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THE IMPACT OF CLIMATE CHANGE ON HOCKEY EXPERTISE IN THE NORTH COUNTRY AND ADIRONDACK REGION OF NEW YORK

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ABSTRACT

Climate change poses varied, and surprising, implications for social systems. We investigate one of those possible effects—the impact of a warming climate on outdoor ice availability and the social implications for hockey player development in the North Country region of New York. We approach this topic by applying a 10,000-hour budget of practice hours needed to become an expert player and assess the amount of outdoor ice available to meet that budget under two future warming scenarios. Our results show that the current amount outdoor ice hours available to a developing player remain the same at the end of the century under a low-emissions scenario equivalent to the targets set under the Paris Agreement. We also show that no outdoor ice would available for future player development at century's end under a high emissions scenario, or the current greenhouse gas emissions pathway. These changes have implications for the regional identity of the North Country as a focal point of elite hockey development.

INTRODUCTION

The St. Lawrence Seaway and Canadian border bounds New York's North Country to the north, Lake Champlain to the east, and Lake Ontario to the west (Figure 1). Much of the Adirondack Park is included within its boundary. However, the North Country is more than a set of cartographic coordinates and physical attributes; it includes a regional identity influenced by ample winter outdoor recreation opportunities.

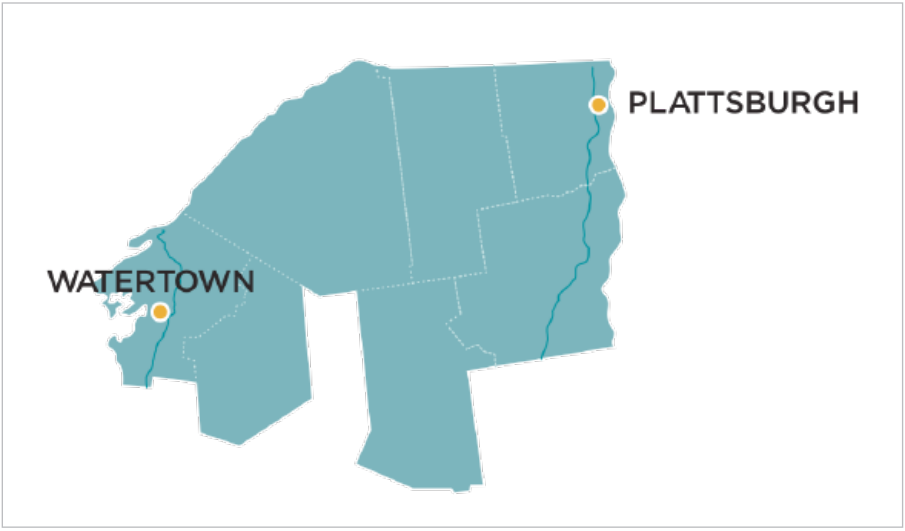


Figure 1. *The North Country as defined by the state of New York's Empire State Development agency (Source: New York State Economic Development Council).*

Regional identity is not monolithic nor determined by one factor, but by many discourses, practices, and rituals influenced by at least gender, class, and power differences (Paasi 2003). Regional identity is relevant to political and economic analysis (Paasi 2009), and applies to a number of fields including folklore studies (Allen and Schlereth 1990, Wrobel and Steiner 2001, Robbins 2001), tourism (Williams et al. 1995), and sport (Roberts 2015). Most relevant to our study is the North Country and Adirondack regional identity related to ice hockey and the changing physical environment where it is practiced and played.

There is a longstanding history of ice hockey in the North Country and Adirondack Region (Figure 2). For example, in her natural and cultural history of ice in the Adirondacks, Tissot (2010: 146) concludes that in places with lake or river ice, "Skating, whether for pleasure or competition, has always been and still remains an integral part of the Adirondack winter scene." Lake Placid residents popularized and promoted skating starting in the late 1800s and those trends increased toward the 1932 Winter Olympics. Tissot explains that hockey has been popular in the Adirondacks since the 1920s, but barrel jumping, speed skating, and figure skating were more popular than hockey until the 1950s. When the United States won the gold medal at the 1980 Olympics in Lake Placid, the so-called "Miracle on Ice," the region's identity merged with national Cold War politics fusing the North Country's affinity with hockey across the country and world (Abelson 2010).

