Climate change and Canadian community grass-based sport fields

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This research sought to understand climate change as it specifically impacts the Canadian community grass-based sports fields are managed. Specifically, the research question focused on: *What are municipal grass-based sports fields providers facing with respect to climate change and what adaptations are they making, if any, due to climate change?* The specific geographic area of focus involved the *Golden Horseshoe* region that included the northeastern forest area that runs from Niagara Falls to Toronto, Ontario, Canada.

Climate Change

The Government of Canada (n.d.) defined climate change as "a long-term shift in weather conditions. It is measured by changes in a variety of climate indicators (e.g. temperature, precipitation, wind" (para. 1). Further, this government stated that "climate change is a warming trend, not just a warming cycle" (para. 5). Additionally, the Government of Canada (n.d.) indicated that "climate change is projected to lead to both changes in average conditions and in extreme weather events. Increases in droughts, heavy rains, floods, and severe storms" (para. 6).

Climate change has been noted as impacting Canada. Researchers for Natural Resources Canada (n.d.) have reported that "atmospheric warming has been widespread across Canada since 1950 … it has occurred in all seasons, but has been most pronounced in winter and spring" (p. 56). Further, these researchers have found "an increase of hot extremes and a decrease in cold extremes of air temperature have been observed across the country" (p. 56).

Natural Resources Canada (n.d.) offered five crucial conclusions concerning the impact of climate change that are applicable to this research, including:

> Extreme weather events are a key concern for Canada and there is growing confidence that some types of extreme events will increase in frequency and/or intensity as the climate continues to warm (p. 2).
>
> Common challenges include increased losses from invasive pests and diseases" (p.3).
>
> Key vulnerabilities are associated with the impacts of extreme weather events, which can overwhelm the capacity of water infrastructure (p. 5).
>
> Adaptation is accepted as a necessary response to climate change (p. 2).
>
> Experiencing extreme weather events, as well as observing impacts of gradual change …. stimulates adaptation" (p. 5).

Literature on Sport and Climate Change

There is a growing body of literature on sport and the safeguarding of the natural environment including topics such as *a content analysis of environmental sustainability (ES) research* (Mallen, Stevens, & Adams, 2011); *a content analysis of ES research in motorsport* (Dingle, 2009); *why sport is involved in ES* (Trendafilova, Babiak & Heinze, 2013); *the development of the International Olympic Committee's environmental policy* (Cantelon & Letters, 2000); *interpretations of ES by the IOC* (Paquette, Stevens, & Mallen, 2011); *ES at sport facilities* (Dingle, 2014; Kellison & Hong, 2015; Mallen, Adams, Stevens & Thomson, 2010); *the carbon footprint of sport* (Chard & Mallen, 2012; Dolf & Teehan, 2015); *sport and pro-environmental*

behaviour (Han, Nelson & Kim, 2015); *a tool to assess sport event environmental performance* (Mallen, Stevens, Adams & McRoberts, 2009; 2010); *a sport event ES performance assessment* (Colllins, Flynn, Munday & Roberts, 2007; Mallen, Stevens, Adams & McRoberts, 2010). Further, this body of literature includes a limited focus specifically on sport and climate. Examples include topics such as *visitors and the climate at the FIFA World Cup in Qatar in 2022* (Matzarakis & Frohlich, 2015); *environmental and weather challenges in outdoor sports* (Brocherie, Girard & Millett, 2015).

Finally, a very limited body of literature focuses directly on sport and climate change. Examples focused on climate change impacts with respect to *pond hockey tournaments* (Fairley, Ruhanen & Lovegrove, 2015); *on the ski industry* (Dawson, 2009; Dawson & Scott, 2010; 2013; Hopkins & Maclean, 2014; Scott & McBoyle, 2007; Scott, McBoyle & Mills, 2003; Steiger, 2010); *on the Olympic Winter Games* (Scott, Steiger, Rutty & Johnson**,** 2015); *the contribution of the 2010 Soccer World Cup to climate change* (Otto & Heath, 2009) *and pro-environmental behavioural change due to football and climate change* (Baldwin, 2010). There is a gap in the literature, however, when it comes to community grass-based sport facilities and climate change. This research sought to, in part, begin to fill this gap in the literature.

Method

Data Collection

The data collection involved in-depth interviews with expert participants.

