

# ArootZ

Transforming the future of Tree Planting



**Sustainable Tree Planting System**

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**Submitted in partial fulfillment of the requirements for the degree of**

**Bachelor of Industrial Design**

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Humber Institute of Technology and Advanced Learning

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# Sustainable Tree Planting

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## Abstract

The objective of this thesis project is to cultivate a design solution that delivers a sustainable tree planting method that facilitates a smoother planting experience while negating the strenuous physical undertaking of planting a tree. The proceeding will rely on participant's interviews and user observation to obtain a better understanding of the challenges the tree planting community confronts with each planting season. The culminated design solution will enable tree planters to safely and proficiently plant trees while simultaneously enhancing the survival of each tree planted. This approach could eventually be applied in the Silviculture and Reforestation industries and will be applied in woodlands and backwoods worldwide.

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## CHAPTER #1      Problem Definition



Figure 1. 1 - - *The Hours Are Long.* [Photograph]. (n.d.). Retrieved from <https://www.tentree.com/blogs/posts/the-5-hardest-things-about-working-a-tree-planting-job>

### 1.1 Problem Definition

Carbon dioxide (CO<sub>2</sub>) is a gas that possesses significant importance to the future of this planet. The emission of CO<sub>2</sub> gas creates a heat-trapping effect known as greenhouse gas caused by human actions such as deforestation, burning of fossil fuels, in addition to natural causes such as respiration, forest fires and volcanic eruptions. When released into the atmosphere the concentration of CO<sub>2</sub> has swiftly increased over the last century to produce copious negative effects on our climate and planet at large (Shaftel et al., 2020, para. 1). With the alarmingly high concentration levels of CO<sub>2</sub> in the atmosphere, efforts around the world are being put in place to diminish the CO<sub>2</sub> concentration, and reduce the international environmental and economic impact. One of the best-known approaches to combat this global problem is to plant trees, due to their ability to absorb CO<sub>2</sub> from the atmosphere. Some of the earth's largest woodland ecosystems like the Boreal forest become highly influential and significant to these worldwide efforts. Canada is home to the Boreal forest and has 347 million hectares of forest leaving it the third most forested country in the world (Government of Canada, 2020). This natural resource is a major export for Canada and plays a significant role in its economy. Tree Planters are

the workers who support this essential industry and allow it to maintain its vitality, while simultaneously providing a more sustainable future. The process of planting trees in these dense woodlands is very strenuous and does not ensure the tree's longevity which is needed to make a positive impact on the changing climate. The technique and skill of tree planting involves high repetition paired with the constant physical demand over an 8-hour day which often leaves tree planters injured and unable to operate. The harsh northern Canadian landscape requires peak physical effort to successfully traverse and plant in these northern woodlands. This harsh landscape prevents automation and automotive assistance leaving a unique situation for human execution. This thesis project seeks to mitigate Tree Planting related injuries and enhance seedlings mortality rates in Canada.

## 1.2 Investigative Approach Taken

To obtain an understanding of problems and challenges that Tree Planters face the following research methods will be applied:

- Literature Review
- Existing Product benchmarking
- One on One user interviews
- User activity mapping
- Ergonomic studies

These fundamental questions will be addressed throughout the design process:

- How can Tree Planting injuries be mitigated?
- What is the most ergonomic and beneficial way to distribute weight across the Tree Planter's body?
- How can we reduce the number of repetitive tasks of the Tree Planting process?
- How can we improve the mortality rates of the planted seedlings?
- What sustainable materials are best suited for the environment of Tree Planting?

## 1.3 Background – Social & Historical Context

Tree Planting is a male predominant industry and employs 210, 615 people in Canada. Tree Planters are typically young adults ranging from 18-30-year-old, with 92% of planters starting between the ages of 18-25.

Tree Planting requires workers to live in remote areas in northern Canada completely secluded from civilization. Typically, Planters will not have cellphone service or contact with anyone throughout the Tree Planting season, except for on weekends if they are able to commute into the nearest town. Typically, Tree Planters live on camp sites in tents or vehicles and spend the majority of their free time with one another. The harsh reality of the job along with the secluded environment creates a very communal atmosphere among Tree

Planters and often results in some of the most memorable aspects of being a Tree Planter. The isolation in nature combined with the intimate planting community is what encourages many Canadians to become Tree Planters and is often the reason many Planters return for another season.

The sense of community is vital to supporting planter's mental health throughout the season. Planters tend to maintain a positive outlook no matter how terrible the situation they are put in. The shared hardship of planting builds a unique outlook on life whereby the planter's mentality is to accept the harsh conditions of the environment and the job-related tasks as part of the way of life without complaining. Developing a mental toughness is viewed as a rite of passage into the Tree Planter's cultural values. This underlying acceptance mindset suggestively plays a role in the lack of innovation in this field. The tree planting bags which consists of a waist belt, shoulder straps, and 2-4 bags has not changed since the 1970s.

Tree planting bags do not sufficiently accommodate the array of different body types that use them. The standard hip belt is often too large for most slender males and small females requiring a bigger range of adjustability. The minimal padding and adjustability of the current design negatively affects the iliac crest and lumbar/lower back areas which causes a multitude of preventable short-term and long-term injuries. Additionally, the shoulder straps are often too large and do not ergonomically adapt to the different planter's body types, causing many users to modify the design or to remove them altogether.

Tree Planters cyclically implant hundreds to thousands of seedlings per day regardless of the weather and the terrain. In addition to this recurring action the Tree Planters carry up to 50-60lbs of weight within their bags. The repetitive routine while carrying heavy loads combined with lack of support provided by the equipment subjects Planters to a variety of injuries and discomforts.



## CHAPTER #2      Research



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This chapter reviews the research that has been completed and the method in which it was accomplished. This research has been conducted in a scholarly manner and aims to uncover the qualitative and quantitative data pertaining to Tree Planting. Research began through literature searches in order to derive an initial thesis direction and validation. These literature searches were consistently done throughout each process of this thesis project. This was followed up by benchmarking existing products and establishing what current solutions are on the market. This base level understanding was further developed through one-on-one user interviews, surveys, and user observation. These research methods provided a more personal and direct understanding of the problem areas within the industry today. With a strong understanding of the problems Tree Planters face, an ergonomic study was conducted to further understand the dimensionality of the human body and how to best accommodate the biological restrictions of the human body. This chapter will showcase both research pertaining to the user and products in which they interact with on the job.

## 2.1.1 – User Persona

### Persona – Primary User – Tree Planter

**Name:** Camilla Mackie

**Age:** 28

**Occupation:** Tree Planter

**Income:** \$25,753/Season

**Education:** Bachelor's Degree – Finance

**Relationship Status:** Single

**Location:** Peterborough, Ontario

**Career/ Seasonal:** Seasonal

**Seasoned Worked:** 5 seasons

**Social:** Works with 10 other Crew Mates on Block

**Frequency of Activity:** Every Weekday (8h) for 3-4 months.

**Hobbies:** Hiking/mountain climbing, rock climbing, Snowboarding, Drawing, Traveling



Figure 2. 3 - Summit Crew bosses. [Image]. (2020). Retrieved from <https://www.summitplanting.com/camilladaniels.html>

### Profile

Camilla Mackie is 28-year-old Caucasian women. She attended university to receive her Bachelor's degree in Finance. She earns a seasonal salary of \$26,000. She has been planting for 5 consecutive seasons with Outland Planting Company in British Colombia.

Camilla began her Tree Planting career at 23 a years after obtaining her degree. She loves the physical intensity and mental determination tree planting requires and enjoys the positivity and culture of tree planting.



### Camilla’s Behavior:

As a seasoned Tree Planter, Camilla has become an Outland tree planting crew boss and strives to be a role model to her crew each season. Camilla goes into everyday with a positive attitude, and ensures her crew makes money, has fun, and sustains a positive attitude. She takes safety very seriously and emphasizes the importance of communication among her crew. She pushes herself and her crew to exceed their goals, and she prides herself on overcoming whatever physical and mental barriers her and her crew encounter. Camilla does not accept complaining and believes that positivity is what ensures successes in tree planting. Camilla enjoys getting to know her crew throughout the season and loves the friendships/relationships she makes each year. She stresses the importance of rest/time off and enjoys the camp dynamic of tree planting. Lastly, she loves the tree planting community and brings the skills she is gained in tree planting into her everyday life.

### Camilla’s Relationship to her Planting Gear:

Camilla received her planting equipment when she first joined Outland. Throughout her 5 seasons of planting the equipment has remained the same. She values the utility and durability her equipment provides, although finds there could be room for improvement regarding its comfort. Over her planting career she has personalized her equipment to best accommodate her needs. She has learned many valuable insights and edits to her equipment through experienced planters in the tree planting community. Throughout each intense season she developed a stronger bond to her equipment and has learned to appreciate the role it plays in the planting process.

### User Profile Summary

User	Description
Primary	Tree Planters
Secondary	Tree Planting Crews
Tertiary	Silviculture Company

Table 2. 1 – User Profile summary

### Primary User Breakdown

Demographics		User Behaviour		Personality		Cognitive Aspects	
Age	20-35	Frequency of Use	Everyday 4-month period	Locus of Control	↓	Technical Skill	↑
Gender	Predominantly Male (~81%)	Duration	Varies (8 hours)	Self-Efficacy	↑	Pre-Requisite Knowledge	↓
Ethnicity	Caucasian (+73%)	Social	Highly Social	Changeability	↑		
Income	Low to Middle Class (\$18,000 to \$35,000)	Level of Focus	Medium - High	Uncertainty Avoidance	↓		
Education	High School Diploma	Location	Rural– Woodlands				

Table 2. 2 – Primary User breakdown

## 2.1.2 - User Observation

### Activity Frequency

Tree planting produces a very intensive planting situation. Since workers are paid at a set rate per tree planted, they tend to push themselves to perform at an extremely high frequency and activity rate. This is a significant source for the high injury rates associated in the Tree Planting industry. The short seasonal and cyclical factors paired with the piecework method of payment method, push Tree Planters to plant as many trees as physically possible within an 8-hour period. This is then repeated 5 days straight with a break on weekends continuously, over a 4-month period.

### Social

Due to the remote northern location of tree planting camps and the intense mental and physical demand that accompanies it, the social dynamic of tree planting becomes a crucial part of the job. Planting camps are often so remote that planters do not have contact with the outside world. With limited options the only social contact would be with one another. This often fosters a very communal, almost family like environment and is one of the most valued parts of the tree planting experience. With the natural isolation and intensive labor that accompanies each workday, planter’s downtime is valued and often very social. A positive outlook and a the support of a positive crew is stressed in order to sustain productivity over the season.

## Lifestyle & Personality

Tree Planters are extremely active people; they spend a lot of time outdoors hiking and exploring their natural environment. An appreciation for nature and the outdoors is required to withstand the long days in the open harsh woodlands of Canada. Planters are known to not conform to the typical fulltime employment lifestyle, as they like to experience life and what nature has to offer. Tree Planters are often positive and self-determined people. A big part of the Tree Planting culture is the mental resilience one must have to push themselves physically to keep planting regardless of the physical challenges and environmental conditions.

## Income Level

Since many Tree Planters work seasonally it is challenging to determine an income level for them. Planters often use their summers to accumulate money, allowing them to return to school, travel or live their ideal lifestyle during the off season. Depending upon the Tree Planter, some tend to travel to other parts of the world to maintain a steady Tree Planting income during the off season in Canada.

## Location

The majority of Tree Planting in Canada takes place in the northern parts of British Columbia, Ontario, and Quebec. These woodland regions typically supply Canada's lumber industry. In turn, the silviculture industry (which is "the branch of FORESTRY that deals with establishing, caring for and reproducing stands of trees for a variety of forest uses" (Painter, & Cooligan, 2015, para. 2). is contracted to re-plant trees in the cleared woodland areas. These remote locations add another challenging aspect to the job, placing more physical and mental strain on Tree Planters.

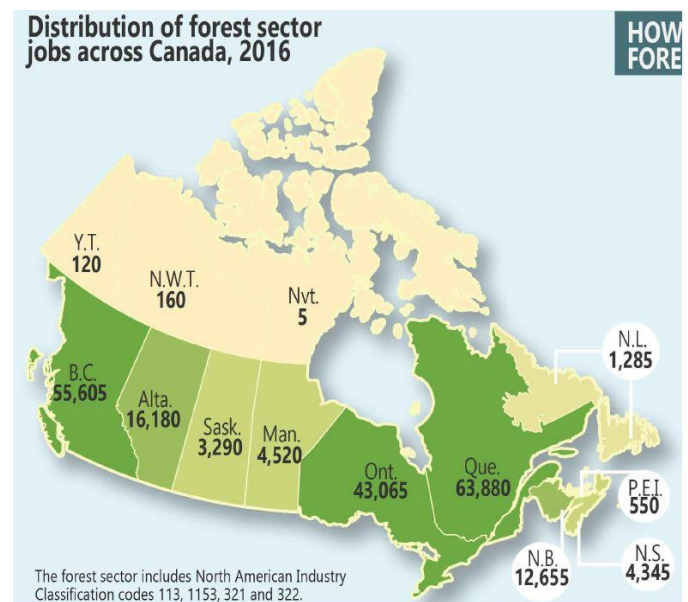


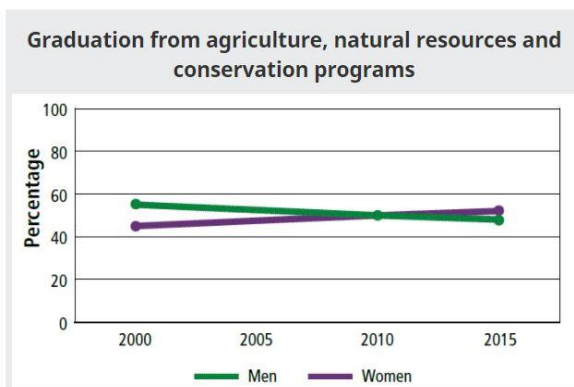
Figure 2. 5 - An Overview of Canada's Forest Sector. [Image]. (2020). Retrieved from <https://www150.statcan.gc.ca/n1/pub/16-201-x/2018001/info/fig/fig02-eng.htm>

## Demographic

### Gender

As inferred from the user demographic search bellow, the majority of the Tree Planting industry is male at a rate of over 80% in between 2000 to 2015. In that same time frame, there has been a steady increase in female workers from 13% to 18%. This increasing shift in females in the forestry industry is reflected in terms of agriculture, natural resources, and conservation graduates across Canada. Within this sector of the industry women have gradually surpassed males. This telegraphs an increase in female forestry employment within the coming years.

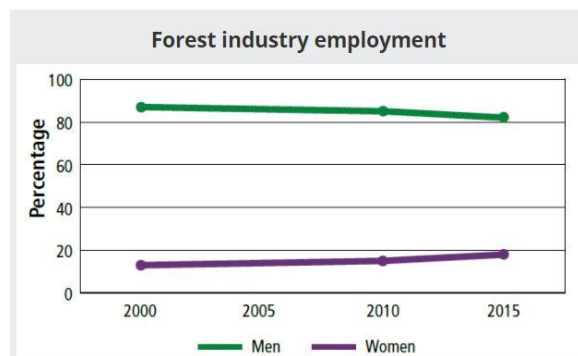
### Women in forestry



▼ Graph data

Table showing the graduation rates for men versus women from agriculture, natural resources, and conservation programs.

Sexes	2000	2010	2015
Men	55%	50%	48%
Women	45%	50%	52%



▼ Graph data

Table showing forestry employment rates for men versus women.

Sexes	2000	2010	2015
Men	87%	85%	82%
Women	13%	15%	18%

Figure 2. 7 – Women in forestry. [Image]. (2020). Retrieved from <https://www.nrcan.gc.ca/our-natural-resources/forests-forestry/state-canadas-forests-report/infographics/20031>

## Ethnicity

Demographically the predominant ethnicity among Tree Planters is White (Caucasian). Although, as shown in the following infographic about 18% of Tree Planters are Indigenous, and about 9% of planters are immigrants.

## Canada's forests are important to the economy

The forest industry directly employed

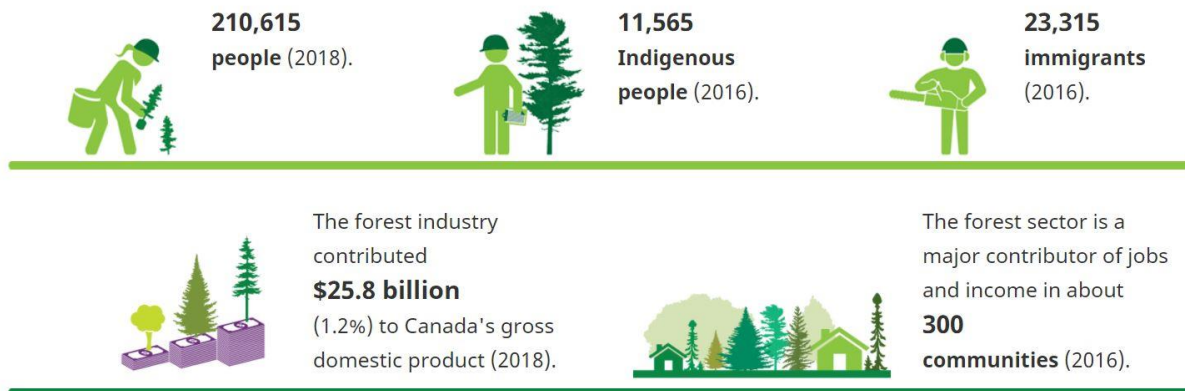


Figure 2. 8 – Canada's forests are important to the economy. [Image]. (2020). Retrieved from <https://www.nrcan.gc.ca/our-natural-resources/forests-forestry/state-canadas-forests-report/infographics/20031>

## Industry Sectors

The Canadian forest product industry encompasses a multitude of different jobs. Canadians can find employment opportunities in an array of different sectors such as; woodlands, Skilled Trades, Sciences and Engineering, Mill Operations, and Administration.

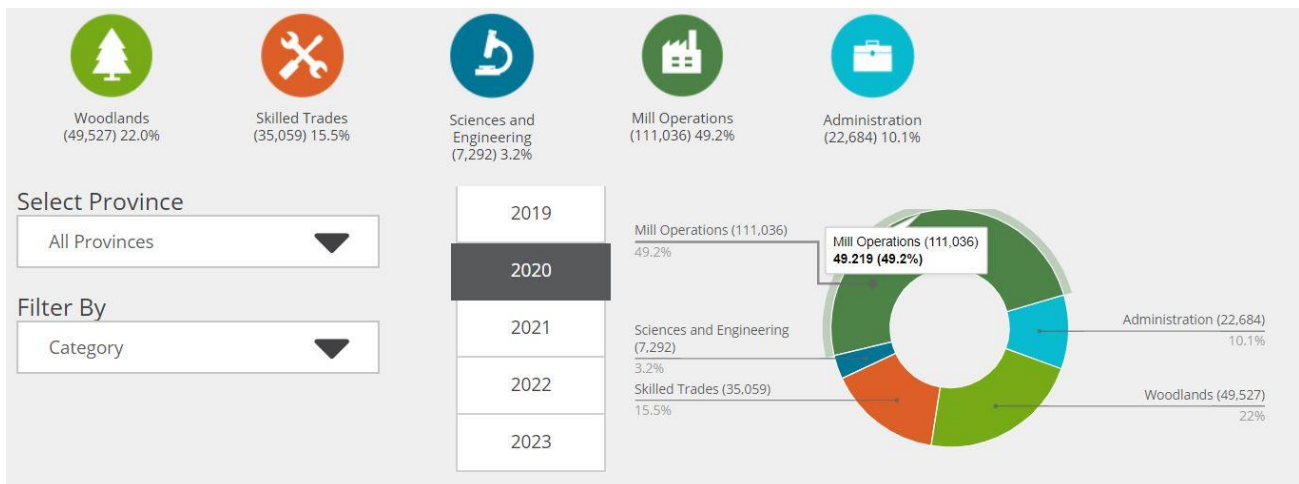


Figure 2. 9 - Total Jobs and Job openings in Canada's Forest Product Industry. [Image]. (2020). Retrieved from <https://thegreenestworkforce.ca/jobs/index.php/en/labour-market-information/forecast/>

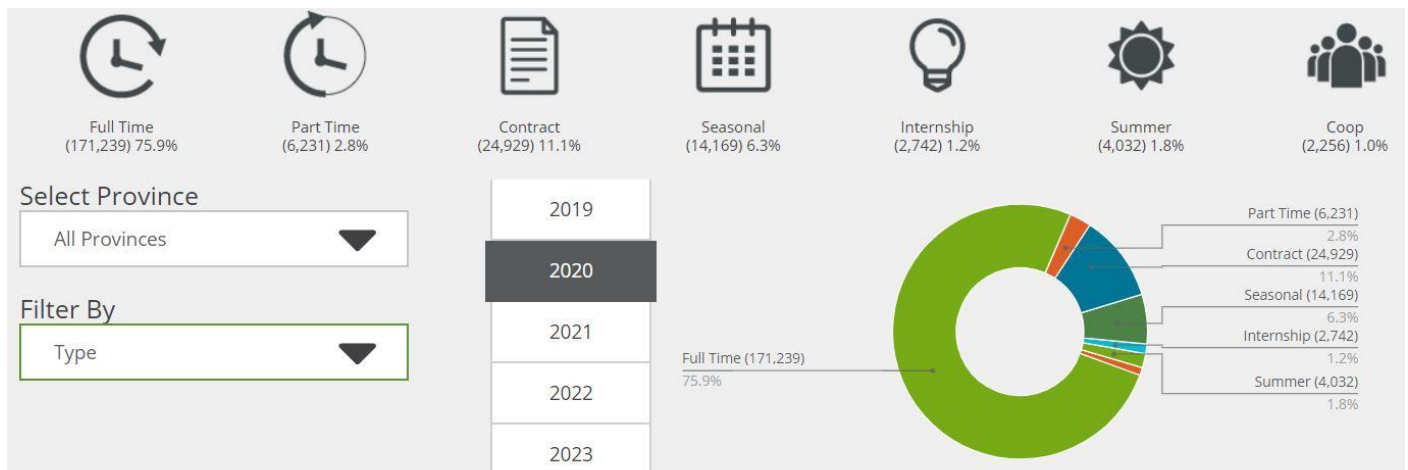


Figure 2. 10 - Total Jobs and Hob openings in Canada’s Forest Product Industry. [Image]. (2020). Retrieved from <https://thegreestworkforce.ca/jobs/index.php/en/labour-market-information/forecast/>

## Income

Tree Planter’s salaries are difficult to quantify due to the nature of the business. Tree planters get paid per tree planted which creates several different variables that can affect their daily income. Generally, the base level price for planting a seedling in Northern Canada is \$0.11. The first variable is how much one seedling is worth, which varies depending on the “blocks” contracted to the silvicultural company. Different “blocks” of land may increase the pay per implant but that generally comes with a harsher situation to plant in. The other variables to consider as to how much a Tree Planter earns, is how many trees the planter plants in one day. This variable depends upon the experience and skill level of the planter. Once a planter gains experience, they often average about 1,900 - 2,000 trees per day. Therefore, assuming they are capable of maintaining this daily quantity they could earn about \$216 a day.

### Tree Planter Salaries

10 Salaries Updated Sep 9, 2020

Average Base Pay

CA\$27 / hr



#### How much does a Tree Planter make?

The national average salary for a Tree Planter is \$27 in Canada. Filter by location to see Tree Planter salaries in your area. Salary estimates are based on 10 salaries submitted anonymously to Glassdoor by Tree Planter employees. Less

Figure 2. 12 - Tree planter salaries Canada. [Image]. (2020). Retrieved from [https://www.glassdoor.ca/Salaries/tree-planter-salary-SRCH\\_KO0,12.htm](https://www.glassdoor.ca/Salaries/tree-planter-salary-SRCH_KO0,12.htm)

### Discussion / Conclusions

This data showcases that the typical Tree Planter appears to be between the ages of approximately 20 to 35. It is also evident that the majority of Tree Planters (about 73%) are a Caucasian ethnicity. Based on the typical method of pay, the income is a difficult to conclude as there are too many variables, including injuries, that affect the planter’s ability to perform consistently throughout the season. Based on the statistical data collected, it is evident that the images portray a reasonable representation of the “average” Tree Planter.

#### Demographics of Tree Planter

Age	20 – 35
Gender	Mostly Male (82%)
Ethnicity	White
Seasonal Income	\$18k - \$35k

*Table 2. 3 – Demographic of Tree Planter*

Overall, most Tree Planters seem to be 20-28-year-old male of Caucasian ethnicity earning around \$18k to \$35K during a 4-month period.

Primary User	Tree Planter
Secondary User	Crew Boss/Foreman
Tertiary User	Silviculture Company

*Table 2. 4 – User Break Down*

The data presented in chapter 2, reflects a general understanding of the personality traits and behaviors of a typical Tree Planter. These images and information showcase that the typical personality and behaviour of a Tree Planter is a positive, adventurous individual who values community and isolation.



### 2.1.3 – Activity Mapping

The following data has been collected by observing the user while executing the task of Tree Planting. For the purposes of this thesis report, observations have been made by analyzing video content of Canadians Tree Planting. The activities conducted while Tree Planting are laid out in chronological order.

- Planning
  - Buy equipment before season starts.
  - Accumulate all needed equipment before you leave for camp.
- Preparation
  - Clean & maintain equipment.
  - Accumulate equipment and get it in one central location for easy access next day.
  - Prep lunch
- Wake up and eat breakfast.
  - Eat and drink as much as possible. Need as many calories as possibly (needed for day)
- Commute to Planting block
  - Get to truck with all your belongings
  - Get in with crew and commute to planting block
  - Catch some more sleep (sometimes)
- Load Bags with Seedlings at “cash” (loading area) ... (First of many)
  - Take bundles of seedlings from box – unwrap the “plugs” and then load as many as you can in your bags (typically 100)
  - Repeat throughout the day each time your bags empty until the day is over
- Plant Trees
  - Find ideal micro site – Properly spaced, good soil content, good lighting/coverage
  - Impact ground with shovel to create opening
  - Place seedling in opening then “close it off” (replace soil)
  - Flag seedling to mark its location so you can see “planting line”
  - Repeat about up to 2000 times – Refilling bags every time you run out of seedlings
- Finish Day – Pack up – Commute back to camp
  - Finish unloading final bag up
  - Walk back to the “cash” – loading area
  - Get in trucks and commute back to camp
- Dinner / Free time
  - Eat dinner
  - Enjoy quality time with fellow planters at camp
  - Prep for next day – shower, equipment check and repairs
  - Sleep



Video Observation:



Figure 2. 13 – A-G - User Observation day planting

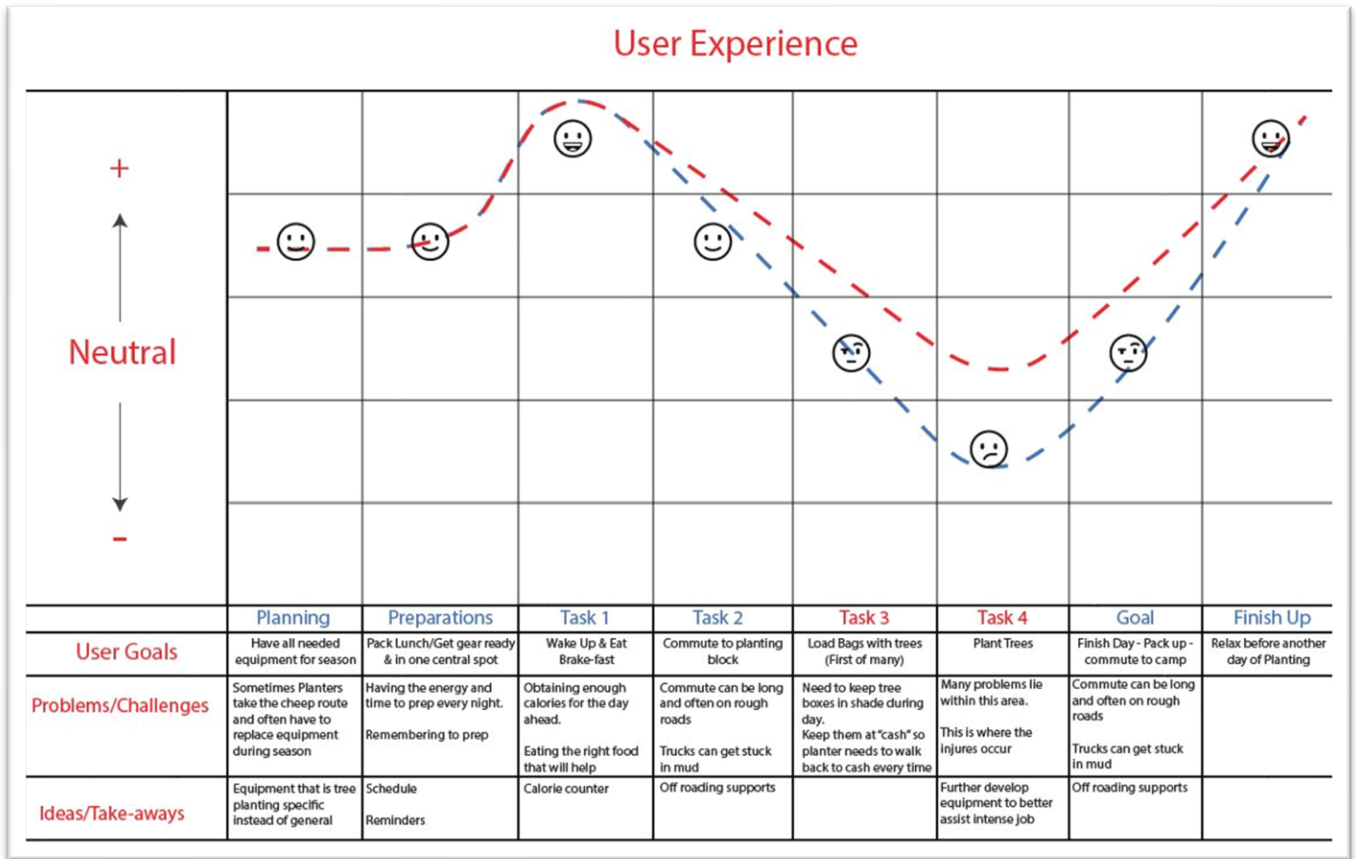


Figure 2. 14 – Activity Mapping - User Experience

### 2.1.4 – Ergonomics (Existing Products)



Wearable products are in constant contact with the human body making the ergonomics extremely impactful. The additional factor is a constant 50-60 lbs. load while wearing the product. This adds further significance to the ergonomics.

The current tree planting harness provides 3 minimally designed pads around the hip belt and padded shoulder straps. Each strap is fitted with an injection molded plastic buckle, which provides the ability of adjustment.

Canadian tree planters are subject to two options when it comes to tree planting harness bags, all provided

Figure 2. 16 - BUSHPRO DELUXE 3 POUCH BAGS. [Image]. (2020). Retrieved from [http://www.bushpro.ca/index.php?area\\_id=1001&page\\_id=1003&page\\_element\\_id=14&item\\_id=2&LIMIT14=0#element14](http://www.bushpro.ca/index.php?area_id=1001&page_id=1003&page_element_id=14&item_id=2&LIMIT14=0#element14)

by the same company. The lack of a market provides planters with little to no options when it comes to sizing and customization.

### 2.1.5 – Safety and Health

Within the tree planting industry there are no standardized health and safety regulations. The industry within the past 5 years has made efforts to provide common safe planting practices through seminars and health courses aimed at preventing injuries by explaining proper planting techniques. In terms of physical products or equipment there are no safety regulations to support tree planter’s ergonomic needs. The lack of safety requirements and small market provide no choice for planters regarding safety options. This is where opportunity lies.

## 2.2 Product Research



Figure 2. 18 – Product Benchmarking – Hunting/Hiking packs

Product research has been executed to identify successful attributes and properties of currently produced products. Due to the lack of innovation and overall market within the Tree Planting industry other closely related industries have been studied. Product research was conducted through literature searches and product benchmarking. For the purposes of this thesis, closely related products have been analyzed to obtain an understanding of what current benefits and features are provided with related markets. The benchmarked products have been chosen from the following industries: hunting packs, military equipment, and exiation/hiking packs. These products have been chosen due to their similarities in function, body contact points and load distribution. During the duration of product bench marking, it became evident that the lack of innovation and variety in the Tree Planting industry itself showcases an opportunity for a new design solution.



## 2.2.1 – Benchmarking – Benefits and Features

A total of 8 hunting/hiking packs have been analyzed. 3 of the 8 packs will be focused on to showcase the spectrum of benefits and features these related industries provide. The following table lists the features that each pack incorporates in its design.




<p>EXO MTN Gear K3 Frame</p>		<ul style="list-style-type: none"> <li>• Water Resistant</li> <li>• Suspension Frame Titanium horseshoe construction</li> <li>• Hip belt with built in lumbar support</li> <li>• YKK coated Zippers</li> <li>• Frame Divy Mode</li> <li>• Compression Straps</li> <li>• Load lifter Straps</li> <li>• Angle adjustable shoulder straps</li> <li>• Durable Rip Stop Nylon Fabric</li> </ul> <p><i>Figure 2. 20 – EXO MTN Gear K3 Frame. [Image]. (2020). Retrieved from <a href="https://exomtngear.com/collections/packs/products/k3-frame-system?variant=19546187333699">https://exomtngear.com/collections/packs/products/k3-frame-system?variant=19546187333699</a></i></p>
<p>Kuiu Pro 1850 Full Kit</p>		<ul style="list-style-type: none"> <li>• Water Resistant</li> <li>• Suspension Frame Spread Tow Carbon fiber construction</li> <li>• Hip belt with built in lumbar support</li> <li>• YKK coated Zippers</li> <li>• Frame Divy Mode</li> <li>• Compression Straps</li> <li>• Load lifter Straps</li> <li>• Angle adjustable shoulder straps</li> <li>• Durable Rip Stop Nylon Fabric</li> </ul> <p><i>Figure 2. 22 – Kuiu Pro 1850 Full Kit. [Image]. (2020). Retrieved from <a href="https://www.kuiu.com/global/pro-1850-full-kit/pro-1850.html?cgid=pack-pro#start=4">https://www.kuiu.com/global/pro-1850-full-kit/pro-1850.html?cgid=pack-pro#start=4</a></i></p>
<p>Osprey Atmos AG 50</p>		<ul style="list-style-type: none"> <li>• Water Resistant</li> <li>• Soft Suspension Frame 210D High tenacity Nylon mesh</li> <li>• Hip belt</li> <li>• Compression Straps</li> <li>• Load lifter Straps</li> <li>• Durable Rip Stop Nylon Fabric</li> </ul> <p><i>Figure 2. 23 – Osprey Atmos AG 50. [Image]. (2020). Retrieved from <a href="https://www.osprey.com/ca/en/product/atmos-ag-50-ATMOS50S18_334.html">https://www.osprey.com/ca/en/product/atmos-ag-50-ATMOS50S18_334.html</a></i></p>

Table 2. 5 – Product benchmarking

**X-Y Graph**



Figure 2. 25 – Product Benchmarking XY Graph

Take Away

1. Features
  - a. Volume (Pack Capacity)
  - b. Lbs. (Load Capacity)

It can be seen that the bigger volume packs (Pack Capacity) does not indicate it has the biggest load capabilities (lbs.). This provides an interesting realization that the pack frame plays a much more significant role when it comes to carrying a load. This implies that the frame of the pack is much more integral to the distribution of weight than the pack, which in turn allows the user to carry more items, more comfortably, at once.

The promotional media and literature of the products selected has been studied to determine the top features and benefits. By highlighting the commonly occurring features, the key benefits can be established, considered, and implemented. The following table outlines the key features and benefits establish from the benchmarked products.

Key Features/Benefits of Compared Products	
Features	Benefits
<b>Suspension Frame</b>	Comfort – Weight distribution
<b>Hip belt with built in lumber padding/support</b>	Health and Safety
<b>Load lifter straps</b>	Light weight
<b>Lightweight durable fabric</b>	Breathable
<b>Dual density foam</b>	Durable

Table 2. 6 – Key features / Benefits of compared products

### **2.2.2 – Benchmarking – Functionality**

As previously stated, the market revolving around tree planting harness bags lacks variety therefore creating a small range of products with minimal functional alternatives. By analyzing closely related products a new range of functionality is uncovered. As establish in the previous section, hunting and hiking packs where studied to uncover this functionality.

