**Bamboo as an Environmentally Conscious Alternative to Polyester in Hockey Jerseys**

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Professional sports leagues are an important part of cultures across the globe. But along with this culture comes waste and pollution from the management, teams and fans. Both leagues and teams have created environmental initiatives in regards to topics such as clean energy and waste reduction. Cooperate Social Responsibly is often the motivation behind organizations creating programs to address various social issues including the environment. An impact of sports that has yet to be address by any team or league is equipment waste. Hockey has various pieces of equipment including a jersey which each have an impact on the environment. Jerseys are typically made of polyester, which has numerous negative effects on the environment. Finding a less harmful alterative would lessen the team's environmental impact. Bamboo fabric has already started being used by some sports wear manufactures and was chosen as the alterative fabric to research. The Erie Otters is an Ontario Hockey League (OHL) team that has yet to start an environmental program. This study, using a Life Cycle Analysis, looks into if using bamboo fabric to create a hockey jersey would provide the same qualities that polyester provides while being less damaging to the environment. Through research it was determined that bamboo would be a viable option for a hockey jersey but a physical prototype would have to be created to reinforce this finding.

Introduction

The sports industry is huge in the United States and around the world. The top 200 stadiums in the US attract almost 181 million visitors a year (Sustainable, n.d.). The monthly utility bills, for stadiums, can be over $200,000 to cover an annual energy consumption of over 23 million kWh (Glubiak, 2009). Waste Management (WM) estimates that the four major sports leagues in the US ( The National Football League, Major League Baseball, National Basketball Association and National Hockey League), release around 35,000 metric tons of carbon dioxide a year solely from fans' waste activities such as packaging from food eaten at games (Sustainable, n.d.). Events such as the Olympics and the Super Bowl create tons of trash and $CO_2$ emissions. The 2014 Super Bowl created 425 tons of trash across a four-day span (Fickes, 2015). There are also major environmental impacts for just the regular season games. These events and games are extremely important to people and culture and not going away anytime soon. They are an important part of culture that brings groups of people together and makes them feel a part of something larger than themselves.

*Corporate Social Responsibility*

As with any large corporation, there is a certain pressure from their customers and clients as well as other organizations within their industry, when it comes to bettering the community around them. This concept is often called Corporate Social Responsibility (CSR). Mohr, Webb and Harris (2001) define CSR as "...a company's commitment to minimizing or eliminating any harmful effects and maximizing its long- run beneficial impact on society." (pg. 47) It can include supporting nonprofits and employee well-being as well as human rights and environmental issues. (Mohr & Webb, 2005) The concept of CSR started in the 20th century as business owners like Carnegie and Ford began to donate their money to improve social conditions (Sheth & Babiak, 2009). There has not been much research into CSR and the sports industry but some of the studies that have been conducted have found that executives feel pressure from their customers, as well as team and employees to become more engaged in CSR (Sheth and Babiak, 2009). As of 2004, according to Sheth & Babiak (2009), about "350 charities and foundations exist in relation to professional teams and athletes, and these charities contribute more than US $100 million annually to community beneficiaries (pg. 437). When answering the question "Which of the following would you include as a part of 'corporate social responsibility'?" In a survey, the 27 respondents ranked "Conserving resources, materials, and minimizing waste" fourth out of eight options and it was considered an ethical cause. The three categories above were listed as philanthropic or ethical (Sheth & Babiak, 2009). Listing environmental concerns as ethical rather than philanthropic gives a tone of it should be done rather than it would be nice if it were done.

*Sports and the Environment*

The sports industry is able to have an interesting, possibly more effective, approach to CSR. The ties sports teams have to their community as well as the general star power of the athletes are something many corporations cannot say they have (Walker & Kent, 2009). Many professional sports leagues and teams already have programs that reflect CSR in place such as athletes volunteering, educational initiatives, community development and community based- environmental programs (Walker & Kent, 2009). Consumers have been skeptical of teams and leagues in the past when it comes to their motives behind CSR programs like these as they can be viewed as advertisements. Because of this team managers should create marketing strategies that educate fans on how they have helped specific causes (Porter & Kramer, 2006). Many leagues and teams have begun to create these programs and materials, which can be seen in the examples below.