Figure 2. *Left panel: barrel jumping circa 1932 in Lake Placid (St. Lawrence University library collection). Right panel: Canton youth playing outdoor hockey in 2019 (photo by Mindy Burwell of Canton).*

Since the "Miracle on Ice," one element of North Country identity is as a place that actively produces elite hockey players. For example, thirteen individuals born in the relatively small North Country communities of Potsdam, Canton, and Massena, have played in or been drafted by the National Hockey League since 1980 (Elite Prospects 2020).

In this paper, we examine the threat climate change poses to the North Country's ability to continue developing elite hockey players and sustain its identity as a focal point of elite player development. Our central question is—will there be sufficient outdoor ice available with climate change this recreatcentury for developing hockey players to practice or play the number of hours needed to reach expert professional proficiency?

Impacts of climate change

Under a high emissions scenario, the climate forecasting scenario for New York and the Northeastern United States projects a lower average number of days with snow cover contributing to reductions in the season lengths for winter recreation as much as 80% by 2090 (Wobus et al. 2017). Research suggests that climate change is, and will likely continue, adversely affecting winter recreation opportunities. For example, a study of the World Heritage List's Rideau Canal Skateway found a decline in length of the skating season at that site (Brammer et al. 2015). Another study of widespread loss of lake ice around

the Northern Hemisphere further corroborates this finding and explicitly notes the decline of ice-based recreation opportunities resulting from ice loss (Sharma et al. 2019). Brown and Hunt (2007) find that climate change would have a detrimental effect on all snow- and ice-based activities in Ontario, and a number of studies from Europe indicate that participation in downhill and cross-country skiing are already declining due to changes in snow cover (Agrawala 2007, Tranos and Davoudi 2014, Landauer, Sievänen, and Neuvonen 2015). Winter recreation activities predicted to be the most adversely effected by climate change include snowmobiling, cross-country skiing, and snowshoeing (Askew and Bowker 2018). A warmer climate decreases opportunities to spend time participating in all snow- and ice-based recreation activities, including ice hockey.

Given the cultural and historical importance of ice hockey to the North Country and Adirondack Region, and given that the opportunities to engage in those activities outdoors may diminish, it is important to investigate the impact of climate change on those opportunities and how it affects the regional identity of producing elite hockey players. We approach this topic as a budget problem from the literature on practice and play hours and expertise. We ask if there will be sufficient outdoor ice this century to allow young skaters enough time to develop elite skills in the North Country region.

Hours of deliberate practice and play

Investigations on athletics, music, aviation crisis management, chess and insurance sales show that the development of expertise requires extensive deliberate practice (Kulasegaram, Grierson, and Norman 2013). Deliberate practice centered on repetitive, purposeful, and intentional training methods are considered the most effective for attaining a desired expert level of proficiency (Ericsson et al. 2004). Training employs a similar set of principles across activities (Ericsson and Pool 2016). Generally, deliberate practice consists of techniques directed toward performance improvement through feedback and correction of errors personally or by a coach (Campitelli and Gobet 2011). Achieving expertise identifies a 10,000-hour threshold occurring over a 10-year period (Kulasegaram, Grierson, and Norman 2013).

Inherited factors, such as height in basketball, offer a divergent explanation of the 10,000-hour rule (Campitelli and Gobet 2011). Even with these doubts, scholars agree that deliberate practice contributes to expert performance and is frequently the main factor differentiating experts from non-experts (Kulasegaram, Grierson, and Norman 2013). Deliberate practice can assist stages of learning and development necessary for attaining key mental representations across activities (Tashman 2013). Sustaining deliberate practice addresses weaknesses recognized by self-assessment and critiqued through feedback (Duvivier et al. 2011). Therefore, additional practice increases performance whether ability is innate or acquired (Ericsson et al. 2004). Achievement of expert performance is a product of the physiological adaptations and complex cognitive mechanisms that come from deliberate practice (Ericsson, Roring, and Nandagopal 2007). Although a causal link between experience and expertise cannot be made, individuals who have consistently and deliberately engaged and sustained high levels of practice throughout their careers have a higher likelihood of attaining expertise (Ward et al. 2007).