Within the market of hunting and hiking packs there is a wide range of varying functionality. In order to narrow down the range of products, only long-distance packs where studied due to their similarities to planting bags. Every pack studied utilizes a suspension frame to distribute weight and provide the most comfortable and ergonomic experience. The following points summarize the key discoveries pertaining to the functionality of the packs analyzed:

- Suspension frames provide a hard structure for weight to be distributed throughout. The frame provides attachment points for straps and features that come together to create an entire suspension system
  - The load the pack is capable of carrying is dependent on the frame not the pack. The lighter the load the less substantial the frame design is

- The smaller the frame the shorter intervals of time the user can wear/carry it without discomfort or pain
- The hip belt incorporates a substantial lumber pad to ensure the forces are being applied in the appropriate spots on the human body
- The more expensive the pack the higher quality materials and foam are incorporated into the design
- The higher priced packs offer more customization for the end user than cheaper packs

All these packs utilize some form of a suspension frame system, this clearly outlines the significance of this feature. Taking that into consideration there is currently no tree planting harness bags that incorporate this type of system. This outlines the opportunity to significantly improve the planting experience by implementing an exclusive suspension system designed for more effective planting.

### **2.2.3 – Benchmarking – Aesthetics**

The aesthetics pertaining to wearables that are used in a manual labor jobs is often overlooked or minimally considered. This is typically because functionality is much more significant in comparison to the design's aesthetics. Additionally, this is often the case due to the product naturally becoming worn and dirty while enduring the harsh working condition of the job.

This thesis hopes to incorporate a realistic sense of aesthetic so the user can appreciate their bags on an emotional and physical level.

### **2.2.4 – Benchmarking – Materials and Manufacturing**

With only one North American supplier, the material information provided is all sourced from their site. Bush Pro (n.d.) supplies all Canadians with their planting bags, which does not provide any alternatives for the planters. Currently Bush Pro states that the harness is made with a "wear and tear-resistant Nylon", and the buckets consist of a "high-grade vinyl" ("Bush Pro, n.d). Nylon is a synthetic fabric that is created by chemically binding two acids. More specifically as stated in CraftTech Industries, Inc. (n.d) article "Nylon is made via a condensation polymerization reaction and is formed by reacting di-functional monomers containing equal parts of amine and carboxylic acid. - In each case, the two molecules combine to make nylon with water as a byproduct" (para. 6). Whereas the vinyl planting bucket although still synthetic, is polyester coated with a PVC plastic adhesive (Phifer, n.d.).

## 2.2.5 – Benchmarking – Sustainability

Sustainability and planting trees go hand and hand. The effort to plant more trees is being pushed on a global scale. In 2020 Canada's Natural Resources Minister O'Regan released Canada's plan to plant 2 billion trees within the next 10 years. "Canada's plan to plant two billion trees over the next ten years is projected to reduce greenhouse gas emissions by up to 12 megatonnes by 2050. It will create up to 4,300 good jobs." (Government of Canada, 2020, para. 3). These endeavors have been put in place to ensure the longevity of our natural environment and planet at large. Although these large-scale initiatives are in place, there seem to be no sustainable developments within the silviculture industry itself. This is where the opportunity lies to truly enhance the industry's ability to minimize its environmental footprint.

## 2.3 - Summary

Chapter 2 outlines every aspect of what it means to be a Tree Planter. It does this through extensive literature searches, user observations and product comparisons. To conclude this chapter data will be retrieved from a user survey and multiple one-on-one user interviews.

As outlined above tree planters promote a positive outlook on their situation regardless of the challenges presented to them. Multiple factors contribute to this. Everything from the temperament and personality that the industry typically attracts, to the actual environment and community that is produced on the job. This outlook often creates an environment of acceptance and compliance with insufficient tools and equipment at hand. Through the survey and interviews a more exclusive sense of the users' needs was established.

Participants expressed multiple minimal feature and design changes that they thought would be beneficial based on past planting experience. Aspects such as more reliable buckles and fastening features, better sizing/ergonomic customization and more sustainable flagging solutions where all addressed a multitude of times. All these small traits can be addressed to better enhance the overall planting experience, although ultimately a more innovative outlook on the industry was taken by participants as opposed to a revolutionary one. This is understandable due to participant's role in the industry at large. In addition, their current procedure and routine with the existing tools plays a major role in the outlook they have as well. Since tree planters are payed per tree planted, efficiency is key. Through communications with participants, they all addressed how they have been able to achieve a procedural memory of the planting processes with the current planting system offered. This is achieved through the immense amount of repetition involved with the job of planting. This procedural "muscle" memory allows planters to perform the tasks "on auto pilot" and not think about their actions throughout their planting day. This level of experience and understanding of the planting process allows the task of planting to become much less mentally taxing and overall, more enjoyable. Therefore, it becomes important to create a process that will allow planters to maintain this workflow and efficiency while aiding them in the areas that are unsuitable and damaging. Overall, the majority of participants referenced the mental and environment



aspects of planting to be the most difficult challenge instead of the physical aspects. This provides insight into the level of innovation that should be implemented into the current planting equipment. Arguably based on this data the primary focus should be to improve the overall efficiency of the planting processes for all users.

In conclusion insights into the issues within the Tree Planting community and industry determine the direction of the design process moving forward. This chapter outlines the user's behaviors, actions, and interactions in detail. It uncovers an understanding of the user, which is then utilized to formulate a design that fully accommodated the user's needs.

## Chapter #3 Needs Analysis



Figure 3. 1 – Canada's Boreal. [Image]. (2020). Retrieved from <https://www.ducks.ca/places/boreal-forest/>

The following chapter will review the content displayed in chapters 1 and 2 and analyze it to best accommodate the user's needs. Compiling all of the user and product research data covers a variety of aspects which the user experiences and interacts with.

### 3.1 – Needs Analysis

Existing tree planting harness bags equip the user with a generic solution that provides minimal support to the wide variety of men and women who plant. The lack of variety within the tree planting equipment market subjects' users to minimal options that typically do not accommodate their needs or body type. This often leads to Planters creating their own home-made solutions to help them get through a season. With the extremely high rate of workplace injury, at (90%), Planters above all need, an ergonomic solution that delivers comfort and support. Furthermore, Planters need a lightweight solution that promotes mobility and efficiency. The bags attached to the harness lack organization and efficiency when dealing with seedlings. This can lead to damaged seedlings, lost time and as a result, money. Improving this aspect of the design benefits the primary, secondary, and tertiary users. Consequently, a planting bag that ensures comfort, support, mobility and efficiency is needed to mitigate work related injury and create the most effective and enjoyable planting experience possible.

### 3.1.1 – Needs/Benefits Not Currently Met

The generic tree planting harness bags that are currently produced lack sufficient sizing options and leave the majority of users unequipped from the beginning. Assuming the planter has a body type that fits their bags, the bags do not withstand the harsh environment they are used in. The most notable issue is the hardware (buckles and strap clips). The hip belt is fitted with an injection molded buckle that often brakes within the first season of use. Additionally, the plastic ladder lock buckles do not hold the straps in place once adjusted. This causes planters to carry a load that is often not properly secured to their bodies leading to even less support in the vital areas. Hardware aside, the planting bags are equipped with low quality foam padding that is not conformed to the human body. Most notably the hip belt provides a small pad in the lumbar area that is no thicker than the surrounding pads around the waist. This does not ensure the weight is being applied to the lumbar area which leads to lower back strain and injury. Lastly planting bags are designed with an “H” harness strap construction for the user’s back. Although this construction method will remain strong under stress it does not provide any support or overall benefit to the user. Planters require a solution that will provide them support in order to carry 50-60 lbs. of weight for an 8-hour period. Planting is a very fast paced and repetitive job that requires efficiency and mobility. Current plantings bag solutions are lightweight and consider the best location for the load based on the task of planting trees, they do not consider how to best distribute that load to ensure ergonomic comfort and durability. The following table showcases the potential areas of improvement.

Needs	Benefits
Support	<ul style="list-style-type: none"> <li>• Less work-related injury - better health and safety</li> <li>• More money for both planter and planting company</li> <li>• More energy reserved allowing for higher physical exertion over a longer period</li> <li>• Less physical strain – allows planter to work a longer planting season</li> </ul>
Comfort	<ul style="list-style-type: none"> <li>• More enjoyable experience</li> <li>• Improved mobility</li> <li>• Increased mental acuity and morale</li> </ul>
Efficiency / Organization	<ul style="list-style-type: none"> <li>• Faster bag up period at cash loading areas– equates to more money and trees planted</li> <li>• Easier access to seedlings while planting</li> <li>• Safer seedling transportation</li> </ul>

Durability	<ul style="list-style-type: none"> <li>• Cost efficient</li> <li>• Reliable</li> </ul>
Aesthetics	<ul style="list-style-type: none"> <li>• Improve visibility</li> <li>• Enhanced morale / connection to product and job</li> </ul>

Table 3. 1- Needs and Benefits not currently met

### 3.1.2 – Latent Needs

Benefits	Fundamental Human Needs	Relationship with Benefit
Ergonomics and Comfort	Physiological, Safety, Esteem	Strong
Improved Health and Safety	Physiological, Safety, Esteem	Strong
Efficiency / Organization	Safety, Esteem	Strong
Aesthetics	Esteem, Love/belonging	Moderate

Table 3. 2 – Latent Needs

### Ergonomic and Comfort

Tree planters spend their entire workday with their planting bags on. It is important that the planting bags are as comfortable and ergonomic as possible to create the most safe and enjoyable planting experience. Creating comfortable tree planting harness bags would greatly reduce the physical burden of tree planting, which in turn would create a better emotional experience. Ultimately this enhancement would provide users the sense of confidence, esteem, and even achievement.

### Health and Safety

A planter’s safety is at risk everyday they plant. A planter’s safety is threatened by a multitude of factors such as wildlife, weather conditions, terrain, and planting related injuries. Providing planters with safer

equipment could prove to be very beneficial. Mitigating these factors would ensure improved physical and mental health. Improvement in the Planter's overall health and safety would enhance the user's overall experience.

## Efficiency

Enhanced efficiency is a benefit for all users involved in the tree planting industry. At the base level, all Planters hope to plant as many trees as they possibly can to reach their planting goals while simultaneously producing more income. The level of success that accompanies a more efficient planting process would enhance morale for Planters, Crews, Silviculture companies, and Lumber companies (planting contractors). With increased efficiency and speed companies could fulfill more contracts each season ultimately enhancing the industry at large. The benefit of increased efficiency also benefits the environment with more trees helping to reduce the effects of greenhouse gases globally.

## Aesthetics

Aesthetic is usually overlooked within the Tree Planting industry due to the harsh environment they work in. The woodlands tend to dominate everything its path, thus causing gear and apparel to be constantly be dirty. The remote nature of planting camps also does not provide an easy cleaning solution causing most apparel and equipment to hardly ever be in a clean and presentable state. Although this is often a part of the planting experience and it can be argued this is why many Planters enjoy the camp environment. Everyone being in the same position creates a deeper sense of community and naturalness showcases who people truly are. With that in mind the aesthetics of Planters bags could be improved to provide more and safety and visibility on the block.



4Figure 3. 2 - Maslow's hierarchy of needs

There is also an opportunity to provide a solution that allows planters to customize their equipment as to create a better connection to their gear.

### 3.1.3 – Categorization of Needs

The design processes will primarily concentrate on enhancing planting bags in areas of weight distribution, planting efficiency, adjustability, and comfort. These needs have been established predominately through a user survey, and one-on-one interviews, in tandem with user observation and literature searches. The resulting user needs are categorized bellow:

#### Wishes/Wants

- More comfortable to use
- More efficient flagging process (less waste)
- Reliable hardware – buckles
- Better adjustment for men and women
- Weight reduction
- Streamlining “bagging up process at cash” ( loading area)

#### Immediate Needs

- Weight distribution around hip, lumber, and shoulders
- High Visibility
- Maximum mobility
- Neutral posture provoking equipment
- Planting - Quality insurance

#### Latent Needs

- Aesthetic – motivated to wear
- Durable, long lasting equipment
- Easy to clean and maintain

### 3.1.4 – Needs Analysis Diagram

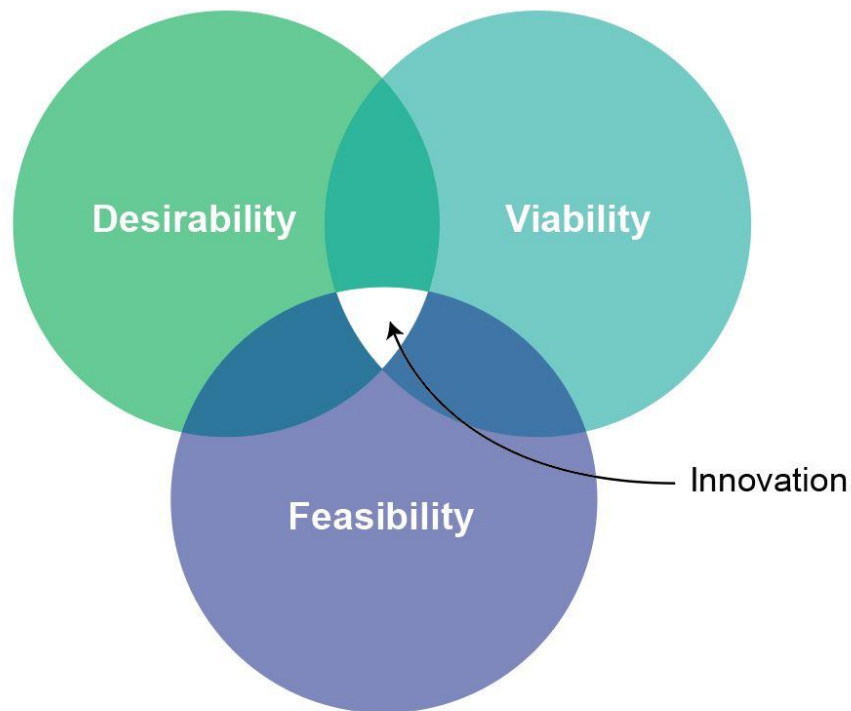


Figure 3. 3 – IDEO'S Needs Analysis Diagram

#### **Desirability**

Planters spend up to 8 hours every day wearing planting bags. As of now tree planting harness bags are inadequately sized, poorly adjustable, deficient (brittle hardware), and provide minimal support to the user. Additionally, Planting bags do not support maximum planting efficiency. This thesis sets out to make enhancements in these areas to provide the best overall experience for Tree Planters.

#### **Viability**

90% of Tree Planters obtain work related injuries. In addition to health concern, this results in lost planting time and missed pay. Improvements in the Planting bags could negate Planter's likelihood of obtaining work-related injury and enhance overall planting workflow and efficiency. Such improvements would improve Planter's health and safety while increasing silviculture companies' productivity and business.



## Feasibility

Currently tree planting bags are made by utilizing past materials and manufacturing methods. The lack of development and innovation in the Tree Planting industry allows for current technologies and manufacturing processes to be implemented and utilized. Hence, using current technological methods of production Tree Planting bags can be advanced to more modern position, making them a more timely solution in the current technological climate of today. Through the utilization of these technological developments, the design is grounded in the reality and feasibility of the market today.

### 3.2 – Usability

#### 3.2.1 – Workflow Mapping

User observation was utilized to uncover specific workflow and planting process. In addition to the activity mapping conducted in 2.1.3, a more specialized look into certain aspects of the planting process has been conducted. The images showcase the journey of the seedling before it reaches the planter, as well as once the planter receives it.

## Seedling Journey to Planters

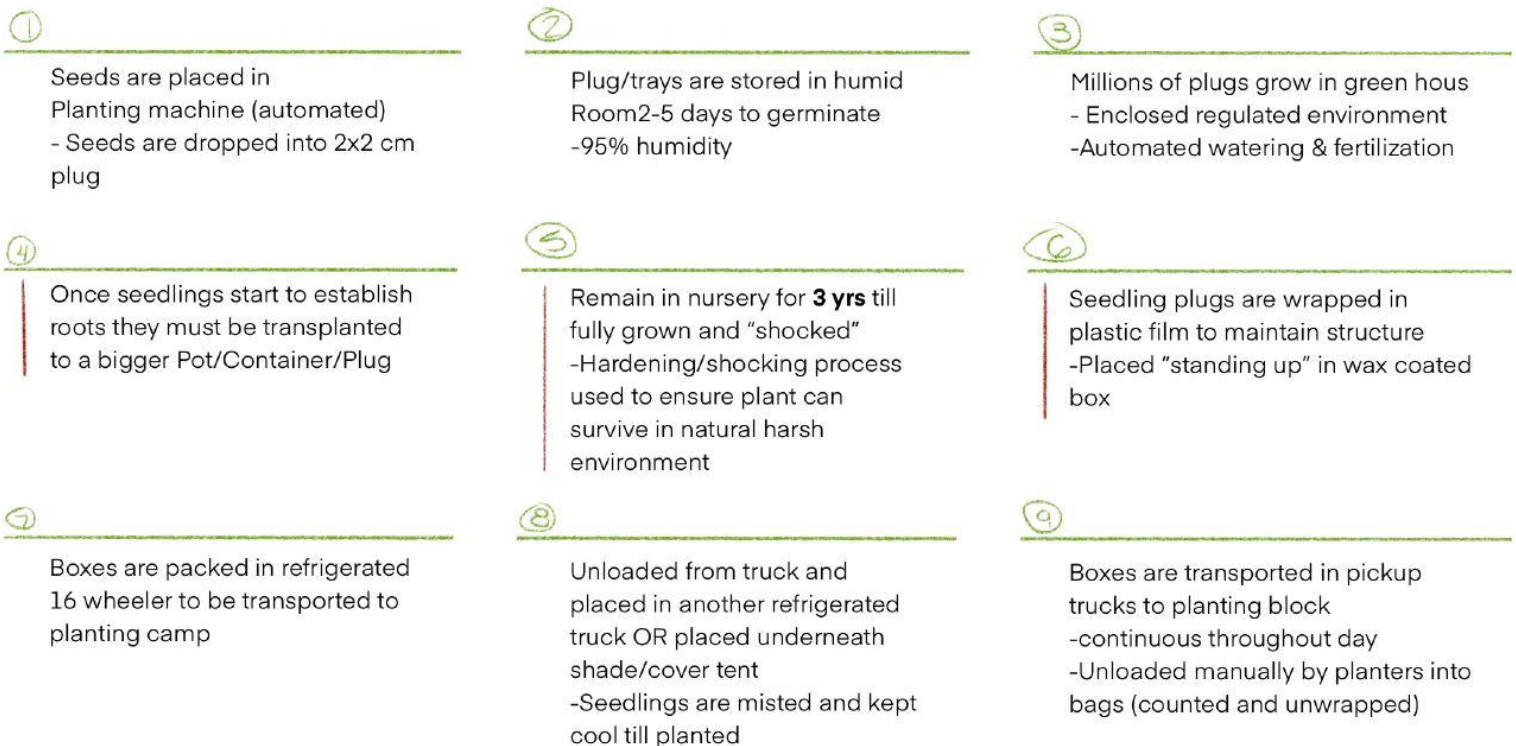


Figure 3. 4 – Seedling to Planter- Workflow Mapping



# Seedling Journey into Ground



Figure 3.5 - Seedling to Ground - Workflow Mapping

Analyzing these processes allows for certain aspects of the process to be highlighted as areas of opportunity. This is shown by the red line outlining possible areas of innovation. These areas are steps 4-6 in figure 3.5 and steps 3, 6, 7 and 9 in figure 3.6.

### 3.2.2 – Experience Mapping

User experience mapping visually represents the data collected through user observation, one-on-one interviews, and literature searches. The following graph plots what the user experience is currently for a day of planting and contrasts it with what the targeted user experience would be once the design solution is incorporated.



Figure 3. 6 – User Experience Mapping

Activity	Current Experience	Potential Improvements
Loading Bags with Seedlings	<ul style="list-style-type: none"> <li>Remove boxes form pickup truck (mode of transportation)</li> <li>Set up “cash” loading area by grouping seedling boxes and creating cover</li> <li>Start removing seedlings from box. Remove bundles (10-20)</li> <li>Unwrap plastic around bundle and stack in bags</li> <li>Lift Bags and strap on waist</li> </ul>	<ul style="list-style-type: none"> <li>Provide easier hand grip points on seedling boxes</li> <li>Incorporate tarp anchor points within seedling box design for tarp setup</li> <li>Packages and nest seedlings in more efficient way</li> </ul>

Planting Trees	<ul style="list-style-type: none"> <li>• Walk to assigned area of block</li> <li>• Locate good micro site (has good soil, coverage, distancing extra)</li> <li>• Impact ground with spade (rotate shovel blade to provide opening)</li> <li>• Reach into bags, retrieve seedling, insert into opening</li> <li>• Close hole, pat down surrounding soil</li> <li>• Rip off flag from tape and wrap around seedling (Repeat x2000)</li> </ul>	<ul style="list-style-type: none"> <li>• Provide planter with tech to ensure proper distancing between seedlings</li> <li>• Create solution that reduces impact of spade</li> <li>• Create efficient processes of retrieving seedling</li> <li>• Provide planter with a depth indicator to ensure proper planting requirement</li> <li>• Have flagging incorporated into seedling to eliminate extra temporary process</li> </ul>
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Table 3. 3 – Experience MappingTable

As demonstrated from the graph, the users outlook starts in a negative state. This is typically when the planter is required to clean his equipment from the previous workday. This can be tough without proper cleaning supplies in a remote camp. The planter then packs and organizes their equipment for the next day, which creates an increased level of fulfillment. As seen from this point forward the user’s experiences declines as it nears the major task of the day. As the user reaches the physical task of loading their bags and planting, they hit their lowest point. As continuously validated throughout this report, this is due to the physical demand, strain, and repetition that accompanies planting. With a new design solution, the entire users experience could be enhanced. If the solution enhances the two low points of the planting experience, a major change in the experience at large would be seen. By enhancing the planting experience morale and overall outlook involving the daily task would change in positive direction as shown by the graph.

## **3.3 – Human Factors**

### **3.3.1 - INTRODUCTION**

In Canada Tree Planting is done in the silviculture industry and employs thousands of young adults every planting season. This job is notorious for being one of the most physically demanding and injury ridden jobs in the world. This is due to the constant repetition of impact while continuously carrying a load. These aspects of the job can be mitigated with enhancements to the current Tree Planting bag design. This segment of the report will focus on the ergonomic enhancements made to current Tree Planting bags. The following ergonomic solutions have been implemented with the intentions of enhancing the overall comfort and safety of the Tree Planting bags in North America. An examination of the existing ergonomic oversights will be exposed through product testing and user observation. Once the current flaws are clearly illuminated, the implementation of additional ergonomic design features will be clearly outlined and justified through the production of a one-to-one scale model.

This report examines the ergonomic constraints of Tree Planting bags when in use. The report analyzes current solutions on the market and enhances its ergonomic viability, in hopes of maximizing the convenience and functionality of the overall design. Current Tree Planting bags have showcased problems regarding sizing, chafing, and weight distribution around the hips and shoulders. The following evaluation process intends to mitigate the negative traits of the current design and maximize the overall comfort and ergonomics. A one-to-one ergonomic buck has been made to evaluate the ergonomic viability of the new design concept. The ergonomic buck showcases a life size representation of all the interaction points on the body. This human factor assessment produced multiple discoveries as to the importance of a structural frame within the bag design showcasing significant improvement in weight distribution and chafing around the legs/thighs of the user. Proceeding to implement and improve these features within the redesigned Planting bags will prove to be beneficial to the end user and maximize the full body interaction with the product.

### **3.3.2 - LITERATURE REVIEW**

The measurement of man and women (Tilley & Dreyfuss, 2002) has been referenced to establish the dimensions and human factors of men and women to ensure the final design accommodates all body types. This reference was heavily utilized due to its precise and detailed assessment of the human body.

### **3.3.3 - METHODOLOGY**

The ergonomic evaluation and analysis of a Tree Planting bag design was conducted with the following considerations:

## Objective

The objective of this evaluation is to expose the challenges of the current full-human bodied interaction design of Tree Planting Bags used in North America. For the purposes of this thesis, full-bodied interaction signifies 3 major body parts that the design interacts with (Chong, Zaccolo, Kappen, Thomson, Burke & White, 2020). This evaluation will concentrate on these three interaction points and will analyze the way in which they co-operate with the end user.

## Decisions to be made:

The following interactions relevant to three major body part areas (Chong et al., 2020) were studied to minimize the negative experiences and maximize the positive experiences of:

1. Walking/hiking through planting block or surmounting debris (Legs)
2. Hip belt comfort and lumbar support (Hips/torso)
3. Shoulder Strap comfort, fit, and mobility (Shoulders and Arms)

## Demographic Profile:

North American Tree Planters were the targeted demographic. Overall, most Tree Planters appear to be 20-28-year-old men of Caucasian ethnicity earning around \$18k to \$35K over the during of a 4-month period. The Majority of Tree Planting in Canada takes place in the northern parts of, British Columbia, Ontario, and Quebec. For this report Canadian Tree Planters have been observed through online sources. In addition, typical North American planting bags have been warning and tested in order to fully empathize with the end user.

## Evaluation process:

The evaluation process involved designing a full scale (1:1) ergonomic buck of the hip belt, suspension frame, and shoulder straps of the new Tree Planting bag design. This model was created based on the issues observed when interacting with the preexisting Tree Planting Bags on the market. Once the ergonomic buck was completed, the two designs were evaluated and compared to understand the critical insights regarding the human interaction points and the overall full-body design. These were established by observing the following:

1. Observing the user stand/wear the Planting Bags while bearing a load of 30lbs.
2. Documenting where the pads touch and interact with the user's hips, shoulders and lumbar.

3. Observing how the Bags interact with the user's legs when walking over obstacles.
4. Observing how the Bags interact with the user when bending down to plant a seedling.
5. Identifying critical human dimensions affecting product use.

### **User Observation Environment:**

For this evaluation, a 90-percentile male was observed wearing Tree Planting bags while mimicking the actions of planting a seedling. For the purposes of this observation, it took place in an empty space with a leveled floor. The same actions were then performed with the 1:1 ergonomic buck (on the same test subject) to compare the fluctuation of the design's viability.

Date of Observation(s): 8/01/2021 (Observation 1)

Location of Observation(s): Aurora, Ontario (Observation 1)



### 3.3.4 - RESULTS



Figure 3. 8 - Preexisting planting bags standing



Figure 3. 7 - Preexisting planting bags stepping

When load is carried bags sway inward putting pressure on users' thighs. As the user lifts their leg or lunges the bags takes its place which makes it hard an uncomfortable to bring the leg back to the neutral position.



Figure 3. 10 - Preexisting planting bags planting motion

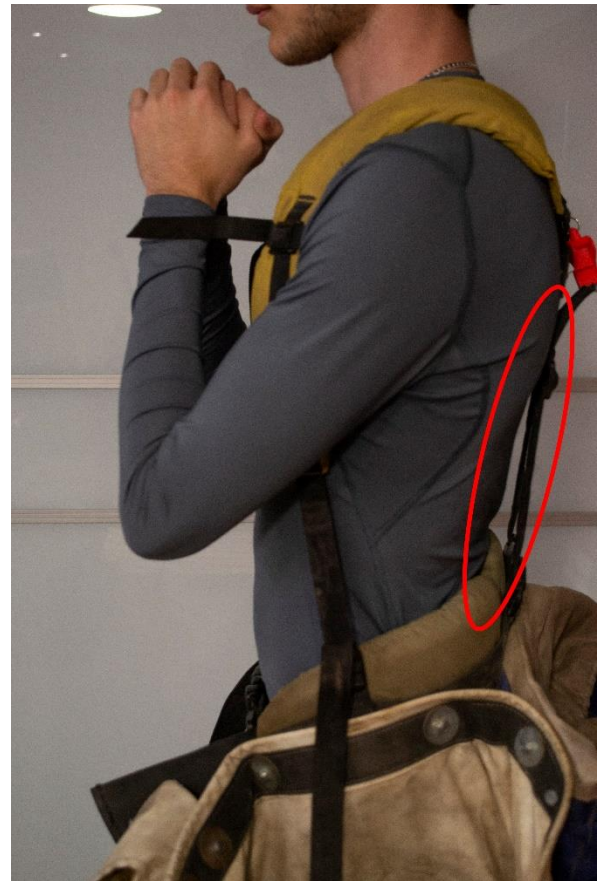


Figure 3. 9 - Preexisting planting bags standing - Lumbar

Here the user can be seen mimicking the position. As the user bends over it can be seen that the majority of the weight is transferred to the shoulders. Currently these shoulder straps dig into the user's shoulders and prevent their range of motion. While wearing the Planting bags it was observed that the Planting bags did not provide support in the lumbar and lower back region. This was observed in every position the planter was in.



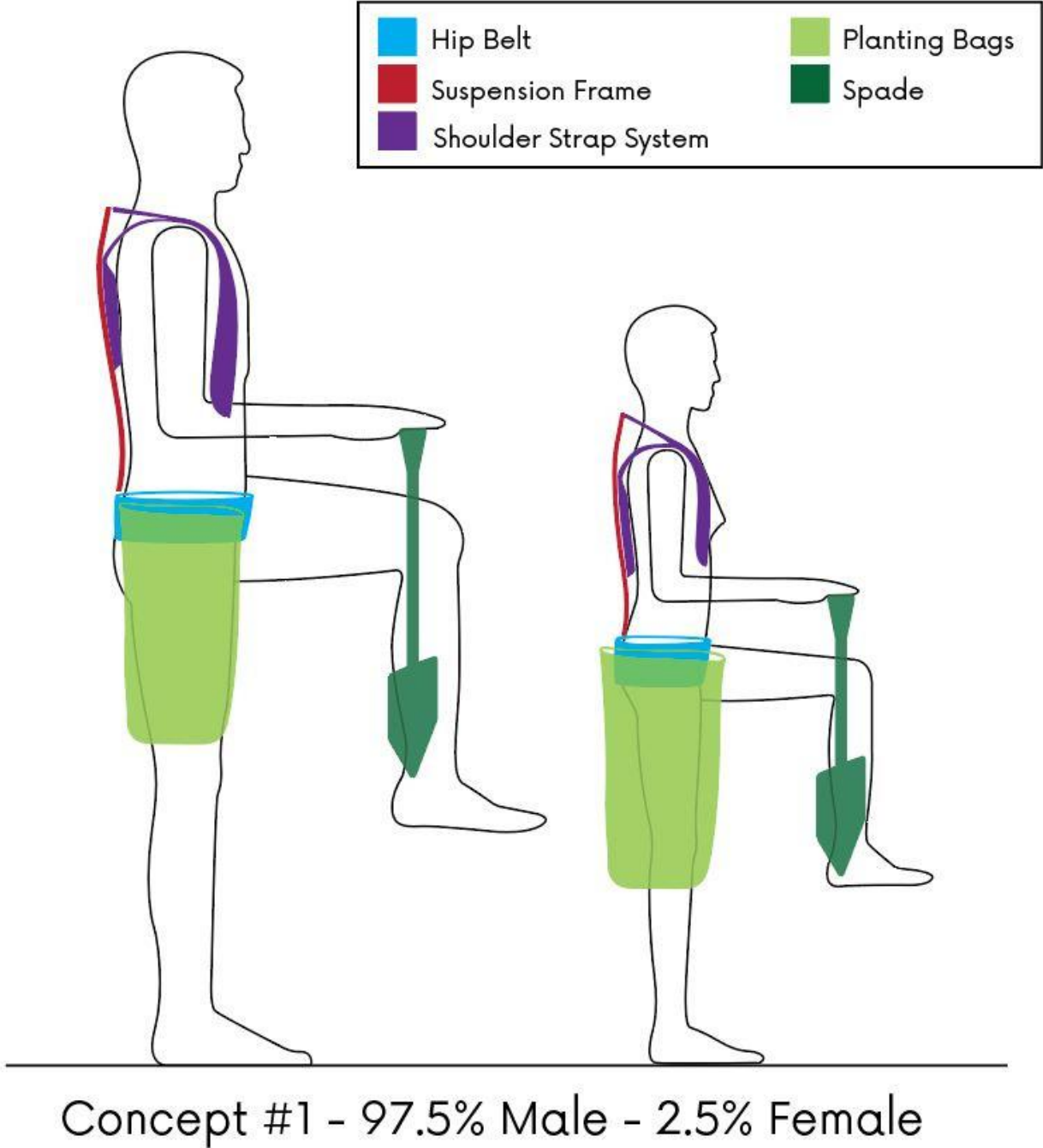


Figure 3. 11 – Ergonomic component Outline

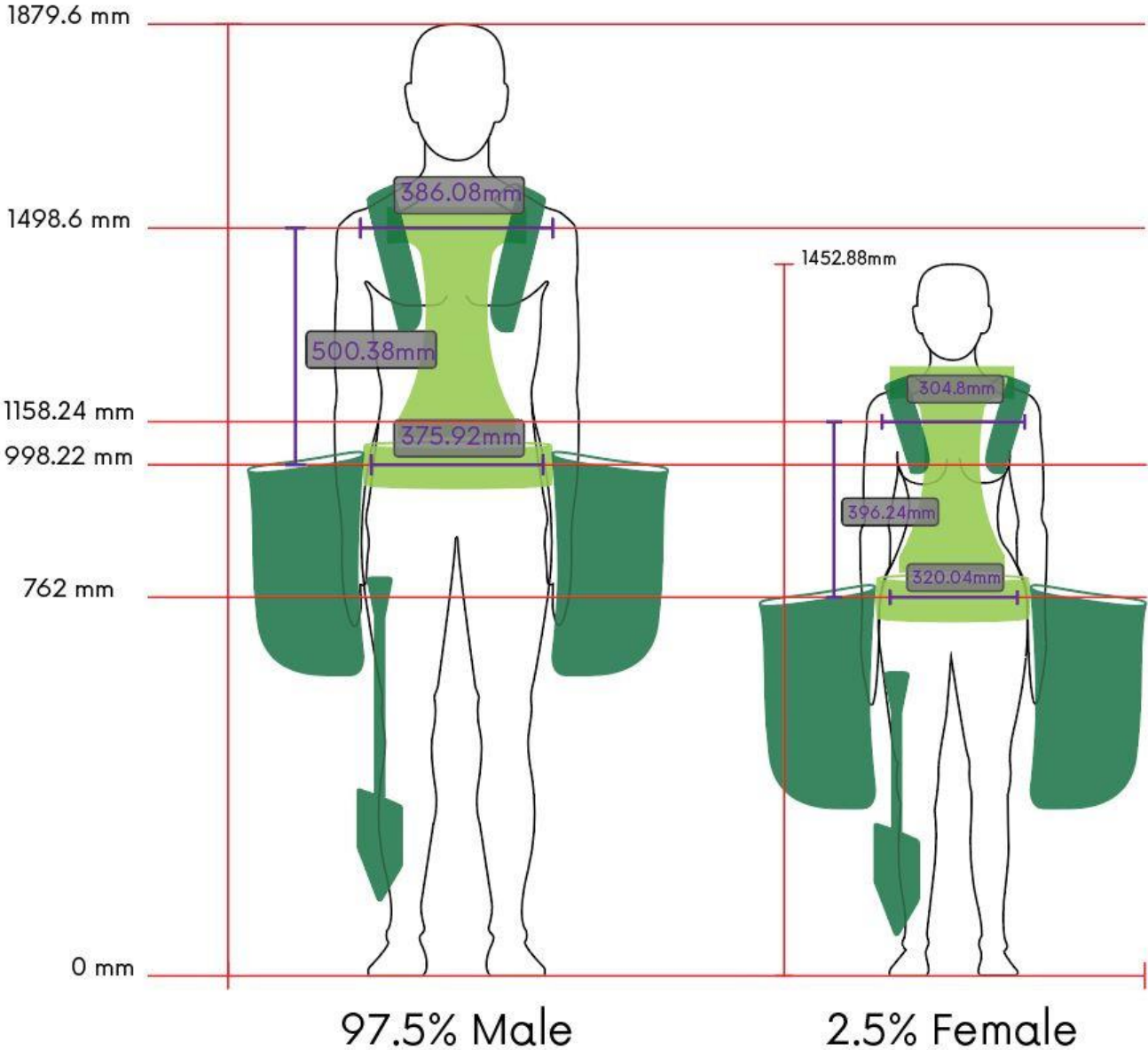


Figure 3. 12 – Ergonomic Outline 97.5% male – 2.5% female

### Ergonomic 1:1 Buck



Figure 3. 13 - Ergo Buck - standing



Figure 3. 14 - Ergo Buck - standing side view



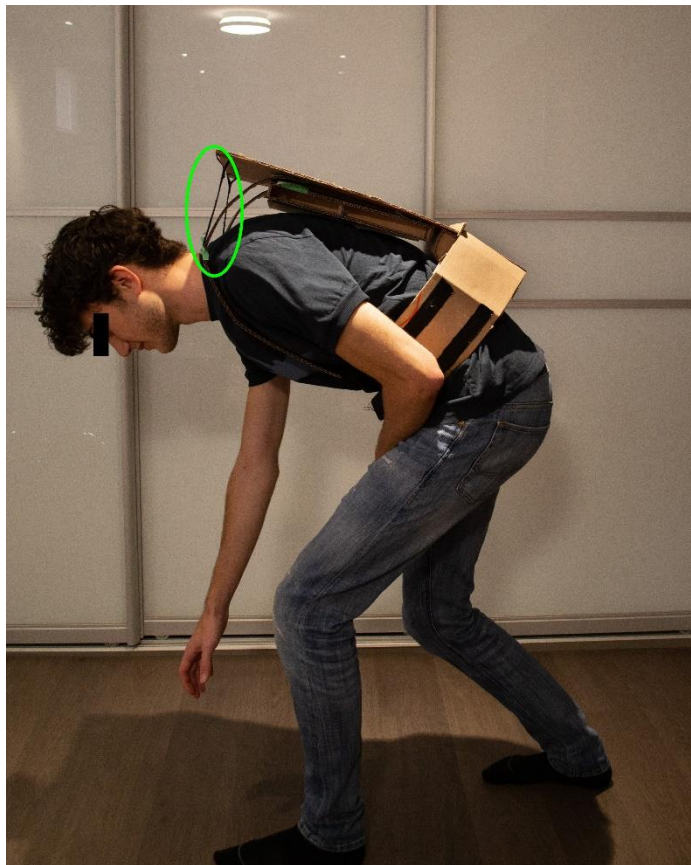


Figure 3. 16 - Ergo Buck - Planting motion



Figure 3. 15 - Ergo Buck - Planting motion - Close up

The ergonomic buck showcases how the additional support frame and back/lumbar padding provides support in the needed areas. By utilizing the support frame shoulder support straps can be implemented to relieve some pressure and distribute the weight throughout the user's shoulders.