Teams from leagues such as the National Football League, Major League Baseball (MLB) and the National Hockey League (NHL) have started initiatives and campaigns to help better the environment. The Boston Red Sox started "Fenway Farms" in the 2015-2016 season which, in a partnership with Stop & Shop, Dole, and Sage Fruit, helped build a 5,000 square foot garden that is estimated to provide 4,000 pounds of produce in its first season (Fenway, 2015). In 2002, the city of San Francisco set a Zero Waste Goal in order to divert 75 percent of material waste. AT&T Park, home of the San Francisco Giants, helped the city reach its goal by diverting 1,750 tons of residuals that year, elevating the park's diversion rate to 75 percent (Sustainable, n.d.). Back on the East Coast, New York's MetLife Stadium made recent upgrades to be more eco friendly including waterless urinals and low flush toilets that have reduced water usage by 11 million gallons per year (Sustainable, n.d.).The Philadelphia Eagles, through a partnership with NRG Energy, have 11,000 solar panels and 14 wind turbines in their stadium complex, which are capable of generating four times the amount of energy used at a home game (NRG, 2014). Across the country in San Francisco, the 49ers took the environment into consideration when they began designing their new stadium. They chose to use a specialized concrete that had lower carbon dioxide levels than traditional concrete, which was estimated to reduce the stadiums carbon footprint by 23 million pounds of carbon dioxide.

*The NHL and the Environment*

The NHL's range of programs cover multiple aspects of environmental issues in order to offset the harm running a professional sports league has on the environment. In its 2014 sustainability report, the NHL estimates that each game attendee results in 56 pounds of carbon dioxide emissions. If multiplied by 17,400, the average attendance of an NHL game (NHL, 2016), that adds up to over 974,400 pounds of carbon dioxide just for one game. The NHL is one of the leaders when it comes to environmental action. In the 2011- 2012 season they established a program titled "Gallons for Goals,"

which restored 1,000 gallons of water to Oregon's Deschutes River for every goal scored (NHL, 2012). During the 2015-2016 Stanley Cup Finals restored 1,075,698 gallons of water to the Colorado River through promising fans to restore 1,000 gallons of water for every pledge to go green they received. The league also purchased sufficient carbon offsets and renewable energy certificates (RECs) to cover emissions resulting from the two arenas and team travel (NHL Public, 2016). They also started the "Green Tree Legacy" project in 2012 where new trees are planted in a local park in the city of the draft that year (Pickens, 2016). Arenas across the country are also beginning to install LED lights and smart thermostats to improve efficiency and cut energy costs and usage (Moriz, 2016; NHL.com, 2016).

*The History of Hockey*

The game of ice hockey that we know today has a few different stories of how it got its start. One says there was a similar game that was played in Egypt in 4000 BC. There was also a hockey league that started in England in the 1600s (Ice, 2004). Hockey became popular across the Atlantic when Europeans interacted with the Native Americans. They played a version of lacrosse on ice, which then evolved into ice hockey. In 1872, James Creighton moved up to Montreal and brought hockey with him along with a design for an ice skate (Ice, 2004). Throughout the 1800s and 1900s hockey continued to spread across North America. As the sport spread further west it also began to spread to the middle and lower class (Ice, 2004).

In the beginning, because there was not much of an organized league, there was not much of a uniform for hockey players. Players would wear a regular dress sweater with a number sewn on the back and sometimes a logo on the front creating the term "hockey sweater" (NHL, n.d.). Most teams would just wear the same color or pattern sweater. As the sport developed and became more organized and professional so did the uniforms. Players began to wear clothing that would enhance their game or at least not hinder it. The transition from cotton or wool sweaters to more breathable lightweight fabric helped to keep them warm while encouraging stretching and movement. Even today the materials and designs of sport equipment are constantly changing in order to improve the playing experience.

*Hockey Today*

Two of the main hockey jersey manufacturers are Reebok and Adidas (Peters, 2015). They have both been the jersey providers for the National Hockey League (NHL) in recent years. Another popular hockey brand is CCM (Canadian Cycle and Motor Company; Edge, 2016). This daughter company of Reebok is the brand that the makes the Erie Otters' game day jerseys (Erie, 2016). CCM's version of a game jersey is called "Edge Gamewear" (Edge, 2016). The material is "Wave knit 180g/m2, wave-knit reversed & mesh 125g/m2 (back and insertion). 100% polyester construction for durability. Ultra-Fresh antimicrobial treatment prevents odors" (Edge, 2016). While polyester is great for making sportswear

because of its ability to not allow water in while letting vapor to pass through, the process of making polyester can be quite harmful to the environment.