In-depth Interviews

A total of 16 in-depth interviews were conducted from May to July, 2016. The interviews were completed with the perspective from Patton (2002) that "qualitative interviewing begins with the assumption that the perspective of others is meaningful, knowable, and able to be made explicit"

(p. 341). A semi-structured (Hesse-Biber & Leavy, 2011) in-depth interview guide (Kiem & Austin, 2013; Patton, 2002) was utilized "to ensure that the same basic lines of inquiry are pursued with each person interviewed" (Patton, 2002, p. 343). The questions aimed to determine the awareness (Hopkins & Maclean, 2014) and impact of changing weather conditions or the problem of climate change (Fairley, Rubanen & Lovegrowe, 2015; Dingle, 2014; Scott & McBoyle, 2007; Steiger, 2010), including the priority of the problem, and weather information sources. As well, the questions sought understandings on the strategies for adapting/mitigating for the issue of climate change (Kiem & Austin, 2013; Natural Resources Canada, n.d.). All interviews were audio-taped and transcribed verbatim for analysis.

Participants

The interview participant selection involved purposeful sampling (Liamputtong, 2009, p. 11) of 'experts' from the field (Nielsen and Thankgagurai, 2007; Mallen, Adams, Stevens & Thompson, 2010). Martino (1993) defined experts as those individuals that know more about the topic under examination than most people due to their working experience. In this research it was assumed that those responsible for the maintenance of grass-based community sport facilities had perspectives regarding the maintenance of such facilities during contemporary times of climate change.

The participants held a variety of key employment positions. The positions included directors, senior managers, managers and key maintenance personnel of departments such as Parks and Recreation, Open Spaces, Parks Operations, Community Facilities, Program Standards, or Parks Maintenance. Each participant was provided a code name, including Participant-1 (P-1) to Participant-16 (P-16).

Sample Size

Consensus was not found in the research literature pertaining to sample size for qualitative interviews (Patton, 2002; Cresswell, 2007; Limputtong, 2009). Determining a sample size has been deemed complex with a recommendation of a sample of at least 12 interviews (Baker & Edwards, n.d.). This research utilized a sample size of 16 interview participants. The study concentrated on the area known as the Golden Horseshoe region ranging from Niagara Falls to Toronto, Ontario, Canada and was further was sub-divided into four sections: north, south, east and west. Four interview participants represented each section.

Data Analysis

Content analysis of the data was utilized and "is a well-established research methodology commonly used in the social sciences" (Stepchenkova, Kirilenko & Morrison, 2009, p. 454). Further, Krippendorff (2004) stated that content analysis was "a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use" (p. 18). Data analysis involved transcribing verbatim, reading and analyzing the content of the transcribed in-depth interviews for the themes (Brymer, Downey & Gray, 2009). Specifically, all data was analyzed and categorized by "topics, key themes, or central questions for interpretation" (Choi, 2010, p. 53). This meant that there were three passes of the data during analysis, one for each category. An overview of the topics was generated during the first pass, including their awareness, source of environmental information, seriousness/priority of the climate change situation, and impacts. Next, the key themes were outlined regarding adaptations during the second pass. Finally, a central questions list was developed during the third and final pass of the data.

Resource-based Theory

This research was framed with resource-based theory that proposes that a sustained competitive advantage can be generated based on the resources (including financial, technological and/or human resources) that are controlled by a firm (Barney, 1991) that are not substitutable (Barney, Wright, Ketchen Jr., 2001). These resources can include a firm's management skills, along with processes and routines (Barney, Wright, Ketchen Jr., 2001). This theory explains the internal sources of a firm's sustained competitive advantage (Kraaijenbrink, Spender & Groen, 2010).

Findings and Discussion

The 16 interview participants worked in the industry for a period of time from three to 36 years and their total combined experience aggregated to 259 years with the average of 16.18 years. Every participant noted that reliable sources of environmental information were necessary in the process of completing their job activities with respect to the provision of municipal grass-based sport facilities. A number of environmental information sources were utilized by the participants. For instance, participants reported utilizing: "A weather app that is on everyone's phone" (P-1); "We monitor the [national] weather channel on an hourly basis" (P-3); "We subscribe to a couple of different weather services and then I also have a couple of different internet websites that I look at regularly throughout the day" (P-4); "The public health department and the weather channel is where we get our information" (P-9); I read daily "Whatever Environment Canada publishes for this area" (P-10); and finally, "Intellicast [an online weather forecast site] is the main one that we use to know the weather every day" (P-11). Overall, the environmental information sources are important as P-14 indicated that "We go on every day as we are planning our work."