Similarly, deliberate play can also develop the skills necessary for the acquisition of expertise (Côté, Baker, and Abernethy 2007). The intent of deliberate play is enjoyment where children self-monitor and enforce their activities (Ford et al. 2009). Like deliberate practice, more time logged at deliberate play results in increased creativity in athletes in ball sports (Memmert, Baker, and Bertsch 2010). Experts in ball sports excel from other players in recognizing and recalling opponent's actions (Raab and Farrow 2015). These skills are a product of greater quantities of activity, suggesting the type or intent of activity is less important for achieving expertise than the duration of a subject's participation (Berry, Abernethy, and Cote 2008). Since deliberate practice and play are critical components in achieving expert performance, an individuals' expertise may be limited by the quality and duration of the available training resources (Ericsson et al. 2009).

Taken together, deliberate practice and play reinforce player development. While deliberate practice may be a more efficient method of achieving expertise than deliberate play, both contribute to improved proficiency and creativity. In addition, the more hours a hockey player logs of both, the greater their chance of achieving expertise.

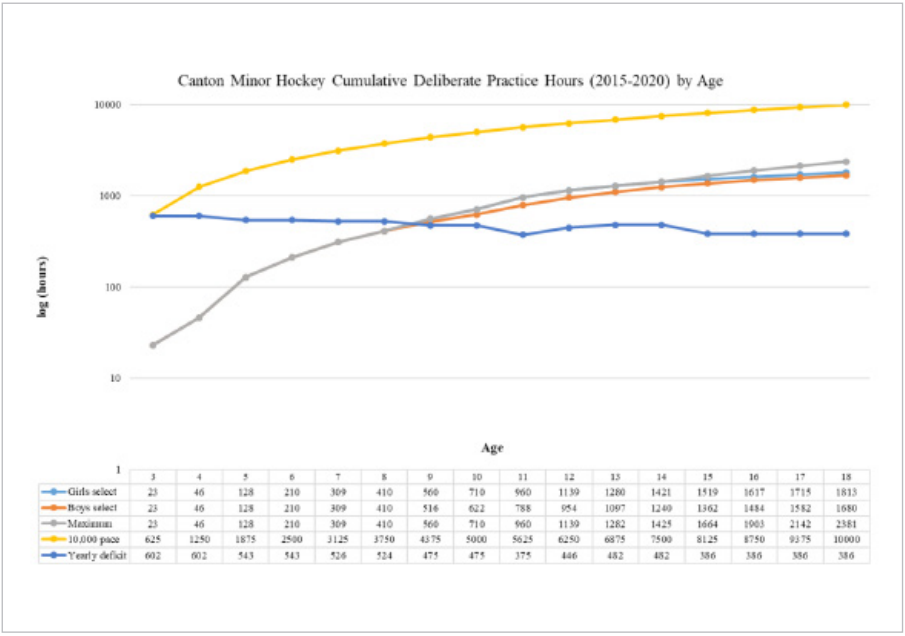
Methodology

Given the literature on player development, hockey associations may assume a 10,000-hour practice and play budget as an aspirational goal to support player development. We first calculate the amount of indoor ice time the Canton Minor Youth Hockey Association offers at its Pavilion facility in Canton, NY. Tallies of total practice time for house and travel teams ages 3-18 from 2015-2020 and total ice time available through open hockey sessions are calculated. These two categories, practice time and open, unstructured hockey represent the total amount of indoor ice time the association provides for a potential hockey player. The difference between 10,000 hours and this total ice time represents the amount of time a potential elite hockey player would need to engage in deliberate play.

To project the amount of deliberate play time a player could spend on outdoor ice, we use the MarkSim® weather simulator tool that can estimate monthly average temperature and precipitation for any year between 2010-2095 (MarkSim 2020). Averaging 17 general circulation models (GCM) used by the Intergovernmental Panel on Climate Change in its fifth assessment report, this simulator enables the user to simulate daily temperature and precipitation amounts for any year between 2010 and 2095 for any location on Earth. We use their simulation of temperature for 2010 as a baseline to compare the estimated hours of potential outdoor ice for Canton, NY and then forecasted temperatures for 2050 and 2095. Malik et al. (2020) assume that at least four days of temperatures below 22° F is required to produce skateable ice in backyard rinks; Damyanov, Matthews, and Mysak (2012) assume three days below 23° F to initiate flooding outdoor skating rinks for municipalities. Since skating on outdoor ponds and river ice is also available in the North Country, we assume a five-day below freezing rule for the potential outdoor ice to be skateable and safe for playing hockey. We therefore looked for 5-day stretches of temperatures below freezing as modelled by the MarkSim® simulator for the years 2010, 2050, and 2095 to estimate the amount of time that might be available in those years for outdoor skating.