The Erie Otters are an OHL (Ontario Hockey League) team based out of Erie Pennsylvania. The OHL is a junior league comprised of 20 teams in Pennsylvania, Michigan and Canada (Ontario, 2017). The team is made up of about 25 players ages 16-20 who play against teams in Canada and Michigan. The Otters play a large role in their community through their outreach programs to local food banks and hospitals. The Otters have yet to add an environmental initiative to their work in the community. Using jerseys that are made from bamboo would be a way for them to raise awareness about the environment. A focus on sports equipment waste and environmental cost is topic that has yet to be touched by sports leagues including major leagues like the NHL. There is very little research that has been done on the topic. Most of the big league teams have begun going green in some sense but the movement has yet to trickle down into the minor and junior leagues. These leagues tend to have fewer fans and less funding and income, which can make initiatives harder to start.

*Clothing Industry*

There are many different environmental impacts that come from the fashion industry. There are plenty of places in apparel life cycles for environmental effects including resource production and extraction, fiber manufacturing, textile production, assembly, packaging, transportation and distribution. The growing popularity of the "fast fashion" business model has created an industry with constantly changing trends leading to a high rate of product replacement. The idea of green fashion came around in the 1990s but was heavily criticized. Green fashion refers to a company or product that has sustainable practices when it comes to materials and manufacturing (Kozlowski et. al, 2012). The idea of green textiles can be skewed from company to consumer. For instance, a customer may think that cotton is a green fabric option when in fact cotton takes large amount of pesticides and water if not grown "organically." In addition, there are often hidden environmental impacts, such as use of harmful chemicals and energy and water use during both material extraction and production, with fabrics that are considered environmentally conscious.

*Senior Project*

I chose to focus my senior project on the impacts of sports because sports have also been something I have loved to play and watch. I was unaware of all the negative impacts that sports have on our environment until I took a class on it in 2016. The Erie Otters are an OHL (Ontario Hockey League) team that plays in the Erie Insurance Arena located in downtown Erie, PA. (Erie, 2016). I decided to choose the Otters also in the hope that they could take my idea to their jersey provider, CCM, and work together to make this project a reality. Most of the environmental initiatives of sports teams currently have to do with fan waste at games and the energy it takes to have a game played in a stadium or

arena. Not much research has been done on the equipment waste that is accumulated over a season or seasons of playing. Players have a minimum of two jerseys a season, for both home and away games. They are given new jerseys at the start of each season and sometimes multiple times during the year due to wear and tear or for memorabilia purposes. I want to look at this aspect of the game and see if there is a way to decrease the environmental impacts while still keeping everything players and fans know and love about the game of hockey.

*Methods*

This project combines research and calculations to comprise a proposal for a more environmentally friendly hockey jersey. Research on some alternatives to polyester in the sportswear industry was conducted in order to determine what options were already in use and may be a good fit. One of the popular options found was bamboo. Bamboo can reach full maturity in six to eight months . This is a relatively short growing period, which makes it a popular option for more environmentally friendly clothing companies. Bamboo fiber is also very strong and has recently been used as a substitute for synthetic fibers in sportswear. While the growing process of bamboo seems to be better for the environment, getting the raw bamboo to a fabric can involve many chemicals that may pose environmental hazards. I researched these hazards more and compare them to the hazards of polyester.

The beginning of my project was comprised of research through articles and websites. I contacted two companies, TASC Performance and Cariloha, in addition to conducting research via their websites. Both companies are already creating bamboo sportswear, such as t-shirts, tank tops and sweatshirts, to ask them about their process and also where they get their bamboo. Most bamboo is grown in China and there is little information on how it is being harvested and just how much land clearing is taking place (Hymann, 2016). I researched the processes that go into producing both bamboo and polyester fabrics with a focus on water and energy consumption. In addition, the effects both materials have on the environment were examined. In order to determine which fabric is better for the environment, both harvesting the material and manufacturing a wearable fabric from those raw materials were looked at. This was done using a Life Cycle Analysis, or LCA. Life Cycle Analyses (LCA) are used to evaluate the different environmental impacts of a certain product from the beginning of its life through the disposal of the product. A typical approach has four aspects to it. The first is a starting definition of the goal and scope of the LCA. Second is a Life Cycle Inventory (LCI) of resources, emissions, wastes and other factors linked to environmental impacts. Next is an assessment of actual environmental effects as well as information on the resource use. Lastly, the information collected is interpreted and ways to improve the environmental impacts are laid out. Using LCAs will help account for environmental impacts through all stages of the fabric production.

