up to 40%. Additionally, resorts can upgrade T12 light fixtures to T8 fixtures. Furthermore, resorts can upgrade their traditional switch lighting systems to automated sensor lighting. Additional benefits can come from heating and insulation upgrades too. To reduce energy consumption, heating timers were installed throughout the resorts in Utah and employees closely monitored temperatures within the lodges [45]. In addition, resorts can use energy audit systems and build new renewable energy installations. However, this can result in extra costs when compared to grid rates [46]. On-site or regional renewable energy projects are also an option and many resorts have already let customers know about their sustainable goals and initiatives on their websites, have signage throughout the resort, and update consumers on their progress or their plans for sustainable strategies [47]. This often includes practices surrounding waste management and recycling.

Many resorts are getting creative in managing the extraordinary amount of visitor waste. Winter Park Resort, Colorado, places recycling bins in every room of their lodges and positions recycling bins on the mountain. Vail Resort, also in Colorado, has a strong initiative to improve recycling, with signage around the resort. They have also partnered with the local county and organized commingled recycling to increase capacity. As part of the agreement with the county, Vail has purchased compactors, bulb eaters, and a can-puncturer to prepare materials for off-mountain transport [46]. At Whiteface Resort, New York, recycled materials are used in all the lodges. This includes everything from beer cups to napkins—the materials can all enter the single-stream recycling bin. Whiteface Resort purchases these materials from Domtar. Domtar produces a line of products called "EarthChoice". These products consist of papers, recycled cardboard, cups, plates, and envelopes [48]. Telluride Resort in Colorado also uses recycled materials within their lodges. The resort uses recycled paper materials as well as bio-degradable plates, cups, and utensils, which are composted [49]. Winter Park Resort was able to negotiate a deal with a local pig farmer [46] to pick up all compostable food waste. Many other resorts have begun to implement positive waste management strategies. However useful these

environmentally responsible strategies are with respect to snowmaking, energy and waste reduction/removal, they are small solutions. The largest issue facing resorts are the effects of climate change.

### *2.4. Climate Change and Tourism Behavior*

Climate change is the largest factor impacting ski resorts achieving sustainability. In Europe, North America, South America, Asia and Oceania, the industry and the tourists notice a reduction in natural snow. Annual snow cover in the northern hemisphere has decreased by about 10% since 1966 and models predict future losses from reduced ski days (an important metric in the industry) are larger than all of the existing ski ticket sales [50]. For those resorts with natural snow, there is wide variability in natural snowfall and the length of the season is contracting [51]. This warming results in an increased temperature at high altitudes and often greater precipitation, but more as rain rather than snow [52]. The irregularity also creates challenges for consistent snowmaking [53], and cold temperatures are required to make snow.

Other climate studies have shown stronger snowstorms are on the horizon; however, they manifest less often or for a shorter season [54]. Additionally, while predicted warming will likely affect only the lower altitudes of ski resorts in the short term, higher altitudes will experience stronger winds, which could result in more lift closures [53]. Other models predict that long-term impacts (100 years) will shorten the season to half as many viable ski days [55,56]. Some mountains are already covering large parts of glaciers in the summer with technologically advanced protective textiles to reduce melting [57]. This climate change will force many mountain ski resorts to rely on more than 50% of their snow from artificial sources to maintain their tourist visitor days.

In addition to climate change, tourism trends, prestige, and competitive advantages are changing the industry [7]. The changing climate will likely create new patterns of travel flow as ski customers travel to new ski regions for better reliability and perceived quality. Some resorts will see increases in customers, while others will see their visitor numbers dwindle [58]. Overall, it is predicted that many mountains at a lower elevation and latitude will have reduced season length, a greater need for snowmaking, challenges to be open during the important December-January holiday period, overall reduced revenue, and possible closure [59,60]. Our study specifically focuses on the closure of ski mountains since the boom of the 1960s and 1970s through 2018.

## 3. Materials and Methods

To compile the data for closed ski resorts, we used various data sources including data in books, magazines and internet sources. The main source includes a data collection of all resorts listed between 1969 and 2019. We specifically compare all resorts still operating between the 4th (1979) and 22nd (1997) editions of *The White Book of Ski Areas: U.S. and Canada*, as well as the September 1969 edition of *SKIING Magazine*, which has a comprehensive list of all resorts in the USA and Canada. We then confirmed their continued operation in the most recent manual of the White Book and with an internet search (2019). In addition, we searched every resort's website to confirm current operations. If a ski area was discovered on the Internet, but not in any of the texts, we searched for corroborating evidence of operation. If a resort no longer had a website and was no longer listed in any book or manual as operational, we searched for news articles indicating the resort had indeed closed, was purchased by another resort, or if there was a possible name change.

We then performed a data analysis. Our analysis includes identifying all open and closed ski resorts in every United States state and Canadian province where skiing exists between the study period of 1969 to 2019. We also identify if a state or province has lost all remaining ski resorts or has only one more ski resort remaining. Furthermore, we use the ArcMap Geographic Information Systems tool to develop a visual representation of number of ski areas closed in each state, ski areas closed in each province, ski areas open in each state, and ski areas operating in each province presently.