The participants had an awareness of atmospheric warming and extreme weather conditions and rated the seriousness of climate change as an issue as 3.625 out of 5 (or 72.4%) and the priority of climate change at 3.71 out of 5 (or 74.2%) with a range of responses from 3 to 5 for both indicators. The seriousness and priority of climate change was, thus, perceived as a medium-level issue.

The Impacts of Climate Change

Participants noted that they were facing impacts due to changing weather conditions that could be related to climate change. These impacts stemmed from two key areas: (i) seasons that were not normal; as well as (ii) new pests and disease.

Seasons that are Not Normal

All of the participants indicated that the four seasons (fall/autumn, winter, spring, and summer) could no longer be expected to be normal. This meant an extremely cold or mild winter; longer summers that are hotter with either lots of precipitation, including a combination of microbursts of rain and/or drought conditions. Overall, unpredictable weather was observed. The impacts on the sports fields included that the grass was either too wet or burnt out and compacted. Examples include P-2's statement that "The summers are getting longer" and P-3's declaration that "The winters are extreme; there seems to be either no real winter or an extremely cold winter. It is now one or the other. There is no consistency." This was reiterated by P-9 that related "It is the extreme cold in the winter with lots of snow or no snow conditions" and P-2 recounted that "This past winter … was mild, but the two before that were ridiculously cold. So it is extremes." Also, P-6 voiced that:

> "We used to enjoy the temperate so much and not now. Certainly we had more snow in April and May than we had in January, February and March – so the snow is coming in the spring so it is off cycle. We barely had snow this year in December and January. The winter before [the year prior] it started snowing on January 1st and I don't think it stopped until March almost."

Every participant mentioned heat in the summer months as a key issue. For instance, P-3 expressed that "The extreme heat seems to be a regular occurrence now." P-2 stated "Heat is the major issue" … "It seems as if the summers are getting hotter and hotter… and [as a result] the water consumption is obviously going way up." Meanwhile, P-3 concurred that "It's getting overall hotter now in the summers" and this heat "burns the grass out earlier." Further, P-10 indicated that there have been "Temperature fluctuations and a temperature rise…. [and this is associated with] "Lots of rain or no rain." Also, P-9 purported: "It is the extreme heat and the extra heavy rainfall that we can get. Meanwhile, according to P-7, "Drought is the biggest issue. And the drought seems to happen earlier in the season compared to years before. Well… it is either too dry or too wet. There does not seem to be a happy medium anymore." This was further supported by P-13 that said "The key issue seems to be the heat and associated drought." P-15 found that "The biggest concern is for sure the heat and the ability to water." P-16 concurred that "The heat and lack of rain for the fields is an issue." Importantly, P-9 expressed further that "The heat aids to compact the soil and then the water just runs off instead of soaking into the field." P-5 also echoed a concern about the "microburst rain in the summer."

Overall, the participants reported an apparent change in weather patterns. The patterns of change related directly to the impacts of climate change as noted by researchers for Natural Resources Canada. Four participants attributed the changes to the climate change issue; however,

generally participants were not sure if it was climate change that was causing the seasons to be abnormal; but it was an undeniable fact that they had to deal with changing weather conditions in the process of maintaining grass-based sports fields for the municipality. The overall opinion was that "the weather is not usual and it is impacting the [sports] fields" (P-2).

New Pests and Disease

Disease and pests were a further concern for the research participants. These issues were noted as arising from multiple fronts. For instance, "Disease is associated with mosquitos that we did not see 20 years ago" (P-3); "There are lots of different molds now that we did not have to worry about in the past" (P-3); "There are more invasive species in terms of weeds" (P-11); and "We now deal with ticks and lime disease" (P-1). Additionally, all of the participants indicated that disease impacting trees was a particularly prominent issue, such as "The ash bore disease has killed about 20% of our trees" (P-7). Additionally, P-14 revealed that:

> "We have trees right now but not for much longer. We're dealing with ash bore disease and they all have it so we have to cut many down. We have over 3500 ash trees in the area and will lose 90% of them as our shade trees in the next couple of years due to disease."