### 3.3.5 - ANALYSIS

When dealing with a wearable product the user has more flexibility when it comes to adjustability and fit. Although, when executing such a physically demanding task the fit and ergonomics become crucial to the user’s safety and comfort. This is displayed when looking into hunting and hiking packs, as they offer multiple size and gender variations. Due to the duration and intensity of Tree Planting a similar approach has been taken regarding sizing. Currently, Tree Planting bags are offered at one size which does not properly accommodate the user’s that deviate from the average male body type. Consequentially, research has been conducted to create three sizing options that properly accommodate all body types. This sizing decision would be executed before the Planter purchases their bags. This providing them with the safest bags for their specific body type. The allotted sizes have been established by referencing the measurement of man and women (Tilley & Dreyfuss, 2002) and are as follows:

Support Frame Sizing	Percentile Range	Measurement Range
Small	Female: 1% - 50% Male: 1% - 25%	w Shoulder Width: 10” – 12.5” h Shoulders – Lumbar/Hips: 17” – 18”
Medium	Female: 50% - 95% Male: 25% - 50%	w Shoulder Width: 12.5” – 14” h Shoulders – Lumbar/Hips: 18” - 19”
Large	Male: 50% - 90%	w Shoulder Width: 14” – 16” h Shoulders – Lumbar/Hips: 19” – 20.5”

Table 3. 4 – Ergonomic sizing analysis

As observed when wearing/testing Tree Planting bags, even when the user does fall within the proper sizing specification, the planting bags inadequately support the user. This is seen in the lumbar/lower back and shoulder regions.

Within the lower back region current planting bags only provide one pad on the hip blet for lumbar support. This pad is 4” wide and 5.5” high. It is also important to note that the pad is no thicker than the other pads on the hip belt (1.25” thick). By increasing the thickness of the lumbar pad, the weight will be transferred and focused to this region. This transfer of weigh is important as it provides the user support while ensuring the

weight remains on the center line or axis of their center of gravity. This adjustment would provide more support and stability for the end user.

Current planting bags seem to provide any support/structure for the remaining areas of the back. Through the addition of a suspension frame two more needed features could be added. As seen in the 1:1 ergonomic buck the suspension frame sprouts from the hip belt behind the lumbar pad and follows the curvature of the planters back. Attached to the suspension frame is two shoulder blade pads that transition into shoulder straps. These adjustable pads allow the user to alter the angle of the shoulder straps to best accommodate their shoulders shape. The dimensions of these pads would vary depending on the size of suspension frame the user has bought, although in this study the medium sized package was utilized. Therefore, the shoulder blade pads were 11" tall 4" wide at the top tapering down to 2" wide at the bottom.

Residing at the top of the suspension frame is two load lifter straps (figure 3.16). These bands connect to the shoulder straps and are anchored to the suspension frame. The load lifter straps pull the shoulder straps up and back towards the suspension frame. Tightening them diminishes the concentration of the load on the Planters shoulders. This provides more mobility and less strain on their shoulders, which ultimately improves the efficiency of their planting.

Throughout the testing process it has become evident that the additions made to the design in the ergonomic buck provide more interaction points for the end user. These interaction points provide the structure and support the planters need to mitigate the risk of back and shoulder injury.

### 3.3.6 - LIMITATIONS AND CONCLUSION

Identifying critical human dimensions affecting product use were as follows:

1. Waist size for properly fitting hip belt.
2. Shoulder width for best contact with shoulder straps.
3. Lumbar and shoulder height to ensure proper suspension frame.

Some ergonomic needs that are not met is providing better leg mobility while reducing the likelihood of chafing. This is shown in (Figure 3.8) it can be seen how when a load is applied to the planting bags, they swing inward toward the user's legs. Additionally, a hip belt that has a padding system which is capable of demobilizing the user's iliac crest. To ensure the hip belt is functioning to its fullest capabilities the user's iliac crest should remain in the center of the hip belt. This is not executed due to the one large pad that is utilized on the current solution. This signifies that there more solution that must be incorporated to provide the ultimate planting experience.

## Alternate possibilities for the future

Based on the current study, the alternate options that could be explored in future are as follows:

1. A protective pad and strap system (between bag and leg) that relieves load of planting bag and reduces friction on legs.
2. Dividing the padding on hip belt into multiple smaller pads. Create a formation that provides envelops iliac crest.

This study helped to uncover crucial ergonomic flaws in traditional tree planting bags. It established the 3 major interaction areas and ensured the development of a full-bodied design that provides support and comfort. This was executed by observing the interaction points when the user utilized their full range of motion during the action of planting. Ultimately providing insights in order to create the most accommodating design as possible, while also establishing areas of further development for the future.

## 3.4 – Aesthetics & Semantic Profile

This section of the report investigates the aesthetic and semantic considerations taken for the redesign of the traditional north American tree planting bags. Influence from the function of the product, the environment it is used in, and the intended symbolic meaning of the product all play major roles in the overall compositions of the final design.

### Symbolism and Aesthetics

The conscious or subconscious feeling you get when looking at or interacting with a product is typically achieved through the product's symbolic characteristics. Consequentially, it is then important to outline the underlying meaning or purpose of the product. In the case of tree planting bags, it can be summed up in one word, regrowth. The underlying focus of this thesis and product is to enhance the sustainability and longevity of our planet's forests and planet at large. This is what inspired the design process throughout its entirety.

Tree planting bags are a very functional product since they are required to endure extreme weather condonations and environmental factors that all contribute to the effectiveness of the product. It is of the utmost importance that above all ells the product is functional and reliable in these conditions. Without reliability this product will never be considered a viable solution for tree planters. So, with that in mind the symbolism in this

design is conveyed through subtle elements and features throughout the product as to not interfere with the functionality and durability that is required.

Inspirational elements of a tree's form, such as its sturdy wide base and flushing branches where the bases for the symbolic elements added to the overall design. The number one element utilized from the form of a tree is the seemingly upward movement conveyed through its trunk and sprouting branches. More specifically recognizing that when looking at a tree, everything seems to sprout from one point. This upward sprouting movement is achieved through the repetition of branches that all flourish from one common point, the trunk.

In efforts to not effect the overall form of the tree planting bags these symbolic elements could be communicated through the stitching details. Creating a sense of repetition through multiple guiding stitching lines that all originate from one place, would provide this subconscious effect of upward movement and regrowth. Additionally, utilizing the form of the suspension frame that erects from the hip belt, could also enhance the portrayal of regrowth and movement.

## Semantics

Regarding semantic and aesthetic trends, there is not much to reference from a tree planting point of view, although inspiration has been taken from other work wear clothing. It is important to outline that tree planting equipment does not require any high visibility components as planters are not in contact with any heavy machinery being as they are in remote northern locations. As stated by The Canadian Center of Occupational Health and Safety (2021) "Most often, high-visibility clothing is worn to alert drivers and other vehicle operators of a worker's presence, especially in low light and dark conditions" (para. 1). There for when looking at work wear for inspiration, subdued or dark color ways are typically the color options. This tends to be due to the nature of physically demanding jobs and the mess often accompanies them. Similarly, tree planting is also subject to very dirty working conditions and would require a color way that does not accentuate this aspect of the job. There for by taking inspiration from trees, the planting bags could be a toned earthy green. This would prevent the emphasis of dirt and grim on the bags, creating a better overall aesthetic.

Technology within the blue-collar industry evokes a very robust and trustworthy appearance to portray reliability, and the capability of enduring harsh working conditions. This is often seen within power tools and stand-alone products that can be used on construction sites. For tree planting, the ability to carry multiple tools or separate components is not attainable due to the nature of the job. This meaning that any technology that is incorporated into the design must be integrated within the existing housing or apparel. Additionally, the process of planting a seedling requires the user to conduct a multi step process, which must be done as efficiently as possible to fulfill their daily quota. This meaning that any incorporated technology must not add an additional step to the process of planting a seedling. There for the ideal method of incorporating any technology would be



to create a design that does not emphasize the use of tech at all. Providing the user with a solution that utilizes technology while the user is not cognisant of it even being there.

## Form

The form of tree planting bags is solely reliant of the function of the product. Tree planting bags being a wearable product, really dictates the overall form. Since its constantly in contact with the user throughout the workday, its form follows the contours of the human body. Overall, the form of tree planting bags would not be significantly affected, although an infusion of natural elements and form factors could be utilized to portray the overall aura of the product. Lastly a slight form of biomimicry could be utilized to further implement the impression of nature.

## 3.5 – Sustainability

This section of the report examines the health, safety, and sustainability of the Canadian tree planting industry. It analyzes the current materials and manufacturing methods used to create the industry standard tree planting bags. Alternative natural material solutions were sourced to minimize the environmental footprint tree planting gear has on the environment, which in turn provides a solution that creates a fully sustainable product life cycle. Additionally, existing health and safety information was evaluated to be applied to a new tree planting equipment solution, striving to enhance the overall health and safety of planters. With the base level of the industry examined a broader look at the silviculture industry was studied. This evaluation indicated that the processing and packaging of seedlings proved to be inefficient and unsuitable for the environment. This constructed a unique seedling solution intended to revolutionize the silviculture industry, making it even more efficient and more sustainable. These findings encouraged multiple unique approaches to a better planting solution for the final design.

## INTRODUCTION

It is undisputed that the planting of a tree is a sustainable act. Although the method in which that tree is planted may not be. This thesis revolves around the Canadian silviculture industry, who are in the business of planting trees. Overall, the industry concerns itself with maintaining a sustainable planting process, although this is primarily done to satisfy contracts and government regulations as opposed to ensuring the longevity of the environment, they subsist in.

Examples of this can be seen throughout the industry. The number one factor to note is that the vast majority of these companies' plant to reforest cut blocks of land that the lumber industry created. Most of these lumber companies are required, by Canadian law to replant the blocks of land that they cut down. "The aim is to ensure that forestry operations and related activities are carried out in ways that support the sustainable management of all forest resources for generations to come." (Natural Resource Canada, 2020, para. 3) This means that most of the silviculture industry is not planting new trees as much as they are replanting to replace old trees. This does diverge from the average company when talking about NGO's and charities, in which they claim to be planting new trees. Once that distinction is taken into consideration, it is important to note that there is a standard method in which the industry plants the trees.

Planting trees in vast quantities in their natural environment is a unique task to execute due to all the irregularities and variability that is encountered. These constantly changing variables are due to the uniquely different landscapes planter's encounter. The extreme fluctuation in soil quality, terrain, and the weather prevents any ability of automation. Mechanical mechanisms and motorized vehicles are incapable of offering the adaptability needed to execute the task of planting in these continually changing environments. Applying these types of solution proves to be too expensive and tend to malfunction. The constant need for repair ultimately generates a slower planting process. For these reasons, the human body has demonstrated that it is the only viable solution capable of adapting to the forever changing natural environment that trees reside in. This in turn creates a very sustainable method of planting, minimizing the need for obtrusive planting processes and the environmental pollution that often accompanies them.

Although the technique of planting a tree is sustainable the journey of the seedling from nursery to the ground is not. Seedlings are typically grown in a nursery for 3 years before being transported to a planting block. From the moment the seedling is grown and ready to be transported, they are bundled in bundles of 5 using plastic wrap. The bundles are then packed into cardboard boxes and shipped across the country to the planting site. These boxes are then brought to the block and unloaded for the planters to pack into their bags. Each planter spends time unwrapping the bundles and placing them into their bags leaving behind an ample amount of plastic and cardboard. As the seedling is planted the planter places a plastic ribbon on each seedling to identify where they have previously planted. This ribbon is called the flag and is only temporarily needed when planters are on the block. Therefore, these flags are left behind and will be disbursed throughout the natural environment, inevitably being consumed by animals, or ending up in the water system. Lastly, the young seedlings planted are left to their natural environment, causing a certain percentage to die as they are not capable of sustaining themselves.

Producing tree planting equipment using sustainable materials and manufacturing processes ensures that the planters using the equipment creates as little environmental impact as possible. Although, by redesigning the packaging and planting process of the seedlings, the industry at large would improve its environmental impact exponentially. Improving the seedling itself could enhance the sustainability of every tree planted.

### 3.5.1 Materials

Information regarding current planting bag materials is scarce. With only one North American supplier, the material information provided is all sourced from their site. Bush Pro (n.d.) supplies all Canadians with their planting bags, which does not provide any alternatives for the planters. Currently Bush Pro states that the harness is made with a "wear and tear-resistant Nylon", and the buckets consist of a "high-grade vinyl" ("Bush Pro, n.d). Nylon is a synthetic fabric that is created by chemically binding two acids. More specifically as stated in CraftTech Industries, Inc. (n.d) article "Nylon is made via a condensation polymerization reaction and is formed by reacting di-functional monomers containing equal parts of amine and carboxylic acid. - In each case, the two molecules combine to make nylon with water as a byproduct" (para. 6). Whereas the vinyl planting bucket although still synthetic, is polyester coated with a PVC plastic adhesive (Phifer, n.d.). Due to these fabrics' synthetic construction, there are very few ways of sustainably disposing of them. Within recent years there have been efforts to upcycle these types of materials, although Bush Pro does not provide their customers with an outlet to do so. The lack of consideration for the life cycle of these fabrics and product at large just disregard the environmental impact this equipment will have on the world after it's lifespan.

Leading-edge technological development in the fabric and apparel industry has granted companies the ability to provide their customers with environmentally conscious fabric solution that not only ensures the same functionality but also consider the products life cycle. These newly emerging solutions are forecasted to become the future of the apparel industry.

Each component of the planting bags has been broken down in the table below. The table showcases the best sustainable material suited for each component.

<p>Main Fabric exterior Hip belt – Shoulder straps</p>	<p>Workwear Canvas "Iron Forge Hemp™" (Patagonia, n.d, para. 5).</p>	<p>"55% industrial hemp/27% recycled polyester/18% organic cotton canvas that is 25% more abrasion resistant than conventional cotton duck canvas, yet comfortable and breathable." (Patagonia, n.d, para. 5).</p>
<p>Foam Padding</p>	<p>Dual Density Foam "Koosh Natural" (Foamite, n.d, para. 10).</p>	<p>"unique cell structure and natural soy content sets new standards. It has a softer surface, greater comfort and support, and better fatigue resistance than conventional polyurethane foam" (Foamite, n.d, para. 10).</p>
<p>Mesh – Foam shielding</p>	<p>Air Mesh</p>	<p>The breathable mesh provides durability and breathability when being worn by the user.</p>

(human contact points)	500D Spacer Air Mesh	
Suspension Frame (Back frame – hip belt stays)	Carbon Fiber “AmpliTex™” (Bcomp, n.d, para. 4).	“The flax fiber quality, yarn thickness and twist are all highly engineered for optimal mechanical properties in the final composite part. The fibers are specifically treated to optimize the fiber-matrix interface. We use European flax and the fibermix is thoroughly controlled for consistent quality over time.” (Bcomp, n.d, para. 4).
Buckles and Clasps	BioPlastic “Terratek® SC” (Green dot Bioplastics, n.d, para. 1)	“The Terratek® SC line of starch biocomposites provides effective solutions to meet growing demand for eco-friendly, biobased goods.” (Green dot Bioplastics, n.d, para. 1)
Buckets (Seedling bags)	Hemp “Hempton” (Hemp Fabric Lab, n.d.).	“Hemp’s tensile strength is eight times that of cotton fibre which accounts for its historical use in sails and rope for the British and American Navies. It is an exceptionally durable and strong ecofriendly fabric.” (Simplifi Fabric, n.d, para. 9).

Table 3. 5 – Product Material Breakdown

## Manufacturing

Sourcing sustainable materials create a much safer and more sustainable production of these fabrics. Synthetic materials often involve destructive chemicals that create problems throughout the product's life cycle. “The synthetic and semisynthetic fiber manufacturing is diversified with the utilization of monomer, chemical agent, precursor, catalyst, and a variety of auxiliary chemicals resulting in the formation of fiber or yarn” (Uddin, 2019, para. 14). The manufacturing of these products creates hazardous environments for the workers and requires safety procedures to be put in place. Additionally, the disposal of synthetic offcuts or excess substances and chemicals requires complicated disposal methods and often just leads to pollution.

The use of these more natural materials changes the processing of these materials at the beginning of the manufacturing process. Although, once the desired elements of the natural materials are distilled, the manufacturing method typically remains the same. The process involves the creation of the fabric which is then advanced to the garment manufacture. As stated by Uddin (2019) the processes “includes textile fiber production and processing through blow room, carding, drawing, and combing; and fabric production including knitted, woven, nonwoven, and subsequent coloration and finishing and apparel manufacturing” (para. 26).

The other components of the design also follow the same manufacturing process as their typical synthetic producers. The carbon fiber supports go through the stabilizing, carbonizing, and treating processes before being sized and cut (Uddin, 2019). All the bioplastics components would be injection molded to their specific specifications. Lastly, all the dual-density foam would be manufactured using the Dunlap process. “liquid form it is foamed and poured into a mold. The mold is then closed up and placed on a conveyor belt. The mold is then moved on the conveyor belt into a vulcanization oven.” (“Sleep on Latex”, n.d, para 5).

### 3.5.2 Health

Tree planting requires the athleticism of a competitive athlete. Planters are required to withstand intense physical exertion for 8 hours every workday, clocking about 40 hours a week. This constant high rate of physical exertion often causes fatigue and leads to injury. As a tree planter, you are subject to an extreme amount of repetition every workday. The human body adapts to the task of planting trees, although when not done correctly the body dismantles and injuries arise. “Given this high repetition and intense physical demand, it may not be surprising that approximately 90% of planters will sustain a work-related injury at some point in their planting career” (Sheahan, 2017).

To combat this, planters must maintain a neutral posture throughout the planting day. The most vulnerable areas for planters are their joints and back. Maintaining the proper position allows the body's muscles and tendons to appropriately manage the impact and repetition a planter encounters on the job. For planters, their wrists and back are the most susceptible to injury due to the difficulty of maintaining a consistent neutral poster. “The stress on your spine depends on your posture while planting, in combination with your bag and shovel set up. Overreaching, twisting while bent, or bending without using your knees are all sources of back injuries.” (Roberts, 2015, para. 2). This aspect of the job could be assisted through better-designed equipment which provides additional support while promoting a better posture.

### 3.5.3 Safety

Safety plays a role in any labor-intensive job, and planting is no exception. The majority of the threat that planters encounter is the consequence of their location. Planting in such remote Northern Canadian woodlands exposes planters to multiple risks, the most notable being the landscape. The extreme terrain leaves planters subject to difficult traversing over unpredictable land and obstacles. Within Northern Canada, the land is often uneven and typically has an incline, especially on the west coast of British Columbia and Alberta. This is in addition to the obstacles strewn across the planting block left behind by the lumber companies, often called “slash” which makes the simple task of walking challenges. Completing this task while carrying a 50 – 60 lb load can be difficult to execute, leaving planters at risk of losing balance and falling. This remote landscape also poses the difficulty of navigation. As a planter, you are on a new part of land every day. The isolated nature of

planting providing little to no direction when out on the block. This highlighting the importance of planting equipment consisting of highly visible garments and identification. Lastly, this secluded northern environment is usually home to wildlife that is not accustomed to visitors. Planters are often instructed to carry bear spray and are equipped with whistles a method of protection and communication with other planters on the block. Although mammals are not the only thing that planters are forced to coexist with, they also need to deal with insects. Insects are one of the most irritating aspects of these natural environments. The bugs are one of the many elements that planters must protect themselves from on the block, although arguably they are tougher to mentally overcome as opposed to physically.

Paired with the extreme landscape is extreme weather conditions. It is not abnormal for planters to encounter heat, rain, hail, and snow all in one day of planting. This adding another element of difficulty when traversing the land and executing the task of planting. The weather can also often become too severe creating a dangerous environment causing planters to seek shelter and wait till the weather clears or they are rescued. All these elements illustrating how the job of planting trees requires extreme durability and adaptability.

## Sustainability Statement

Maintaining the traditional method of planting through the utilization of physical labor assures the most sustainable solution for the mass planting of trees. This report has brought to light the areas of the silviculture industry that require sustainable improvement.

On micro-level planters, gear should be made with as few synthetic materials and manufacturing methods as possible. The purposed final design will incorporate materials that are derived from plants and natural resources. This provides a fully sustainable product life cycle allowing for biodegradation, upcycling, or recycling of the gear.

On a macro level, the industry's method of packing and transporting seedlings was evaluated. The consistent use of plastic throughout the seedling journey into the ground became a focal point for improvement. Utilizing a better packing method at the nursery level would prove to be more sustainable while additionally creating a more efficient unpacking method for the planters. Within the purposed final design, the elimination of seedlings bundled in plastic would encourage a new approach to packing and unloading seedlings in the industry. This is executed by replacing the seedling box with a hemp bag. This bag would be used as the planter's "buckets" leaving the seedlings with no extra waste. Once each bucket is done the hemp bag could be disposed of and would biodegrade into the natural environment. Furthermore, the method used to distinguish a planter "line" or where they have previously planted, also requires evaluation. The use of the "flags" or torn plastic ribbons creates arguably one of the most damaging aspects of the planting process. Within the final purposed design, flags would be replaced with a supportive structural stem that would be made of biodegradable plastic derived from lignin. This structural stem is planted with the seedling at the nursery and

follows it through its journey into the ground. Residing at the top of the structural stem would be a neon color which would replace the use of the plastic flags, while still providing planters the ability to see their line.

## Conclusion

Overall, the substitution of synthetic materials with natural-based ones allows the planting equipment to have a fully sustainable product life cycle. Additionally, by modernizing the packaging, transporting, and flagging process it one efficient hemp bagging process the silviculture industry at a large can reduce its emissions and impact on the environment significantly.



## Chapter #4 Design Development

### 4.1 - Idea Generation

This chapter will revolve around the design development of the proposed tree planting bag solution. The chapter will thoroughly go through the design processes in its entirety, from idea generation to modeling, and rendering the final design. Multiple forms of media will be showcased throughout the chapter to accurately display the individual steps of the process.

# Mood Board



Figure 4. 1 – Inspiration for the design's form factor and overall aesthetic

### 4.1.2 – Mind Mapping

An example of mind mapping that took place early in the design process. The mind map was broken up into three main categories to help guide the design thinking. The user, helping inform you would be using or benefiting from this solution. Product benchmarking, providing insight into what products currently exist related to this problem and if any inspiration can be taken from them. Environment of use, which help clarify where this solution would be used and how the environment of use affects the overall solution.

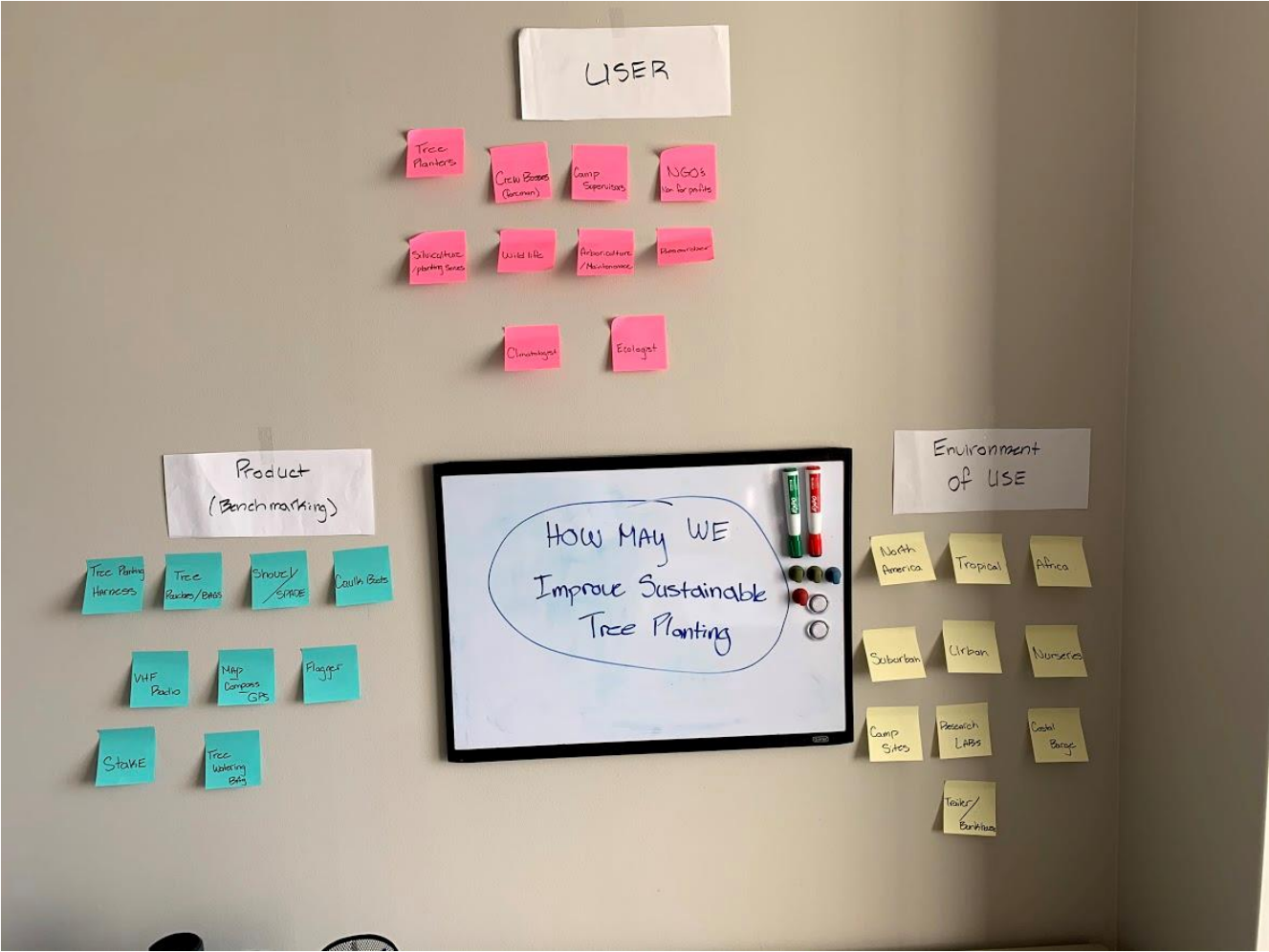


Figure 4. 2 – Concept Development Mind Mapping

### 4.1.3 – Ideation Sketches

Early interactions were broad in scope and tackled a variety of challenges expressed by the end user. All concepts revolved around enhance the health and safety of tree planters when planting. In the end it was determined that focusing on the tree planting equipment or more specifically the bags was the most beneficial way to improve the majority of the user’s pain points

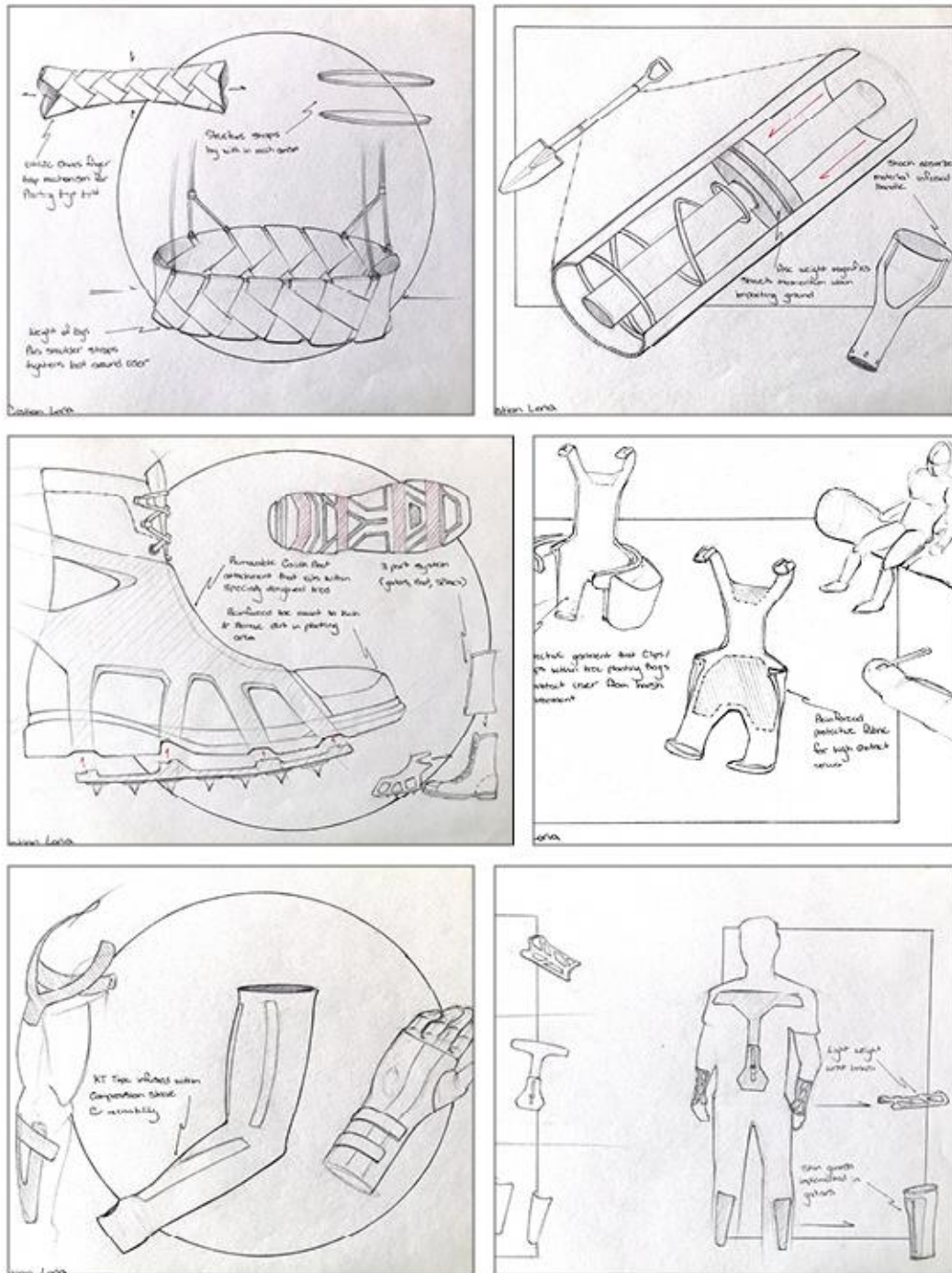


Figure 4. 3– Idea generation



### 4.2 – Preliminary Concept Exploration

#### Concept #1

Concept #1 outlined a tree planting harness that put emphasis on the hip belt padding with the addition of a suspension frame. The concept stressed the modularity and customization of the hip belt padding while also improving overall posture through the addition of a suspension frame.

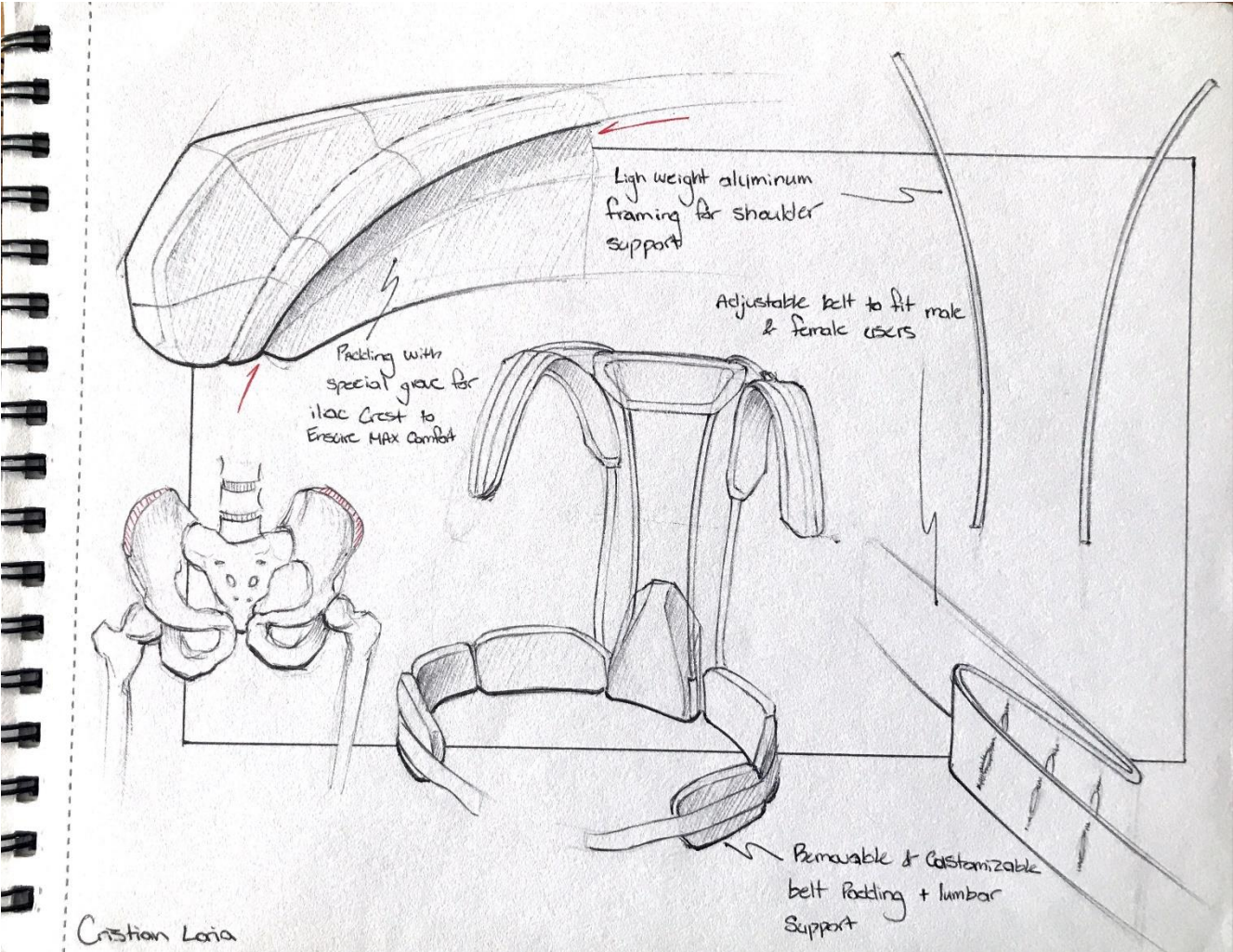


Figure 4. 4 – Preliminary Concept Exploration #1

Concept #2

Concept #2 introduced the idea of having a connection between the planter's shovel and bags. This would provide reduce the need for the planter to bend over while planting a seedling. Although further research and development with this concept needed to be done to see if it could handle the harsh environment in which it would be used.