Another important part of this project was to determine if bamboo is a comparable material to polyester. The qualities polyester gives to the hockey jersey were looked at in order to determine if bamboo can also offer these qualities. The Erie Otters were used as an example. Steve Tuholski was contacted as he is the Head Equipment manager for the team. Through a conversation with him the qualities needed for a dependable hockey jersey for the Otters' players were identified.

After all the data had been compiled a more simple, bulleted version of this project was created to be given to the Otters detailing why they should or should not consider switching to a jersey made from bamboo fabric. The one page fact sheet is a tool to be used when having a in person conversation so that all parties involved can a general idea of the study without having to do an in-depth reading. If bamboo is a viable alternative the Otters will be asked to pitch the idea to their jersey provider, CCM. CCM does not currently make a bamboo jersey. If bamboo was found to be equal or worse for the environment compared to bamboo then the information can be used to support further research into other polyester alternatives.

Life Cycle Analysis

This chapter provides be a Life Cycle Analysis (LCA) of both polyester and bamboo fabric. This will provide a side-by-side comparison of both polyester and bamboo fabric. After the LCAs there will be a comparison of the two fabrics in regards to their use in a hockey jersey. Durability, moisture wicking and breathability are all qualities that polyester has that bamboo needs to have in order to be comparable to traditional hockey jerseys. For most materials, the weaving and manufacturing of the actual garment use the same amount of energy so the differences will come from harvesting the material and creating the of textile (Palamutcu, 2010). The goal of these LCAs is to compare the environmental impacts of polyester textile to bamboo fabric. The LCA will include Life Cycle Inventories (LCI) for both polyester and bamboo followed by assessments of environmental impacts for both fabrics. The last section will be an environmental comparison of the two fabrics. The LCA will cover from the growing and harvesting of bamboo and the retrieving of petroleum and follow to product through the production of the finish product which in this case will be the hockey jersey.

**Polyester**

*Life Cycle Inventory*

Polyester comes from coal and petroleum, which are both nonrenewable sources. When these materials are being mined, it disrupts natural habitats and ecosystems (Impacts, 2010). The process of taking these materials and turning them into polyester is a long, energy intensive process (Environmental, 2000). Various materials such as minerals and alcohol are mixed in a vacuum at high temperatures and then cooled. Once they have cooled, the polymer is a solid ribbon, which is then cut into chips. These chips are naturally hygroscopic, which means they absorb water from their surroundings. Hot air is passed through the chips, which absorbs some of the moisture so the chips do not take it all. Then air is cooled and passed through a drying agent to get rid of the moisture. The air is then heated again and passed through the chips. This process is repeated until the chips have less than 40 parts per million of water. The chips then get spun into fibers through a process called melt spun. This consists of heating the chips until they melt. The material is then forced out of spinnerets creating thin fibers that set when they are cooling. The fibers are then heated and stretched five times their length to be made into yarn (Gerard, 2015; Kosy, 2015). The yarn can then be used to make the clothing and sportswear.

*Assessment of the Actual Environmental Effects*

The mining process for polyester is energy intensive and can damage the surrounding habitat. Damaging habitat can lead to the disruption of animal and plant life as well as throw off ecosystems. Everything within an ecosystem directly or indirectly depends on all the other part, especially with energy sources. If plant species are diminished it will affect all the other organisms higher up in the food chain.

With all the heating, cooling and water use required to create a finished product polyester is very harmful to the environment. The mining process can ruin natural habitat not to mention that the materials being mined are nonrenewable. Fuel must be used to transport the materials from the extraction site to where they will be manufactured (Kahn, 2010). Creating the polyester takes over 80 kJ, or 80,000 watts, of energy as well as 5.5 tons of water for just one ton of polyester (Summerscales, 2006). The process also emits between 2-7.5 tons of carbon dioxide for every ton of product produced (Kim & Dale, 2005). This can be up to the same amount of emissions for 1.25 cars in a year.