The participants purported that government regulations concerning pesticide bans impacted their ability to manage the weeds and pests. Further, P-11 said "I would say there is more invasive species in terms of weeds and with the regulations with the pesticide bans [it impacts] … the ability to control the weeds." Again, the changes noted by the participants related directly to the conclusions made by Natural Resources Canada concerning the impact of climate change that included challenges from invasive pests and disease.

Adaptations Due to Climate Change

Natural Resources Canada concluded that "Adaptation is accepted as a necessary response to climate change" (p. 2). The participants outlined their adaptations which involved five (5) key sport field maintenance themes that are discussed below.

Theme 1: Adaptations in Grass Seed Selection

Selecting seed for the grass-based sport facilities was presented as being a complex issue to determine. This was illustrated as P-3 indicated that "It is important to know which kind of grasses to put in that can handle the winter, the wet in spring, heavy downpours, as well as the heat of the summer."

A variety of seed selection strategies are being used as participants sought to identify the ideal blend for the variety of conditions. Seed related strategies that include blended seeds, quick germination seeds, drought tolerant seeds, perennial rye grass, fescues, Kentucky Blue grass seed are outlined in Table 1.0

Table 1.0: Seed Selection Strategies

Participant	***Seed Selection Strategy***
P-4	"We have tried a bunch of varieties of grasses... such as a subpoena grass that is a northern turf grass from Europe that a lot of soccer clubs are using for their fields. And that grass will germinate at cooler temperatures – so being in Canada it will germinate earlier in the spring and will allow play to begin to start happening on the grass in April instead of May. We also use bluegrass, Kentucky but they do not germinate at a cooler temperature, so if you start playing on it earlier in the spring the damage you cause is a long term effect – so we have been involved in trials with different grasses. The trials have not been bad – we are finding the early germinator is great for early April and into May and June and then when we get into our summer high heat periods in July and August it goes brown … but late September or into October it starts to recover. So we use a variety of grass types." We are also "adding a quick germination seed; we have gone with a blended seeds so we are putting down perennial rye and Kentucky blue just because each seed has its own qualities concerning recovery."
P-5	"We are using multiple types of grasses to overcome issues at every stage of the season.
P-6	"We are adding more drought tolerant seeds in the turf … We tried different fescues as they generally tend to be a clumping grass and tend to be a little more drought tolerant. They can be a difficult mix to use because if the turf does thin out because it is a tuft it tends to be a little bit uneven but we certainly look for drought tolerant for our selection. … Even with the extreme rain we are having, we are still putting in drought tolerant grass seed because they tend to be able to tolerate heavy rains."

P-7	"The perennial rye grass is so much improved… the new varieties almost look like bluegrass but they are green during drought and they can handle the heat. It is amazing how much tougher it is now. We use a mix bag of seed but the rye grass is the main staple."
P-8	"With fescues, which are ideal, the sports fields love that … we use it in with the rye grass, such as bluegrass. So we have a good combination or blend of seeds that are used."
P-9	"We use seeds that are special on the non-irrigated fields, the seed and the water – it's more the irrigation aspect that makes the field better. There is more temperature related seed with fescues – so we use different types of fescues on the sports fields and they will vary according to whether the field is irrigated or not. Water … that's more of the driver, but fescues tend to be more heat tolerant. Our seed has to meet a specific standard and it is established by the national turf grass evaluation program on seed. They test different types of seeds for different qualities and that is what we are choosing from. We are picking seed based on scientific evidence and they have to be graded by this organization. The seeds have to meet a certain threshold for us to use them. So you start to really specify the seeds used – they are all North American seeds."
P-10	"It is very difficult to keep a native type grass growing any more. It is difficult to get Kentucky Blue started through the growing season. We are bound by using stuff like different varieties of perennial rye grass. There are a variety of hybrid or different plants of grasses." "Most of our soccer pitches now are 60% sand; some are probably 70 -75% sand with a large perennial rye grass combination with that. We had the winter of 2014 where we had a long term freeze that damaged the long term turf all over the province and we did notice some issues in the spring of 2015 when we really got lambasted because of the percentage of the rye grass seeds that had been used. We just don't have the time. We are trying to get the grass so that it can handle the summer dryness … but also the spring wet season, especially if it was a heavy snow winter where there is a lot of spring runoff. Then it doesn't work well with the type of grass seed we are now using so the balance is a difficult one. It is very difficult."
P-12	"We have switched to a slightly different grass seed over the past 2 years – with more rye grasses that tolerate drought a little bit more and they tolerate a little more trampling as well. In the past we used a generic grass seed used all over the city and in the past two years we have switched to a more athletic field seed when we are over-seeding everywhere. I believe the seed is Canadian… I know some of it is an exotic species, such as Kentucky Bluegrass, but the rye is Canadian."