Results

As scheduled over 2015-2020, Canton Minor Hockey players could accrue up to 24% of the 10,000-hour mark (gold line) between ages 3 and 18 through deliberate practice and open hockey offered by the association (Figure 3). Over that period, the amount of deliberate practice time available to girls outpaced that of boys by 8% (light green and red lines respectively). The total amount of deliberate practice ice time available to either boys or girls is 2,381 (grey line). That leaves a deficit of 7,619 hours from reaching the 10,000-hour mark that would have to be completed in some other form, presumably deliberate play. The amount of time each year a player would need to accrue deliberate play activities ranges between 386 and 602 hours (dark blue line) to achieve 10,000 hours. Those activities could include other forms of non-ice hockey, including floorball, street hockey, and roller hockey. The most direct replicate of deliberate ice hockey practice, however, is deliberate play on frozen ponds and rivers. The amount of available frozen ice is depleting due to climate change.



	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Girls select	23	46	128	210	309	410	560	710	960	1139	1280	1421	1519	1617	1715	1813
Boys select	23	46	128	210	309	410	516	622	788	954	1097	1240	1362	1484	1582	1680
Maximum	23	46	128	210	309	410	560	710	960	1139	1282	1425	1664	1903	2142	2381
10,000 pace	625	1250	1875	2500	3125	3750	4375	5000	5625	6250	6875	7500	8125	8750	9375	10000
Yearly deficit	602	602	543	543	526	524	475	475	375	446	482	482	386	386	386	386

Figure 3. *Average deliberate practice hours for Canton Minor Hockey players (2015-2020) ages three to 18, and total deficit hours per age from a 10,000 hour pace.*

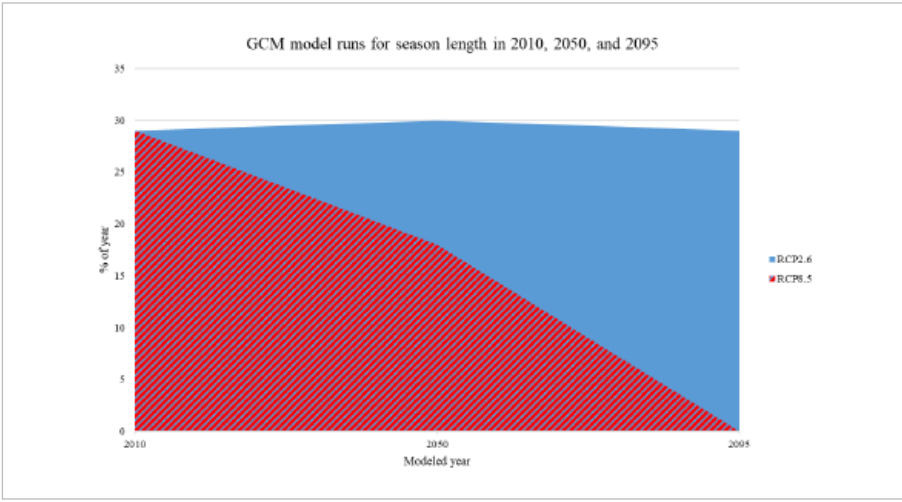


Figure 4. *Estimate percent of the year outdoor ice would be available for skating in 2050 and 2095 compared to a 2010 baseline using MarkSim® simulations.*

The MarkSim® modeling indicates that the amount of ice time available this century is dependent on climate change mitigation (Figure 4). The number of days after the first five-day freezing event modeled for 2010 under the high (RCP8.5) and low (RCP2.6) emissions scenarios is 107, or 29% of the year. For 2050, those increase slightly under the low emissions scenario to 110, and decrease to 66 under the high emissions scenario, or 18% of the year. For 2095, the length of the outdoor ice season remains at 107 days under the low emissions scenario, but falls to zero under the high emissions scenario. For all these scenarios, except the high emissions scenario in 2095, the outdoor ice season runs from November 29-March 19, as indicated by the initial five-day freezing stretch.