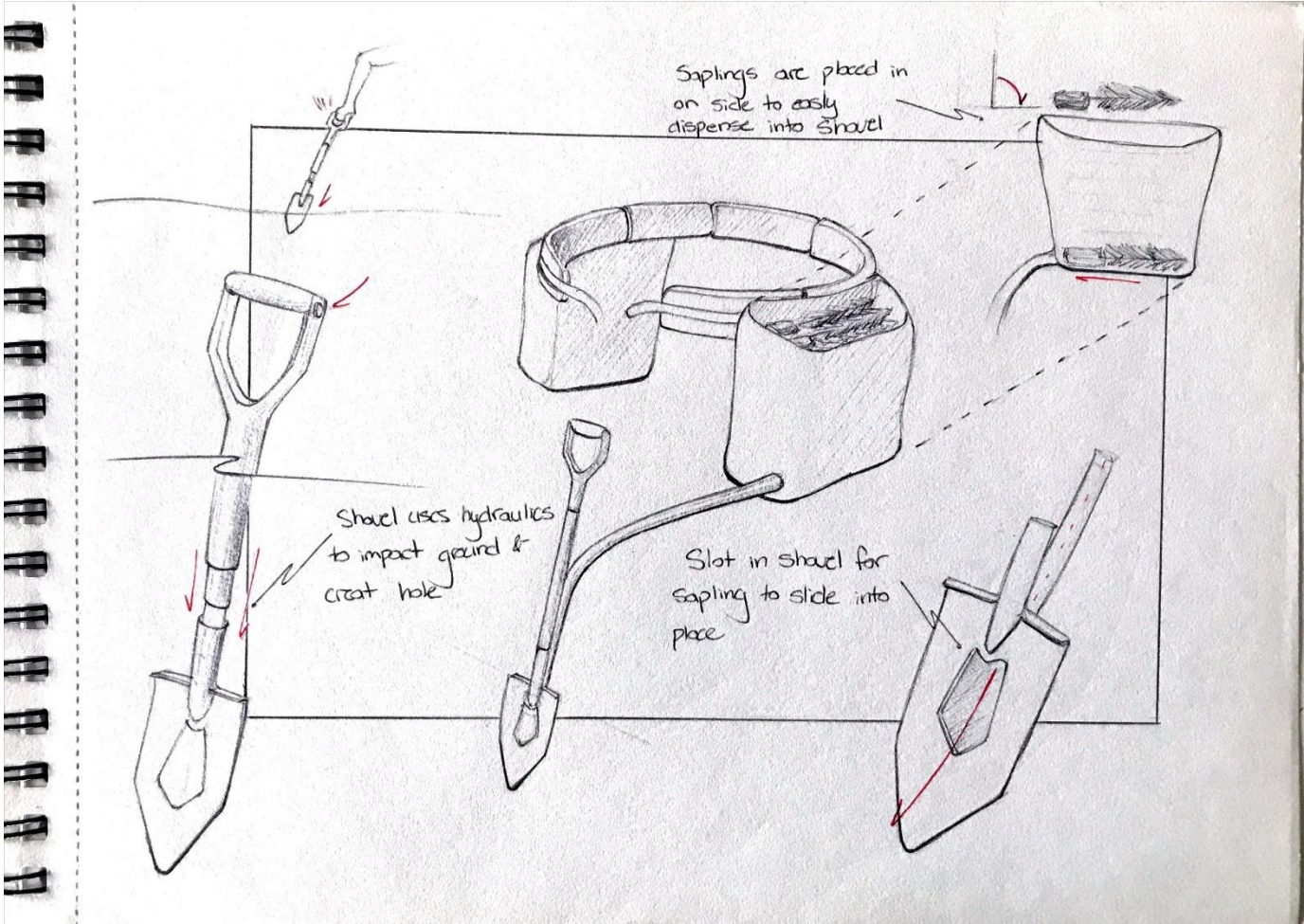


Figure 4. 5 - Preliminary Concept Exploration #2



### Concept #3

This concept introduced the ability of having an Exo skeleton like hip brace that would lock when the user bend down. Although integrating this into a planting bag design proved to not be beneficial.

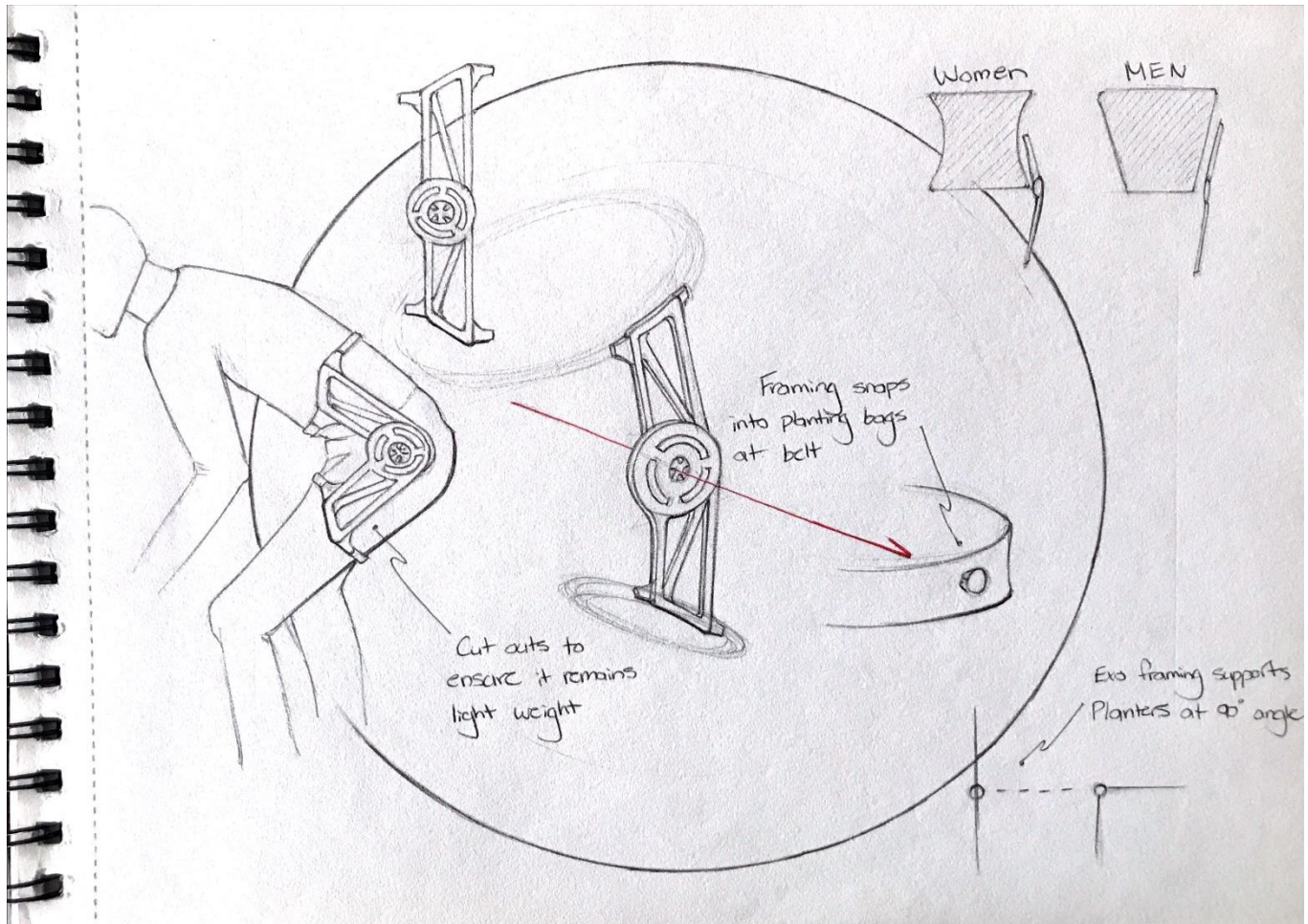


Figure 4. 6 - Preliminary Concept Exploration #3

### 4.3 – Concept Strategy

Concepts #1 and #2 were further developed as they held the most promise in terms of solving the users pain points. A configuration diagram was conducted to further understand scale and human factors regarding both designs. The insights and data collected from this stage helped inform which design was best suited for the end user.

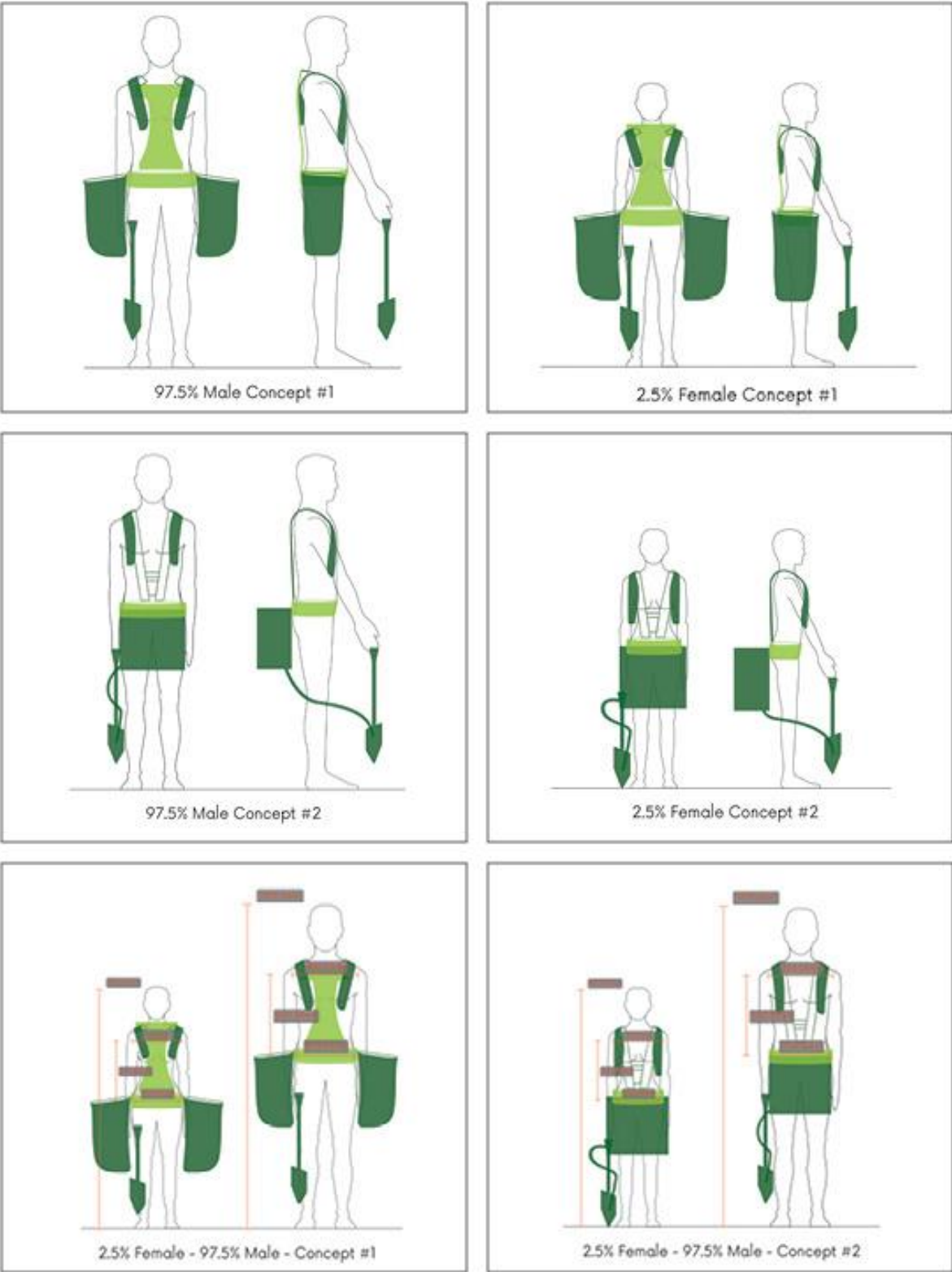


Figure 4. 7 – Configuration Diagram



### 4.4 – Concept Refinement

The majority of the concept refinement took place on Procreate where concepts #1 and #2 were further visualized to fully understand their overall appearance and form. This type of visualization provided insights into the pros and cons of each solution. This ultimately led to further developing concept #1, as concept #2 proved to be too complex for the harsh environment in which it would be used. Ultimately creating more problems than benefits.

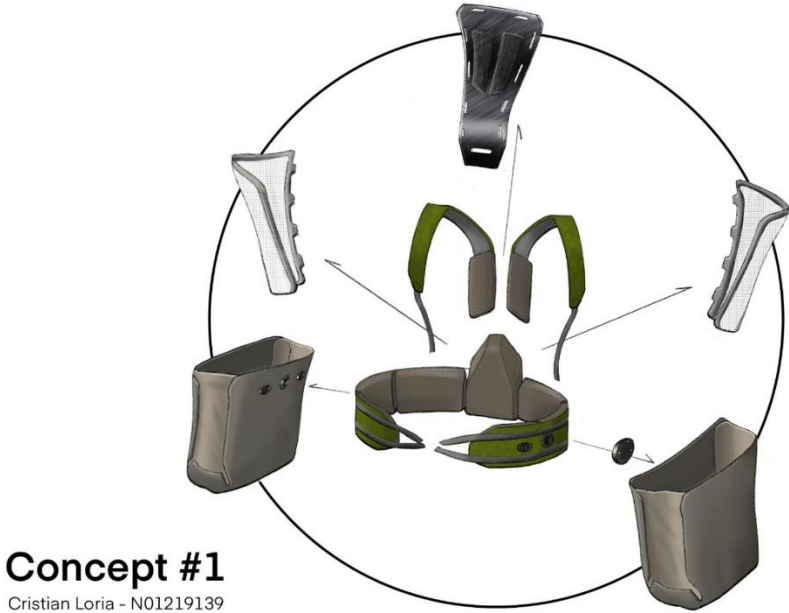


Figure 4. 8 – Concept refinement #1

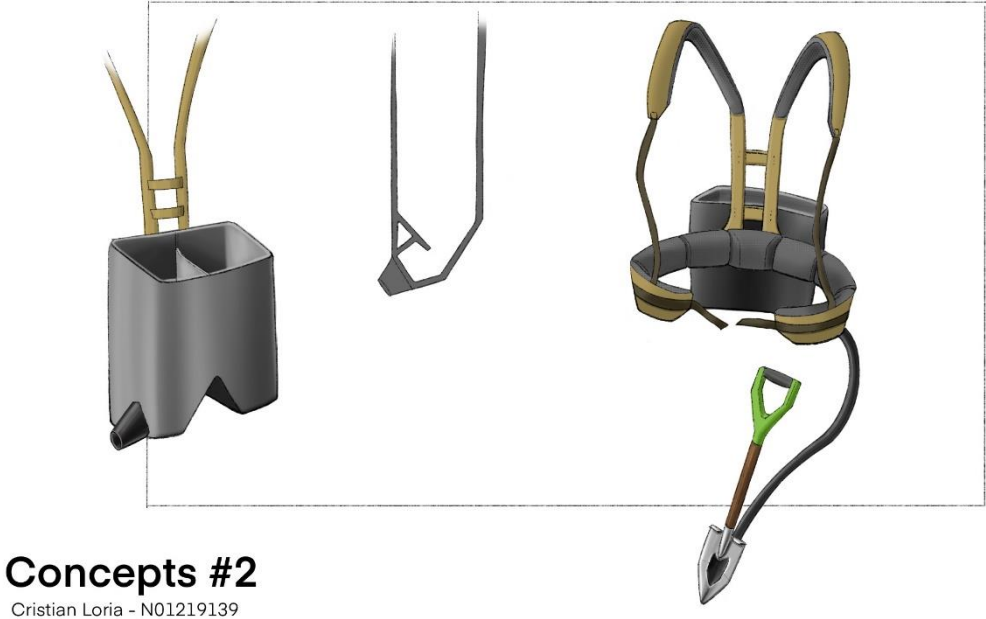


Figure 4. 9 - Concept refinement #2

### 4.5 Design Realization

The design realization phase is when the concept developed past just the planting bags and began to incorporate multiple elements to the solution. This phase is when the pain points of the secondary, and tertiary users where consider in addition to the primary user. The first major improvement was enhancing the way the seedlings were packed and tracked throughout the entirety of the planting process. It was established that by improving the packing/packaging of seedlings while incorporating a biodegradable grow stick, the planting process could be enhanced for all three users. At this stage, the incorporation of leading-edge technology like biodegradable plastics and RFID chips were researched to facilitate this solution.

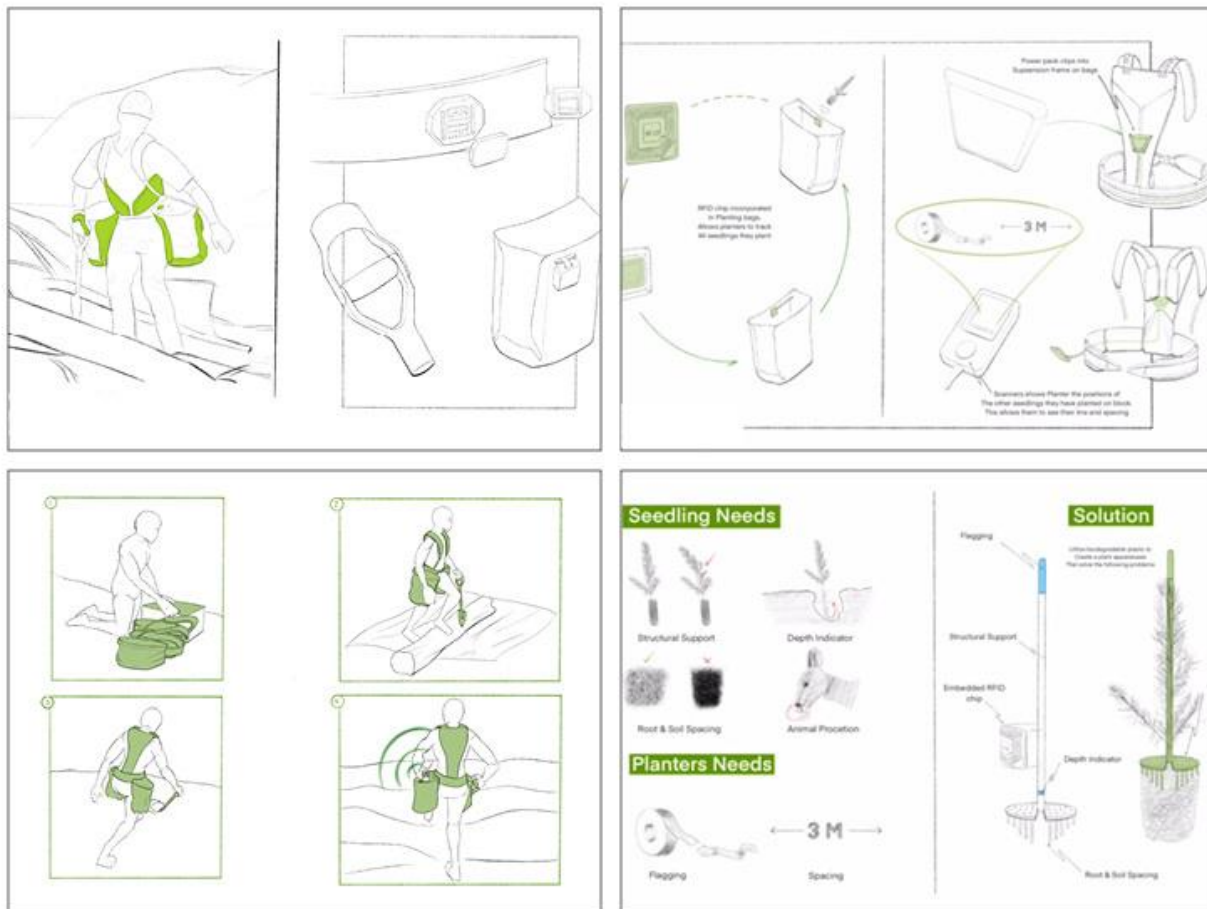


Figure 4. 10 – Design Realization

### 4.5.1 – Physical Study Model

A full-scale model was fabricated from cardboard to fully understand the dimensions and human factors of the concept. The main touch points were then evaluated and tweaked to establish the best overall fit and form possible.

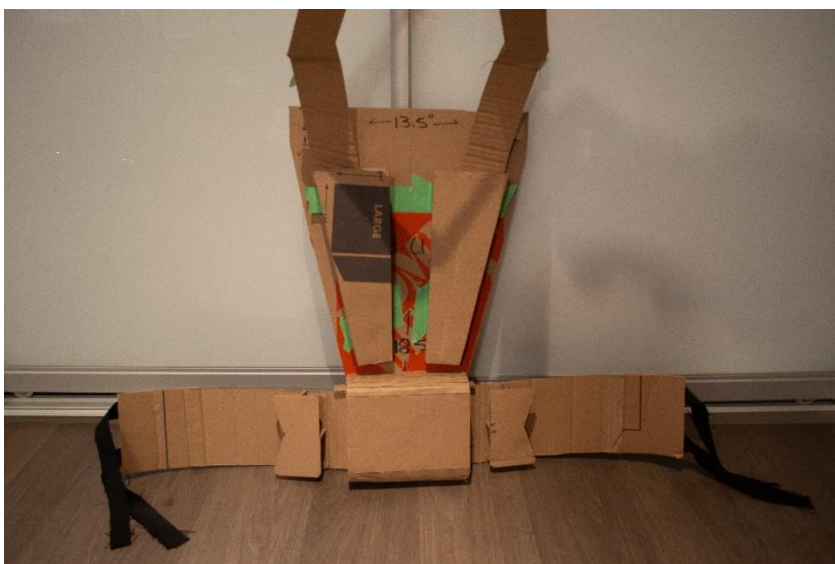
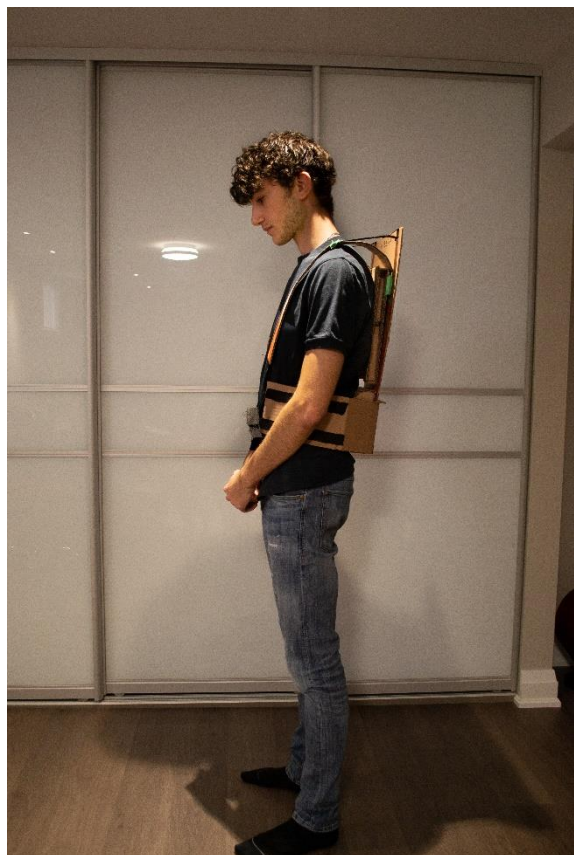
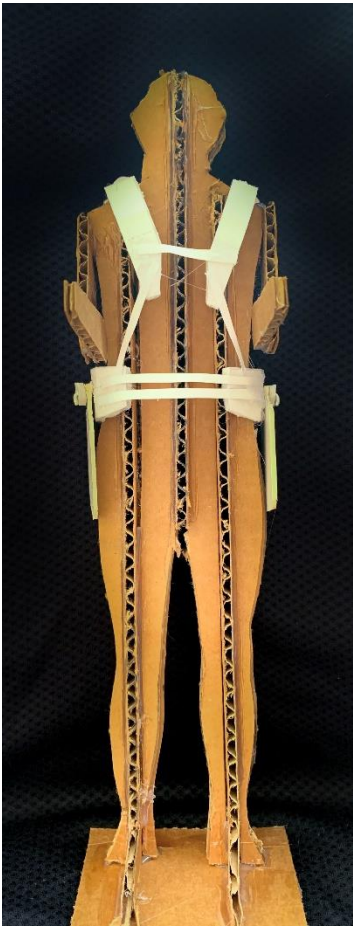


Figure 4. 11 – Physical study model 1:1





78 Figure 4. 12 – physical model study

### 4.6 – Design Resolution

Resolving the design consisted of narrowing down the details. The main components that were the focus of this stage was resolving the hip gimbal mechanism, bag clips, and suspension frame. Sketching, modeling in virtual reality (VR), and making mock-ups out of cardboard where the methods used to fully understand and grasp these details.