Our methods also include data collection and representation of alternative ski pass models. First, the multi-mountain ski pass sale/phenomenon that has accelerated over the past 5–10 years. Second, the alternative (or creative) model for ski resort management/competitiveness. With so many ski resorts closing across North America, alternative models of management, pass sales, climate change adaptation, and sustainability will be required.

## 4. Results

We found that, at the beginning of the study period, North America had a combined total of 1840 ski resorts operating. As of 2019, 1079 ski resorts (59%) have since closed. Of those closed resorts, 970 were in the United States and 109 were in Canada (see Table 1). There is significant variability by state and/or province with no discernable state/province/administrative pattern.

**Table 1.** Summary of findings North American Ski Resorts (changes from 1969 to 2019).

| Country | OpenSki Resorts (2019) | Closed Ski Resorts (1969–2019) | % Ski Resorts Closed (1969–2019) |
|---|---|---|---|
| USA | 520 | 970 | 65% |
| Canada | 241 | 109 | 31% |
| North America Total | 761 | 1079 | 59% |

Our research found only six states (Delaware, Florida, Louisiana, Mississippi, Oklahoma, South Carolina) and one province (Nunavut) never had an official ski resort during the study period. However, during this period, an additional six states (Arkansas, Georgia, Hawaii, Kansas, Kentucky, Nebraska) closed their only existing resorts. Now, 12 states have no ski resorts. No other Canadian province closed all remaining resorts. In addition, at the time of research, there are five states (Alabama, Maryland, Rhode Island, Tennessee, Texas) and two provinces (Northwest Territories and Prince Edward Island) with only 1 resort remaining. Details of state/province/territory data can be seen in Table 2.

Resorts closing in southern, or warmer, states, such as South Carolina (2) or Hawaii (1), may seem normal given the already warm climates; however, many historically cold-weather and northern states have had significant closures as well. New Hampshire closed 118 resorts, Alaska 36, Colorado 75, and New York closed 125 ski resorts. This is far more than the number that are still open in those states. Visual representation of all resorts that closed in the United States and Canada can be seen in Figures 1 and 2.

**Table 2.** State/Province/Territory of open and closed resorts (between 1969–2019).

| State/Province/Territory | Open | Closed | State/Province/Territory | Open | Closed |
|---|---|---|---|---|---|
| [X] Alabama | 1 | 0 | North Carolina | 6 | 6 |
| Alaska | 14 | 36 | North Dakota | 4 | 4 |
| Arizona | 3 | 2 | Ohio | 5 | 8 |
| [#] Arkansas | 0 | 1 | * Oklahoma | 0 | 0 |
| California | 32 | 30 | Oregon | 13 | 5 |
| Colorado | 32 | 75 | Pennsylvania | 26 | 63 |
| Connecticut | 5 | 28 | [X] Rhode Island | 1 | 4 |
| * Delaware | 0 | 0 | * South Carolina | 0 | 0 |
| * Florida | 0 | 0 | South Dakota | 3 | 2 |
| [#] Georgia | 0 | 2 | [X] Tennessee | 1 | 0 |
| [#] Hawaii | 0 | 1 | [X] Texas | 1 | 0 |
| Idaho | 19 | 13 | Utah | 14 | 6 |
| Illinois | 7 | 6 | Vermont | 30 | 75 |
| Indiana | 2 | 7 | Virginia | 4 | 6 |

**Table 2.** *Cont.*

| State/Province/Territory | Open | Closed | State/Province/Territory | Open | Closed |
|---|---|---|---|---|---|
| Iowa | 4 | 16 | Washington | 18 | 7 |
| # Kansas | 0 | 1 | West Virginia | 5 | 8 |
| # Kentucky | 0 | 1 | Wisconsin | 35 | 44 |
| * Louisiana | 0 | 0 | Wyoming | 11 | 5 |
| Maine | 23 | 33 | Alberta | 35 | 12 |
| X Maryland | 1 | 7 | British Columbia | 41 | 20 |
| Massachusetts | 15 | 92 | Manitoba | 8 | 4 |
| Michigan | 45 | 54 | New Brunswick | 4 | 1 |
| Minnesota | 22 | 25 | Newfoundland and Labrador | 4 | 1 |
| * Mississippi | 0 | 0 | X Northwest Territories | 1 | 0 |
| Missouri | 2 | 4 | Nova Scotia | 4 | 1 |
| Montana | 17 | 15 | * Nunavut | 0 | 0 |
| # Nebraska | 0 | 2 | Ontario | 56 | 40 |
| Nevada | 5 | 4 | X Prince Edward Island | 1 | 0 |
| New Hampshire | 30 | 118 | Quebec | 83 | 23 |
| New Jersey | 3 | 19 | Saskatchewan | 5 | 7 |
| New Mexico | 10 | 10 | Yukon | 3 | 0 |
| New York | 51 | 125 | | | |

* No resorts found in state during study period. # All resorts in state closed during study period. X Only one resort remains.