As modeled, the representative concentration pathway scenario of a 2.6 W/m^2 increase of the radiation budget at the tropopause (RCP2.6) retains the conditions and outdoor ice availability in the North Country region as existed in 2010. RCP2.6 limits global warming to 2° C this century (van Vuuren et al. 2011) and is consistent with the goals set out in the Paris Agreement developed through the United Nations Framework Convention on Climate Change and came in to force in 2016 (United Nations n.d.). Currently, the parties to the treaty have enacted policies and measures that would produce warming between 2.1° C and 3.9° C from pre-industrial levels (New Climate Institute and Climate Analytics 2021). Even so, actual greenhouse gas emissions continue to increase (Le Quéré 2018; Peters et al. 2019) following a business as usual pace.

We therefore also chose to highlight outdoor ice conditions in the North Country under an RCP8.5 scenario, a high emissions scenario roughly equivalent to business as usual, or assuming governments pay little regard to climate policies (IPCC 2013). The RCP8.5 scenario represents the future conditions we are creating. Under this scenario, mid-century outdoor ice availability would fall by 30%, and then disappear by 2095.

Discussion

Under current policies and measures, if a future North Country player logs 10,000 hours of deliberate practice and play this century, increasingly those activities will not include doing them on outdoor ice. This may have implications for the type of player the region can produce. Future elite players may not be as proficient skaters as less skating time will be available to them. Future elite players from the region may be more proficient at non-ice related skills, such as inline skating and/or stick handling by practicing on driveways, roadways, and outdoor facilities. Assuming North Country villages do not invest in more indoor ice arenas, future indoor ice available to skaters in this region will be limited. Currently, the Canton PeeWee Association maximizes its ice time across all age groups considered in this investigation. Increasing indoor ice time for ages 3-18 is not an option.

Important cultural implications emerge from a reduction in outdoor ice hockey opportunities in the North Country region. Hockey and the cultural identity of the North Country are inextricably intertwined, whether as a region known for producing elite players or as nostalgic two-time home for the Winter Olympics that includes the "Miracle on Ice." While the loss of outdoor ice in the North Country may be estimated and quantified, a loss of cultural identity is less easily calculated. Our investigation suggests that global climate policy, that is, what humanity does about climate change, determines whether the North Country can maintain its identity as a region for elite hockey player development.

Hockey associations, along with local and county governments, may be interested in mitigating that loss and anticipate alternate forms of practice and play. Associations may anticipate warming with adaptation measures, such as investing in roofs over outdoor ice rinks to mitigate melting on warm winter days. Municipalities could also invest on alternative deliberate play opportunities such as converting tennis courts to inline hockey rinks. Hockey coaches may consider providing feedback to their players on how to approach deliberate play hours for non-ice practice, such as working on wrist shots with floor ball equipment on driveways or adding floor ball leagues played in gyms to the schedule with assistant coaches providing pointed feedback. As with other social structures, hockey will no doubt adapt to climatic changes. Anticipating those changes offers a higher chance of retaining North Country traditions and cultures associated with ice hockey. Scholars working on climate change may be interested in our methodology to couple emerging GCM model outputs with associated socio-cultural change.

REFERENCES

Agrawala S. 2007. *Climate change in the European Alps: adapting winter tourism and natural hazard management.* Paris, France: Organisation for Economic Cooperation and Development (OECD).

Abelson, D.E. 2010. "Politics on ice: The United States, the Soviet Union, and a hockey game in Lake Placid." *Canadian Review of American Studies* 40(1): 63-94.

Allen, B. and Schlereth, T.J. (Eds.). 1992. "Sense of place: American regional cultures." *The Annals of Iowa* 51(5): 558.

Askew, A. and J.M. Bowker. 2018. "Impacts of climate change on outdoor recreation participation: Outlook to 2060." *Journal of Park and Recreation Administration* 36(2): 97-120.

Berry, J., B. Abernethy, and J. Côté. 2008. "The contribution of structured activity and deliberate play to the development of expert perceptual and decision-making skill." *Journal of Sport and Exercise Psychology* 30(6):685–708.

Brammer, J.R., J. Samson, and M.M. Humphries. 2015. "Declining availability of outdoor skating in Canada." *Nature Climate Change* 5(1): 2-4.