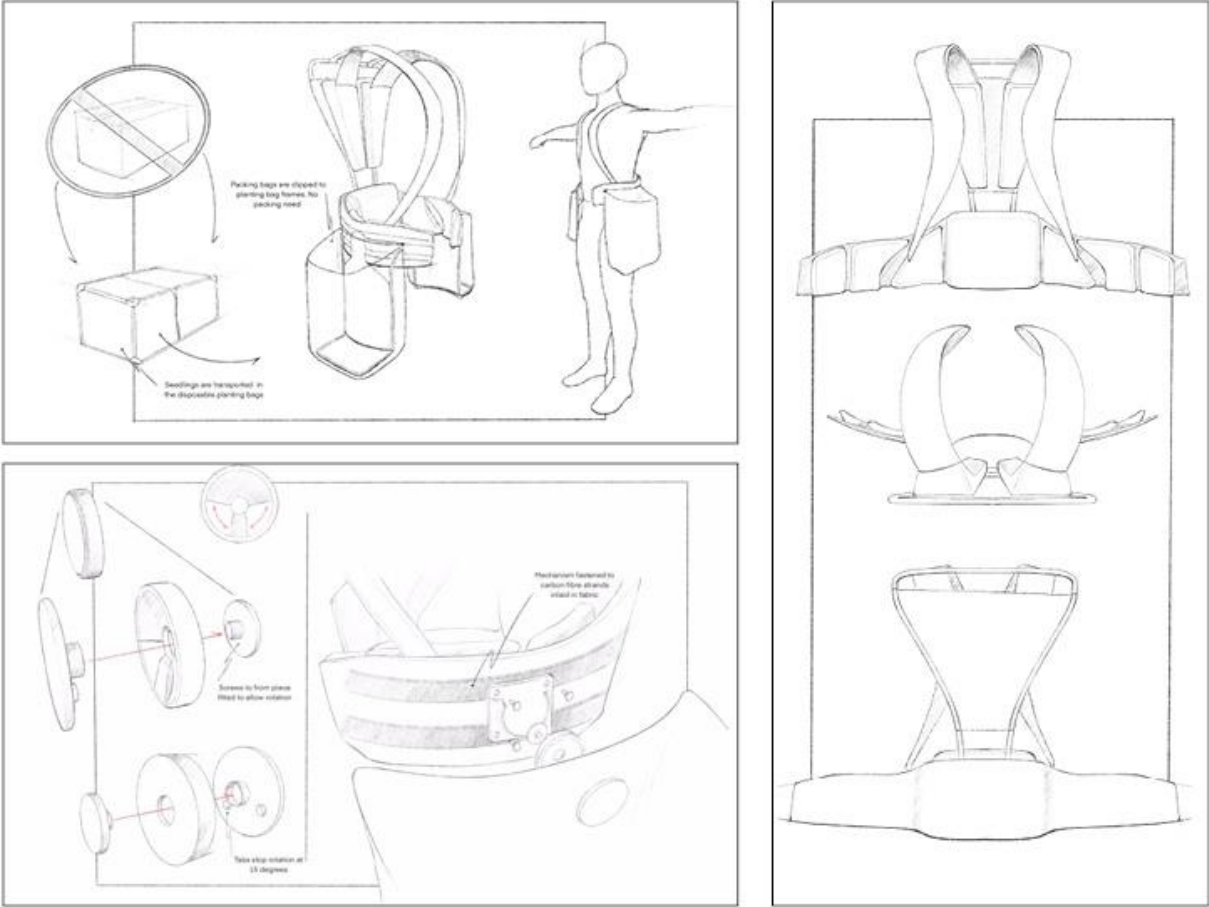


Figure 4. 13 – Design Resolution

4.7 – CAD Development

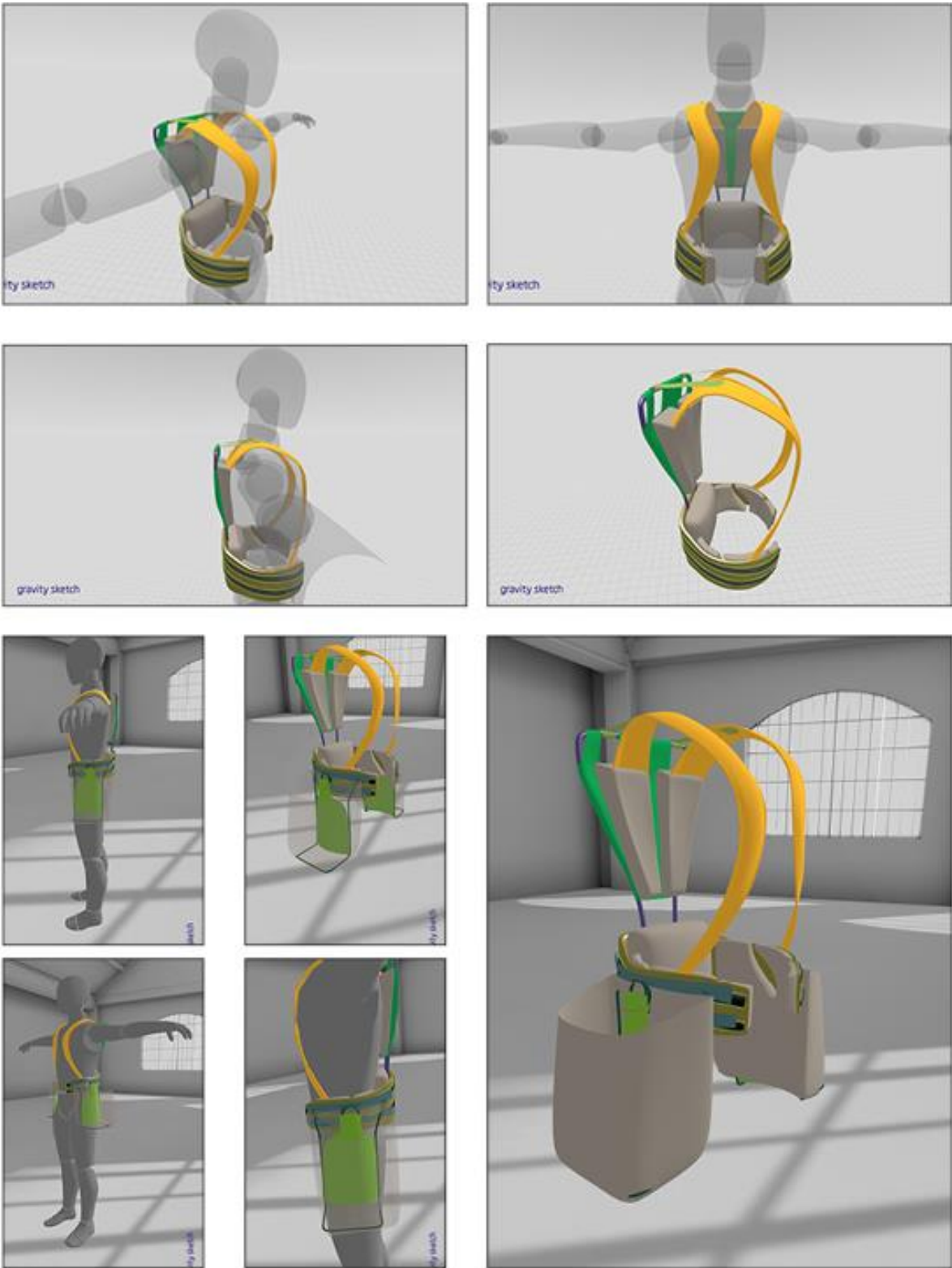


Figure 4. 14 – CAD Modeling – Gravity Sketch #1



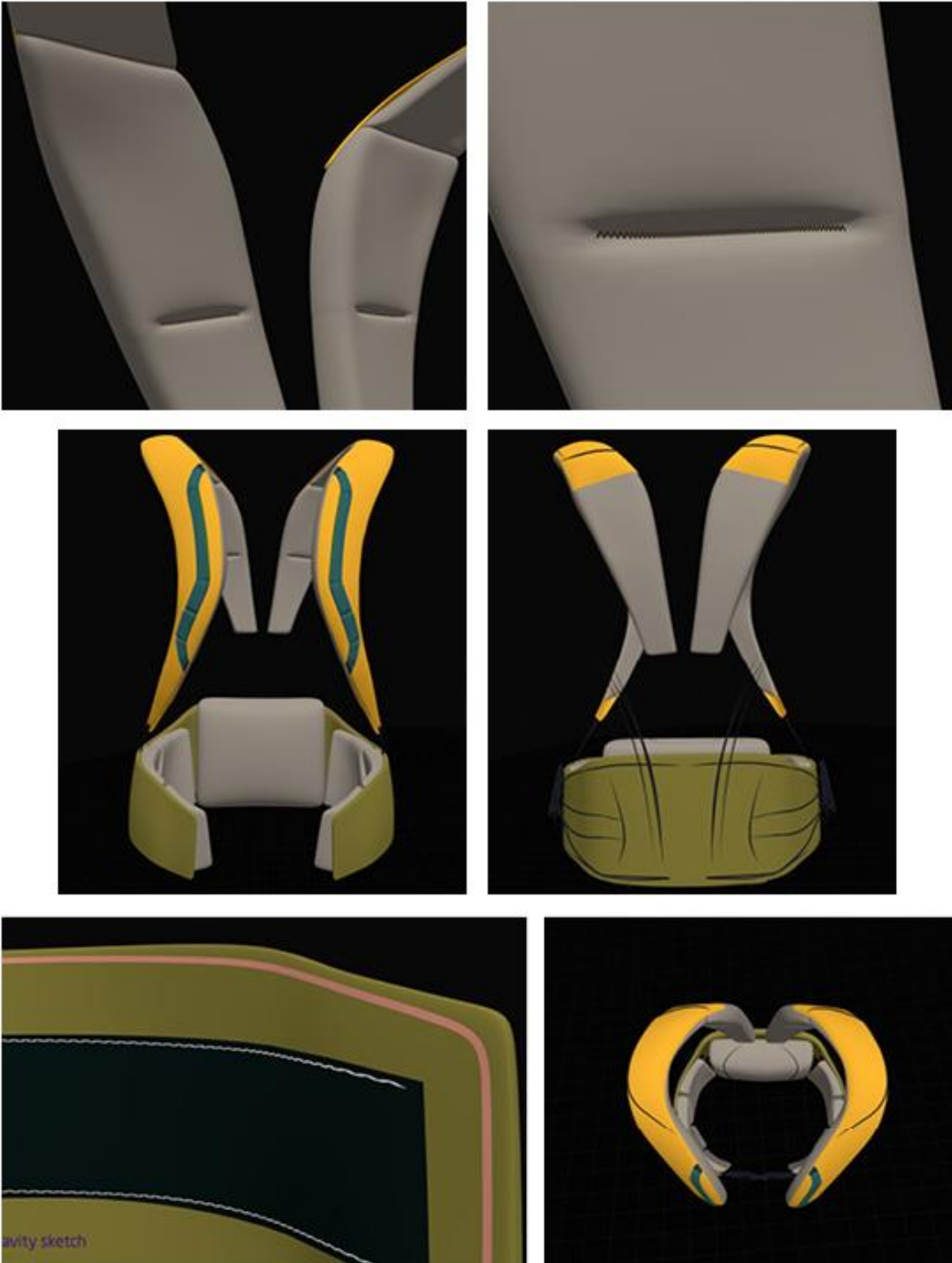


Figure 4. 15 – CAD Modeling – Gravity Sketch #2



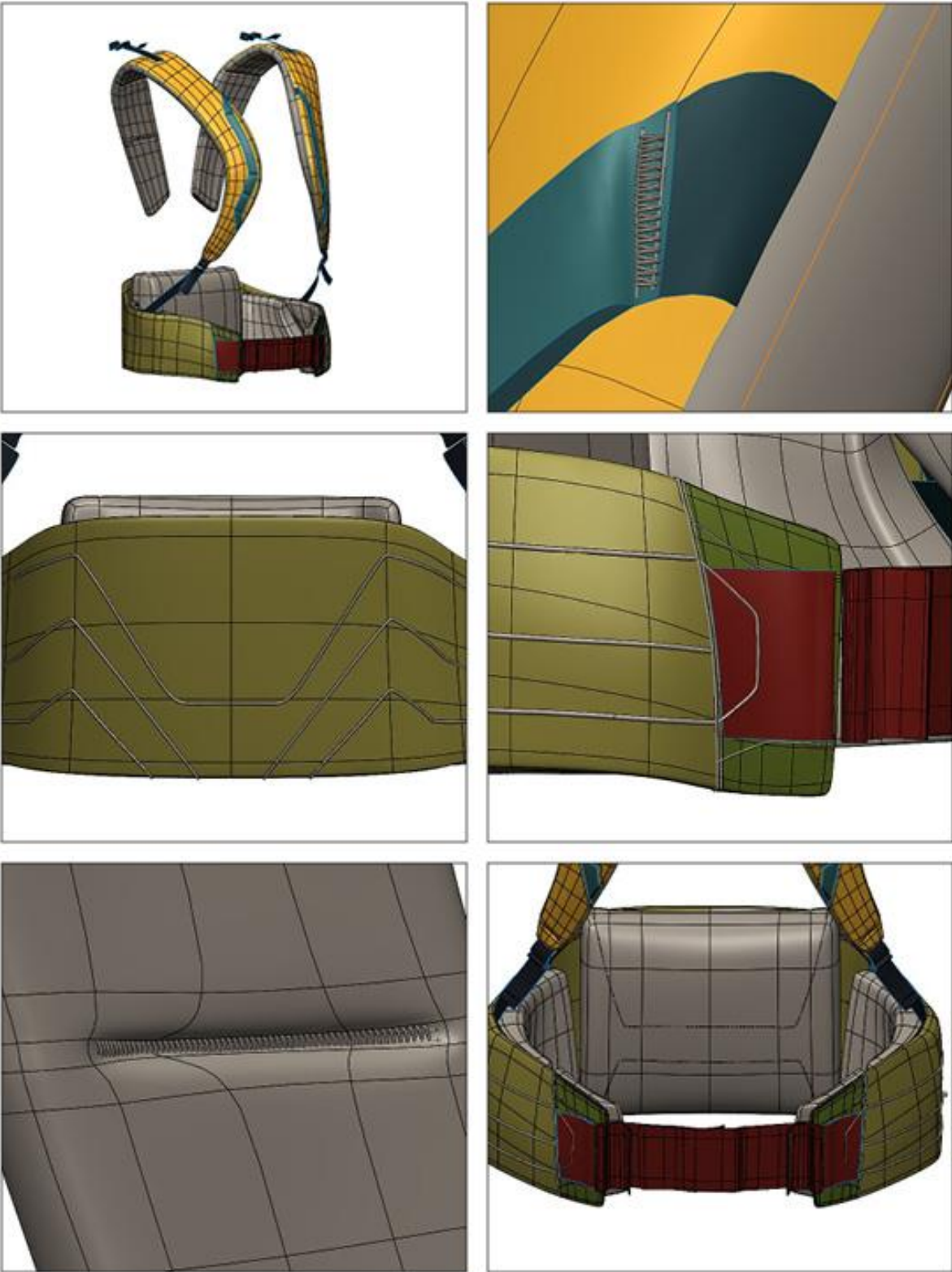


Figure 4. 16 – CAD Modeling – Solidworks #1



Figure 4. 17 -- CAD Modeling – Solidworks #2



Figure 4. 18 – CAD Modeling – Solidworks #3

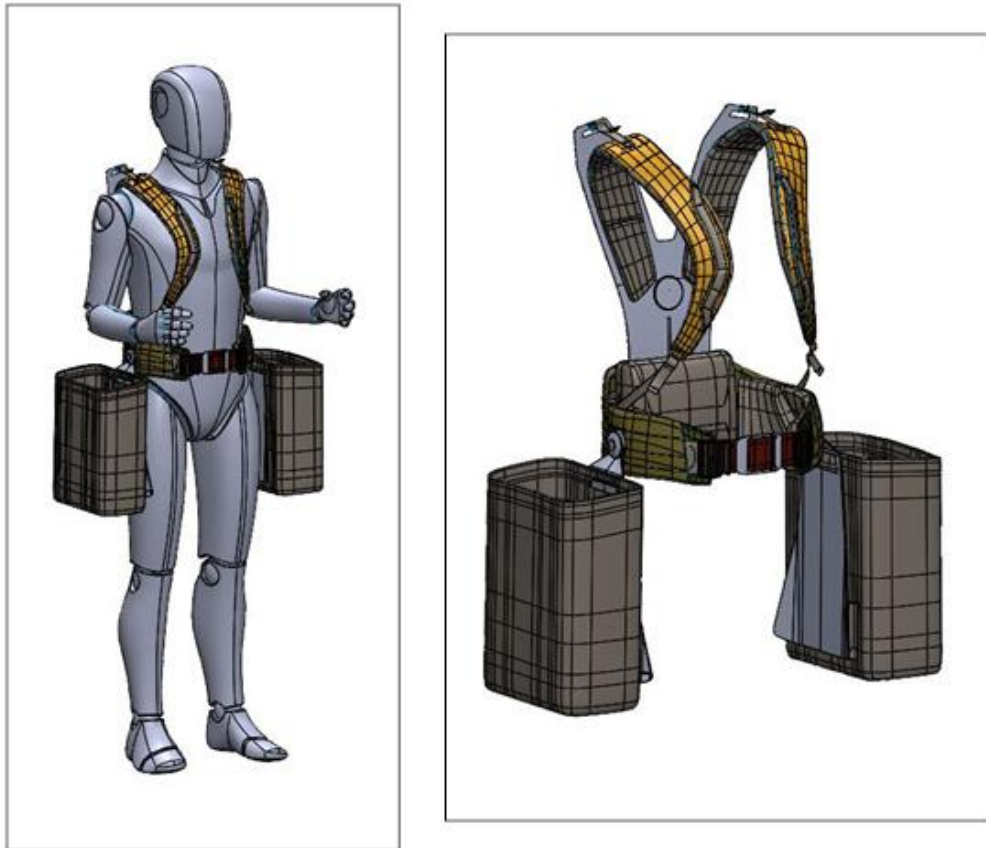


Figure 4.19 – CAD Modeling – Solidworks #4

The CAD model was created using combination of Gravity Sketch and Solidworks. Gravity Sketch was utilized to create and fit all the soft goods seen in the final model. The components consisting of the shoulder straps, hip belt, stitching paths, all the hip belts padding, and belt strap. Gravity Sketch provided a very uniquely helpful modeling experience as it is a VR model application. Gravity Sketch supplied a virtual 1:1 scale model that I could virtual walk around and experience in any space. This enhanced the ability to understand the final form and scale of all the components created within it.

Additionally, all the hard goods and stitching details were created in Solidworks. The components consisted of the hip gimbal mechanism, thigh protector, suspension frame assembly, and belt buckle. Solidworks enabled all the different components to come together within an assembly to finally visualize and prep the model for the next stage of the design process.

The CAD modeling process was conducted over the span of a month while simulations completing other school related tasks. The workflow created whilst using two very distinctly different modeling applications was challenging at time although proved to be beneficial when dealing with soft goods appearance.



## 4.8 – physical model fabrication

The model fabrication that took place proved to be a unique process compared to the typical graduating years. Due to the state of the world being in a global pandemic the model fabrication process was impaired. The main two factors that impaired the model making process was the lack of finance and shop capabilities. Since the previous summer did not provide the typical revenue stream, the model could not be financed in the manner it typically would be. Additionally, completing the model making process from an apartment with minimal to no access to shop tools and services, forced the model fabrication process to take place from home on a budget.

To complete the physical model fabrication a Flash Forge Adventure 3 3D printer was utilized. The print was divided up into 3 separate prints to fully maximize the scale of the model. Once each component was printed, they were then glued together to produce the final model. The print roughly took 4 days although multiple days were taken to troubleshoot printing problems that arose throughout the fabrication process.

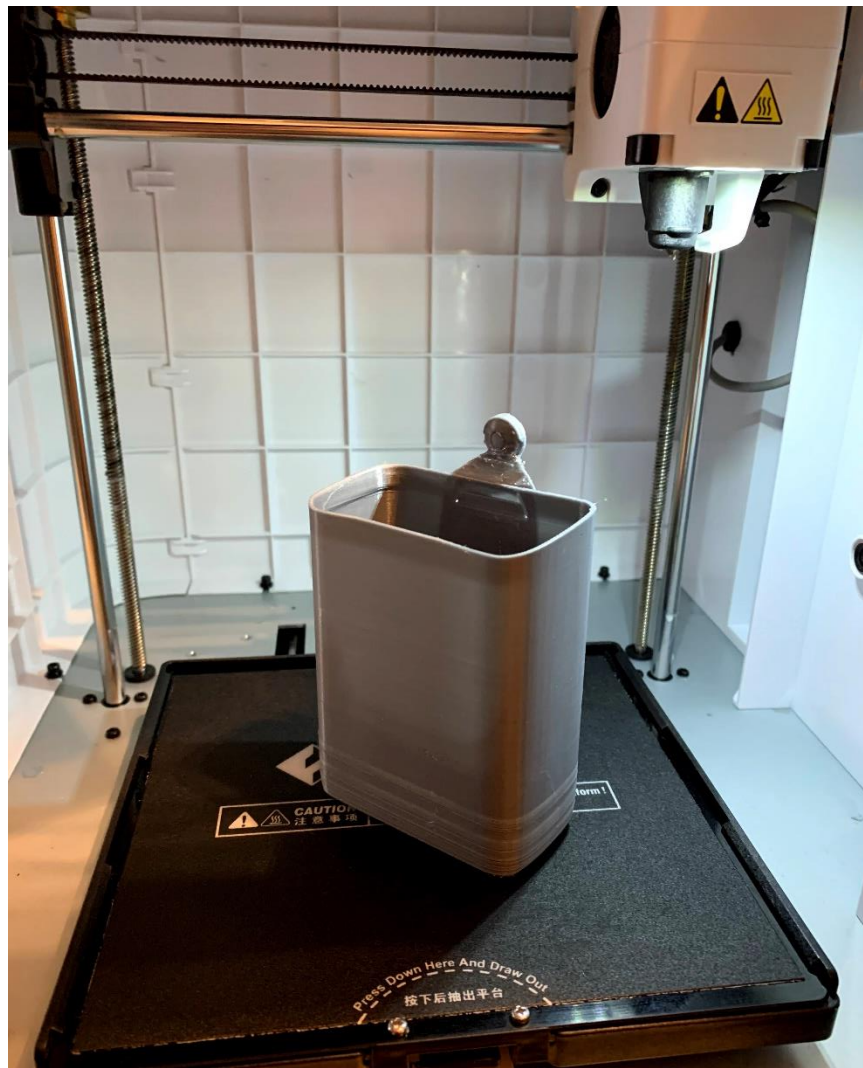


Figure 4. 20 – Physical Model Fabrication

## Chapter #5 Final Design



Figure 5. 1 – Trees – Chapter 5

This chapter will summarize the final design outcomes. It will outline the product design and how it interacts with the human body, materials and their estimated cost, in addition to implementation and feasibility. It will also feature the final design through computer generated renders, as well as a physical model.

### 5.1 – Summary

#### Description

ArootZ is a comprehensive sustainable tree planting system that integrates an ergonomic harness with technology that increases tree re-population while improving the user's overall well-being. It incorporates a suspension frame that evokes proper posture while affectively distributing the weight across their back and lumbar. The harness, which is offered in multiple sizes, provides a highly adjustable solution to accommodate a multitude of body types. Additionally, the incorporation of RFID technology and biodegradable materials allows

ArootZs to improve tree re-population while increasing the efficiency and productivity of the tree planting industry at large.

## Explanation

Tree Planters are the workers who support the essential industry of reforestation, while simultaneously providing a more sustainable future. The process of planting trees in these dense woodlands is very strenuous and does not ensure the tree's longevity which is needed to make a positive impact on the changing climate. The technique and skill of tree planting involves high repetition paired with the constant physical demand over an 8-hour day which often leaves tree planters injured and unable to operate. The harsh northern Canadian landscape requires peak physical effort to successfully traverse and plant in these northern woodlands. This harsh landscape prevents automation and automotive assistance leaving a unique situation for human execution. This thesis project seeks to mitigate Tree Planting related injuries and enhance seedlings mortality rates in Canada.

## Benefits Statement

ArootZ is a tree planting harness solution that provides enhanced safety, comfort, sustainability, and efficiency while planting. By doing so, ArootZ serves a benefit to the entire silviculture industry and tree planters by minimizing lost-time and pay from work related injury, while simultaneously providing data to better track and understand the growth and regrowth of Canadian forests.

## 5.2 – Design Criteria

This section includes elements of the ArootZ system and how they satisfy the design criteria.

### 5.2.1 – Full bodied interaction

The ArootZ system resides on the user throughout their workday, resulting in multiple contact points on the human body. Overall, the system comes in contact with the user's legs (thighs), back, and shoulders. The following section will go into further depth as the systems contact points and there benefits to the end user.

The suspension frame sprouts from the hip belt behind the lumbar pad and follows the curvature of the planters back. Attached to the suspension frame is two shoulder blade pads that transition into shoulder straps. Theses adjustable pads allow the user to alter the angle of the shoulder straps to best accommodate their shoulders shape. The dimensions of these pads would vary depending on the size of suspension frame the user has bought.



Residing at the top of the suspension frame is two load lifter straps. These bands connect to the shoulder straps and are anchored to the suspension frame. The load lifter straps pull the shoulder straps up and back towards the suspension frame. Tightening them diminishes the concentration of the load on the Planters shoulders. This provides more mobility and less strain on their shoulders, which ultimately improves the efficiency of their planting.

Connected to the hip belt is the thigh protectors that provide the user a barrier between the bags and their thighs. This separation reduces the common hinderance of chaffing that course with the current tree planting systems. The hip gimbal mechanism allows the planting bags to pivot with each step the user takes, ensuring that the load remains aligned with the user's center of gravity no matter what terrain they encounter. Overall this component provides added efficiency for the overall system while aiding in the users posture and weight distribution.

## 5.2.2 – Materials, Processes and Technology

From the moment the seedling is grown and ready to be transported, they are bundled in bundles of 5 using plastic wrap. The bundles are then packed into cardboard boxes and shipped across the country to the planting site. These boxes are then brought to the block and unloaded for the planters to pack into their bags. Each planter spends time unwrapping the bundles and placing them into their bags leaving behind an ample amount of plastic and cardboard. As the seedling is planted the planter places a plastic ribbon on each seedling to identify where they have previously planted. This ribbon is called the flag and is only temporarily needed when planters are on the block. Therefore, these flags are left behind and will be disbursed throughout the natural environment, inevitably being consumed by animals, or ending up in the water system. Lastly, the young seedlings planted are left to their natural environment, causing a certain percentage to die as they are not capable of sustaining themselves.

Producing tree planting equipment using sustainable materials and manufacturing processes ensures that the planters using the equipment creates as little environmental impact as possible. Although, by redesigning the packaging and planting process of the seedlings, the industry at large would improve its environmental impact exponentially. Improving the seedling itself would enhance the sustainability of every tree planted.

ArootZ incorporates two elements that develop these processes. The first being a grow stick that is planted with the seedling at the nursery stage. This grow stick is made from a biodegradable Lignin plastic which is derived from saw dust. This meaning that the left of saw dust created by the lumber companies can but utilized to create these grow sticks which aid in the transporting, and planting of seedlings. This development ensures a fully sustainable cycle that leave no waste behind while aiding in the mortality rates of the seedlings. Secondly the seedlings would be packed using an automated system at the nursery. The seedlings would be packed into biodegradable hemp bags. These bags would then be taken off the transport truck and clipped onto

the planters harness with no additional processing. This increases efficiency when planting, and once the bags are empty the planter can dispose of the bags which have a net 0 carbon emissions on the environment.

Leading-edge technological development in the fabric and apparel industry has granted companies the ability to provide their customers with environmentally conscious fabric solution that not only ensures the same functionality but also consider the products life cycle. These newly emerging solutions are forecasted to become the future of the apparel industry.

The use of these more natural materials changes the processing of these materials at the beginning of the manufacturing process. Although, once the desired elements of the natural materials are distilled, the manufacturing method typically remains the same. The process involves the creation of the fabric which is then advanced to the garment manufacture. As stated by Uddin (2019) the processes “includes textile fiber production and processing through blow room, carding, drawing, and combing; and fabric production including knitted, woven, nonwoven, and subsequent coloration and finishing and apparel manufacturing” (para. 26).

The other components of the design also follow the same manufacturing process as their typical synthetic producers. The carbon fiber supports go through the stabilizing, carbonizing, and treating processes before being sized and cut (Uddin, 2019). All the bioplastics components would be injection molded to their specific specifications. Lastly, all the dual-density foam would be manufactured using the Dunlap process. “liquid form it is foamed and poured into a mold. The mold is then closed up and placed on a conveyor belt. The mold is then moved on the conveyor belt into a vulcanization oven.” (“Sleep on Latex”, n.d, para 5).

### 5.2.3 – Implementation and feasibility

This section of the report will outline the Bill of Materials (BOM). Since the ArootZ system utilizes leading edge material technology, an estimation of cost and viability has been conducted. Due to the novel nature of this concept, this BOM has been modeled after existing products on the market that utilize similar methods of production and pricing.

**Cost Breakdown**

Class A	High Cost	
Class B	Medium Cost	
Class C	Low Cost	

Table 5. 1 – Cost Breakdown

Component	Material	Price - \$
Main Fabric exterior Hip belt – Shoulder straps	Workwear Canvas - “Iron Forge Hemp™” (Patagonia, n.d, para. 5).	
Foam Padding	Dual Density Foam - “Koosh Natural” (Foamite, n.d, para. 10).	
Mesh – Foam shielding (human contact points)	Air Mesh 500D Spacer Air Mesh	
Suspension Frame (Back frame – hip belt stays)	Carbon Fiber - “AmpliTex™” (Bcomp, n.d, para. 4).	
Buckles and Clasps	BioPlastic - “Terratek® SC” (Green dot Bioplastics, n.d, para. 1)	
Buckets (Seedling bags)	Hemp - “Hempton” (Hemp Fabric Lab, n.d.).	

Table 5. 2 – Bill of Materials

In order to create an accurate representation of the materials and material costs of ArootZ a more comprehensive BOM would need to be completed. Without the pricing listed on the majority of the sustainable material suppliers a quote would need to be provided to better understand the pricing of a ArootZ harness. Additionally, an entirely different pricing evaluation would have to take place depending on the scale of production of ArootZ harness. Assuming this equipment would be mass produced it is safe to assume that material costs per unit would significantly decrease.

5.3 – Final CAD Renders

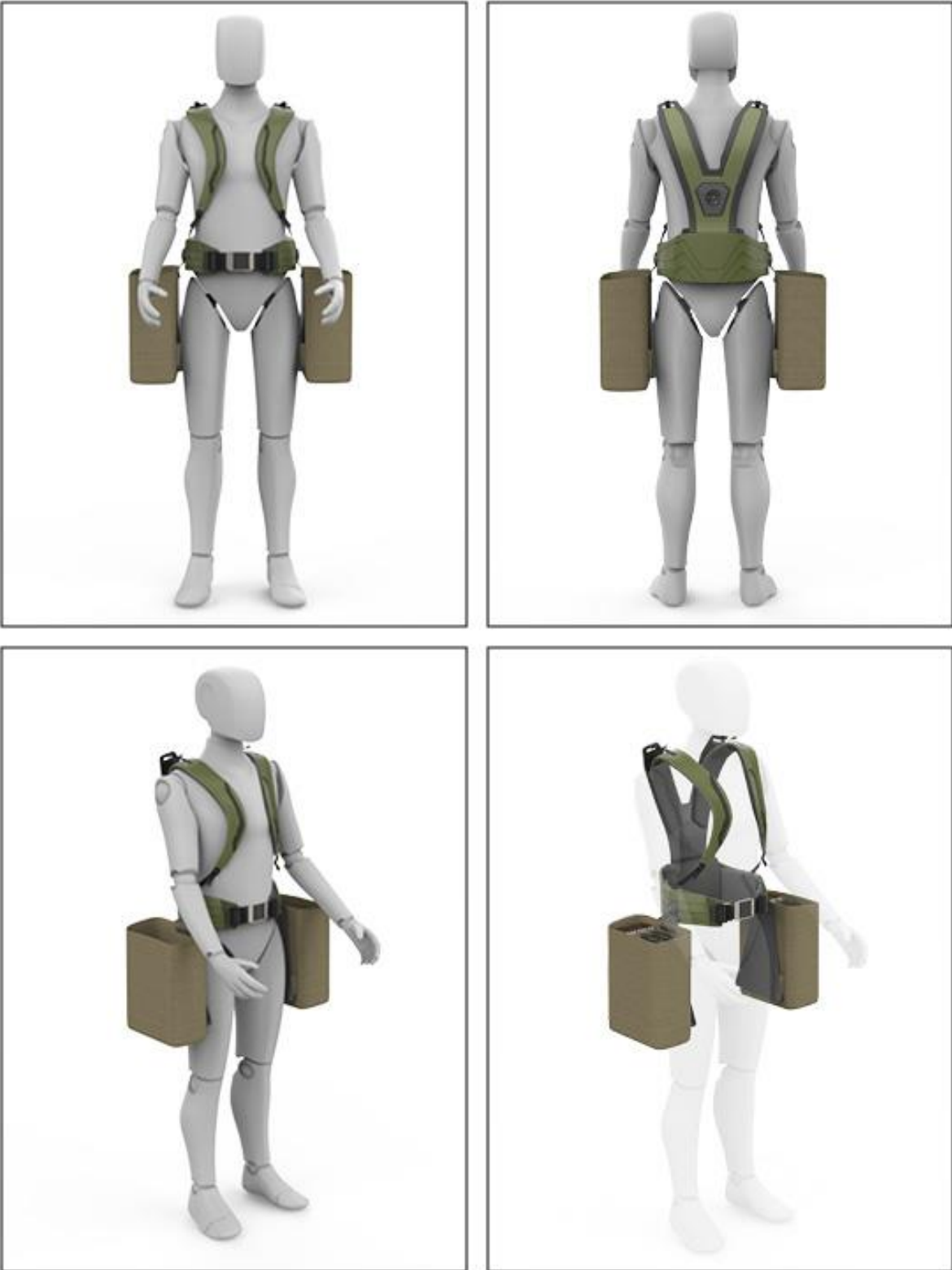


Figure 5. 2 – CAD Renders #1

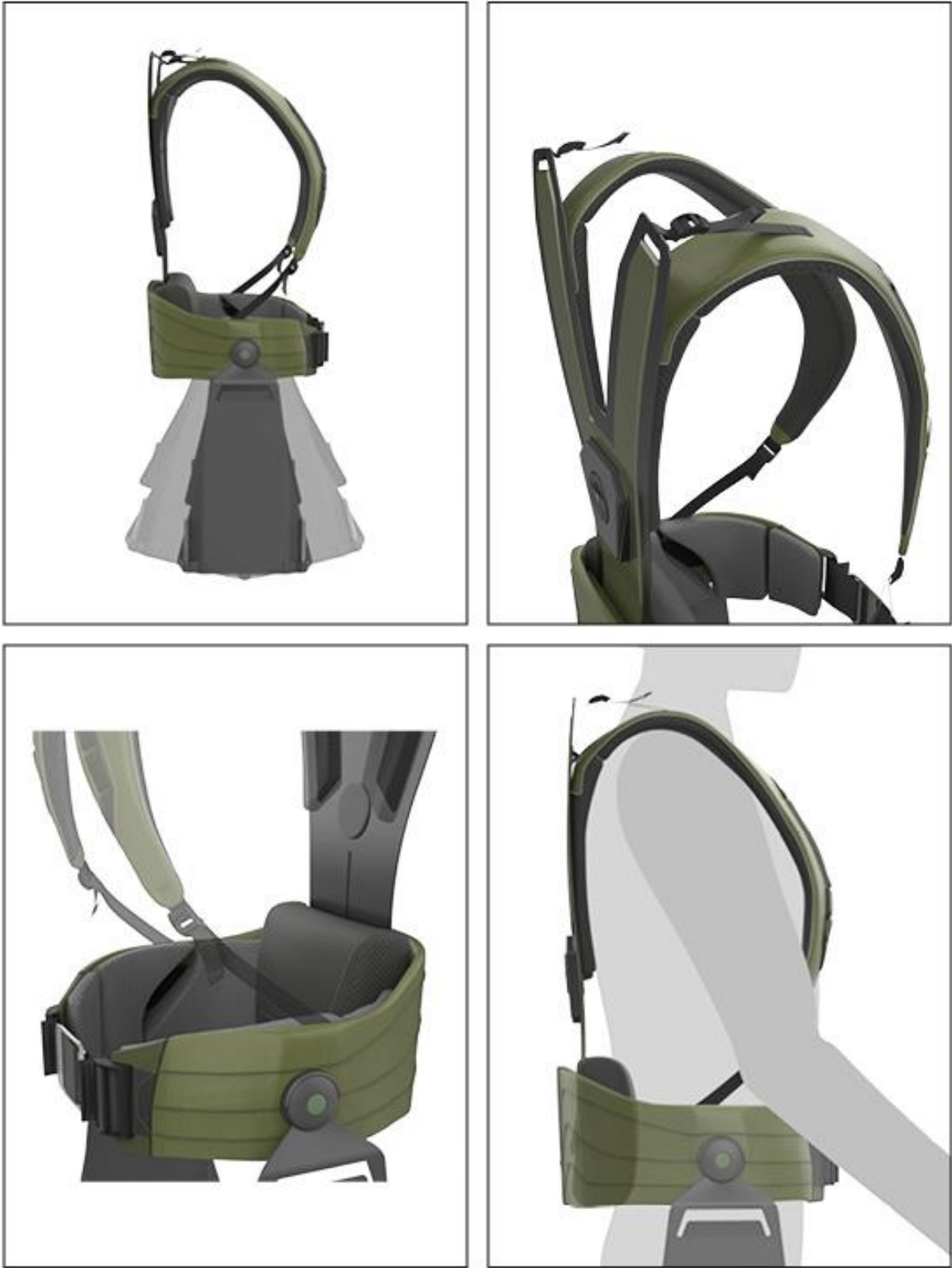


Figure 5. 3 - CAD Renders #2



Figure 5. 4 - CAD Renders #3



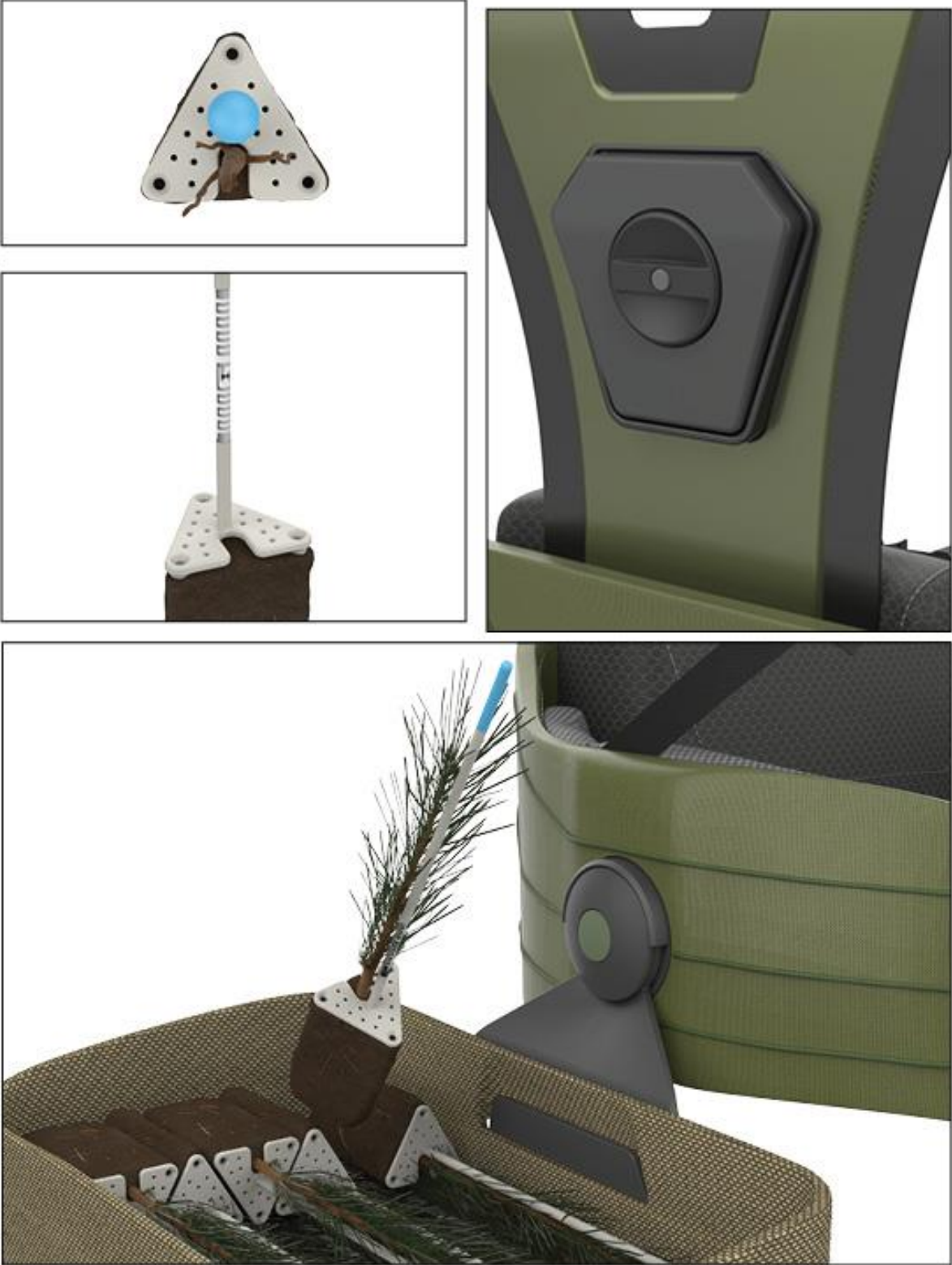


Figure 5. 5 - CAD Renders #4



### 5.4 – Physical Model



Figure 5. 6 – Physical Model

5.5 – Technical Drawing

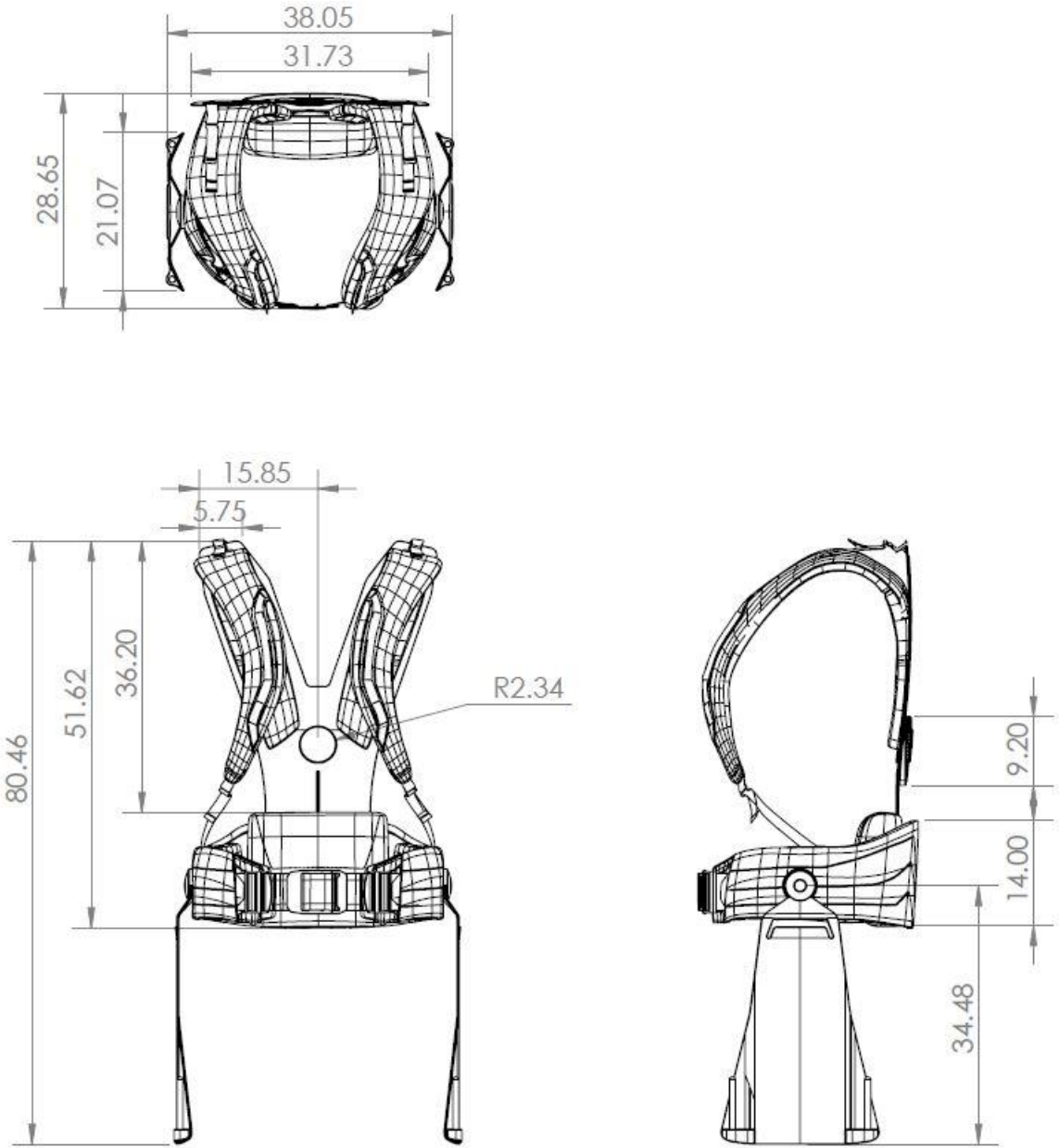


Figure 5. 7 – Technical Drawing

## 5.6 – Sustainable

Maintaining the traditional method of planting through the utilization of physical labor assures the most sustainable solution for the mass planting of trees. This report has brought to light the areas of the silviculture industry that require sustainable improvement.

On micro-level planters, gear should be made with as few synthetic materials and manufacturing methods as possible. The final design incorporates materials that are derived from plants and natural resources. This provides a fully sustainable product life cycle allowing for biodegradation, upcycling, or recycling of the gear.

On a macro level, the industry's method of packing and transporting seedlings was evaluated. The consistent use of plastic throughout the seedling journey into the ground became a focal point for improvement. Utilizing a better packing method at the nursery level would prove to be more sustainable while additionally creating a more efficient unpacking method for the planters. The final design eliminates the use of seedlings bundled in plastic which encourages a new approach to packing and unloading seedlings in the industry. This is executed by replacing the seedling box with a biodegradable hemp bag. This bag is used as the planter's "buckets" leaving the seedlings with no extra waste. Once each bucket is done the hemp bag would be disposed of and would biodegrade into the natural environment with net 0 emissions. Furthermore, the method used to distinguish a planter "line" or where they have previously planted, also required evaluation. The use of the "flags" or torn plastic ribbons creates arguably one of the most damaging aspects of the planting process. Within the final design, flags are replaced with a supportive structural stem that would be made of biodegradable plastic derived from lignin. This structural stem is planted with the seedling at the nursery and follows it through its journey into the ground. Residing at the top of the structural stem would be a neon color which would replace the use of the plastic flags, while still providing planters the ability to see their line.

Overall, the substitution of synthetic materials with natural-based ones allows the planting equipment to have a fully sustainable product life cycle. Additionally, by modernizing the packaging, transporting, and flagging process with an efficient hemp bagging process the silviculture industry at a large can reduce its emissions and impact on the environment significantly.

## Chapter #6

## Conclusion



Figure 6. 1 – Chapter 6 In Situ

Within the 20<sup>th</sup> century the rise in atmospheric CO<sub>2</sub> concentration has become an alarming concern for all of humanity. With the rise in concern for the global effects of CO<sub>2</sub> emissions humanity has looked to the thing that soaks it up. Trees.

Although, the lack of innovation within this industry has left tree planters subject to work related injury. The current tree planting bags on the market lack support and comfort tree planters need when dealing with the extreme conditions of planting trees. Additionally, the industries use of harmful plastics diminishes the positive effect they have on the world while harming the natural environment around them.

ArootZ provides a solution for the silvicultural industry which is tasked with aiding in this global issue. ArootZ is a fully sustainable cyclical system that incorporates the following elements: ergonomic tree planting harness, technological efficient transport and tracking tools, and sustainable seedling cycle integrating bioplastics harvested from wood by products. Overall, ArootZ is a comprehensive sustainable tree planting system that integrates an ergonomic harness with technology that increases tree re-population while improving the user's overall well-being.