Not all participants had shifted to new seed strategies as two indicated that they continued to use the same seed selection that has been used over time, with Bluegrass (P-11; P-15). The new seed strategies being implemented due to the complex environmental conditions, however, meant that "People will have to get used to a different type of grass" (P-9).

Interestingly, P-4 stated that there is existing seed that is not available to them as "farmers can use seed that is genetically altered and can have pesticides right in the seed to aid the farmer to get a better yield and so on … but we cannot use it on our sports fields turf" (P-4). This leads to the question: Does the debate on the use of genetically altered seed need to

continue, especially concerning the addition of pesticides that are banned for use on sports fields?

One participant promoted the development of grass on a sports field with seed, rather than using sod. P-7 stated

> "If you can seed the field instead of sod then it is by far the better turf in the end. It is tougher … even though it takes longer to establish itself at the beginning but it is worth it in the long run. Then the fields do not need as much water. We are better off with the seed developed field."

Additionally, the practice of over-seeding sports fields has continued, but traditional methods are deemed generally ineffective. P-7 noted that "We have never had a good result with over-seeding." Yet, P-4 indicated that adding to the challenge is that:

> "Now the pesticides are banned completely and we have found that most of our sport fields are up to the 50 to 70 percent weeds. The items that are available to control the weeds do nothing (not even close... pardon the expression ... but it is snake oil). It does nothing to the weeds. So one of our biggest concerns now is that we are overseeding regularly."

A strategy being utilized to meet this concern involves *split seeding*. P-14 explains that this involves that:

> "We over-seed but not by just spreading seeds. We plant seed with a farmers' disc that cuts the soil on an angle and the grass seed is planted into the soil and then a piece comes by and flattens the soil out so the seed is underneath the soil and has a better chance for growth."

Theme 2: Sports Field Irrigation Adaptations Lead to a Polarization of Perspectives

To begin, some sort of irrigation, natural rain or an irrigation system, is needed to keep the grass-based sport facility green. P-7 stated that when the sports fields do not get rainfall or irrigation then "the grass thins out and then the weeds come back, so it is a cycle." An unreliable situation concerning natural rain for irrigation has led the majority of municipalities to install irrigation systems to maintain their sports fields. P-2 indicated that "Years ago we never had to worry

about putting in irrigation … but now when you go to build it is always included." This was reiterated by P-3 that stated "We used to just build the fields, now we would never build a soccer pitch or baseball diamond without putting in irrigation… now there are lots of extreme heat days to deal with and irrigation is crucial." Also, participants are changing the timing of their irrigation due to the heat. P-1 stated that "We do not irrigate during the day any more like we used to … it's just too hot to do that and we don't want to burn out our grass that way." Further, participants are installing "low volume nozzles on the hoses, so it looks like there is water coming out, but the amount of run off is less, the amount of evaporation is less, we put it on at a slower rate and I think it is better for the grass in the long run" (P-7). The participants indicated that irrigation of the grass-based sports fields was an issue due to atmospheric warming and extreme weather conditions they were experiencing. Generally, the participants indicated that they are irrigating more these days (P-11; P-12).

Some municipalities have invested in sophisticated irrigation systems for their sports fields. For instance, P-6 said their system "cost about $200,000.00 for the centralized system itself over two years to start" and that there were additional costs for "a valve that shuts the system down if too much or an unusual amount of water is being used and that also counts the amount of water being used" and more "costs as you add fields to the system" (P-6). According to P-5, this type of "system allows us to not water when we do not need to… the soil determines the amount of water needed and when it needs to be applied" (P-5). As such, "we are not wasting any water" (P-6) and over-irrigation is not occurring "otherwise you end up with mold on the surface … then we wasted the water and we have to replace that section of grass" (P-1).