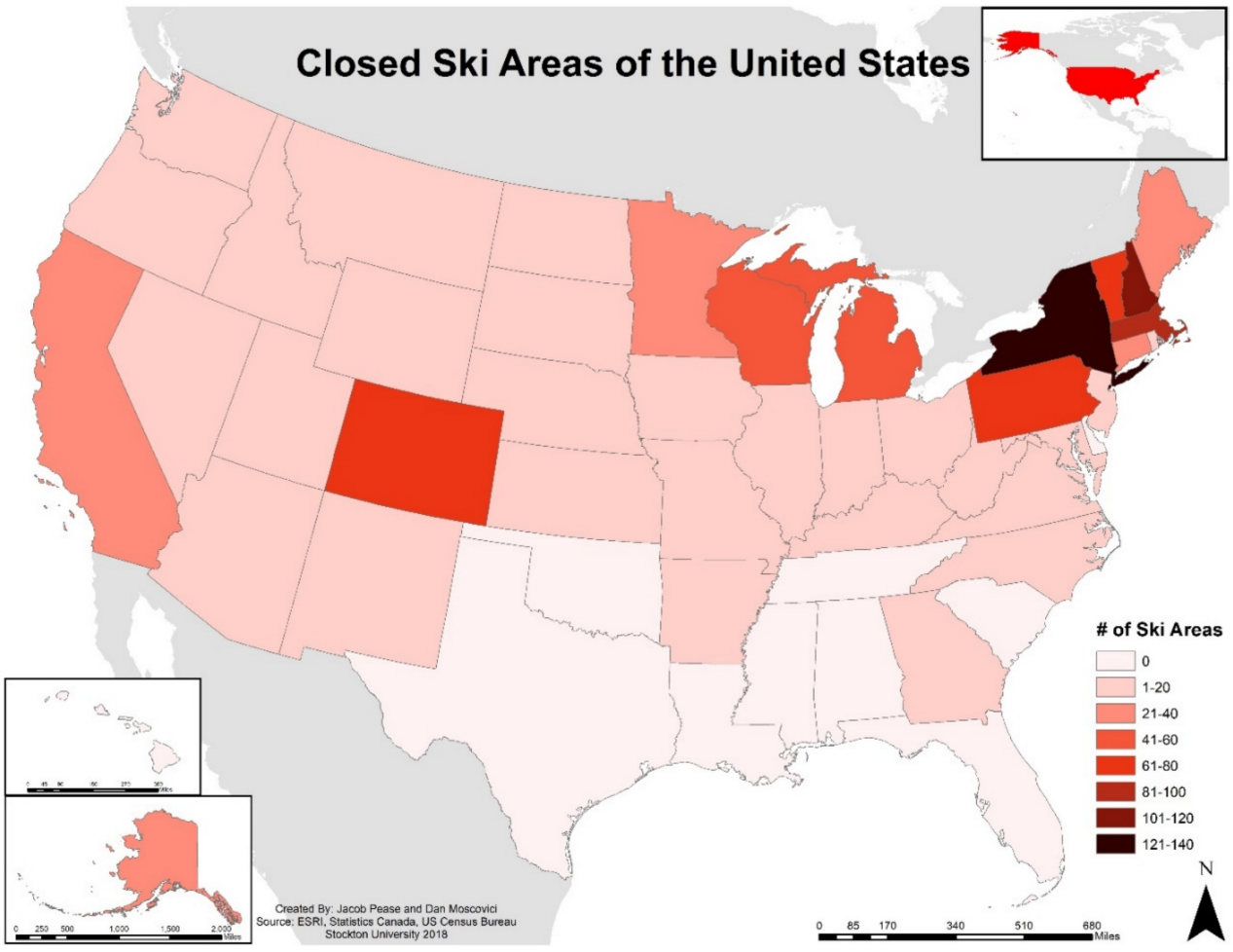


**Figure 1.** Number of ski resorts of the United States that were closed during the years 1969–2019.

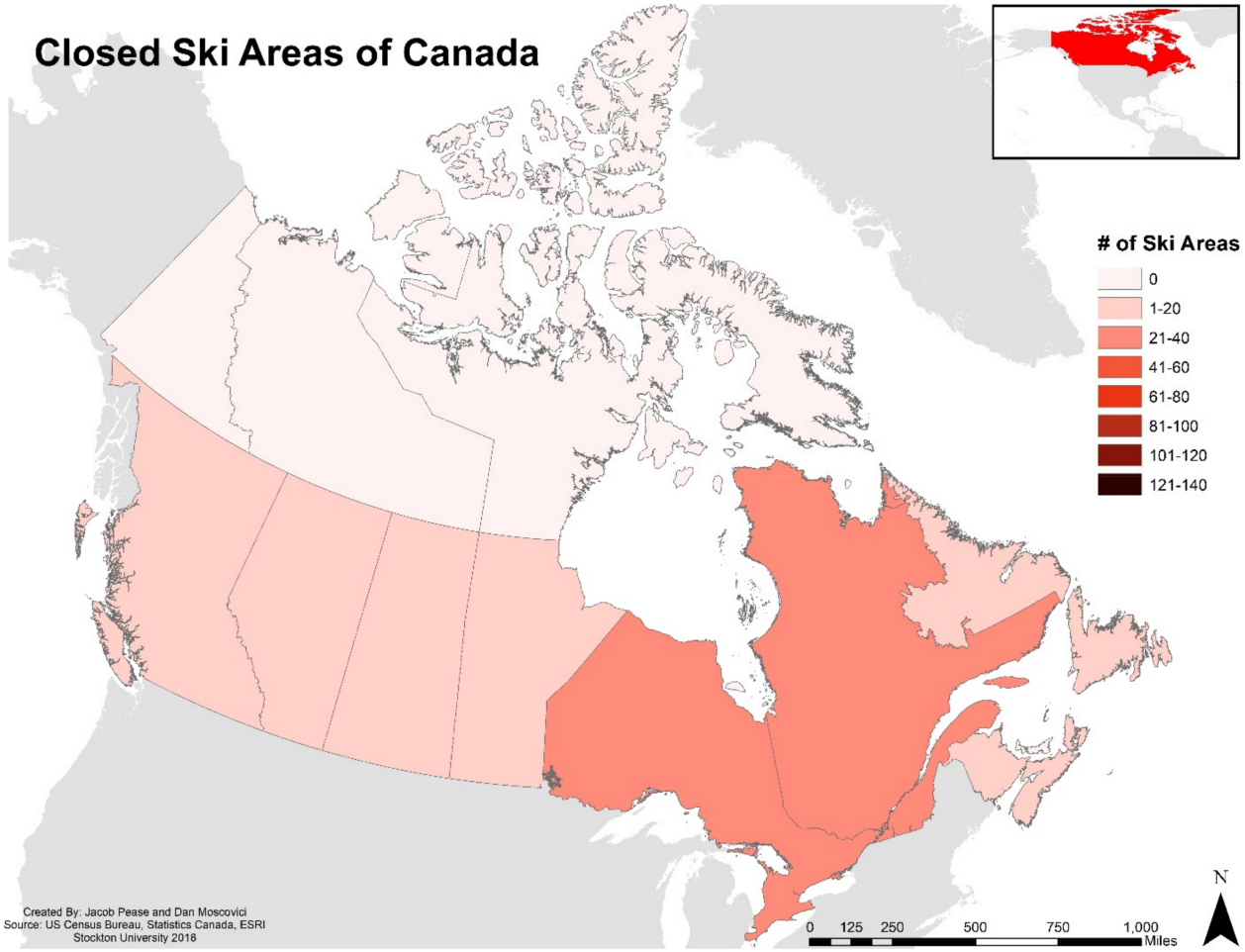


**Figure 2.** Number of ski resorts of Canada that were closed during the years 1969–2019.

Looking more closely at the news and historical stories from a few of the resorts, we learn that environmental conditions and climate change are indeed factors leading to many of the closures. Mont Blue, the only ski resort in Kansas, required a significant investment in snowmaking and water to be successful. Even with a conditional approval for water withdrawals from the Kansas Water Resource Division, the resort was not able to remain open past 1986 [61]. Oregon Ridge in Maryland had close proximity to the Washington, D.C. market, yet closed because the climate was not cold enough to support consistent snowmaking [62]. Marshall Mountain (Montana) also closed in 2002 due to the changing climate and unreliable snowfall [63]. In Virginia, Cascade Mountain closed in 1985 due to the lack of natural snow and warmer winter temperatures [64]. The stories of how these mountains closed are found in newspaper archives, historical land records, and internet blogs. These closures are linked to climate change and an inability to achieve a sustainable balance.

## 5. Discussion

### *5.1. Solutions: Sustainability Teams and Eco Certification*

The research found that 59% of ski resorts (more than 1000) have closed in North America (65% in USA, 31% in Canada) from the time of the early resort building booms. Aside from a few cases, we did not identify the reason every mountain closed—it was not an original research question in our study. We believe that the impetus for closure should be a priority research area for the more than 1000 resorts that closed in North America.

Nevertheless, we find there are closures across the entire continent and there is a shift in which states/provinces have the most resorts across North America. Historically,

the highest number of resorts appeared in the states of New York and New Hampshire. However, presently, no US state has retained as many as Quebec and Ontario, with 83 and 56 open resorts, respectively. Given the significant percent difference in closed resorts, it is possible that, long-term, Canada will be able to maintain more of their ski resorts and become the future leader in North America. While latitude and colder weather could position Canadian resorts with a competitive advantage, long term, sustainability initiatives will also be a factor.