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## Appendix

### Appendix – A                      Discovery

#### Key Article 1

##### Method

A key article for this topic was sourced and selected. Required article content ( Introduction, and Conclusion sections) was copied and highlighted.

- Search Engine: Humber Library Discover
- Key Words Used in Search: “enhance, tree planting, experience, review”Findings

#### **Citation:**

Sheahan, P. J., Cashaback, J. G. A., & Fischer, S. L. (2017). Evaluating the Ergonomic Benefit of a Wrist Brace on Wrist Posture, Muscle Activity, Rotational Stiffness, and Peak Shovel-Ground Impact Force During a Simulated Tree-Planting Task. *Human Factors*, 59(6), 911–924.

<https://doi.org/10.1177/0018720817708084>

**Key Content: is reproduced below.**

#### **Introduction**

Every year, Canadian tree planters are responsible for replanting hundreds of millions of trees to combat the deforestation that occurs throughout large portions of rural Canada. Tree planters work at up to 60% of their maximal aerobic power (Hodges & Kennedy, 2011; Smith, 1987) while enduring difficult weather and terrain conditions to meet planting quotas. Depending on soil conditions, the average worker can plant anywhere from 2,000 to 4,500 seedlings per day (Tree-Planter.com, 2015), with some planters planting a tree every 5.6 seconds (Stjernberg, 1988). **Given this high repetition and intense physical demand, it may not be surprising that approximately 90% of planters will sustain a work-related injury at some point in their planting career (Smith, 1987). Wrist and hand injuries represent 20% of all injury claims from the tree planting industry.**

**These injuries are likely the result of deviated postures, high impact forces, repetitive motion, and overexertion (Stjernberg & Kinney, 2007). This is consistent with recent biomechanical evidence characterizing wrist posture and forces during a planting cycle.** Denbeigh, Slot, and Dumas (2013) showed that tree planters experience high wrist loads at shovel-ground impact (average resultant forces at the wrist were equivalent to 31.4 N) and exhibit extended wrist postures (6.1°–7.2° of extension). While previous research has focused on the kinetics and kinematics at shovel-ground impact, to our knowledge, there has not been any research on the potential role that both braces and muscles may play in **increasing wrist stiffness. Increasing wrist stiffness would act to prevent highly deviated postures and may decrease the risk of injury during tree planting.**

Reforestation companies currently recommend engineering (equipment) and administrative (technique training, warm-up, etc.) controls to mitigate injuries. For example, a common risk control approach is to teach planters how to keep the wrist as neutral (hand and forearm are coplanar) as possible throughout the planting cycle, especially at shovel-ground impact. Other recommended injury prevention approaches include warming up, using an ergonomic or staff-style shovel, and ambidextrous planting (Stjernberg & Kinney, 2007). Planters are also taught to identify safe soil conditions for planting and use appropriately fitted equipment. While each control option likely has some merit, injuries persist. This is likely a result of our limited understanding of injury mechanism within the treeplanting sector. By advancing our understanding of the injury mechanisms that underpin tree planting, we might better design targeted musculoskeletal disorder prevention strategies for this high-risk occupational group. **Within the tree-planting community, custom wrist braces are beginning to emerge as a possible musculoskeletal disorder prevention strategy. In the field, planters are often seen fabricating and wearing their own custom wrist braces. Anecdotally, planters report that custom-fabricated wrist braces help to maintain a more neutral posture and provide more support for the wrist at shovelground impact.** From a mechanistic standpoint, it is plausible that a brace could promote a more neutral posture by helping to restrict range of motion (Rempel, Manojlovic, Levinsohn, Bloom, & Gordon, 1994). In other activities where high impact at the wrist is a possibility, such as when performing an activity like snowboarding, wrist bracing has been associated with a reduction in wrist-related injuries (Machold et al., 2002; Ronning, Ronning, Gerner, & Engebretsen, 2001).

Many areas of research continue to explore the influence of braces. When considered broadly, experimental research documenting the benefits and limitations of a wrist brace is mixed. At the wrist, bracing can influence the dynamic impact response (Greenwald, Janes, Swanson, & McDonald, 1998) and help restrict motion without any negative consequences to carpal tunnel pressure (Rempel et al., 1994). Brace use can also cause unanticipated changes such as increased humeral elevation angle (Mell, Childress, & Hughes, 2005), compensatory motions at the thumb and index finger (Liu, Chiang, & Chen, 2015), and altered muscle activity (Di Domizio, Mogk, & Keir, 2008; Ferrigno, Cliquet, Magna, & Zoppi Filho, 2009), depending on the task. These diverse findings describing brace use are task and context specific. This reaffirms the need to determine the prospective benefits and potential risks of brace use with respect to the target application or task, such as tree planting. Of particular note are both postural and muscle activity changes as a function of brace use. Both these factors influence the ability of muscles to provide stiffness to the wrist (Holmes, Tat, & Keir, 2015). Previous research has examined the role of wrist bracing on muscle activity and postural variables independently. However, the combined effects on muscle activity and posture due to bracing has not been examined. Joint stiffness is an important physiological property regulated by the nervous system that is influenced by muscle activity and posture (Cashaback & Cluff, 2015). Thus, a joint stiffness analysis may offer a direct outcome to inform our understanding of the influence of wrist bracing, which may have specific relevance to tree planting. Without external bracing, the sensorimotor system must act to stabilize our joints. It does so by co-contracting the muscles that surround a joint, increasing muscular contributions to joint rotational stiffness (Bergmark, 1989; Cholewicki

& McGill, 1996). For example, increased co-contraction leads to greater rotational stiffness about the wrist joint (Holmes et al., 2015). However, increased co-contraction and joint stiffness come with a cost: greater joint loading (Cholewicki & McGill, 1996) and higher energy expenditure (Cashaback & Cluff, 2015; Hogan, 1984). Thus, it is possible that using a brace to externally augment joint stiffness may reduce the need for the sensorimotor system to internally increase muscular contributions to joint rotational stiffness. Such a strategy would lead to reduced joint loading and energy consumption (Cashaback & Cluff, 2015). Considering the intense physical demand and high external loads applied to the wrist during tree planting, this occupational group may greatly benefit from a potential reduction in joint loading and Evaluation of a Brace for Tree Planters 913 energy consumption that may be afforded by a brace. Currently, our knowledge of tree planting is limited to kinematics and external forces. Further, given the mixed results of brace use, it is unknown how a brace may influence posture and muscle activation patterns that dictate muscular contributions to joint stiffness. Understanding how both braces and muscles act to stiffen the joint is likely most important at the instant of peak shovel-ground impact, where external loads are greatest.

The goal of this study was to characterize the kinematics and muscular activation requirements at the instant of peak shovel-ground impact during a tree-planting task with and without the use of a wrist brace. Using these data, we aimed to quantify muscular contributions to joint rotational stiffness at the wrist to determine if an external wrist brace added support to the wrist such that muscular contributions to wrist joint stiffness were reduced. We hypothesized that the brace would maintain the wrist in a more neutral position, reduce wrist flexor and extensor muscle activity, and reduce muscular contributions to joint rotational stiffness.

## Conclusions

The purpose of this study was to characterize the kinematics and muscular activation requirements at the instant of peak shovel-ground impact during a tree-planting task with and without the use of an external wrist brace. In the current study, the use of a wrist brace influenced wrist posture about the flexion/extension axis toward a more neutral ( $0^\circ$ ) orientation but away from a more neutral orientation about the ulnar/radial deviation axis at the instant of peak shovel-ground impact. Muscle activity was not different between conditions; however, moderate effect sizes were observed in FCR, ED, and ECU. Moderate changes in muscle activity, along with significant changes in wrist joint alignment, drove increases in global joint rotational stiffness (D) at peak shovel-ground impact when wearing the brace relative to the no-brace condition. Specifically, we found greater stiffness about the flexion/extension axis of the wrist (KFE) and a greater interaction stiffness between the two axes (KFEUR).

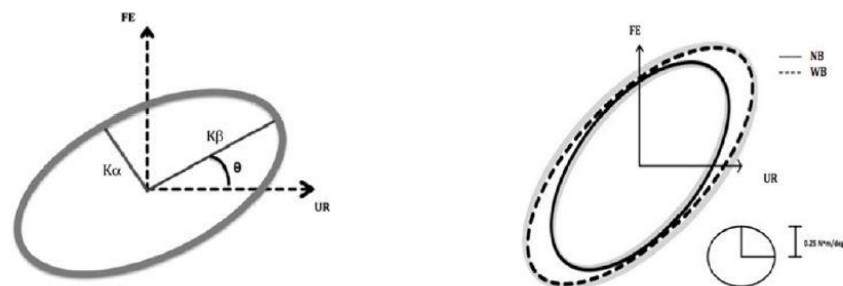


Figure 6. The ellipse represents stiffness about the flexion/extension (FE) and ulnar/radial axes. For a given stiffness matrix ( $K$ ), eigendecomposition was used to determine the lengths of the major ( $K\alpha$ ) and minor axes ( $K\beta$ ) of the ellipse. These axes are orthogonal, and their lengths correspond with the eigenvalues of  $K$ .  $\theta$  is the angle that  $K\beta$  makes with the ulnar/radial axis (UR). Based on our hypothesis, we expected a decrease in  $K\alpha$  and  $K\beta$  when participants wore the wrist brace. This would represent an overall decreased need for muscles

to provide joint stiffness given the added external stiffness provided by the brace. We did not expect any changes in the ratio between  $K\alpha$  and  $K\beta$  or  $\theta$ , all of which dictate the shape of the ellipse.

*Figure 5.* Mean muscle activity (standard error) observed at peak shovel-ground impact during the no-brace (NB) and with-brace (WB) conditions.  $*p < .05$ . Evaluation of a Brace for Tree Planters 921 We hypothesized that an external brace would provide a prophylactic benefit. Specifically, we expected that the added external stiffness provided by the brace would reduce the demands on the sensorimotor system to provide joint rotational stiffness about the wrist (i.e., reduce KFE, KFEUR, D,  $K\alpha$ , and  $K\beta$ ). We expected the brace to restrict range of motion, promoting a more neutrally oriented wrist alignment at the instant of peak shovel-ground impact. A more neutral posture would increase moment arm lengths for musculotendon units crossing the wrist. Greater moment arms would act to decrease the force requirements needed to provide the same moment and stiffness contributions about the wrist. Supporting our hypothesis, we found that **planters exhibited closer to neutral postures about the flexion-extension axis when wearing the brace compared to the no brace condition**. However, contrary to our hypothesis, joint angles about the **ulnar/radial deviation axis were more deviated from neutral when wearing the brace**. We believe that the design of the brace may have served to confound its potential benefits.

As highlighted in Figure 1, the brace had a “notch” at the distal end that could clasp to the shovel handle. This feature was designed to reduce gripping requirements when holding the handle in between plants. However, an unintended consequence of this design feature is that it also increased the handgrip diameter. Several participants ( $n = 11$ ) **reported difficulty grasping the standardized planting shovel in the withbrace condition due to the size of the brace**. In particular, they expressed a challenge in gripping with the fourth (ring finger) and fifth (little finger) digits, where increasing ulnar deviation about the wrist would provide a motor control adaptation to address the grip issue, explaining the increase in ulnar deviation that we observed. The preliminary size of the shovel handle was 32 mm (the optimal size for gripping tools), and with the brace, the total grip diameter (brace plus shovel handle) was extended by 6 mm to approximately 38 mm. An increase in tool diameter has been shown to affect properties such as grip force (Sancho-Bru et al., 2003). *Figure 7.* Mean stiffness (Nm/°) ellipses at the instant of peak shovel ground impact for participants in the with-brace (WB) ( $\bullet$   $\pm 1$  standard error) and no-brace (NB) ( $\circ$   $\pm 1$  standard error) conditions. FE and UR denote the flexion/extension and ulnar/radial axes of the wrist, respectively. Each ellipse is scaled to the circle in the bottom right corner of the figure.

Changes in grip force influence muscle activity, co-contraction, and wrist rotational stiffness (Holmes et al., 2015), where altered difficulty in gripping the shovel was also likely linked to the moderate but nonsignificant changes observed in our muscle activity measures. As a result, we attribute the unexpected increases in joint rotational stiffness to the changes in tool grip diameter during the with-brace condition. **Muscle activity in the forearm muscles typically ranged between 40% and 50% of maximum activation at the instant of peak shovel-ground impact within the planting cycle in the no-brace condition**. Moreover, it did not decrease with brace use as expected. Previously, treeplanting research has targeted kinetics and kinematics (Denbeigh et al., 2013); however, our data demonstrate that muscle activity or moreover the threat of muscle fatigue from repetitive dynamic work may be a real concern. Drawing on the classic recommendations proposed by Jonsson (1978), sEMG for long-lasting or dynamic intermittent work (like tree planting) should not exceed 14% MVC. We observed EMG well exceeding that threshold, where planters are likely to sustain these contractions over 2,000 times per day, depending on the number of trees they can plant. These data reaffirm a need to consider muscle activation dynamics and the potential for muscle fatigue as plausible injury mechanisms within the tree planter population.

Further, interventions that effectively reduce muscle demands about the wrist during tree planting, perhaps via a reduced need to contribute to wrist joint rotational stiffness, should continue to be explored.

**The absence of decreased sEMG in the withbrace condition may also be due to the “notch” design feature that also likely effected ulnar/ radial deviation**. We know that grip diameter can influence forearm sEMG (Ayoub & Presti, 1971). The modest increase in grip diameter ( $\approx 0.6$  cm) required when donning the brace may explain the modest but nonsignificant (sample size limitation) increases in sEMG for select muscles. **This finding highlights the importance of validating brace designs**. The brace was intended to support the wrist at impact and via the notch at the distal end to reduce grip requirements when carrying the shovel between plants. While we did not focus on grip demands between plants, these data suggest that the notch design produced an unintended negative consequence of increasing grip diameter. The larger grip diameter may have undermined the ability of the brace to reduce muscular demands at impact. The use of a joint rotational stiffness model enhanced our ability to understand how the brace may have influenced how the sensorimotor system controlled the wrist musculature at the instant of peak shovel-ground impact during tree planting. **The stiffness analysis described previously has several advantages over the independent evaluation of mean postures or muscle activations**. Sometimes, muscle activity is used to calculate a co-contraction index, which is then used as a metric to indicate how much neural drive is sent to the muscles to modulate stiffness. However, the joint rotational stiffness analysis used in this experiment better represents sensorimotor control as it accounts for muscle activity, posture, muscle force-length and force-velocity relationships, and muscle moment arm lengths. **Had we only considered kinematics, which is common when evaluating “ergonomic” devices, we may have incorrectly deemed the brace a “success” since it restored flexion/extension angles toward a more neutral alignment**. Conversely, had we only considered kinematics and sEMG, with sample size large enough to detect moderate sized effects in sEMG, we may have inferred that the brace likely has a minimal effect: more neutral wrist orientation but modest increase in sEMG. **Instead, by combining these data using a joint rotational stiffness approach, we have more compelling evidence to highlight current deficiencies in the design**. By accounting for muscle force and stiffness (via sEMG) and muscle lengths, velocities, and moment arm lengths (via kinematics and OpenSIM), our stiffness ellipse (Figure 7) provides a clear picture to highlight the lack of a clear net benefit considering the current brace design. Moreover, joint stiffness is likely an important physiological property controlled by the sensorimotor system (Cashaback & Cluff, 2015), and thus changes in stiffness may provide valuable insight to how the sensorimotor system accounts for the brace. Considering the logic we presented in the intro Evaluation of a Brace for Tree Planters 923 duction, for a brace to be effective at the instant of peak shovel-ground impact during tree planting, it should reduce the demand on the sensorimotor system to provide wrist joint stiffness, not increase it. From this perspective, we believe the addition of a rotational joint stiffness analysis enhanced our ability to comprehensively evaluate the effectiveness of the current brace design.

**Improvement in the design of the current brace will be essential if practical benefits can be realized for tree planters in the future. Our analysis suggests that an improvement in the attachment of the brace to the shovel grip will be necessary to address the potential confounding effect associated with the**

increased grip diameter. Moving forward, a revised attachment mechanism preserving the initial grip diameter may provide more benefit. Moreover, a revised brace design may also facilitate improvement toward a more neutral wrist joint alignment about the ulnar deviation axis at shovel-ground impact. Future research should also consider the role of grip force and the effect of the brace on tree planting quality (depth, accuracy, and speed) as well as other biomechanical outcome measures at other body regions (the shoulder and lower back) to ensure that other unintended consequences do not arise.

This study confirmed that tree planters exhibit non-neutral wrist postures when planting. These wrist postures were similar to those reported in previous laboratory research (Denbeigh et al., 2013), but we cannot confirm if these data do indeed generalize to the actual angles experienced in the field. On account of the confounding effect of altered grip diameter associated with the use of the brace, it may be premature to conclusively discuss the merits of bracing, using this design, as being either “good” or “bad” in the context of tree planting. Instead, our research reinforces the importance of validating an intended brace design by considering all of its features. Here, we revealed that one design feature (notch to clasp onto shovel) had an unintended consequence on the potential benefits of other design features (provision of enhanced stiffness). Moreover, we demonstrate how our joint stiffness model provided a window into how the sensorimotor system controls the wrist musculature, which provided us with enhanced information over observed kinematic and sEMG

### Summary Statements

1. Approximately 90% of tree planters are subject to work-related injury likely because of the high repetition and intense physical demand associated with the job. Roughly 20% of all the injury claims from tree planting industry are related to the wrist and hand.
2. Factors such as posture, high impact forces, repetitive motion, and overexertion all play a role in obtaining these hand and wrist injury. Deviation in these facts determines the severity of the injury obtained.
3. Reforestation companies recommend technical training on how to keep your wrists in a neutral position during spade ground impact to mitigate injury. Within the tree planting community, it is common to fabricate and customize existing safety equipment (such as wrist braces) to better support the high impact and high cycle rates that they endure.
4. The study measured the deviation of the flexion-extension axis along with ulnar/radial axis of the wrist when encounter peak shovel impact. The study showed that planters exhibited closer to neutral postures in the flexion-extension axis when wearing a wrist brace although the ulnar/radial axis deviated from neutral more when wearing the brace. Stating “We believe that the design of the brace may have served to confound its potential benefits”.
5. Some planters found that the wrist brace impeded their abilities to grasp the standardized planting shovel. This creating more strain and deviation in ulnar/radial axis. The shovels handle was 32mm although with wrist brace the grip diameter was extended by 6mm to 38mm
6. The study showcases that tree planter display non-neutral wrist posture when planting. Although it may be “premature to conclusively discuss the merits of bracing, using this design, as being either good or bad in the context of tree planting”. Although it underlines the importance of a brace design that considers all these features for the specific use case of tree planting.



## Key Article 2

### Method

A key article for this topic was sourced and selected. Required article content was copied and highlighted.

- Search Engine: Google scholar
- Key Words Used in Search: Enhance, Tree Mortality Rates, Boreal Forest

### Findings

Citation: Brecka, A. F., Shahi, C., & Chen, H. Y. (2018). Climate change impacts on boreal forest timber supply. *Forest Policy and Economics*, 92, 11-21. <https://doi.org/10.1016/j.forpol.2018.03.010>.

**Key Content: is reproduced below.**

#### Abstract

Recent studies have assessed the ecological [effects of climate change](#) on [boreal forests](#); however, our understanding of the economic impacts of climate change on timber supply remains limited. Forestry is an important boreal industry; hence, it is necessary to better understand the ecological impacts that directly and indirectly affect this sector. [We reviewed published literature concerning ecological impacts of climate change on biome shifts, regional forest disturbances, and tree growth, mortality and species compositional shifts in established forest stands.](#) Subsequently, we examined how each factor influences timber supply and forestry. Tree species ranges have been and will continue migrating north to find more suitable growing conditions, but at a slower rate than climate change. Biome shifts from forests to shrub or [grasslands](#) may occur under persistent [drought](#) conditions. [Warmer temperatures and lower climate moisture availability increase forest disturbances; notably fire and insect outbreaks, creating younger forests dominated by pioneer species and limiting harvestable material.](#) While tree growth and mortality rates are spatially variable across established forest regions, tree mortality has temporally increased with climate change; accompanied by reduced growth or increased growth at a rate lower than mortality loss, [resulting in a reduced rate of volume accumulation and timber available for harvest.](#) Moreover, climate change favors pioneer species (*Pinus* spp. and *Populus* spp.) over late successional species (*Picea* spp. and *Abies* spp.). Our findings suggest that climate change has strong negative effects on boreal timber supply but may prompt operational adaptations, opening opportunities for [forest industry](#) to incorporate species such as *Populus*.

#### Introduction

The [boreal forest](#) is one of Earth's largest forest [biomes](#), with an area of 1.2 billion hectares; stretching from Russia, across [Scandinavia](#) and throughout North America ([van Lierop et al., 2015](#)). The boreal forest constitutes approximately 30% of the world's most densely forested area ([Crowther et al., 2015](#)), while storing nearly half of the global forest carbon, primarily within soils ([Gauthier et al., 2015a](#); [Soja et al., 2007](#)). This forest region is immensely critical to the global timber products market. Roughly 33% of [lumber](#) and 25% of paper exports in the global market originate from the boreal forest ([Gauthier et al., 2015a](#)). However, most ecological functions and processes, such as tree growth, proceed slowly in the boreal forest due to short growing seasons with severe, cold winters ([Fettig et al., 2013](#); [Kellomaki, 2000](#)). Despite similar presences of tree genus (*Picea*, *Pinus*, *Populus*, *Larix*, and *Betula*), disturbance regimes and management histories and strategies differ between Eurasian and North American boreal forest regions ([Gauthier et al., 2015a](#); [Rogers et al., 2015](#); [Schaphoff et al., 2016](#)).

Climate change has a profound impact on global forestry, and continues to accelerate with increasing anthropogenic [greenhouse gas emissions](#) ([IPCC, 2014](#)). Higher latitudinal areas are expected to undergo the largest increases in temperature ([Diffenbaugh and Field, 2013](#)) and experience variable shifts in precipitation regimes ([Gauthier et al., 2015a](#); [Reyer et al., 2015](#)). Changes in site conditions and frequency of disturbance regimes have also affected the boreal forest as a result of climate change ([Price et al., 2013](#)). [Understanding climate change impacts on boreal forest dynamics and timber supply is crucial to the continued viability of boreal forest industry.](#)

Timber supply, defined in this review as the quality and quantity of standing timber available for harvesting, directly impacts the forest industry; in both the short run and long run. The difference between the two timelines is the amount of time required to transition between capital investments in equipment and product development ([Zhang and Pearse, 2011](#)). Short run supply occurs within a timeframe that is too short for industry to adjust their capital stock and standing timber inventory; slower growth rates and higher rotation ages (particularly in the boreal forest) slow this process. This lack of flexibility means that industry can only adjust their variable inputs (fuel and labour) or utilize their facilities more intensively. In the long run, industry is able to reinvest in profitable areas and change supply to better suit the market ([Zhang and Pearse, 2011](#)). The duration of the long run depends on products (lumber or engineered wood products), [industry \(logging or pulp and paper\)](#) and geographic location (boreal forest or tropical). **However, long run timber supply is difficult to anticipate because of a number of factors that affect trees: growth and mortality rates, disturbances, harvesting rotation schedules and demand of forest products ([Zhang and Pearse, 2011](#)). Climate change further complicates this process of product evaluation and timber supply ([Sohnngen, 2014](#)). Analyses of the impacts of climate change on boreal timber supply should involve both short term and long-term research to properly forecast the implications of ecological change on the economy.**

Recent advances have been made toward understanding climate change impacts on forest productivity, species range shifts and forest disturbances ([Boisvenue and Running, 2006](#); [Hofgaard et al., 2013](#); [Kurz et al., 2008](#)), though there have been few publications synthesizing these impacts. Several published reviews on the boreal forest and climate change include: global boreal forest health ([Gauthier et al., 2015a](#)), impacts to North American forests and ecosystems ([Price et al., 2013](#)), implications to forest [carbon balance](#) ([Kurz et al., 2013](#); [Schaphoff et al., 2016](#)), forestry adaptation practices ([Gauthier et al., 2014](#)), and a recently proposed concept of using biodiversity to mitigate climate change impacts on ecosystem functioning ([Hisano et al., 2018](#)). However, the impact of climate change on industrial timber supply and its economic implications is an area that demands continued investigation. The existing forestry related reviews suggested that there would likely be increases in global timber supply (though high regional variation) from greater forest productivity ([Kirilenko and Sedjo, 2007](#)) leading to probable decreases in wood product prices and demand ([Sohnngen and Tian, 2016](#)).

Modeling studies have addressed the economic impacts of climate change in specific countries or regions ([Mendelsohn et al., 2000](#); [Ochuodho et al., 2012](#); [Solberg et al., 2003](#)), whereas others have considered the forest industry in a global context ([Lindner et al., 2002](#); [Perez-Garcia et al., 2002](#); [Sohnngen et al., 2001](#); [Tian et al., 2016](#)). Older global timber models suggest higher timber productivity from tropical regions, compared to [temperate regions](#) with on-going climate change ([Perez-Garcia et al., 2002](#); [Sohnngen et al., 2001](#)), whereas, the latest global timber model predicts a similar overall increase in forest productivity in both regions ([Tian et al., 2016](#)). Generally, timber resources are expected to increase across the globe and result in lower product prices ([Sohnngen and Tian, 2016](#); [Tian et al., 2016](#)). **However, empirical evidence from [tropical forests](#) revealed that climate change has led to greater [biomass loss through tree mortality than growth gain, resulting in less standing biomass](#) ([Brienen et al., 2015](#)). Further, these studies typically simulated consistent future disturbance regimes possibly leading to yield inaccuracies ([McKenney et al., 2016](#)). Nevertheless, these modeling studies do not specifically analyze the productivity of the boreal forest under climate change; rather they have focused on temperate and tropical forests. Therefore, modeling climate change impacts on boreal forest timber supply remains needed.**

The purpose of this review is to synthesize the impacts of climate change on boreal forest dynamics directly relating to available timber supply ([Fig. 1](#)). Specifically, this review will: i) **examine how climate change has affected boreal ecological processes at a variety of spatial scales (biome, regional, stand and individual levels), since the impacts to ecological processes differ across scales, ii) analyze how these ecological changes will impact timber supply, iii) detail management adaptations, and iv) identify gaps in current knowledge for future research.**

## Conclusion

Climate change affects ecological processes at different spatial scales and impacts timber supply in [boreal forests](#). **First, the area of productive boreal forest may decrease as northern migration rates are slower than the speed at which southern limits retreat from unfavourable climate conditions. Second, forest disturbances have increased in recent decades and are anticipated to increase in severity and/or frequency, leading to younger forest age structures and increased dominance of early successional tree species over late-successional species. Third, tree growth in established forests has increased in areas where water availability is not limiting as the result of warmer temperatures, longer growing seasons and CO<sub>2</sub> fertilization. However, widespread increases in tree mortality have occurred over the last several decades due to direct heat stress, [drought](#) and increased disturbances. Increased mortality has occurred at a greater rate than growth increases, or has accompanied reduced growth rates, leading to decreased net growth and net volumes. Moreover, late successional tree species are more vulnerable to climate than early successional species in established forests, leading to the increased dominance of early successional conifers and broadleaves. These trends are expected to continue as warming and extreme weather conditions are anticipated to be amplified in the 21st century.**

Changes in timber quantity and quality have profound impacts on the [forest industry](#). First, lower net harvestable volumes will likely be available since climate change induced mortality losses are greater than growth gains. Second, product manufacturing will need to accommodate new supply demographics, though it is costly to alter processing facilities; despite this, new unforeseen opportunities may arise. Third, locating sufficient mature timber may become more difficult as increased disturbances skew the forest age structure to younger levels. Lastly, the overall quality of extracted wood is likely to decline since there will be greater impact from disturbances and greater proportion of less desirable species. However, once again, this may offer a new range of opportunities for specific niches in product manufacturing. Additionally, even if there are fewer disturbance events at a given site, accelerated growth rates can lead to lower quality [softwood](#) timber because of decreased mechanical wood properties.

Therefore, adaptations in the forestry sector are needed to keep the industry viable and sustainable during this time of change. Certain adaptations are more applicable in areas over others; thus, [careful planning, and in some cases new policy, is necessary](#). Management adaptations include: [assisted migration into favorable growing areas, fire and pest management to protect mature stands, and improving resilience and adaptive capacity to disturbances by enhancing forest diversity](#). Innovation and research will be necessary to better understand the full scope of their consequences and to improve our understanding of future timber supply.

Continued research is required to properly assess the future impacts of climate change; there is still much uncertainty. To conclude, we propose four areas of future research.

(1)

It is known that boreal forests are shifting northward, yet this may differ regionally depending on climate moisture availability ([Fei et al., 2017](#)). More knowledge of species specific responses is required; the continued study of [provenance](#) trials could provide a wealth of information ([Pukkala, 2017](#)). Further, more definitive rates of decline in southern boreal limits and rates of expansion in northern limits are needed since there exist many conflicting estimates ([Chen et al., 2011](#)). Better understanding this will provide information on the productive forest area available to industry in the future, which has been suggested to be decreasing ([Hanewinkel et al., 2013](#)). Repeatedly measured satellite imagery may likely assist in accurately determining forest migration rates ([Hofgaard et al., 2013](#)).

(2)

Boreal forest wildfires are expected to increase in the future ([Flannigan et al., 2009](#)) but can differ considerably among boreal forest regions ([Girardin et al., 2013](#)). We need to better understand how younger, fire-origin forests feedback into [wildfire](#) regimes ([Boulanger et al., 2017](#)). It is also necessary to improve our understanding of the changing relative importance of different disturbance types under on-going climate change, and its spatial variations ([Hansen et al., 2013](#); [Logan et al., 2003](#)). Our knowledge is also limited concerning the development of future forest diseases; it is unclear what role they will play in conjunction with forest dynamics and other disturbances.

(3)

Efforts have been made to study the impacts of climate change on net forest [biomass](#) accumulation in western Canadian boreal forests ([Chen and Luo, 2015](#); [Chen et al., 2016](#)). However, there has been little research done on this topic in other regions. [As well, there is no clear understanding of how large scale mortality will affect the succession of tree species compositions](#) ([Anderegg et al., 2013](#)). [Compositional shifts of tree species are important to forest industry](#). While observational ([Searle and Chen, 2017](#)) and simulation ([Shuman et al., 2015](#)) studies have shown that climate change induces compositional shifts to early successional tree species in western Canada and Russia, it remains unclear whether this trend is pan-boreal.

(4)

It is important to determine the economic and societal consequences of changes in the boreal forest. [Intensively managed areas, providing economic benefits, may respond differently to climate change than unmanaged forests, prompting continued study](#). As well, previous results based on simulation studies ([Perez-Garcia et al., 2002](#); [Sohnngen et al., 2001](#)) generally differ from the empirical evidence that we have synthesized. There is a need to reconcile this disparity to clearly inform policy makers and forest managers.

### Summary Statements

1. The boreal forest is one of Earth's largest forest biomes, with an area of 1.2 billion hectares; stretching from Russia, across Scandinavia and throughout North America. The boreal forest comprises approximately 30% of the world's most densely forested area, while storing nearly half of the global forest carbon, primarily within soils
2. Evidence revealed that climate change has led to greater biomass loss through tree mortality than growth gain, resulting in less standing biomass.
3. Forest disturbances have increased in recent decades and are anticipated to increase in severity and/or frequency, leading to younger forest age structures and increased dominance of early successional tree species over late-successional species. Tree growth in preexisting forests has increased in areas where water availability has not been affected as the result of warmer temperatures. This has provided longer growing seasons and CO<sub>2</sub> fertilization. However, an extensive increase in tree mortality have followed over the last several decades due to direct heat stress, drought and increased disturbances.
4. Climate change has resulted in a profound impact on global forestry. Higher latitudinal areas are expected to endure the largest increases in temperature and experience varying shifts in precipitation patterns. Understanding climate change impacts on boreal forest dynamics and timber supply is crucial to the continued viability of boreal forest industry.

### Cameron Fox – Interview – Transcript

Unknown 0:10

Testing.

Unknown 0:11

All right, we're rolling. So just to clarify again, you're okay with me recording the call.

Unknown 0:17

Awesome, sweet.

Unknown 0:20

So, at any point in time, if you if you don't want to answer you got to go or whatever, pick up another time, no worries at all. I'll just start off by, you know, introducing myself and kind of my position on the whole thing. I'm in my fourth year of industrial design, as you know, and I'd never tree planted before, I do have a big connection to nature. The way I ended up stumbling upon tree planting is I originally wanted to design something to help sustain trees growth or their mortality rates. And then I quickly realized that that's a pretty hard thing to do. And then I stumbled upon the people who actually plant those trees and realize that you guys have one of the hardest jobs in the world and from there from there, I was like, Oh wow, this is this is crazy and then, you know, as I kept doing research I actually become more and more enticing To the point where I've started to seriously consider actually wanting to do it myself. Which part of me thinks might be enough? And considering the things that you guys go Through but it seems Like a quite an interesting job. So yeah Just start off by some background questions. So just to start it all off. Where did you grow up?

Unknown 1:40

Ottawa

Unknown 1:41

Awesome

Unknown 1:42

and You know, I know this might change Depending on how many seasons you've planted but where have you Planted

Unknown 1:50

In my first season, I planted in Ontario which is Significantly worse, everyone In the tree planting industry will tell you that Ontario sucks . Compared to like out west in BC and Alberta. So okay and my experience definitely tells more to that than that. My first season I had a had like a really really shitty camp that was called like a rookie mill basically. It was like a full rookie camp and it was just a shit show. So, my first season was like that it was probably my most brutal season. Like when I was the youngest, like, when I didn't know was going on, I like by far the hardest season. And for the past three years I've been in scooters camp, so Out West and we plant in like British Columbia for about a month, maybe a little longer. And then we do about two months in that Alberta.

Unknown 2:44

Okay. Cool and is that just based on like, you know you guys finish a block and like a contract And you guys just switch it up contract

Unknown 2:53

So usually we have one contract, maybe two in British Columbia, usually bcts, which is a government in British Columbia Tree Service, I think bcts Okay. That's usually like a really good contract with the government, they pay really well it's like usually **burned land**. So if you If you plant there it's lots of money at the beginning of the season and then we go Well Eastern to Alberta And we have a couple of contracts there like scooter usually holds The same about like using a similar contract. Extra percent of the season. So, we have One company called Miller Western Alberta. We have one with a company called spray lakes sawmills. Those two companies that go really far Vacuum Cleaner so we almost always do that 2000 on production. yeah

Unknown 3:51

Cool. And just because I'm Curious burn Land I'm assuming is control burn Are those dependencies could be like a natural forest fire

Unknown 4:02



lately they have actually been replanting forest fires like so just great big pieces of land that's been burnt up and from my understanding sometimes were replanting it, like blocks that were previously planted like this. This is like a section of land someone has bought and planted in it. So, And they can cut it down in the future. And that burns down to someone who owns that. Their Land burned down then now they need to replace it. Or, it's like Crown land or like unknown like later on, but the government land Yeah, and it's environmental reforest thing like they've burned down so they're sending people back into trying Put some trees back in that area. right but yeah It's naturally burnt, like no one goes in there afterwards. Right, right yeah

Unknown 5:01

cool and I know you kind of I should

Unknown 5:05

I should also mention sorry Sometimes

Unknown 5:09

they're on many blocks within what they'll do and like you're not this is this is not in the in the burn blocks but like a regular cut block, They will push like all the torn down trees there not using like scrap wood, Slash is what they call it. And they will put them in these piles and burn that. Like this is what it's called like the, the torn down trees and they're not using any less scrap was to put them in these piles and like pour gasoline on it and light it. Okay, they will do controlled burns like that and in that you'll have like a you'll see a circle of Burns and you will plant that as well.

Unknown 5:45

Cool. Awesome. And I know you you kind of touched upon it there a little bit but just to clarify how long have you been planting how many seasons

Unknown 5:57

One in Ontario Three out west so four total.