Campitelli, G. and F. Gobet. 2011. "Deliberate practice: Necessary but not sufficient." Current Direction in Psychology Science, 20(5): 280–285.

Côté, J., J. Baker, and B. Abernethy. 2007. "Practice and play in the development of sport expertise." In G. Tenenbaum and R.C. Eklund (Eds.), *Handbook of Sport Psychology*. Hoboken, NY: John Wiley & Sons Inc.

Damyanov, N.N., Mathews, H.D and Mysak, L.A. 2012. "Observed decreases in the Canadian outdoor skating season due to recent winter warming." *Environmental Research Letters* 7(1): 014028.

Duvivier R.J., van Dalen, J., Muijtjens, J.M., Moulaert, V.R., van der Vleuten, C.P. and Scherpbier, A.J. 2011. "The role of deliberate practice in acquisition of clinical skills." *BMC Medical Education* 11(1): 1-7.

Elite Prospects. 2021. Stats Pages. Accessed from: https://www.eliteprospects.com/stats.

Ericsson, K.A., Nandagopal, K. and Roring, R.W. 2009. "Toward a science of exceptional achievement." *Annals of the New York Academy of Sciences* 1172(1): 199-217.

Ericsson, K.A., Delaney, P.F., Weaver, G. and Mahadevan, R. 2004. "Uncovering the structure of a memorist's superior 'basic' memory capacity." *Cognitive Psychology* 49(3): 191–237.

Anders Ericsson K., Roring, R.W. and Nandagopal, K.. 2007. "Giftedness and evidence for reproducibly superior performance: An account based on the expert-performance framework." *High Ability Studies* 18(1): 3–56.

Ericsson, K.A. and Pool, R. 2016. Peak: *Secrets from the New Science of Expertise*. Boston, MA: Houghton Mifflin Harcourt.

Ford, P.R., Ward, P., Hodges, N.J. and Williams, A.M. 2009. "The role of deliberate practice and play in career progression in sport: the early engagement hypothesis." *High Ability Studies* 20(1): 65–75.

IPCC (Intergovernmental Panel on Climate Change). 2013. *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* New York, NY: Cambridge University Press.

Kulasegaram, K.M., Grierson, L.E. and Norman, G.R. 2013. "The roles of deliberate practice and innate ability in developing expertise: Evidence and implications." Medical Education 47(10): 979-989.

Landauer M., Sievänen, T. and Neuvonen, M. 2015. "Indicators of climate change vulnerability for winter recreation activities: A case of cross-country skiing in Finland." *Leisure/Loisir* 39(3): 403-440.

Le Quéré, C., Andrew, R.M., Friedlingstein, P., Sitch, S., Hauck, J., Pongratz, J., Pickers, P.A., Korsbakken, J.I., Peters, G.P., Canadell, J.D., Arneth, A., Arora, V.K., Barbero, L., Bastos, A., Bopp, L., Chevallier, F., Chini, L.P., Ciais, P., Doney, S.C., Gkritzalis, T., Goll, D.S., Harris, I., Haverd, V., Hoffman, F.M., Hoppema, M., Houghton, R.A., Hurtt, G., Ilyina, T., Jain, A.K., Johannessen, T., Jones, C.D., Kato, E., Keeling, R.F., Goldewijk, K.K., Landschützer, P., Lefèvre, N., Lienert, S., Liu, Z., Lombardozzi, D., Metzl, N., Munro, D.R., Nabel, J.E.M.S., Nakaoka, S., Neill, C., Ono, C.T., Patra, P., Peregon, A., Peters, W., Peylin, P., Pfeil, B., Pierrot, D., Poulter, B., Rehder, G., Resplandy, L., Robertson, E., Rocher, M., Rödenbeck, C., Schuster, U., Schwinger, J., Séférian, R., Skjelvan, I., Steinhoff, T., Sutton, A., Tans, P.P., Tian, H., Tilbrook, B., Tubiello, F.N., van der Laan-Luijkx, I.T., van der Werf, G.R., Viovy, N., Walker, A.P., Wiltshire, A.J.,Wright, R., Zaehle, S. and Zheng, B. 2018. "Global carbon budget 2018." Earth System Science Data 10(4): 2141-2194.