A majority of polyester is blended with materials such as nylon, which can take up to 40 years to decompose. So even after its usable lifetime is over the product still has negative impacts (Kahn, 2010). One redeeming quality of polyester is that after it is used much of it can be recycled. Since polyester is a petroleum based product, using recycled materials to begin with makes it much more green from the very beginning of manufacturing. Making a polyester product out of recycled material takes a significantly less amount of energy compared to creating a project with virgin material. However, in many cases, creating a product from already used materials may result in a lower quality product than if new materials were used, (NRDC, 2011) which is not what professional athletes would want. Creating a polyester like fabric without using a nonrenewable source would lead to a much greener product.

**Bamboo**

*Life Cycle Inventory*

Bamboo fabric has recently begun to be used to make sportswear in order to create less of an environmental impact. TASC and Cariloha are two companies utilizing bamboo to create active wear that is light and breathable (About, 2016; Our, 2016). Bamboo plants have a short growing period, which makes them a more renewable source than polyester. (Bamboo, 2016; Bamboo, n.d.). Bamboo is typically found in tropical and subtropical climates, which include Southeast Asia, South America and parts of the Southern United States. Bamboo has been growing on the planet for millions of years and is considered one of the fastest growing plants with some species able to grow three feet in 24 hours (Bamboo, 2016).

Bamboo textiles are created from the soft pith on the inside of the bamboo stalk. These are extracted through an industrial steaming process and then mechanically crushed and dissolved in vats of sodium hydroxide, or as lye. Lye can also be found in materials such as paint thinner and, if spilled, can be toxic. (Macpherson, n.d.). The lye reduces the pulp to a liquid, which is then squeezed out a nozzle, creating thread. The threads are soaked in acid, which neutralizes the lye, and helps set the thread. This thread can then be dyed and woven into fabric and textiles.

One company that uses this production method is TASC. Started by a father and son in 2006, TASC's goal is to create sportswear that is just as good as the types made from polyester without all of the negative impacts on their environment. They spent two years creating their process that produces a

fabric that feels just like cotton without needing chemicals to enhance its performance. They use Moso timber bamboo sourced from the Sichuan Province in China that is grown without the use of pesticides and managed responsibly meaning it is FSC (Forest Stewardship Certified) certified as well as certified organic by the OCIA (Organic Crop Improvement Association) (TASC, 2016). Once they extract the inner pith from the hard outer trunk it is mixed with a caustic soda solution, which separates from the pulp from the cellulose. According to task, this is a closed loop system which means 99% of the solution is able to be reused (TASC, 2016). The cellulose is then spun together with organic wool creating a soft yarn. The yarn is then woven and dyed to create the desired texture and color for the final product.

Another bamboo company, Cariloha, uses a slightly different process to manufacture their clothing. They harvest the bamboo and soak it in a solution, which, just like TASC, is a closed loop system to make sure materials are reused (Cariloha, 2016). The solution helps extract the pulp, which is then flattened and dried into sheet. When the sheets are completely dried they are milled into a fluffy material called viscose. The viscose is then spun into thread or wool so it can be knitted into the finished product (Cariloha, 2016). Cariloha grows their bamboo for their product in the 24,600,000-sq/m-bamboo farm located in the Sichuan Province in China, the same as TASC (Cariloha, 2016; TASC, 2016). They claim that from one stalk of bamboo they can manufacture either five pairs of socks, four pairs of underwear or five shirts (Cariloha, 2016).

*Assessment of the Actual Environmental Effects*

There are 22 million hectares, or 543,638,184 acres, of bamboo forest around the world, which are able to provide over 30 million tons of bamboo fiber per year (Rawi et. al., 2012). There are between 1,200 to 1,500 species of bamboo that can grow in a variety of climates. There are roughly 20 species that can survive in temperatures as low as -20 degrees Fahrenheit and still continue to grow in the spring and summer seasons (Bamboo, 2008).

Companies that use bamboo also tend to have more sustainable manufacturing processes. Both Cariloha and TASC use a closed loop system in order to create a more environmentally conscious process. For example, TASC's product is manufactured in India using 90 percent renewable energy, which makes their energy consumption better for the environment. Their products contain a mixture of bamboo, cotton and Lycra to create a product that's good for a variety of athletic activities (TASC, 2016). Cotton takes between 1.6-2.24 kwh/kg of fabric spun to produce (Palamutc, 2010) and most of the bamboo clothes created are roughly 50 percent cotton. Around 5 to 8 percent of the fabric is made up of Lycra, which is a type of spandex often used in athletic wear to give it the stretch consumers want (TASC, 2016). Creating Lycra is a two-step process using natural and synthetic materials that requires both energy and chemicals to create the finished product (Environmental, 2000). In order to create a ton

of bamboo fabric 2.5 kJ, or 2,500 watts, of energy are used. This process also releases about 0.13 tons of carbon dioxide, which is around the same amount that 0.022 cars emit in a year.