Many ski resorts have already shut down. Proactive strategies may keep many more from closing in the coming decades. To stay in business, the existing resorts in North America (Figures 3 and 4) must devise sustainable models and practices to remain in business [60]. Options to remain competitive from an environmental and sustainability perspective include: developing sustainability initiatives, becoming certified by a third-party environmental certification, incorporating new technology to make snow with less water and energy, devising new modes of collaboration between resorts, or creating unique ownership models to counter rising costs.

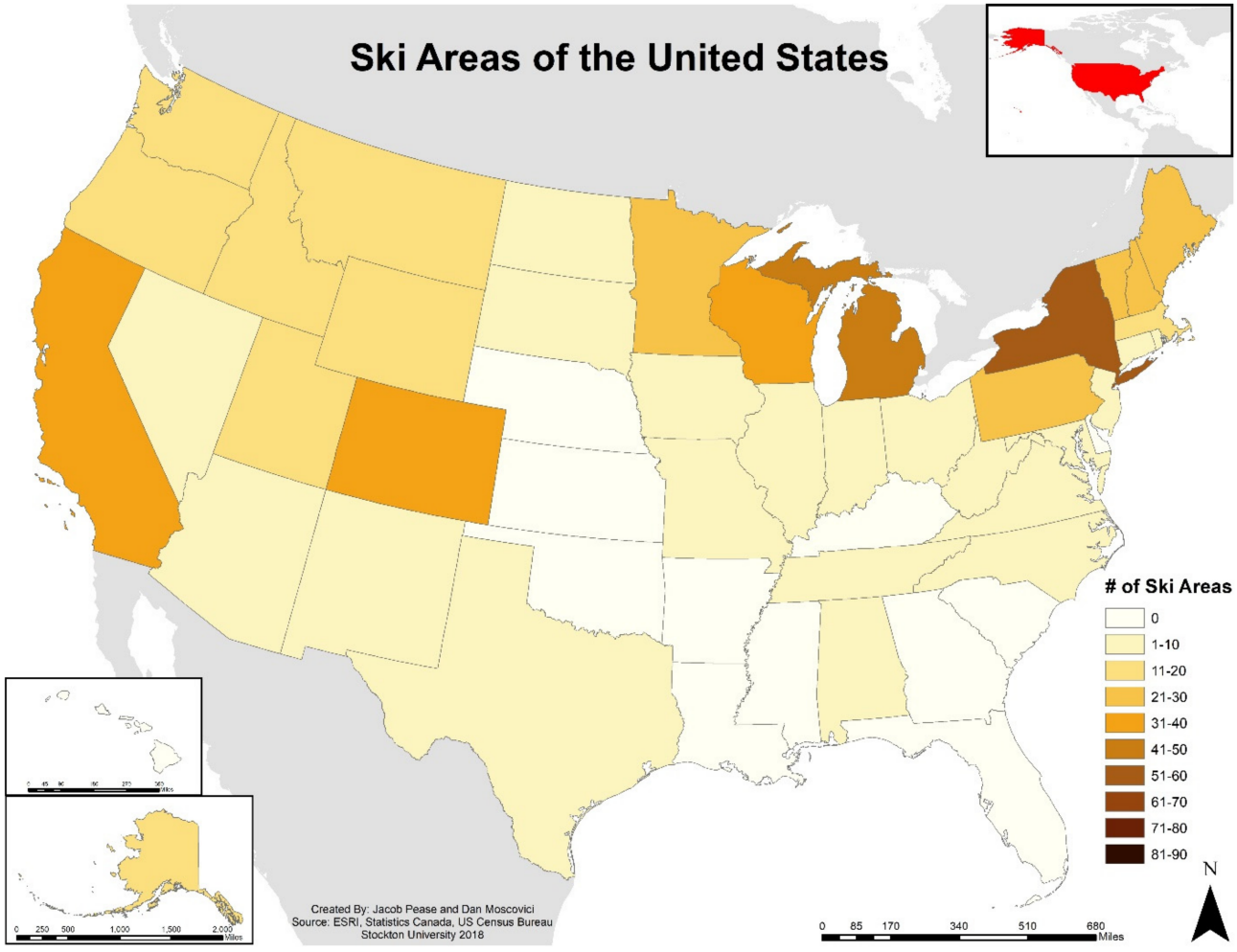


**Figure 3.** United States ski resorts in operation in 2019.

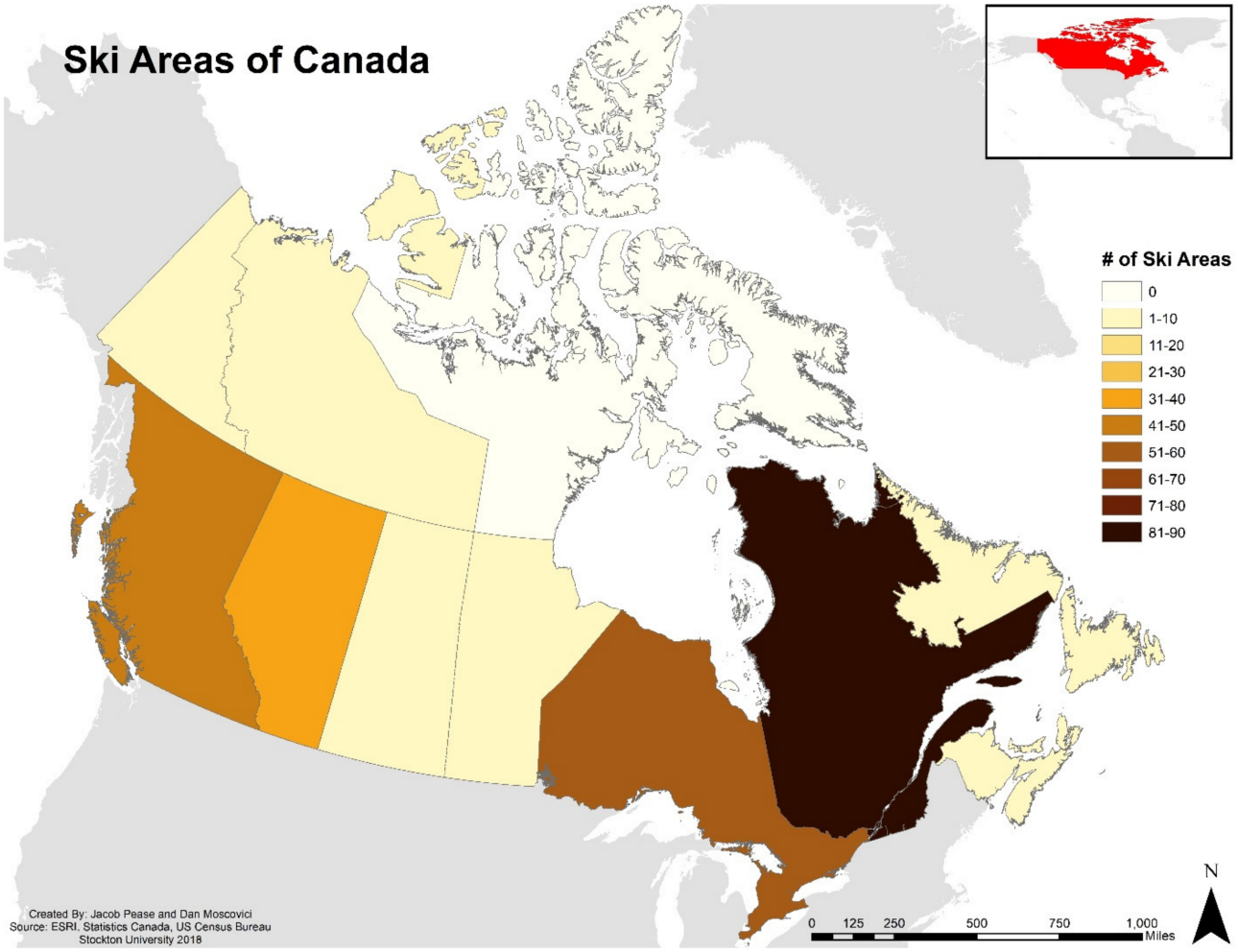


**Figure 4.** Canadian ski resorts in operation.

To reduce environmental damage and keep costs lower, some resorts have committed to sustainability and have hired individuals or teams that focus exclusively on sustainability initiatives and climate change adaptation [65]. The new management position of Director of Sustainability at Snowbird in Utah is charged with reducing the carbon footprint, improving air and water quality, and engaging with the community, employees and guests [66,67]. Vail Resorts also has hired a Senior Director of Sustainability, whose job is to implement initiatives on all of the mountains they own. Ski resort companies will need to hire professionals to manage the environmental side of ski operations. Furthermore, these individuals should work with the existing environmental management systems (eco labels, environmental certifications, sustainability systems) to achieve sustainability goals.

There are multiple existing eco-labels from which a mountain can choose to implement substantial changes to their operations to increase sustainable practices. The Environmental Management Systems (EMS) is a self-evaluation and self-improvement tool for business, environment, and society [20]. The United States National Ski Areas Association (NSAA) has agreed to an Environmental Charter which encourages proactive environmental stewardship [68]. They also have a Climate Challengers group through the Sustainable Slopes Program. This is a voluntary program used by the US National Ski Areas Association in partnership with the federal and state agencies. [69,70]. Additionally, grants are available to support resort sustainability projects. More than USD 523,000 in cash and in-kind grants has been awarded to further sustainability in the industry [71]. Through these programs, it is recommended that resorts focus on substantive changes and not solely on programs that will create a new image or green-washing [72].