Malik, K., McLeman, R., Robertson, C. and Lawrence, H. 2020. "The original six NHL cities form citizen science data. *The Canadian Geographer/Le Geographe Canadien* 64(4): 1-12.

MarkSim®. 2020. *MarkSim® weather file generator*. Accessed from: http://gismap.ciat.cgiar.org/MarkSimGCM/.

Memmert, D., Baker, J. and Bertsch, C. 2010. "Play and practice in the development of sport-specific creativity in team ball sports." *High Ability Studies* 21(1): 3–18.

New Climate Institute and Climate Analytics. 2019. Climate Action Tracker. Warming Projections. Global Update. Accessed from: https://climateactiontracker.org/publications/global-update-climate-summit-momentum/.

New York State Economic Development Council. 2021. *North Country*. Accessed from: https://nysedc.org/north_country.php.

Paasi, A. 2003. "Region and place: regional identity in question." *Progress in Human Geography* 27(4): 475–485.

Paasi, A. 2009. "The resurgence of the 'region' and 'regional identity': theoretical perspectives and empirical observations on regional dynamics in Europe." Review of International Studies 35(S1): 121-146.

Peters, G.P., Andrew, R.M., Canadell, J.G., Friedlingstein, P., Jackson, R.B., Korsbakken, J.I., Le Quéré, C. and Peregon, A. 2019. "Carbon dioxide emissions continue to grow amidst slowly emerging climate policies." Nature Climate Change 10(1): 3–6.

Raab, M. and Farrow, D. 2019. "A recipe for expert decision making." Farrow, D., Baker, J. and MacMahon, C. (Eds.) In Developing Sports Expertise. Abingdon-on-Thames, England UK: Routledge Press.

Roberts, S. (Ed.). 2015. *Sport, Media and Regional Identity*. New Castle, UK: Cambridge Scholars Publishing.

Robbins, W.G. (Ed.) 2001. The Great Northwest: The Search for Regional Identity. Corvallis, OR: Oregon State University Press.

Sharma, S., Blagrave, K., Magnuson, J.J., O'Reilly, C., Oliver, S., Batt, R.D., Magee, M., Straile, D., Weyhenmeyer, G., Winslow, L. and Woolway, R.I. 2019. "Widespread loss of lake ice around the Northern Hemisphere in a warming world." *Nature Climate Change* 9: 227-231.

Tashman, L. 2013. "The development of expertise in performance: the role of memory, knowledge, learning, and practice." *Journal of Multidisciplinary Research*, 5(3): 33-48.

Tissot, C. 2010. *Adirondack Ice: A Cultural and Natural History*. Saranac Lake, NY: Snowy Owl Press.

Tranos, E. and Davoudi, S. 2014. "The regional impact of climate change on winter tourism in Europe," *Tourism Planning & Development* 11(2): 163-178.

United Nations. N.d. *Treaty Collection*. Accessed from: https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-d&chapter=27&clang=_en.

van Vuuren, D.P., Stehfest, E., Elzen, M.G., Kram, T., van Vliet, J., Deetman, S., Isaac, M., Goldewijk, K.K., Hof, A., Beltran, A.M., Oostenrijk, R. and van Ruijven, B. 2011. "RCP2.6: exploring the possibility to keep global mean temperature increase below 2°C." *Climatic Change* 109(1): 95-116.

Ward, P., Hodges, N.J., Starkes, J.L and Williams, M.A. 2007. "The road to excellence: deliberate practice and the development of expertise." *High Ability Studies* 18(2): 119–153.

Williams, D.R., McDonald, C.D., Riden, C.M. and Uysal, M. 1995. "Community attachment, regional identity and resident attitudes toward tourism." *In: Proceedings of the 26th Annual Travel and Tourism Research Association Conference Proceedings*. Wheat Ridge, CO: Travel and Tourism Research Association: 424-428.

Wobus, C., Small, E.E., Hosterman, H., Mills, D., Stern, J., Rissing, M., Jones, R., Duckworth, M., Hall, R., Kolian, M., Creason, J. and Martinich, J. 2017. "Projected climate change impacts on skiing and snowmobiling: a case study of the United States." *Global Environmental Change* 45: 1-14.

Wrobel, D.M. and Steiner M.C., Ed. 2001. *Many Wests: Place, Culture, and Regional Identity*. Lawrence, KS: University Press of Kansas.