TASC uses a blend of bamboo and cotton to create a softer more wearable fabric. They call their fabric MOSOtech, which is a mix of 52 percent cotton, 43 percent bamboo and 5 percent Lycra (TASC, 2016). Having cotton in the mixture makes the product less environmentally friendly because cotton is a very water intensive crop especially when grown in warm dry climates (Pace, Cralle, El-Halawany, Cothren & Senseman, 1999). In order to create a more environmentally friendly product, the company would have to find a greener substitute for cotton as well as Lycra and, perhaps, find a way to create a fabric completely out bamboo materials. Currently greener options for both cotton and Lycra have not been researched and neither has creating a bamboo product without them.

**Environmental Comparison**

From the beginning of the production process bamboo is more environmentally friendly than polyester. Bamboo is a fast growing, low water use plant, which is much better for the environment compared to drilling petroleum, a nonrenewable source. However, since most bamboo is grown in China there will have to be energy used to transport it to both where the garment is manufactured and then its final destination, which in this case would be the Erie Otters. Bamboo can also be grown in the southern United States (Where, 2008), which may be a way to cut down the transportation energy if the garment were to be manufactured in the United States. In the creation of the textile, polyester releases between 1.87 - 6.87 more tons of carbon dioxide than the creation of bamboo fabric (Dongwek et. al, 2011). Bamboo also uses 77,500 fewer watts of energy than polyester meaning that more fabric could be produced while still using less energy than polyester. If closed loop production systems were used, like those of TASC and Cariloha, the waste of chemicals used can be decreased as well. Overall, the processes for growing and creating a bamboo textile are less harmful to the environment than the steps to create polyester. Changing from polyester to bamboo would create much less strain on the environment.

Can Bamboo Compare to Polyester?

Polyester has many qualities that make it an ideal material for sportswear such as its breathability, or ability to allow water vapor to diffuse through them while not allowing liquid water to pass (Kapp,1999). The fabric can also be pre-shrunk so that the garment does not shrink when someone put it through the wash (Chaudhari et. al., n.d.). It is flexible, allowing the wearer to move without being restricted by their clothing (Caine et. al., 2012; Dion, 2013). But regardless of its qualities, the negative impacts on the environment outweigh its positive impact in the sports world. Looking for a fabric that is comparable in sportswear qualities while having less of impacts on the environment would help to lessen the environmental impact of the sports industry.

Cariloha says their products are twice as soft as cotton while being moisture wicking and naturally odor resistant. They also claim that their product keeps the wearer three degrees cooler compared to traditional sports wear (Cariloha, 2016). TASC claims that their products have qualities very similar to those of polyester. The material is moisture wicking and breathable so the wearer will be comfortable (TASC, 2016). TASC has an ambassador program for their product that is comprised of two athletes, Jeff Evans and Melissa Arnot, as well as 22 ambassadors with a range of interests from running, hiking, skiing, tennis and more (Ambassador, 2016). The product having so many people supporting it speaks to the good quality of the product and backs up what the company says about their product.

Through a conversation with Steve Tuholski, it was found that because the Otters are sponsored by CCM, their jerseys do not have a moisture wicking quality. Bauer, another sports equipment company, has the rights to this technology. Steve said that having this moisture wicking ability could be extremely helpful especially later into hockey games. It could keep a player a few degrees warmer or cooler and thus provide a major advantage. If the Otters switched to a bamboo based jersey, they could better their environmental footprint as well as gain this moisture wicking technology. Tuholski also said that his team looks for a strong, durable jersey. He said that the players have three jerseys of different colors and about half of his players go through two of each jersey a season. Many of the jerseys are switched out because of game wear memorabilia and similar things (Steve Tuholski, personal communication, October 18, 2016). Most jerseys get ripped and torn throughout the season so having a jersey that is tough is a must. Polyester is extremely durable which is why it is often used for sports jerseys. It can handle the rough nature of most sports, especially hockey, without hindering the wearer's performance.