Other certifications include the Alpine Pearls, which focuses on transportation as a way for mountain municipalities to deal with climate change in the Alps, if communities in all countries in the Alps—Switzerland, Germany, Austria, France, Italy and Slovenia—are enrolled. There is also Flocon Vert, developed by the Mountain Riders Association and used as a way for mountains to have sustainable development—mostly in the Swiss and French Alps. Green Globe, another accreditor, is more broadly for sustainable travel and tourism. It is based on the ISO certifications and only one ski resort in France has adopted the strategy [73]. The Environmental Protection Agency (EPA)'s Project XL certifies US mountains located on US federal Forest Service lands. This is a system that rewards innovation in environmental protection, while focusing on the relationship between the Forest Service, ski resort developers, and environmentalists [74]. Unfortunately, certified ski mountains are primarily in North America and France, and of course, different countries will have different standards and capabilities to manage conflict, equity and sustainability [75]. Even with these certifications, many mountains will need to consider efficiencies and new models to remain competitive.

### *5.2. Creative Solutions and Models for Sustainability*

While historically ski resorts operate only in the winter months, mountain managers now recognize a need to move from a standalone winter market mindset to a year-round resort model. The changing climate and increased visitation during these "off-season" periods now force all ski resort managers to develop year-round management plans and revenue streams if they want to remain competitive in the business [76]. It is even more essential for mountains at lower elevations to diversify their offerings to being year-round [77]. Mountains will need to stay open, experiment with creative models, and/or partner with other mountains where they can share customers.

Mountains that have adapted to a more sustainable model will need to heavily advertise this transition. Customers appreciate sustainable skiing and are willing to pay for some sustainable attributes including those that have smaller resorts, renewable energy, transferability of ski passes, or have expanded with low environmental impact [78]. Mountains will need to continue to make snow and remain open even if conditions are not ideal. While the literature suggests that snowmaking can have some environmental consequences, especially water and energy, the use of new technology and equipment is available to lessen this impact [79]. Mountains cannot afford to close due to poor weather. The risk of behavioral substitution by customers is significant. Infrequent skiers who planned to visit on a day the mountain closes might ski less overall in their lifetimes or stop skiing all together. Only expert skiers are likely to travel to another resort that may have better conditions or be open [79].

The creative ideas to avoid shuttering include different ownership models, consolidation/technology sharing, and multi-mountain passes. Japan, for example, had a similar ski resort boom from 1960–1980 and a subsequent decline in later decades. However, rather than close many of the mountains in the Hakuba region, they reorganized into a collective resort destination, with ski pass transferability, thereby allowing an economically successful and sustainable downsizing of resort infrastructure [80] to remain competitive. Resorts in North America have also begun consolidating and collaborating in the past decade.

Multi-mountain passes are now commonplace (see Table 3). While some are a result of mountain mergers in the industry (for example, Vail's Epic pass includes mostly mountains owned by Vail Resorts), others are loose collectives between unaffiliated mountains (such as the Indy Pass). Furthermore, the passes have very different offerings. Some will have unlimited access to all mountains (Ikon Pass), while some have 2 or 3 day passes at each mountain (Mountain Collective), and many will mix all access and limited days depending on the mountain. Some of the passes are specialized to a region (NY Ski 3) and others attempt to attract people with their global options (Epic Pass). There are often multi-tiers available that will give customers different options with respect to access, blackout dates, cost, regions, and more—ideally catering to as many different types of customers as possible.

The consolidation in the industry and the multi-pass model may be a creative way to stem the tide of resorts closing. However, there are a few other creative solutions mountain managers and owners can consider.

**Table 3.** Multi-mountain ski passes—North America 2020–2021.

| Multi Mountain Pass Name | No. of Mountains Available | No. of States and/or Provinces Available with Pass | No. of Countries Available with Pass | Full Cost of the Pass [1] | Year Pass was Established | Multi Tiers/Options Available? [2] |
|---|---|---|---|---|---|---|
| **Epic Pass** | 61 | 17 | 8 | USD 1099 | 2008 | x |
| **Indy Pass** | 59 | 25 | 2 | USD 399 | 2019 | x |
| **Ikon Pass** | 43 | 18 | 7 | USD 1149 | 2018 | x |
| **Mountain Collective** | 26 | 10 | 6 | USD 449 | 2012 | |
| **Powder Alliance** | 18 | 7 | 4 | Varies * | 2013 | |
| **Ski Utah Pass (Gold and Silver)** | 15 | 1 | 1 | USD 5400 | 1979 | x |
| **Yeti Pass** | 15 | 1 | 1 | USD 649 | 2011 | |
| **Freedom Pass** | 10 | 6 | 1 | Varies * | 2014 | |
| **Power Pass** | 10 | 4 | 1 | USD 1199 | 2018 | x |
| **Rocky Mountain Passport** | 7 | 2 | 1 | CAD 2780 | 2003 | x |
| **Maine Pass** | 4 | 3 | 1 | USD 1599 | 2020 | x |
| **The New England Pass** | 3 | 2 | 1 | USD 499 | 2008 | x |
| **NY Ski 3** | 3 | 1 | 1 | USD 1019 | 2013 | |

[1] based on 2020–2021 season for unlimited full access. [2] based on individual pass websites/advertising. * buy seasons pass at one of participating mountains with access to others.