Experimentation with regard to irrigation was also noted as occurring. P-8 stated that they were involved in a pilot project "to electronically manage the irrigation of the sports fields – so

we don't have to physically go out to each of our areas to see how dry it is and then irrigate it." This meant that irrigation for each sport field could be adapted for the conditions at every field and managed using a smartphone from off-site (P-8). Overall, P-8 indicated that "The ideal would be to have all of our sports fields with irrigation systems. Right now it is about 30-40% of the fields are irrigated. Water is the biggest concern." Importantly, these participants promoted the perspective that the science-driven irrigation-based system was the effective direction for the future (P-4).

The results disclosed that 81.25% of the participants focused on installing irrigation systems in order to maintain their sports fields. This did not preclude concerns arising with regard to safeguarding water resources in the process of irrigating the fields. The participants sought sophisticated irrigation systems to not just water consistently once per week, but to water when the soil conditions indicated that it was necessary. This perspective generally reflected the perspective of participants from large municipalities or urban areas with a higher tax base and larger field maintenance budgets.

A polarization of perspectives was revealed as the other 18.75% of the participants indicated that they safeguarded the financial and water resources ahead of having green sports fields. These participants were generally from small and/or rural municipalities with tight budgets for field maintenance; or the influence may have stemmed from their environmental perspective. P-11 indicated that "Whatever we get is what we get. We are using the natural rain for our sports fields and that's it." Further, P-7 stated that with regards to "Our soccer fields …. the trend is away from having these lush fields. You keep them alive without keeping them crazy green." This did not mean that all participants that made safeguarding the resources as a priority

did not have any irrigation systems, just that they used them sparingly. To further illustrate the polarized perspectives P-7 further expressed that some municipalities have a

> "passion … to have the best of the best so their fields are all green, green, green right with irrigation systems and everything that goes with it. We are at the other end of that curve. And the people here … for example the hardball diamond, the infield stone is okay, the grass … the outfield is only okay and they [the sports participants] have been educated that this is conservation of water. We are at the other end of the curve, like I said, and the artificial irrigation systems pumping water full of chlorine, well it keeps the grass but there is nothing better than a good rain – a good natural rain does the best job."

Overall, P-7 purported that "Our constituents would find the cost of water was too much if we kept the fields pristine" and further, there was expressed concern that water conservation was going to be a growing issue in the future. By not providing lush grass-based sport facilities, these participants indicated that their sports field users were already adapting and being educated concerning the need for water and financial resource conservation. Overall, this perspective was positioned as "being so far behind that they are ahead of the curve" (P-7).

The polarization of perspectives on the appropriate direction concerning grass-based sports field irrigation in times of atmospheric warming and extreme weather conditions was generated based on resource-based theory. Debates on the central question concerning the appropriate balance in terms of expectations for safeguarding water and financial resources and the level of irrigation for grass-based sport facilities are needed. These debates are particularly important as P-10 stated:

> "If people in this city knew what I pay to water for these fields for kids to play on they would flip. As the population is aging and we have a much higher percentage of people over age 55 and a smaller group with young children, I can see the future where there is a change and instead of a t-shirt and shoes to play soccer for $125.00 fees for the season; they'll have to pay for the water and it'll be $600.00 per child to play due to water costs for irrigation. And we don't irrigate like we'd like to right now or it would cost even more."

The appropriate direction for the future has yet to be determined.

Theme 3: Drainage that can Manage Extreme Rain Events

It is important to note that participants indicated that sports field drainage was an associated sport field maintenance element with respect to the impacts of climate change, particularly the heavy or extreme rain events. For example, P-9 stated:

> "I think one of the challenges of the extreme weather is that the precipitation events it is drainage … So what happens when it rains is the challenge of the drainage system – especially in our older sports fields. So that really, really affects our management of the fields and the playability and the quality of turf on these fields… as far as plant management goes it creates a lot of problems. Water is not draining properly off the fields so we took out a prescribed program for the sports fields and one key component is top dressing and we are more involved in a top dressing program now to crown the fields so the water is dispersing off better to the sides where the isn't drainage collection system underneath. With lots of play and use we get what they call is 'bird baths' or puddling on the fields and that affects playability as well and there is a safety issue so we have to use the top dressing to level the fields and create the crown. That is how we try to get the drainage to be more efficient on the fields."

P-1 concurred and indicated that "We now have to ensure that the soil allows for excellent drainage." P-3 further revealed that "We are careful to use 'sparkle' or red clay on the [baseball] diamonds … If we have a heavy rain, then this ensures that the rain drains down under the surface."