Bamboo fabric is very similar to polyester textile in the qualities it can provide for a wearer. It is breathable and moisture wicking which are two important qualities for athletes. Many clothing items, such as shirts, usually made with polyester have been made with bamboo fabric. Bamboo is strong and durable which is what athletes, professional or not, look for in their athletic apparel. Based on the

research done, bamboo would be able to compare to polyester and provide the wearer with a functional garment that has a smaller ecological footprint.

In order to implement the use of bamboo jerseys for their team, the Otters should look to form a partnership with CCM. As an OHL team, the Otters have less funding and income as compared to professional sports teams. The Otters also have a smaller and more local fan base. Being a smaller teams means that CCM could use their team as a smaller trial run for the bamboo jerseys. If CCM were to take on this project, they would be the first company providing amateur and professional sports teams to do so. Therefore the Otters would not be the only organization to benefit from this project partnership. CCM would have a chance for expansion to other teams and leagues. CSR plays a large role in the possibility of this partnership for both organizations seeing as neither group has an environmental initiative yet.

The Otters will have to discuss price with CCM. There will not only be the cost of materials and manufacturing but the cost of researching and designing. The Otters management should use CSR when discussing this plan with CCM. The two companies can split the cost of the jerseys with CCM paying for more than the Otters since CCM is a larger organization that has more income as well as a greater potential for future profit from this project. While the Otters may not be able to profit as much they will gain an opportunity to start a new initiative for the environment that they can share with their fans. The overview sheet provided in Appendix 1 is meant to help start and guide the conversation between the two parties.

*Future Plans*

Future research should investigate other possible polyester alternatives. Hemp is another textile that is gaining popularity as an greener alternative and could be a good option for sportswear. Many other studies could be done to determine the most environmentally friendly textile option. Research into other possible alternatives should be done in order to determine which would be both the most environmentally viable option as well as the material that would provide the best product athletic performance wise. Studies similar to this one could be done on the other options, such as hemp, in order to determine which prototypes would be worth putting time and funds into. The ecological footprint of polyester is negative from start to finish and with the nature of rapid sporting equipment changes a more environmentally conscious option should be invested in. In addition, jerseys are not the only type of equipment that could be researched. Hockey pad, sticks and skates also get thrown away often with changing advancements in sports technology. Making this equipment out of more sustainable materials would make their shorter life span less harmful to the environment.

In order to obtain the most accurate idea of whether or not a hockey jersey can be made out of bamboo fabric as opposed to polyester a physical prototype will have to be created and tested. Bamboo

fabric appears to be able to compare to the qualities of bamboo but in order to get the most accurate idea if bamboo can keep up with polyester.

This study has determined that a prototype of a jersey would be worth making in order to help make the sport of hockey, and more specifically the Otters, a little greener. In addition to launching an environmental initiative for the Otters this could start a movement for greener clothing in the NHL and other professional sports league where the concept of equipment waste has yet to be taken into consideration. There would also be the opportunity for bamboo clothing to gain more recognition and spread more into the more recreational sports community.

Appendix 1

Included below is the sheet meant to start and aid the conversation for the Otters about how they can go about the implementation of bamboo jersey use.

**Bamboo Jerseys**

*Sports and the Environment*

- The 4 major sports leagues (MLB, NBA, NFL, NHL) release around 35,000 metric tons of carbon dioxide a year solely from fans' waste activities such as packaging from food eaten at games (Sustainable, n.d.).
- In its 2014 sustainability report, the NHL estimates that each game attendee results in 56 pounds of carbon dioxide emissions. If multiplied by 17,400, the average attendance of an NHL game (NHL, 2016), that adds up to over 974,400 pounds of carbon dioxide just for one game.
    - Average attendance of Otters games over past 4 years is 4,540 multiplied by 56 pounds of carbon dioxide equals approximately 254,240 pounds of carbon dioxide per game
- So far teams have created programs for waste reduction, composting, energy reduction, cleaner energy and water usage

*What The Otters Can Do*

- No sports team in any league, professional or not, has started a project with sporting equipment waste
- You can significantly reduce the Otters' ecological footprint while creating opportunities to educate and inspire fans to do the same

*How it can be Done*

- Discuss a partnership with your jersey provider, CCM
- By them helping create bamboo jerseys they will also gain great media and become the first jersey manufacturer to rise to this challenge
- Collaboration will mean that both the Otters and CCM can work to get as most out of this project as possible

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