In our research, we discovered other creative models that we believe can help a ski mountain stay open and competitive (see Table 4). Public and university ownership may keep prices low, while other mountains might charge ten thousand US dollars or more. Some mountains, such as Winter Park (Wisconsin) or Powder Mills Ski Hill (New York), are owned and operated by a county or municipal government. These destinations can diversify the expense of a ski mountain through the local tax base and across other county parks. They may also have reduced insurance costs as they have a policy for tourists year-round. A similar example is federal ownership. Badger Pass (California) is located and owned by Yosemite National Park. Other models include mountains that are owned by a university, college or boarding school. Middlebury Snow Bowl (Vermont) is owned and managed by Middlebury University. Coppervale Ski Area (California) is owned by Lassen College. Kent Hill Boarding School has its own mountain (Maine). These mountains and others owned by universities or colleges blend athletics, education and public outreach into a sustainable ski resort model.

**Table 4.** Creative models for ski resort management/competitiveness.

| Management Model | Example | Cost of Season Pass | Comment |
|---|---|---|---|
| University Ownership | Middlebury Snow Bowl (VT) | USD 529 | Owned and managed by Middlebury University |
| Federal Ownership | Badger Pass (CA) | USD 435 | Located and owned by Yosemite National Park |
| Municipal/County Ownership | Powder Mills Ski Hill (NY) | USD 675 | Owned and operated by Monroe County Parks Department NY |
| Private Club Ownership | Yellowstone Club (MT) | USD 300,000 to join + USD 36,000 annual fee | Members Only—Fee required |
| Traditional Mountain Ownership | Taos Ski Valley (NM) | USD 1450 | Individually owned Ski Corporation |

Another interesting model is the private club or private residential mountain resort. You get an exclusive experience if you can pay for the luxury. In this template, you must pay a membership fee and/or own a property on the mountain to recreate and ski. These very high and often secretive sliding-scale fees cover the increasing cost to support purchases in new equipment and infrastructure. These unique paradigms make it possible (albeit risky) for these mountains to stay open and to become sustainable. They draw fewer visitors, have less impact, and are able to financially support adaptations due to environmental changes. The Hermitage Club at Haystack Mountain (Vermont) is an example of this. While it declared bankruptcy in 2018, it opened again in 2020 as a private member-owned club. The Yellowstone Club (Montana) also claims to be the most exclusive private ski mountain in the world. Cimarron Mountain Club (Colorado) is another example. Unfortunately, these mountains are often inaccessible to the average tourist, and less inclusive by design.

## 6. Conclusions

### *6.1. Recommendations*

One goal of ski industry sustainability is having a positive, year-round impact on local residents and the public. However, what if a resort closes, like so many have done in North America? Local populations will be most affected. They may lose their industry jobs, struggle to sustain related businesses and stores, and lose value in their homes. Partnering with communities on projects will be essential [81] in the coming decades. Collaboration and communication between the resort, the local community, and any federal/public agencies that surround the resort are crucial. Resorts and locals need successful dialogue and teamwork towards climate change adaptation [82]. Resort municipalities, mountain operators and providers need to work together and show leadership for the sustainable development of these mountain communities [83]. By instilling sustainability awareness and values in their employees, resorts can encourage change from within and contribute to civic sustainability [84,85].

We believe that resorts that focus on sustainability with both a proactive planning approach and a concern for citizens [86] will create a competitive advantage in the industry and will earn business from repeat customers [87]. Customers will visit a resort more often if mountains adopt and promote their voluntary environmental programs [88] and focus on moving towards sustainability [89]. Overall, we believe fewer resorts will close as mountains become more sustainable, collaborate within the industry, and invest in new environmental technologies and practices. Consolidation in the industry, multi-mountain passes, and unique models (municipal, university, non-profit ownership) have kept many mountains from closing in the recent past.

### *6.2. Study Limitations and Future Research*

However, we believe sustainable skiing requires additional research. While outside of the scope of our original research, it would be useful to have a detailed analysis of the more than 1000 mountains that closed in North America to determine precisely when and why they shuttered. We believe that future research should evaluate the precise reasons (using news or historical archives) for these closures to determine if they were shut down primarily due to environmental factors or for other reasons. It would also be prudent to conduct a detailed statistical analysis to determine if there is a relationship between size (skiable terrain), latitude, altitude, and average annual temperature of the closed ski resorts. These could possibly become a predictor for future closures.

We also believe more research on the multi-mountain passes is required. Most of these were created in the past five years, and their true impact remains unknown. Furthermore, we believe that more research is needed to determine a clear definition of sustainability and some kind of sustainability scoring in the ski industry is required. There is already confusion with the many different models of third-party environmental certifications. Additionally, resorts tout their practices as sustainable—but are they holistically sustainable? Future research may begin by analyzing the practices of the ski mountains (from a variety of ownership models) already claiming sustainability success. Sustainability in the ski industry is core to the business and here to stay. The future research in this field is broad and interesting to those who care about the environment, citizens who want to see their rural communities survive and even thrive, and businesses that seek strong growth models in skiing and tourism-related businesses.

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