Theme 4: Pressure for Aeration and Fertilization Due to Compaction

The hotter atmospheric conditions were noted as contributing to the compaction of the sports fields. This issue was noted as "huge" (P-8), "due to the fields being dry" (P-11); and that "there is more compaction on the fields that we have to deal with now" (P-13). Overall, the issue was noted as difficult and "It is hard to keep on top of that" (P-14).

To manage compaction, participants aerated the sports fields. P-8 outlined that "aerating affects the ability to absorb the water during irrigation and rainfalls." Despite needing to aerate more (P-10), regular aeration leaves 'plugs' of soil on top of the field and this can impact play. It

is, thus, a delicate balance between ensuring the fields are aerated properly and ensuring the fields are best for sports play. P-10 outlined that they have added a process whereby

> "On a regular basis - about every 6 weeks – it's not a core aeration, all it is is running spikes 6-8 inches long in the field and opening it up so that when it does rain the water soaks into the field and doesn't run off and go into the drainage. It adds a certain amount of aeration to the field too. But there are still compact issues... without the rain there is absolutely the compact issue."

Further, participants discussed the use of fertilizer and indicated that "our fields recover from the heat when the rain does come if we use some fertilizer because there is thicker grass" (P-2). According to P-15, "Optimally we probably want to fertilize three times per year … but because we cover so many sports fields we probably average twice per year for most fields." Meanwhile, P-16 stated that "We do fertilize and we never used to but now we have to fertilize a lot more because we cannot control the weeds with pesticides. We put fertilizer pellets on the fields right now and we have a liquid that we use sometimes too and we wash it in with the sprinklers." P-7 indicated that:

> There is an environmentally friendly product called *Fiesta* that we use, well on the infields on the diamonds to get rid of the weeds. It works if you apply it 3-4 times per year and the timing is everything. It is an expensive product and it is not practical for all of the sports fields. It injects iron and the grass grows taller and thicker and it helps to get rid of the weeds. But… it doesn't kill the whole weed like years ago when we had products that we were allowed to use that did that."

P-14 stated that "The fertilizer we use now is all biodegradable and we only use the natural stuff. If we had to cut it out then we'd have 2-3 more weeks of non-green grass once it gets dry. If you don't get rain then the fertilizer does not help anyway." Importantly, there is a movement to safeguard water when considering fertilizer. P-7 indicated that "we use low nitrogen fertilizers and low phosphorous because we are trying to protect the river."

Theme 5: Managing Sports Fields Access

Generally, the atmospheric changes observed by the participants was noted as generating a longer growing season. This referred to the early arrival of spring and extended autumn/fall season. The early arrival of spring meant that patrons expected early access to the grass-based sport fields. This caused maintenance issues as the fields had not yet recovered from the winter, and were too wet to be playable. This was illustrated as P-9 stated

> "Something that I think we have noticed is the shoulder seasons. They seem to be stretched out more – in the spring and in the fall because it is warmer so we get more demand for the sports fields. The players and the organizations are saying well we are ready to go… but the turf isn't – so that is really, really challenging. They are ready earlier before the turf is ready and want to stay later on the fields when they need to recover."

Two strategies were noted to manage the extended shoulder seasons. The first was the addition of artificial turf. P-10 noted that:

> "The demand is now for an extended season so we are getting one artificial turf field to put them. They can start early like they would like on the artificial turf. We are putting football, lacrosse, soccer on this field starting in April. That is why we have the artificial turf field now ... for the shoulder season and they can start in April and go until almost the end of November."

The second strategy involved enforcing the sport field use policy. The access was restricted if rain leaves the fields wet, particularly in the rainy spring season. P-6 indicated that "We'll shut our fields when it is at capacity for the rain sitting on top of it …. We protect the fields." Also, the pressure to use the fields earlier in the season was so great in one community that they placed security personnel at the fields during the 1-week school March break to ensure patrons stayed off the fields (P-10).