Unknown 5:59

Cool and then, you know what, what, what got you started in in tree planting like You know, especially I guess after that career first season what got you coming back As well

Unknown 6:14

The first thing I was I just flew He's done my first year of University and I was looking for a summer job and one of my friends, older brother, her The brother had done it a couple years since I'm sure Reading and all the folders. Was that hard work? It's good money. And I'm like, okay, sure That sounds good. I like I enjoy hard work. I already knew I like that so and but I didn't do I did absolutely zero research so I actually thought we were gonna go in there and plant like big Christmas Right. Like I really thought, be like you plant like couple a day or something and you've done it. I really expect As we've tossed around, but it really brought me back Like, was like the sheer challenge. Like the down those bring like the The

deeper down Bring the higher ups you know like like how for sure Like depressing rain days like than when you get home and you Like a meal is like the best meal. You We're having the entire life like it's like yeah, it's so There's, you're never bored There's your net like there's never like a moment of your day. We're here. If you don't get a nine to five or something, Please spend most of them Yeah pre planning. You're either in pain or really happy. You know, like it's like, you don't have a chance to get bored right? Ideas display and the people and people Some people come back from just like the camp life people just love being out. It means like there's a million reasons to come back and For me, I even really like Like the bad reasons, I really like the pain and the suffering and like the, it's like, I like that. It really brings up so much better and

Unknown 7:50

Yeah, no i i can definitely I can definitely relate to that or I can have I have that understanding As well there's been many points I think it's it has almost I I always find it accompanies nature I have a lot of the summer did a poor cause trip and a very similar things like you have some very rough nights like rain you know paddling for hours trying to find a site but then like you said it just it I

Unknown 8:21

feel like it

Unknown 8:23

I don't know it's it's it's experiencing life you know, it's it's better than the office chair sitting and losing your mind that way but cool. Awesome. So then this question, this one might be a little bit of a weird one, but what do your friends and family Think about your job as a tree planter? Like what do they think when you ship off every summer? Or you tell them about these stories?

Unknown 8:48

My my family I think is

Unknown 8:52

very supportive as they like they really don't know how much I love and everything but I think they'd rather have me home. rather see me more often. I guess I'm gone for like Three, four months, right? So it's like I think that but I don't know my my whole family is like, like really excited to hear about it and everything like hearing the stories and everything. So they usually I do generally well supported, just like Yeah, everyone likes it. Awesome. Yeah.

Unknown 9:22

Cool. Um, yes, uh, you know, I know you're saying the first season was dead. Definitely a surprise but scooter was saying his email that you're one of the top planters with And do you go into each planting season with any goals? Like, do you, you know, it's like oh, I'm gonna try and get this many You know, trees planted this season or is it more just kind of day by day thing or

Unknown 9:44

um well I guess my My progression was like in my first season I did very well to repeat, and then my second Season heiligen all right season it was already finished. just lost motivation because I want to be the best anymore because I was like Big small fish in a big pond at that point, right? It wasn't it wasn't just rookie So I'm surrounded with people who actually planted a lot before. Felt like we've got to just spend a minute motivation and third season motivation I like the golden rule of tree planning, I guess is what what makes you plant the most and have the best time and that is not you have to go into tree planting with your goal being the effort itself. Like you If you made your this is a real lesson you can you can teach yourself about, about happiness as well but year it has to come. You can't be basing your happiness off the trees you plants every day I think the number or the money you make every day Good, both of them Things are out of your control right? Like because like some sometimes you have just Get fucked around all day. And you can't plant like you're just in Trump for too long and then the movie From the blockages and you just don't get you don't hit your goal that If you sent her a three goal, it's not a good idea. control the money supply Just getting paid very little percentage for for some land You just don't make any money that day. But one thing you can always Always take control of your effort. And if your effort is the reward like you'll never go home upset as long as you put in, you have to try your absolute hardest, every day. And then you can always be happy with the result if you know that you put in your best and like that, like really carries on to life as well like right You have to realize your inherent worth, you know if you base your worth off of being good at sports or academics or business something could happen, right? Like you could break a leg. Now you can't. anymore your worth plummets, you know, or someone you basically worse off is this beautiful woman that you're dating and she leaves you and now your worth plummets at your solar responses like, there's this. There's lots of lessons to be learned from the tree planning itself, but that's just one of them. So my goal is always to try my absolute hardest My third season I did and and was was number one with me In my main my friend partner playing together we both came in number one. And then last season. I wanted to again I wanted to plant at least as much light as the season before I guess but I was like, once again, my main goal was to try as hard as they could and I surpassed By my last season why 20

Unknown 12:24

Damn. Wow, that's awesome. That's a That's an incredible insight that takes a lot of people a long time to come to have that mindset. That's awesome. Cool. And so you know getting to these coming from Ottawa. How do you get to your tree planting season or get to camp is it I mean, if you're going to be See, I would assume by plane, bus car and kind of

Unknown 12:56

the past two seasons, sorry, in my second and third season I flew out there. I just I just fly to the airport. And then my foreman or crew boss, or the guy in charge of me, I guess the guy in charge of my crew. Yeah, so like a good friend of mine. He, he usually picks up a load of people at the airport. Because almost every like, it's actually kind of funny, like, on the flight to Prince George. Let's see where we usually fly in is with about 50% tree planters. Oh, wow. Probably more probably more than 50% actually. And they're all and most like a portion of them are probably in your company because you're flying in at the same time. Right? And it's like you already meet people in the airport. It's pretty funny and we get picked up in a low they bring into campus setup and everything. So last season, I drove out there actually rented a car. Oh, wow, with some friends.

Unknown 13:51

That was an awesome.

Unknown 13:53

They want to do like the flight and sweeper kind of recommended as well. And we had time so we drove out who's nice?

Unknown 14:01

Yeah, that must have been awesome.

Unknown 14:03

Yeah, it was pretty cool.

Unknown 14:06

Just like stopping at like gas stations and stuff. Set up pretend to the parking lot.

Unknown 14:12

You know, like,

Unknown 14:13

yeah, that's the key. They let you stay for free. Yeah. And yeah. Cool. Awesome. So then what do you do when the chief planning season's over? I know you're saying you were in school in your first season so I'm not sure.

Unknown 14:30

My mental math. Okay, awesome.

Unknown 14:33

I just graduated from University of Guelph with a mechanical engineering mechanical engineering degree. Cool. And also partially I think why scooter put me in contact with you because my capstone engineering project was tree planning related. Oh there Yeah, we manage devices to try and help mitigating injuries and tree planting injuries. And so that's one but now that I've been in school I haven't been counseled with a real plan with COVID Yeah, I'm just looking for a job Mike have a weapon we're gonna see Oh, I guess that might be how I spend this. This winter.

Unknown 15:11

Awesome. Nice Yeah, that's that's really cool insights for the for engineer. I got a got a few buddies that go to University of Guelph as well.

Unknown 15:22

I'm not sure.

Unknown 15:23

I said I'm at Humber College. Um, I mean, Ontario as well. But yeah, so that's That's cool. Nice. So next question. You're just going to be a little bit more geared towards you. Your gear and equipment and We'll go from there. So, I've watched a ton of videos and the CI planning community does a really good job of kind of, you know, providing these insights. You guys are just very overall Just great people from from my interaction so far, which is which is awesome. But so I've watched a few videos And I think I know how you guys received the saplings. Although I'll tell you what i what i think and let me know if there's anything that changes. So I believe you guys get them in those boxes. I see that standard white box. In most videos. I don't I don't know how many treats usually provided in that but then I know they think they're in bundles. I believe With a kind of plastic wrap around the bottom, and then from there you unwrap Put them and put them in your bags.

Unknown 16:26

Yep Free con. So yeah They come in boxes from the nursery. They come in like a reefer or a refrigerated box thing, right? They come in there and we we take them out and put them in our insulated truck like that. We This huge boxes of the backward like, standard like we use the F 350s. Okay in our in our camp They come with a huge box as well with a built in a complete and put them on them in there for the day. The trees in the box are anywhere from anywhere. I don't know Actually anywhere. Can you name a number of this one They're 90 I think there's a loss of see 90 trees in a ball. Oh, wow. Okay.  
1200

Unknown 17:12

Wow, okay, yeah, really big range.

Unknown 17:15

Little lowest and highest but, but generally we planted almost 274 Almost the entire season this season just 270 trees of us Which is pretty low, but I think the industry is good From what I hear the industry is moving more and more Towards the end And there's like plugs Like there's there's names for Besides the plug in everything like I've formatted we've got all screwed up together talking about LED on very interesting I guess. But like there's the besides played six inch or something to kind of diameter and this kind of fertilizer so it goes into a tree. remedies becoming generally bundles of 15

Unknown 18:02

sometimes bundles of 20 sometimes bundles are like 10

Unknown 18:07

but I've been Generally the 272 73 is a box 15 per bundle.

Unknown 18:14

Right? Yeah. Cool.

Unknown 18:17

Yeah. And sir just so from my understanding the plug is that is that the bottom part like with the soil and the roots is that?



Unknown 18:23

Yeah. Okay, cool. Yeah.

Unknown 18:27

This one's the With this quote next question is a little bit bigger general. What is the I mean there might be multiple things. I don't know if you can say there's one but was the hardest thing about tree planting in your opinion

Unknown 18:42

Water, water interesting. Okay,

Unknown 18:45

I would say They my I have an RA The idea that like in nature and water in It's both your worst enemy and your best friend. You know, like Right like you need water Live but you still want at any time. Right right But I find it The rainy day is the cold, rainy days. are usually the hardest I think I think everyone I think most of them agree with the hardest days or when it like just sit down for that it's like freezing out like it's like on a like rain and then like actually snow and then rain again. Like oh my god those days can really like can really really be tough like you can't feel your hands and it just like adds to the to what you're already doing Elder Law Get through a breeze you're sliding around like a monitor. And then you get home and your stuff in the left you got to find a way Try it, but you work the next day and like We're in 25 Perception instances with coolant water in your tank in there, and now you're sleeping in water like it's just like There is A lot of bad things come from water from rain, right rain and water. Just like leaks in your tent. And now if your sleeping bag or something like now you're sleeping in that like,

Unknown 20:09

wow,

Unknown 20:10

yeah, it's not just yeah, it's not just the rainfall. It's everything also comes after.

Unknown 20:15

Yeah. Like there's ways to prevent having a wet, wet look, you can be proactive but a certain extent, if you're gonna get unlucky and you're gonna get screwed. Rain, it's gonna rain. Let's say it's the water rain. Interesting.

Unknown 20:33

Okay, cool.

Unknown 20:36

So again, from what I've seen, see videos, I've seen a lot of people kind of making changes and edits to their equipment, Have you made any changes to your equipment and added anything on and if so, why?

Unknown 20:52

I have the one thing I guess is the thing I designed which is kind of a for mine for engineering. It's really like a shock absorber for the shovel, okay, to try and reduce some of the shock and the tendons. So I haven't had a chance to make we have many prototypes in my group, but it's heartening to me to like find a middle there leave there like we need we need like we I wish I could work in right like access to and we've cultivated like, I don't know, like people I've been kind of that's like a thing. But with that with my show, we'll do exclusive tests. But in general, I keep everything pretty soft. Like my shovel. Every everyone should have their shovel to the length that they work best that no one should have a falling shovel. I don't like I'm six foot four. And I still cut it down to I cut it down pretty far. And I see some people using yourself as too long for sure. For sure. Other than that, I think the standard three baggers, we have two big bags, two big buckets on each machine, one bucket inside of your head. And then like a bag of your belongings on your back. Right. Those are the ideal bag. Heads. People will say that the four baggers are good or putting another bag in your bag. But another bucket on your back is better because you can fit more trees. But I'm totally like three baggers, all the way right. Like the original bags are the most standard bags. And the best way to do is for beggars. They get it they cover over top of your sides of it. So every time you raise your thigh you're pushing you're like lifting the weight of all the trees. Just slow and silly

Unknown 22:45

tasting

Unknown 22:45

unfamiliar, maybe if you're planting on the coast with like six species and you got to separate them into different piles, then maybe four baggers, but when and also when people people will change out their back. The back bag for like personal belongings like very small, I think really small. People change that out for a full size bucket and put like loaded floating with trees. But it's actually really bad for your back to have

Unknown 23:13

weights round and on your back. They're

Unknown 23:17

beautiful. A guy coming every year at Stanford and talk to us about something that's one thing he says don't put stuff in your backpack and people do it anyways, they get back in threes and I say I fucking told you. Right. Right. So saner bags has a shovel

Unknown 23:39

other like equipment. Yeah.

Unknown 23:40

That's That's perfect. So that's actually that's my next question. I was gonna say Do you have any outside equipment that you that is not necessarily standard such as gloves, gators, tape, braces.

Unknown 23:52

Boots.

Unknown 23:56

I the boots. The boots are a big question. I think

Unknown 24:01

there's a book also. I don't know.

Unknown 24:02

Yeah, that's it. That's how I ended up reaching out. I rifled through that it was it was perfect. It really encompass really everything I was I was had questions about so yeah

Unknown 24:16

I remember in the book he said okay

Unknown 24:21

no answer. I think There's no answer to what to what works. A lot of people will use Walmart rain boots like just fucking \$10 15 hour. Walmart rain boots for like the whole Season would be fine. I would really hire juniors and like me support I use zamberlan by on to lenders out there like it. They keep Like a gore tex hiker, okay? They're pretty expensive. But they're I find them to be the best. I've lost a lot of people and can't use them. Neverland boots Some people use shitty, like steel toed boots. Some stuff like I think the options for boots are Neverland like something like a Very expensive, good waterproof hiker, sturdy hiker. You can use warmer rain boots they work for you or you can use There are Viking corporate boots. There's these like kind of like these heavy duty rubber bits that are cork in the bottom Without corks And they are That's another option. What I see is from I don't know. But there's gloves. There's a couple options. I think I think theater recommend gloves or we're not using them. Okay. Some people will keep their fingers but I think scooters again as well I think in his years he's realized that gloves are superior to keep custody your hands. Perfect with that you could lose a couple days around And then usually tights and shorts Like you wear your shorts you'd like the smoking cut up. That's pretty common. And then a like white dress shirt as like your shirt to keep the sun off of you and also not like until EQ, right, which is also pretty engaging like I use like a sailing shirt this year which is really nice that they're so cool and then a beat so definitely, definitely essential keeping much cooler right

Unknown 26:35

Cool and and any like, do you have you? experimented? I know you're saying for your your capstone project there you have the attachment for the shovel for the tendinitis and all that. I see seeing some stuff with people playing around with, you know, sports tape like t with a T k t tape t I can't remember what it's called. But yeah, I used to Yeah, I used to use it personally playing some sports but I don't know. It's I don't know if you've ever tried that or if you find that any beneficial at all

Unknown 27:08

Which is a huge thing and I can't wait. I mean dimension As well as the big thing in our campus we have a big game guy. comes in with a company called modal video and they will actually work Tree planters directly, like they know about. They know the injuries associated with tree planting and they have a tape job for just about anything. Oh wow anyone is tendinitis And isn't ticked off for that. It's very simple. It's just like keeping your thumb in place you don't see too As your risk, right you keep your risk in a neutral position. So kind of just keep that in It makes you makes you mindful of keeping your is morally good. Training tape. You know you want to get your techniques and you don't want to Having all the time okay. Learn Learn, learn your technique, and then stick with it. So, there's like a person on every crew who knows paint jobs and they'll, they'll take care of like every injury. Like, yeah, there's like to go for your knees and everything goes Yeah, most of our crew is like heavily taped up, right? Interesting. Tape everywhere.

Unknown 28:16

Right cool. Definitely. Yeah, I might I might see if I can reach out to the physio group that sounds pretty, pretty interesting. Yeah cool

Unknown 28:26

to do so in total physical

Unknown 28:29

awesome. um the the next two questions here kind of along the same lines I'm assuming Want to the answers would be your own solution to your capstone project but is there anything that would ease the process of tree planting or making The tree planting experience better

Unknown 28:52

Good rain. year being prepared for Rain So like like a Good wool sweater or like merino wool base layer right good rain jacket for those cold days and good like a good sleeping like the sleeping bag and sleeping like a good Hello like just the sleeping quarters and having good tension, everything it makes makes a significant difference, right to make it easy Hear us I guess. You just have the mentality is really good Biggest thing though is that right to come in and you No, especially as a rookie like you're not going to be you're going to be really Really bad compared to anyone who's playing to before. Right like even the worst side You will be way, way, way better than Mike This would be

Unknown 29:42

interesting. So experience

Unknown 29:46

Right right It's really big news. You difference. It's like a big learning curve.

Unknown 29:52

Right, cool um would you Say just as you know you touch upon how important the reindeer is like How does how does that work? I know you have the you know that smaller bag in the back for personal belongings and I'm assuming, you know you get to the block in a vehicle of some sort like how do you get your check in the weather and then you bring what you need or you bring each that that rain gear and that stuff every day just in case like how do you Where do the layers go? You know, when you're taking that off as the day gets hotter

Unknown 30:23

Yeah, so usually, for everyone has their own way of doing things. Huge bags of block. I try and keep it a little lighter because it's really annoying packing around Addis Ababa chickens. Sometimes we have to walk it in there and because hired more waste have just like a backpack for standard like it's my Old School backpack round just on my Ranger. I've been in there and it'll have way At least one layer or two layers of things to put on it. He starts raining okay? But if it's especially rainy in the morning, and I could just tell It's gonna be a cold one that I'll bring like, maybe Make yourself

Unknown 31:04

and then I'll just I will do my bags.

Unknown 31:06

And then so that bag You're not carrying that around with you while you're planting Are you are See that stain that stays in the truck.

Unknown 31:13

I'll drop it off at my cash. So like my there Like there's a cache of a bunch of boxes that you're Your formal setup okay? And then I just think That's kind of like your

Unknown 31:26

base camp for the block. Canada

Unknown 31:28

yeah cool Ready to use, he'll probably set up to do whatever Dependent it'll set up a whole bunch of them along for different peoples and has to be sharing it with two three people. You'll be sharing a cache with, like half the crew and you can have your cash alone. It's just he's just driving blocks off for you and you're filling your own little bubble of trees. But yeah, you drop off your bag. There's your lunches there, and all your stuff is there. And so when you go back to refill For trees when you put more trees in your bag, that's when you quickly eat something and then if you need to refactor something, put it all in there.

Unknown 32:03

Cool.

Unknown 32:05

Sweet. So then these these next little set here, it's gonna be a little bit more job related questions. Training

Unknown 32:13

based

Unknown 32:13

so you know before you arrive to your to your tree planting season Do you do any physical training like get yourself ready? I know sometimes a reading in scooters book like you should try and kind of come prepared or you know, make sure that you're ready to go or do you just kind of the first week is going to be a ground, your body Go through it and then go get used to it kind of thing.

Unknown 32:38

I kind of take that approach My first weekend when I do like, I mean just want to stay in shape in the offseason just just because I Want to say like, I like doing active thing, so I definitely don't come in that That in that bad shape, it is really hard to come Like planting seeds because you know it's a very specific yes yeah A bunch of muscle groups right so There is like a thing on the internet. With one of the planking companies made a fist to plant called fit the plan is the workout routine. Oh cool. You can start like 30 date before, something like that and think You know you're in supposedly safe This season, my goal is to actually go for plants. The coast before the real interior season happens. Okay? coastal planting is just worse and rainy and cold and sucks, but you get less money for it. And it's harder. Wow. Some people do it right I'm going to try that if it's basically the whole, we can restart from the beginning and talk about postal now. It's almost also something. Oh, wow, that's really interesting. I'm gonna do that before the season so that I can shape for the right for the real season, right. And then but also to make a bit more extra More money. So

Unknown 34:03

right add on cool. Um, so then how did you learn how to tree plant I know you're saying you were with a different company that first season is it do rookies kind of get a the first day some some training or is it just you know, put your shovel in the ground and just go for it or

Unknown 34:25

in my experience came to do a really good job. I think they have like a rookie school. I think it's like three, two I know I want to go through anymore, but I can't. My first season they actually just pulled me out there. They showed us all the gumball The crowns are like my crew boss. He planted one tree and we took a couple steps and planted another Dreams a bad thing you do it and then just let it Wow while we've completely fucked up we have been so bad So long.

Unknown 34:58



Wow, that must

Unknown 35:01

be hard but

Unknown 35:02

re interesting has made the experience a little bit harder than it had to be.

Unknown 35:10

Right? I could imagine

Unknown 35:12

course and now now that you you know, you've had these years under your belt you have, you know, a tree planting technique again, I've seen some videos have kind of like you know, this arc movement that you kind of do with your shovel. I don't know if I mean is that the standard technique Have you formed kind of your own little touches up on it to that you find most beneficial.

Unknown 35:39

Like, like, just like

Unknown 35:44

it's really just comes so naturally I guess to the point where you Been actually really complimented with having like a really smooth shuttle throw from what people tell me. Okay? I've heard that like my throat is very, very smooth and lightly direct and precise. Like you get very good at Spring. throwing yourself exactly where you want to put it. People usually exactly didn't get Better and better a great but as for technique to This

Unknown 36:21

unconscious thing

Unknown 36:24

becomes almost like an extension of your arm just kind of muscle memory. Cool.

Unknown 36:29

Yeah.

Unknown 36:31

The throat but there's also like there's many other techniques on how You manage your land like how are you going to fill up this land efficiently and how like there's How do you get around this obstacle efficiently? You're going to climb over you can plant around it are you gonna go? Like are you gonna go up to Taylor you get plants can we take plants up and down the hill now you're Aren't you running up and down a hill right? They come to the right energy to get a plane to the top of the hill and work your way down.

Unknown 37:01

And then there's like, there's just like

Unknown 37:04

Different things for each situation like situations that you'll be faced with. You get better and better at dealing with One interest, one, the one thing I guess would be just never, ever Like the biggest technique thing I get our biggest strategy and planning is don't take every second counts like every, even though it doesn't seem like it would. If you added up the math on the second they wouldn't you wouldn't Even as much time but you have to have the mentality that like every second that you're out there, like every day you're wasting. You've had this like insurgency, right has to be every second is your planting, planting, planting you when you're the cash you're eating while Your victories your bags, and then you don't you don't sit down for a second. There's no right. You don't take a break or anything that's freaky get is when you're putting the trees in your bag but you're also eating and drinking as much water as you can and then you're like running back out there,

Unknown 38:00

right like it's like that like athlete mentality, your mid game you're in it. You're like you're getting the objective done. Cool. That's actually the answer one of my later questions, which was going to be about lunch. I've heard that that you don't want Show. You don't want to rest which which I can relate to, I mean, again to compare to tree planting is Probably disgraceful but I had a landscaping job. I had a changing jobs on a golf course. And similar to similar sort of deal. I remember he took off your Your steel toes like at lunch. He was just brutal like getting back On and getting back into it's just not not a good yeah anyways cool

Unknown 38:46

What I mean you make way more money Ready like the thing with key planning is you're already self motivated. Because you're getting paid by the tree right right. Getting more, more for

Unknown 38:57

profit Probably one of the most unique things about it That which, which, like you said, can motivate you and also if Like you were talking about that mindset of just in maximum effort instead of cost like that it can eat could either it can either propel you you know motivate you or trip shattered I would imagine. Yeah, depending On the day cool And okay, so this next Question. I have it in here. I don't really know if It's even a good question but like what is it typical They have tree planting I'm assuming every day is quite Different but if there is Some sort of standard or kind of, you know routine

Unknown 39:38

Yeah, I guess the standard one would be

Unknown 39:42

it was a little different this season was COVID made a little bit but manner, the way Now

Unknown 39:48

we need a quarter to

Unknown 39:53

ship Alternatively but I think we would leave it quarter to seven 645 Okay, wake up. Wake up round corners. Think Cuz like sometimes I wake up. Yeah, usually we get caught Six an hour earlier because I like to I really take a long time eating in the morning right? Do I need to put a lot of food in me and I'm really not hungry. Possibly buying some tired one I'd like a long time to eat. Some people will wake up Like right before the bell and just fucking jump in the truck pretty early comparatively. I sit down you As much oatmeal as I possibly can for breakfast A wheel is like super energy until he's all you as much like And then I'll go and I'll make my lunch in the tent. Sometimes we'll do that first and then I pack up for the day and then I feel like water if I usually I tried to build before though to save some time. Okay well my water jugs and everything and then I grab all my stuff. The same goes boots, bags, shovel water and lunch. Five things you got to remember. Everything else is whatever, you know, right? So those are the five things you need to get through the day. The thing that you put in the trunk, you leave at a corner some sharp like my foreman. is very strict on on time range. I think it's very fair. I agree like may 645 not a minute later after we leave At that time, and every everyone has a responsibility to be there. We give him when we drive anywhere. from five minutes in the block to like two hours, two and a half Ours wow he Get 45 minutes maybe. Okay, we're 30 minutes, maybe an hour, somewhere in that range. Free advocacy drive You get there like it's like half an hour or 45 minutes and it's now it's 830

Transcribed by <https://otter.ai>

Appendix – B      User Research

**User Demographics**

Targeted demographic criteria for which general characteristics and information was obtained included age, gender, ethnicity, income, and education.

Image search for General Demographic Characteristics


A Google Image Search was performed to understand what typical Tree Planter looks like. The



following search terms were used:

- “Tree Planter”
- “Tree Planting Crew”
- “Reforestation Industry”
- “Silviculture”

**Findings.**

Findings have been collected in a Table.

IMAGE	DEMOGRAPHIC INFORMATION
 <p><i>Figure 1 - Forsyth, L. (Photographer). (2018). For Cash and Pride, Replanting Canada’s Forests by The Millions. [Photograph]. Retrieved From <a href="https://www.nationalgeographic.com/news/2018/06/reforesting-canada-forests-youth-photography/">https://www.nationalgeographic.com/news/2018/06/reforesting-canada-forests-youth-photography/</a></i></p>	<p>Age: 25-35</p> <p>Gender: mixed, predominantly male</p> <p>Culture: White</p> <p>Income: uncertain</p> <p>Educational background: Uncertain (Mixed)</p>

	<p>Age: 25-35</p> <p>Gender: Mixed</p> <p>Culture: White</p> <p>Income: uncertain</p> <p>Educational background: Uncertain (Mixed)</p>
<p><b>Figure 2 - Forsyth, L. (Photographer). (2018). For Cash and Pride, Replanting Canada’s Forests by The Millions. [Photograph]. Retrieved From <a href="https://www.nationalgeographic.com/news/2018/06/reforesting-canada-forests-youth-photography/">https://www.nationalgeographic.com/news/2018/06/reforesting-canada-forests-youth-photography/</a></b></p>	
	<p>Age: 23-25</p> <p>Gender: Male</p> <p>Culture: Dakar, Senegal, West Africa</p> <p>Income: uncertain</p> <p>Educational background: University, Electrical Engineering</p>
<p><b>Figure 3 - Leistner, R. (Photographer). (2018). Tree planting is a rite of passage for young Canadians. [Photograph]. Retrieved From <a href="https://www.nationalgeographic.com/culture/2019/04/tree-planting-rite-of-passage-young-canadians/">https://www.nationalgeographic.com/culture/2019/04/tree-planting-rite-of-passage-young-canadians/</a></b></p>	

Literature Search for Demographic Data

A literature search was also performed on the Humber Library website and Google to find statistical data relevant to Tree Planters. The following search terms were used:

- “Tree Planter Demographics”
- “Tree Planters Data”
- “Tree Planters Income”
- “Environment Statistics Canada”
- “Natural Resource Canada (NRCAN)”

## Findings.

Findings have been summarized below according to the relevant categories: Gender, Ethnicity, Industry Sector, and Income.

**Gender.** As inferred from the user demographic search above, the majority of the Tree Planter industry is male. This seems to be the norm over that past decade and a half although a steady increase in female works can be seen since 2000. This is noticeable different in terms of agriculture, natural resources, and conservation graduates across Canada. Within this sector of the industry women have gradually surpassed males. This telegraphs an increase in female forestry employment within the coming years.

### Women in forestry

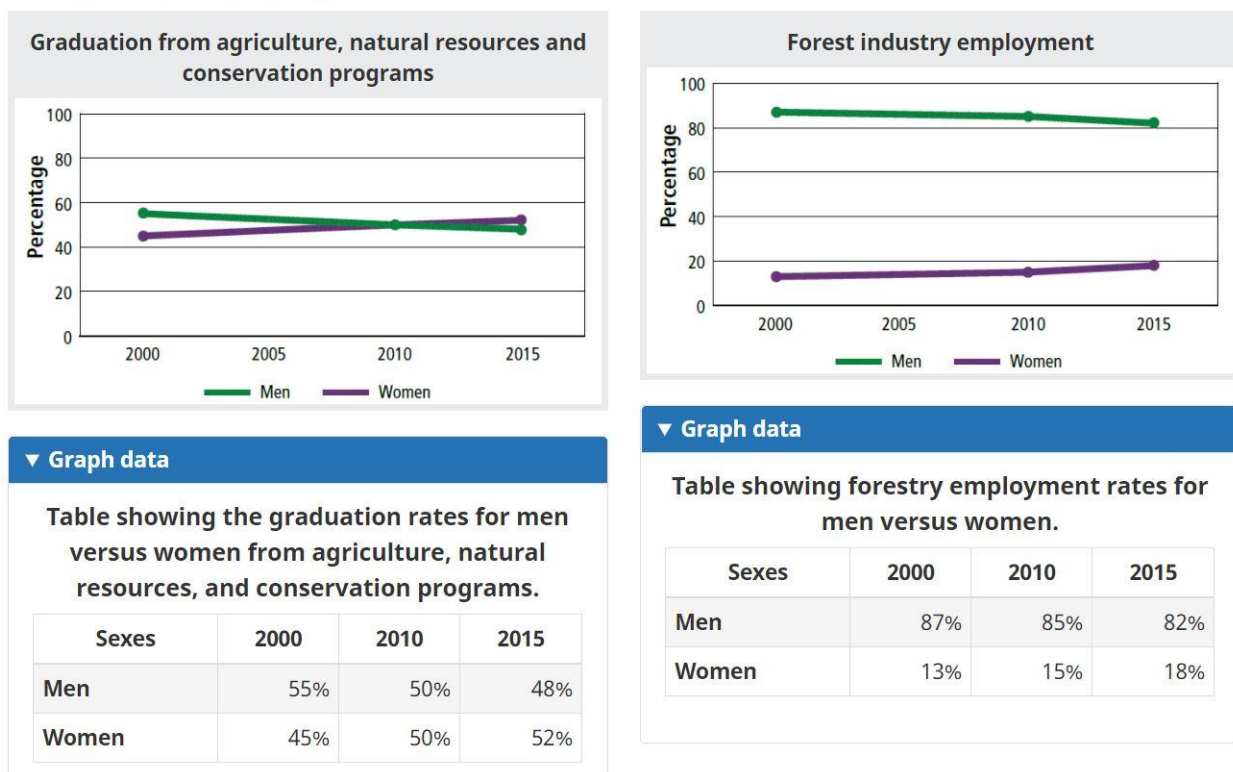


Figure 1 – Women in forestry. [Image]. (2020). Retrieved from <https://www.nrcan.gc.ca/our-natural-resources/forests-forestry/state-canadas-forests-report/infographics/20031>



**Ethnicity.** Again, as seen with the images the predominant ethnicity among Tree Planters is shown in demographics as being White (Caucasian). Although, as shown in the following info graphic about 18% of Tree

Planters are Indigenous, and about 9% of Planters are immigrants. This is also showcased in Figure 3, where an international engineering student is shown Planting for a season.

## Canada's forests are important to the economy

The forest industry directly employed



Figure 2 – Canada's forests are important to the economy. [Image]. (2020). Retrieved from <https://www.nrcan.gc.ca/our-natural-resources/forests-forestry/state-canadas-forests-report/infographics/20031>

**Industry Sectors.** The Canadian Forest Product industry encompasses a multitude of different jobs. Canadians can find employment opportunities in an array of different sectors such as; woodlands, Skilled Trades, Sciences and Engineering, Mill Operations, and Administration.

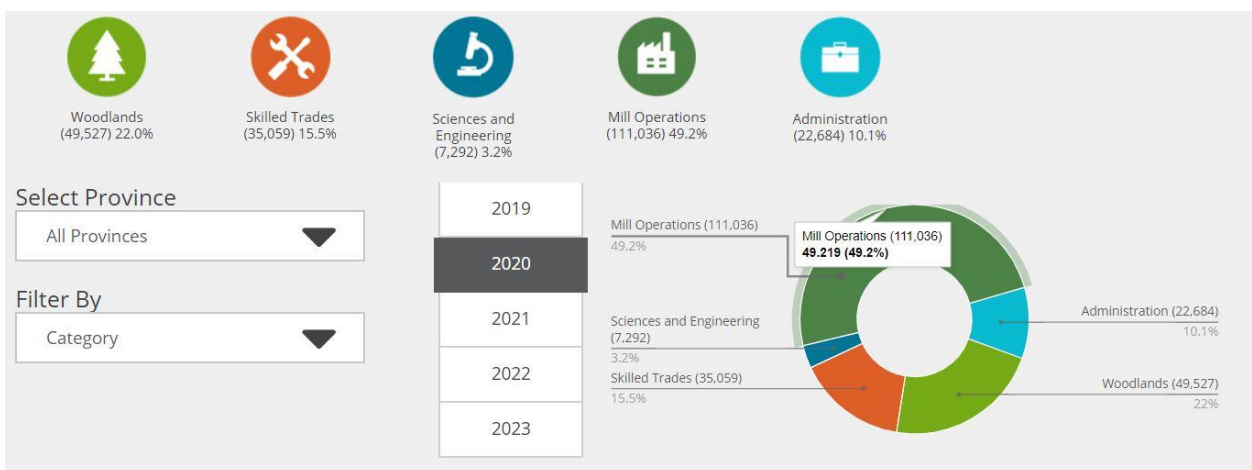


Figure 3 - Total Jobs and Job openings in Canada's Forest Product Industry. [Image]. (2020). Retrieved from <https://thegreenestworkforce.ca/jobs/index.php/en/labour-market-information/forecast/>

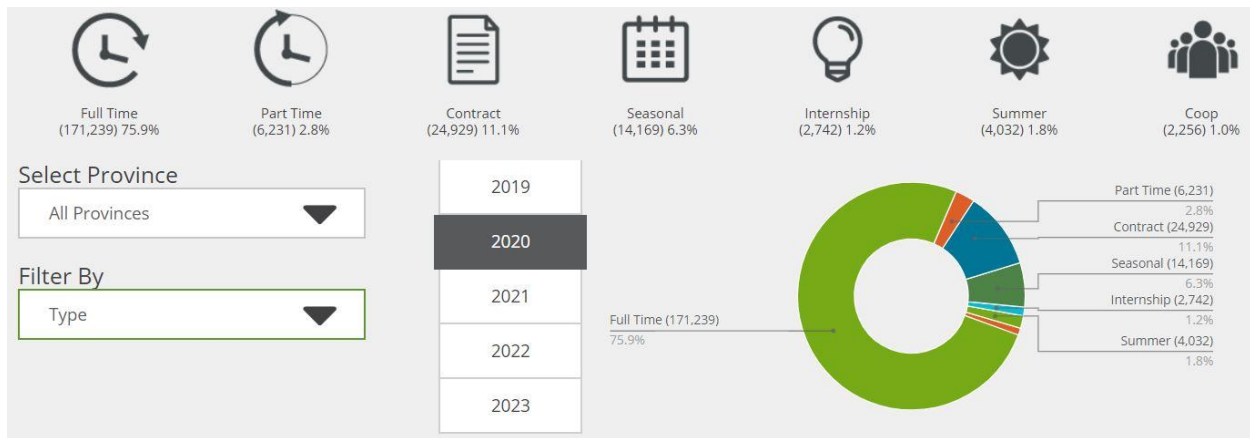


Figure 4- Total Jobs and Job openings in Canada's Forest Product Industry. [Image]. (2020). Retrieved from <https://thegreenestworkforce.ca/jobs/index.php/en/labour-market-information/forecast/>

**Income.** Tree Planters salaries are difficult to quantify due to the nature of the business. Tree planters get paid per tree planted which creates several different variables that can affect their daily income. The first variable that needs to be considered is how much one sapling is worth on that planting block the worker is planting on. Although the base level price for planting a sapling in Northern Canada is \$0.11. The other variable to consider is how many trees the Planter plants in one day. This variable depends upon the experience and skill level of the planter. Once Planters gain some experience, they often average about 1,900 - 2,000 trees per day. Therefore, assuming they are capable of maintaining this quantity they will earn about \$216 a day.

### Tree Planter Salaries

10 Salaries Updated Sep 9, 2020

Average Base Pay

CA\$27 / hr



#### How much does a Tree Planter make?

The national average salary for a Tree Planter is \$27 in Canada. Filter by location to see Tree Planter salaries in your area. Salary estimates are based on 10 salaries submitted anonymously to Glassdoor by Tree Planter employees. Less

Figure 8 - Tree planter salaries Canada. [Image]. (2020). Retrieved from [https://www.glassdoor.ca/Salaries/tree-planter-salary-SRCH\\_K00,12.htm](https://www.glassdoor.ca/Salaries/tree-planter-salary-SRCH_K00,12.htm)

### Discussion / Conclusions

With the images above a general overview of who is working as a Tree Planter and what they look like. These images showcase that the typical Tree Planter appear to be between the ages of approximately 21 to 35. It is also evident that the majority of Tree Planters (about 73%) are a Caucasian ethnicity. Based on the typical method of pay the income is a difficult to conclude as there are too many variables that change depending upon the Planter themselves. With the statistical data collected, it is evident that the images portray a reasonable representation of the “average” Tree Planter.