A New Strategy - Winter Grow Tarps to Revitalize the Sports Field in Front of the Goal or at Centre Field

Interestingly, P-10 outlined a new strategy for revitalizing sports fields by creating a micro climate that aids in grass recovery. This included the use of grow tarps placed over specific areas of the field during the late fall/autumn and winter months. The participant indicated:

> I used them for the first time in October, not on the full pitch as we could not afford that, but on the creases where the areas are beat up near the goals and I top dressed it and aerated it and screened the plugs and seeded it with perennial rye grass, Kentucky Bluegrass and red fescue – probably 60% - 20% and 20%. Then I top dressed it and left it for 10-15 days – then it is now October and I irrigated it pretty heavily, the rye grass started to germinate. So in the middle of October I put the grow tarp over it and put big staples in the edges to keep them down. I believe the tarp was 20x40. I left the tarp on all winter and it worked terrific. I went out in the middle of March this year and we didn't have any snow I believe but it was frozen. I took off the tarp to look and it had grown about 3-4 inches. All the grass had germinated early in the spring. I put the tarp back down and took it off in mid-April and mowed it by hand and bagged it in sections and put the tarp back down. I turned the irrigation on in mid-April and took the tarps off and the fields opened up the first weekend in May and the creases were terrific and they held up until now about 9 weeks of play. So the only damage they are getting is that the use that they are getting and the goalies are on it and there is too much use for it. So I can bring it back every year. I am going to budget for more of those tarps this year and do more fields this year with the tarps in the crease area and the centre circle. Each tarp was about $600.00 but we can use it every year – it has to be dried out and then put away… I put it away in the same bags they came in and they are guaranteed for 3-5 years I believe. Another city I know has a whole bunch of them and they found that they did not work very well as they are further north and their winters were too much snow load on tarp of the tarps and it starts the freeze-thaw cycle that kills the grass under the tarps. We did not have a lot of snow last year so it worked well for me. But another year I will add spaces in it. I will put a half-dozen bales of hay around it. I would split the bales in half so they are not as high and use it that way. That would keep the tarp up and it would act like a small greenhouse or a small microclimate."

Municipalities are Coping With the Impacts of Climate Change

Overall, municipalities indicated that they were adapting to the changing weather related impacts on the grass-based sports fields, as well as the new pests and diseases that impact the fields. P-3 indicated that "We are coping with whatever we get," although they were being "Reactive,

definitely reactive." Further, P-10 said "We are coping. We have issues and we are managing them. We manage whatever comes our way."

P-6 stated "The weather we are getting is changing and we are changing our thinking due to that. We are responding with computerized technology for irrigating the fields to ensure excellent fields and controlling the use of our water." Overall P-15 concluded that "We are doing well with whatever we are getting; when it rains too much or when it is hot and dryer. We are just managing as best we can to provide the fields in whatever weather we are facing." The interview participants were positive in their outlook regarding their ability to continue to provide community grass-based fields for sport in times of contemporary climate change.

Conclusions

This research sought to advance understandings related to municipal grass-based sports fields and the impacts of climate change. A total of 16 experts were interviewed that have a combined 256 years of experience, with an average of 16.18 years of experience each. The participants indicated an awareness of climate change as a medium-level issue and that they were experiencing – and needed to adapt - to the impacts of unpredictable weather, seasons that are not normal, as well as new pests and diseases. They reported changing weather patterns associated directly to the conclusions on climate change by Natural Resources Canada.

Adaptations due to the reported impacts fell into five key sports field maintenance themes. The first theme involved adaptations in grass seed selection. The second theme pertained to sports field irrigation adaptations. The adaptations were shown to involve a polarization of perspectives and raise a central question concerning the appropriate balance relative to

expectations for safeguarding water and financial resources and the level of irrigation for grass-based sport facilities. The third theme involved field drainage that can manage extreme rain events. The fourth theme dealt with the pressure for aeration and fertilization due to compaction. And finally, the fifth theme involved the increasing pressure for managing and allocating access to the sports fields. Additionally, a new winter growth tarp strategy was outlined. All of the themes related to resource-based theory. Overall, the participants indicated that they are in the process of adapting their philosophies and practices to account for the impacts of climate change on grass-based sport facilities. Most believed that they were having success in coping with these challenges .

This research contributes to understanding on grass-based sport facilities and the impacts and adaptations being made due to climate change. Our understandings of the topic, however are still in the infancy stage and much research remains to be completed. Suggested research topics include barriers to adaptations for climate change; the associated costs and financial impacts; organizational change, including education for safety due to climate change impacts, and policies for procedures; adaptations to reduce greenhouse gases; and future directions, particularly on the central question concerning the appropriate balance in terms of expectations for safeguarding water and financial resources and the level of irrigation for grass-based sport facilities are needed. The municipal participants are coping – but for how long?

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