#### Demographics of Tree Planter

Age	21 - 35
Gender	Mostly Male (82%)
Ethnicity	White
Seasonal Income	\$18k - \$35k

*Figure 5 - Based on data retrieved from <https://datausa.io/profile/soc/firefighters> and from <https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/Emergency-responders/osfdprofile.pdf>*

Overall, most Tree Planters seem to be 25-28-year-old male of Caucasian ethnicity earning around \$18k to \$35K during a 4 month period.

Primary User	Tree Planter
Secondary User	Crew Boss/Foreman
Tertiary User	Silviculture Company

## User Behaviour

A literature search was performed to uncover a Tree Planter's traits relating to user behavior. For this search Google and the Humber Library website were used to extract relevant information. The following search terms were used:

- “Tree Planting Forums”
- “Tree Planting Community”
- “Tree Planters Camp Life”
- “Environment Statistics Canada”
- “Tree Planter Statistics”

### Findings.

Discoveries have been summarized below corresponding to the relevant categories: Activity Frequency; Group or Solitary; Motivation and lifestyle; Income Level & Purchasing Power; Location; Personality and cognitive aspects.

### Activity Frequency.

Tree planting requires an extremely high frequency and activity rate. This is the explanation for the high injury rates that accompany the industry of Tree Planting. The seasonality of Tree Planting forces a very intensive planting situation. This paired with the per tree planted payment method, Planters push themselves to plant as many trees as physically possible within an 8-hour period. This is then repeated 5 days straight with a break on weekends continuously, over a 4-month period.

Social.



Figure 6 - The inner world of tree planting. [Image]. (2020). Retrieved from <https://charlatan.ca/2020/03/the-inner-world-of-tree-planting/>

Due to the remote norther location of Tree Planting and the intense mental and physical demand that accompanies it, the social dynamic of tree planting becomes a crucial part of the job. Planting camps are often so north that planters do not have contact with the outside world. This leaving their only social contact to be with one another. This often fosters a very communal, almost family like environment and is one of the most valued parts of being a planter. With the natural isolation and labor that accompanies each workday, Planters downtime is valued and often very social. A positive outlook and a positive crew is stressed in order to last the season.

## Lifestyle & Personality.

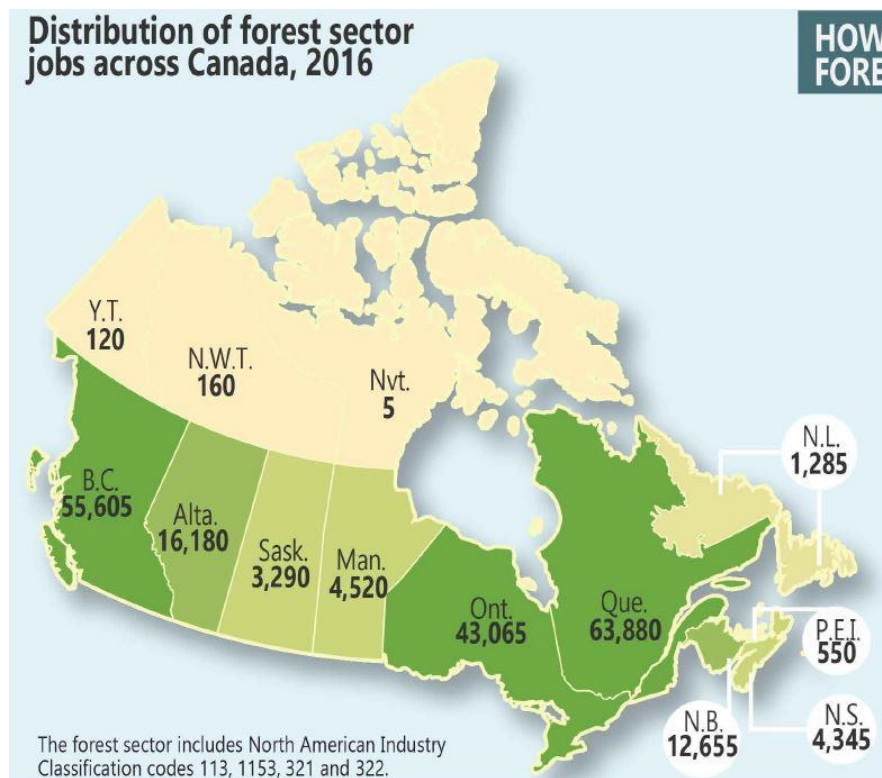
Tree Planters are extremely active people; they spend a lot of time outdoors hiking and exploring their natural environment. An appreciation for nature and the outdoors is required to withstand the long days in the open harsh woodlands of Canada. Planters are known to not conform to the typical fulltime employment lifestyle, as they like to experience life and what nature has to offer. Tree Planters are often positive and determined people as a big part of Planting is the mental resilience one must have to push themselves physically to keep planting.

## Income Level.

Since many Planters work seasonally it is challenging to determine an income level for them. Planters often use their summers to accumulate money, allowing them to travel or live their ideal lifestyle. Although depending upon the Tree Planter, some tend to travel to other parts of the world to maintain a steady Tree Planting income during the off season in Canada.

## Location.

The Majority of Tree Planting in Canada takes place in the northern parts of, British Columbia, Ontario, and Quebec. This typically dependent on Canada's woodlands and the Lumber industry. In turn the silviculture industry obtains contacts based upon the cleared woodland areas. These remote locations add another challenging aspect to the job, placing more physical and mental strain on Tree Planters. *Figure 7 - An Overview of*



Canada's Forest Sector. [Image]. (2020). Retrieved from <https://www150.statcan.gc.ca/n1/pub/16-201-x/2018001/info/fig/fig02-eng.htm>



## User Profile Summary

User	Description
Primary	Tree Planters
Secondary	Tree Planting Crews
Tertiary	Silviculture Company

### Primary User Profile

Demographics		User Behaviour		Personality		Cognitive Aspects	
Age	20-35	Frequency of Use	Every day 4-month period	Locus of Control	↓	Technical Skill	↑
Gender	Predominantly Male (~81%)	Duration	Varies (8 hrs)	Self-Efficacy	↑	Pre-Requisite Knowledge	↓
Ethnicity	Caucasian (+73%)	Social	Highly Social	Changeability	↑		
Income	Low to Middle Class (\$18,000 to \$35,000)	Level of Focus	Medium - High	Uncertainty Avoidance	↓		
Education	High School Diploma	Location	Rural – Woodlands				

### Conclusions

With the images above a general understanding of the personality traits and behaviors of Tree Planters have been exhibited. These images and information showcase that the typical personality and behaviour of a Tree Planter is a positive, adventurous individual who values community and isolation.

## Persona

**Name:** Camilla Mackie

**Age:** 28

**Occupation:**

**Income:** \$25,753/Season

**Education:** Bachelor's Degree – Finance

**Relationship Status:** Single

**Location:** Peterborough, Ontario

**Career/ Seasonal:** Seasonal

**Seasoned Worked:** 5 seasons

**Social:** Works with 10 other Crew Mates on Block

**Frequency of Activity:** Every Weekday (8h) for 3-4 months.

**Hobbies:** Hiking/mountain climbing, rock climbing, Snowboarding, Drawing, Traveling



Figure 8 - Summit Crew bosses. [Image]. (2020). Retrieved from <https://www.summitplanting.com/camilladaniels.html>

## Profile

Camilla Mackie is 28-year-old Caucasian women. She attended university to receive her bachelor's degree in Finance. She earns a seasonal salary of \$65,000. She has been planting for 5 consecutive seasons with Outland Planting company in British Colombia.

Camilla began her Tree Planting career at 23 a years after obtaining her bachelors. She loves the physical intensity and mental determination tree planting requires and enjoys the positivity and culture of tree planting.
















## User Behavior:

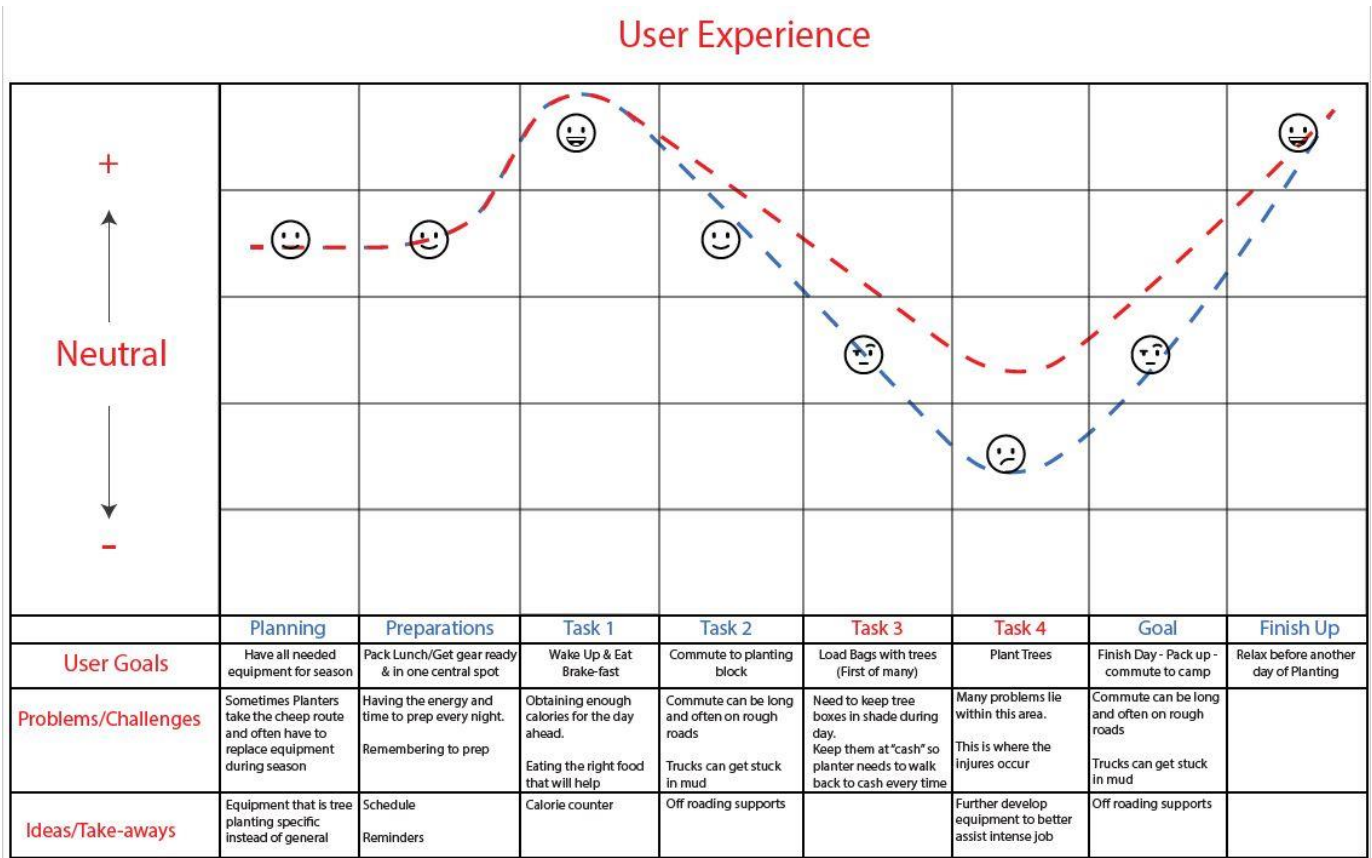
As a seasoned Tree Planter, Camilla has become an Outland tree planting crew boss and strives to be a role model to her crew each season. Camilla goes into everyday with a positive attitude, and ensures her crew

makes money, has fun, and sustains a positive attitude. She takes safety very seriously and emphasis the importance of communication among her crew. She pushes herself and her crew to exceed their goals, and she prides herself on overcoming whatever physical and mental barriers her and her crew encounter. Camilla does not accept complaining and believes that positivity is what ensures successes in tree planting. Camilla enjoys getting to know her crew throughout the season and loves the friendships/relationships she makes each year. She stresses the importance of rest/time off and loves the camp dynamic of tree planting. Lastly, she loves the tree planting community and brings the skills she’s gained in tree planting into her everyday life.

season she developed a stronger bound to her equipment and has learned to appreciate the role it plays in the planting process.

### USER JOURNEY MAP

	Planning	Preparations	Task 1	Task 2	Task 3	Task 4	Goal	Finish Up
<b>User Goals</b>	Have all needed equipment for season	Pack Lunch/Get gear ready & in one central spot	Wake Up & Eat Brake-fast	Commute to planting block	Load Bags with trees (First of many)	Plant Trees	Finish Day - Pack up - commute to camp	Relax before another day of Planting
<b>User Actions</b>	Buy equipment before seasons start accumulate all needed equipment before you leave for camp.	Clean equipment depending on day before. Accumulate equipment and get it in one central location for easy access next day. Prep lunch if you can	Wake Up & Eat Brake-fast  Eat and drink as much as possible b/c you will need the calories for the day ahead	Get too truck with all your belongings  Get in with crew and commute to planting block  Catch some more sleep sometimes	Take bundles of saplings from box - unwrap the "plug" and then load as many as you can in your bags  This happens every time bags empty until day is over	Find spot to plant. Impact ground with shovel to create opening. Place sapling in opening then close it. Then flag tree.  Repeat about 2500 times in a day	Finish off sapling is bag and walk back to "cash" to be picked up  Commute back to camp	If it's a week night it is usually just talking with the crew and eating dinner then sleeping  On Fridays there is always a big party with a lot of drinking and .....
<b>User Thoughts</b>	What can I get that is the best quality but not too expensive	Planing ahead for next day making their early morning as easy as possible	Typically social and talking with crew mates  Getting ready for planting day ahead	Sleeping  Still mentally getting ready for the day  Enjoy scenery	Often good moment because you know you have just planted another 100 trees	Often hard to keep entertained and positive.  Think about the effort they are putting in not # of trees planted	Extremely tired and sore  Thinking about eating and relaxing at camp	Enjoying life in the backcountry with like minded people
<b>Storyboard/Photos</b>								
<b>User Experience</b> + Neutral -								
<b>Problems/Challenges</b>	Sometimes Planters take the cheap route and often have to replace equipment during season	Having the energy and time to prep every night.  Remembering to prep	Obtaining enough calories for the day ahead.  Eating the right food that will help	Commute can be long and often on rough roads  Trucks can get stuck in mud	Need to keep tree boxes in shade during day. Keep them at "cash" so planter needs to walk back to cash every time	Many problems lie within this area.  This is where the injuries occur	Commute can be long and often on rough roads  Trucks can get stuck in mud	
<b>Ideas/Take-aways</b>	Equipment that is tree planting specific instead of general	Schedule  Reminders	Calorie counter	Off roading supports		Further develop equipment to better assist intense job	Off roading supports	



## Summary

Major Take-aways from the User Journey Map and User Experience Map

Purchasing the right equipment can save up a lot of money and heart aches

Routine is very important because it helps you maintain a healthy lifestyle and maintain your equipment

The mentality is the most important aspect of Tree Planting. Maintaining that positive attitude and focusing on the things you can control such as the effort you put in.

It's very important to eat a healthy meal that provide a lot of calories due to the amount you burn during Tree Planting

The posture that planting a tree forces you in plus the continuous repetition of planting trees creates a lot of muscle strain and fatigue

Small changes in the equipment would be extremely beneficial overtime

## Appendix – C      Product Research

### *Benchmarked Product*

## 1. Mystery Ranch Terraframe-65 Pack

<https://www.mysteryranch.com/terraframe-65-pack>



### **Description:**

An expandable load hauler for your biggest mountain adventures. The new TERRAFRAME 65 is for mountain zealots who need options when going big. We've offered the OVERLOAD® feature in hunting and military packs for years, yet backcountry climbers, fisherman, guides and others have been asking for a mountain-inspired version of this versatile, load-taming design. Featuring rigid, carbon fiber frame stays, the suspension allows an ideal amount of torsional flex while providing ample support for loads up to 150 lbs.

### **Specifications:**

- Guide Light MT™ frame
- OVERLOAD® load sling
- Telescoping yoke for custom torso fit
- Quick attach frame cap hardware provides easier OVERLOAD® feature conversion
- Daisy chain with adjustable tool attach loops
- Top Loading shroud with full bag zippered panel access around back pockets
- Two external long pockets for ease of organization
- Internal compression straps
- Two full-length side zip access
- Hydration reservoir compatible
- Convertible Daypack Lid with porting for hydration
- Stretch-woven water bottle pockets
- 330D Lite Plus CORDURA®
- YKK® coated zippers for durability and water protection
- Autolock SJ buckles on compression straps



## 2. Kuiu Pro 1850 Full Kit

<https://www.kuiu.com/global/pro-1850-full-kit/pro-1850.html?cgid=pack-pro#start=4>



### Description:

The PRO 1850 may be used with or without the ICON Carbon Fiber Frame. In the lighter weight frameless configuration, PRO or ULTRA suspension systems attach directly to the bag and utilize the equipped Easton® 7075-T9 aluminum tubing stays for added rigidity and support.

New reinforced Hypalon attachment yokes link the side compression straps—allowing you to cinch the pack down tight against the frame for a sleek, low profile, or for securing the heaviest loads. Extremely durable 500D CORDURA® ripstop fabric throughout adds durability for the worst conditions.

Each pack may be easily transitioned into Load Sling Mode, which opens an extra 2500 cu in of storage for hauling meat or gear between the Carbon Frame and Bag. Combine this feature with KUIU Game and Gear bags to complete the system.

The PRO 1850 bag easily packs inside the larger PRO 6000 and 7800 for the trip to camp. When it's time to hunt, swap out the bags and you're set for ultralight day trips out of base camp.

KUIU packs are made with materials chosen for performance and durability, including Spread Tow Carbon Fiber, CORDURA® Nylon fabric, YKK® Zippers, and Duraflex® hardware. With five different sizes to choose from—1850|2300|3600|6000|7800—you may quickly change out bags and adapt to any situation.

### Specifications:

#### Pack

- Easy access center-divided rear cargo pockets
- Hydration system compatible
- Load use tested to over 150 lb
- K-DWR coated fabric for water resistance
- 500D Nylon CORDURA® ripstop face fabric
- Zippered hydration port
- Full horseshoe zip opening
- Improved bag-to-suspension connection hardware
- Additional webbing loop attachment points for accessories
- Hook and loop retainers on all webbing ends

#### Support Frame

- Fully compatible with PRO and ULTRA suspension and bags
- Spread Tow Carbon Fiber by Chomarat, using fiber from Toray, Made in USA
- Frame built by Rocket Composites Inc., Made in USA
- Frame is included in any Full Kit pack purchase
- Pair with suspension system and bag to make a functional pack



### 3. Strong Glacier Archer-6400

<https://www.stoneglacier.com/collections/expedition-packs/products/sky-archer-6400>



#### Description:

The Sky Archer 6400 is the perfect pack for ultralight mountain bowhunting, weighing 5 lbs 7oz on a Medium Xcurve Frame. The bag is convertible to a 4,000 cubic inch bivy-mode using a unique top compression strap system with an integrated storm flap. Topside seams and storm flap are sewn to create the natural folds for compression of excess fabric and complete weather protection when in Bivy Mode. Designed with the backcountry archer in mind, the Sky Archer boasts a 25" panel style side zip allowing access to the main bag without having to remove your bow while strapped to the pack.

Just inside the panel side zip are ¾" tri-slide buckles to attach Swing Out pockets and/or Camp Pockets for added organization. The center compression straps have added length and dual adjust male and female buckles for increased versatility when attaching a bow. The Sky Archer also has two side pockets, the left pocket on the zipped side of the bag is specifically for a tripod or arrow tube, the larger right-side pocket is designed for additional storage. With 6,400 cubic inches of volume and 2,500 plus cubic inches of load shelf expansion, this pack can deliver on everything from trips measured in weeks to those measured in hours.

#### Specifications:

- Weight - 5lb 7oz. on Medium Xcurve, bag only weighs 2lb 7oz.
- 5,900 cubic inch main bag
- 4,200 cubic inch bivy-mode
- 500 cubic inch lid (included)
- 30" side zip access panel
- 150+ pound load rating (check [Design](#) page for load rating info)
- Hydration compatible ([Hydro Sleeve](#) - Sold Separately)
- 2,500+ cubic inch expandable load shelf
- Belt attachments
- Internal Spotting Scope pocket
- Heavy-duty YKK #10 zipper
- Cordura 500 and Xpac fabric
- Heavy-duty, 1" Duraflex military approved buckles and webbing
- Made in the USA

## 4. Exo MTN Gear K3 Frame

<https://exomtngear.com/collections/packs/products/k3-frame-system?variant=19546187333699>



### Description:

Ultralight without sacrifice. **At less than 3 pounds**, the new K3 Spyder Frame offers incredible comfort, unparalleled mobility, and unrelenting durability for the most demanding hunts. Integrated Load Shelf between the frame panel and pack bag offers secure load-hauling and 2,500ci of extended capacity. **Reversible Frame Extensions** allow you to change the frame height in seconds, providing greater mobility at the shorter setting or increased load performance at the taller setting. **Adjustable Hip belt** Design offers increased adjustability for precision fit and comfort, as well as additional stability to prevent sagging with heavier loads. **Custom-Fit Lumbar Design** features user-customizable inserts to achieve the desired level of lumbar support.

### Specifications:

- Weight of only 2lbs 14oz
- Modularity allows all Exo Mtn Gear bags fit the K3 Frame
- Titanium Frame is lightweight, yet offers unparalleled strength
- Torsional Flexibility enables the frame to move with you as you hike on uneven terrain or get into shooting position with a bow or rifle
- Tested and Proven with loads weighing over 250lbs, this frame can carry more weight than you will practically need to
- Frame Height Options ensure precision fit for a wider variety of individuals. The Short frame is 24-25.5" in length, and the Tall frame is 25-26.5" in length.
- Micro-Adjust Torso adjustments to fit 15-23" torso lengths
- Shoulder Harness Design provides excellent ventilation, easier adjustability, and refined stretch materials that increase comfort
- 2" Hip belt Webbing offers greater stability when mounting hip belt pouches, holsters, bear spray, or other items
- Assist-Pull Hip belt provides a secure fit and prevents slip under load
- Angled Compression Straps prevent loads from sagging or swaying
- Heavy-Duty hardware and 1" webbing

## 5. Seek Outside Revolution Suspension Pack Frame

<https://seekoutside.com/revolution-suspension-pack-frame/>



### Description:

**\*Talon not included.** If your legs can carry it, this frame can haul it. The Revolution suspension consists of hip belt, frame panel, harness, and compression. Talon not included.

Add a Talon and use as a freighter frame / hauler for tree stands or add one of several packs bags for extended backcountry trips. The load shelf provides an additional 2000 Ci when used with a pack bag. Great as a lightweight hunting backpack, day hunting pack, pack rafting pack, and rescue work.

- Our most adaptable lightweight backpacking and hunting pack, use as a hauler, or with several different pack bags
- Backpack includes a load shelf which adds 2000 Ci overhaul capacity
- Frame height is adjustable between 24 and 28 inches
- Comfortable, Versatile, Durable, Lightweight and Made in the U.S.A

### Specifications:

- Patented Articulating Frame
- Interchangeable pack bags or use as a Hauler
- Several Belt Sizes with PALS grid
- Harness includes Daisy Chains, Forward facing Micro Adjustment, Field Replaceable Plastic Hardware, Steel Sliders in high stress areas
- Hip belt Includes PALS grid
- Cross Stays (7075) prevent barreling at all frame heights and reduce back intrusion while allowing some air flow and maintaining optimal center of gravity
- Load sling included
- 6 Compression straps included plus one common loop to add an extra compression strap per side
- Over the top strap included and extra compression strap for common loop
- Integrated Rifle Sling Carry

## 6. Osprey Atmos AG 50

[https://www.osprey.com/ca/en/product/atmos-ag-50-ATMOS50S18\\_334.html](https://www.osprey.com/ca/en/product/atmos-ag-50-ATMOS50S18_334.html)



### Description:

The Atmos™ AG 50 is the best-fitting, most ventilated and comfortable pack ever made for traditional backpacking trips lasting a weekend or more. The innovative AntiGravity suspension makes it feel like you're carrying less weight and seamlessly wraps around your body, which means you'll enjoy every mile more than ever. From easy to use stretch mesh side pockets, Stow-on-the-Go trekking pole attachment, and FlapJacket for lidless use, the Atmos™ AG 50 is still the top contender. Backed by our All Mighty Guarantee, forever.

### Specifications:

- Anti-Gravity suspension - feels like you are carrying less weight than is in your pack
- Removable floating top lid with dual zippered pockets and web attachment points
- Integrated Flap Jacket protects gear when top lid is removed
- Stow-on-the-Go trekking pole attachment allows you to stow your poles in steep terrain or whenever you need your hands free
- Adjustable harness and Fit-on-the-Fly hip belt to dial in perfect fit
- Internal hydration reservoir sleeve accommodates up to a 3L reservoir
- Front stretch mesh pocket stores rain gear for easy access when skies darken, or wet gear after the downpour stops
- Dual access stretch mesh side pockets for storing water bottles and other gear with Inside Out side compression straps
- Dual upper and lower side compression straps stabilize loads and maintain a streamlined profile
- Zippered hipbelt pockets keep snacks and smaller items close at hand
- Lower zippered sleeping bag compartment with removable divider
- Dual ice tool loops
- Removable sleeping pad straps
- Sternum strap with integrated safety whistle

## 7. Arcteryx Bora AR 50

<https://www.arcteryx.com/ca/en/shop/mens/bora-ar-50-backpack>



### Description:

Designed for 2-3 day trips, the Bora AR 50 backpack leverages hybrid materials and advanced hipbelt technology. The RotoGlide™ hipbelt rotates side-to-side and glides up and down for a more natural stride that reduces chafing and improves balance. GridLock™ shoulder straps adjust both in width and height for a precision fit. The highly durable pack body is made from 420d and 630d nylon fabrics and is capped with weatherproof AC<sup>2</sup> fabric in areas exposed to rain or snow.

Regular 2.18 kg / 77 oz / 50 L Tall 2.27 kg / 80 oz / 53 L

Sizing Chart: [Pack Sizing Chart](#)

Activity: Hiking / Trekking

Model: 18790

### Specifications:

#### Technical Features

- Weatherproof construction
- Durable

#### Pack Pocket Configuration

- Kangaroo pocket
- Mesh hipbelt pockets
- Side pockets can carry 1L bottles or trekking poles
- Thermo-molded Tegriss® frame sheet and aluminum stays

#### Pack Hydration

- Hydration bladder compatible

#### Pack Design & Construction

- RotoGlide™ hipbelt reduces chafing by adjusting to changes in back length
- Hybrid materials mapping uses weatherproof AC<sup>2</sup> fabric in areas of high exposure to rain or snow
- Ventilated back panel

#### Pack Suspension Configuration

- GridLock™ shoulder strap adjustment system

#### Pack Loading & Closure Configuration

- Lid closure with two buckles
- Top loading with side access zips

#### Pack Lid Configuration

- Removable/ extendable top lid with zippered compartment

#### Pack Attachment Configuration

- Two ice axe loop

## 8. Gregory\_Paragon 68

[https://www.gregorypacks.com/packs-bags/backpacking-packs/paragon-68-1268PAR68.html?dwvar\\_1268PAR68\\_color=Graphite%20Blue&cgidmaster=packs-backpacking#start=1](https://www.gregorypacks.com/packs-bags/backpacking-packs/paragon-68-1268PAR68.html?dwvar_1268PAR68_color=Graphite%20Blue&cgidmaster=packs-backpacking#start=1)



### Description:

A fully featured backpacking solution in a **lightweight, breathable package**. The Paragon 68 boasts enough space for self-supported trips into the Grand Canyon, and with the **adjustable FreeFloat dynamic suspension**, you can commit to the early start knowing that you'll stay comfortable all day long. Hybrid suspension featuring Gregory's **FreeFloat dynamic comfort cradle lower back system** and breathable **3D foam upper backpanel support**. Full length **side-loading access zipper** for easy unloading and gear organization. **Quickstow system** on shoulder harness for a secure, scratch free way to store your sunglasses

### Specifications:

- FreeFloat breathable suspension with dynamic flex panels that move with the natural movements of your body
- Adjustable torso length with 3D perforated foam breathable backpanel
- 3D comfort cradle adjustable hipbelt with 3D construction for hotspot free, body-hugging comfort
- Perforated dual density shoulder harness with sternum strap with hose clip
- Wishbone alloy frame and fiberglass anti-barreling cross-stay for stable load management and torsional flexibility
- Raincover included in dedicated zippered pocket under top lid for added organization
- Full length side-loading access zipper for easy unloading and gear organization
- Sunglass QuickStow system on shoulder harness for quick, secure and scratch-free access to your shades
- Internal hydration sleeve with SpeedClip hydration hanger compatible with Gregory's 3D Hydro reservoir (reservoir not included)
- Floating top pocket with large zippered compartment and an underside zippered pocket, reflective attachment points and key clip
- Dual side stretch mesh pockets, one with side trail access, with pass through for over or under compression
- Front oversized stretch mesh pocket with secure buckle closure
- Quick-pull drawcord closure and top webbing compression
- Zippered bottom sleeping bag compartment with removable divider
- Adjustable attachment loop and upper shock lock for trekking poles or an ice axe
- Custom comfort-grip molded zipper pulls and molded webbing keepers for strap management



## Appendix – D      Analysis

NEEDS		DESCRIPTION	COMMENTS BASED ON EVIDENCE & EMPATHY			
Category of Fundamental Human Needs (Max-Neef)	Category of Psychological Needs (Maslow)	Interpretation of possible relevance to design problem space	Comments about Needs discovered in topic/problem space (include source from discovery search, if possible)	Level of Relative Importance to design of new product		
				Slight	Moderate	High
Basic Needs						
Subsistence		-Need ability to transport water and snacks while planting -Shelter or clothing to withstand harsh weather conditions	-Tree Planters typically work in open deforested areas that don't provide shelter  - Planters steadily work further away from their supply truck			High
Protection		-Living in remote locations often encounters extreme weather conditions  -live on camp sites due to remote planting locations takes workers away from family and friends	-During the summer months  (3-4 months) planters are  Removed from typical living  Quarters to live on planting Camp			High
Affection		-Need for positivity among planting crew is crucial for mental health	-Planting is extremely demanding and planters are removed from their families, so the social team aspect is important  -You plant alone b/c you need to spread trees out, so planters need to keep themselves entertained		Moderate	
Physical (the need for air, water, food, rest, health)		- (See water point)  -Planter work long 8h labours days so rest at the end of the day at camp is important  -Healthy meals with protein rich foods are important to contrast extreme labour	-Planters are often provided meals at camp by the camp cook and supervisor			High

<p>Security (the need for safety, shelter, stability)</p>	<ul style="list-style-type: none"> <li>-Bracing for joints. (ankles, wrists, back/spine)</li> <li>-Protection from wildlife in remote areas</li> <li>-Water security is important. Don't have access to clean water that far north</li> <li>-First aid kits and qualifications are important in remote areas</li> </ul>	<ul style="list-style-type: none"> <li>-Planters are often working on obstructed/ very uneven ground</li> <li>-Bear spray is provided and required on sites</li> <li>-Water trailers hold camps safe drinking water</li> </ul>			<p>High</p>
<p>Social Belonging (Effort/ resources to belong to a 'tribe')</p>					
<p>Understanding</p>	<ul style="list-style-type: none"> <li>-Planting techniques and protocols are crucial to understand so planters don't damage body</li> </ul>	<ul style="list-style-type: none"> <li>-Proper planting techniques are taught to new planters to ensure their safety and physical health.</li> </ul>		<p>Moderate</p>	
<p>Participation</p>	<ul style="list-style-type: none"> <li>-Dedication and respect are essential attributes for planters due to the hard-tedious work</li> <li>-Chain of Command is needed in a tree planting company to get through season</li> </ul>	<ul style="list-style-type: none"> <li>-All workers must be dedicated to the job and respect one other (runs on team/friend/family environment)</li> <li>-Structure within tree planting company is essential</li> </ul>		<p>Moderate</p>	
<p>Leisure</p>	<ul style="list-style-type: none"> <li>-Leisure time is essential for planter's mental health</li> <li>-Mental entertainment is needed during tedious planting days</li> </ul>	<ul style="list-style-type: none"> <li>- Often takes place at camp after workday. The social dynamic at camp &amp; around the campfire is a big part of planting</li> </ul>		<p>Moderate</p>	
<p>Social (the need for being loved, belonging, inclusion)</p>	<ul style="list-style-type: none"> <li>-Need for competition</li> <li>-Need for team environment</li> <li>-Need social interaction while planting</li> </ul>	<ul style="list-style-type: none"> <li>-Planters get paid per tree planted. So, the more they plant the more they make. Friendly competition is often talked about among planters</li> <li>-Planting is very hard and your crew is like your family. Everyone is going through the same physical battle each day</li> <li>-The actual action of planting trees is very lonely since the crew</li> </ul>			<p>High</p>

		needs to be widely spread across the land			
Ego (the need for self-esteem, power, recognition, presitge)	-Need for encouragement and recognition due to hard grueling work	-Social expectation for positivity and respect when working hard with others -Social status becomes evident among the crew. (positive, funny, fastest planter) -social recognition plays a role in motivating each other to plant more each day			High
Personal Accomplishment					
Creation	-Need for more user sympathetic design to accommodate harsh physical strain during planting job  -Need for joint support while under repetitive stress	-Need to be able to withstand heavy repetition and weight.  -Endurance is key for tree planting. Consistent bending over + movement with heavy weight			High
Identity	-Needs to be environmental sustainability	-Sustainability is one of the main reasons for tree planting  -Although Planting is extremely hard most people who have been planters have many fond memories of their experiences. (friendships and stories)		Moderate	
Freedom	-Tools and equipment need to fit all different body types	-Everyone who plants are slightly different		Moderate	
Self-Actualization (the need for development, creativity)	-Needs to provide pleasure, function acoustic, tactile, haptic -Needs to include aspects of emotional response, such as: excitement, fun, nostalgia -intrinsic pleasure  -Needs to trust in abilities	-The hard nature of the job requires the workers to like their equipment and tools			High

Appendix – E CAD Development (Refer to body of thesis)

Appendix – F Physical Model Photographs (Refer to body of thesis)

Appendix – G Technical drawings (Refer to body of thesis)

Appendix – H Manufacturing Cost/Info

**Cost Breakdown**

Class A	High Cost	
Class B	Medium Cost	
Class C	Low Cost	

Component	Material	Price - \$
Main Fabric exterior Hip belt – Shoulder straps	Workwear Canvas - “Iron Forge Hemp™” (Patagonia, n.d, para. 5).	
Foam Padding	Dual Density Foam - “Koosh Natural” (Foamite, n.d, para. 10).	
Mesh – Foam shielding (human contact points)	Air Mesh 500D Spacer Air Mesh	
Suspension Frame (Back frame – hip belt stays)	Carbon Fiber - “AmpliTex™” (Bcomp, n.d, para. 4).	
Buckles and Clasps	BioPlastic - “Terratek® SC” (Green dot Bioplastics, n.d, para. 1)	
Buckets (Seedling bags)	Hemp - “Hempton” (Hemp Fabric Lab, n.d.).	

**Appendix – I Sustainability Info/Data**

<p>Main Fabric exterior Hip belt – Shoulder straps</p>	<p>Workwear Canvas “Iron Forge Hemp™” (Patagonia, n.d, para. 5).</p>	<p>“55% industrial hemp/27% recycled polyester/18% organic cotton canvas that is 25% more abrasion resistant than conventional cotton duck canvas, yet comfortable and breathable.” (Patagonia, n.d, para. 5).</p>
<p>Foam Padding</p>	<p>Dual Density Foam “Koosh Natural” (Foamite, n.d, para. 10).</p>	<p>“unique cell structure and natural soy content sets new standards. It has a softer surface, greater comfort and support, and better fatigue resistance than conventional polyurethane foam” (Foamite, n.d, para. 10).</p>
<p>Mesh – Foam shielding (human contact points)</p>	<p>Air Mesh 500D Spacer Air Mesh</p>	<p>The breathable mesh provides durability and breathability when being worn by the user.</p>
<p>Suspension Frame (Back frame – hip belt stays)</p>	<p>Carbon Fiber “AmpliTex™” (Bcomp, n.d, para. 4).</p>	<p>“The flax fiber quality, yarn thickness and twist are all highly engineered for optimal mechanical properties in the final composite part. The fibers are specifically treated to optimize the fiber-matrix interface. We use European flax and the fibermix is thoroughly controlled for consistent quality over time.” (Bcomp, n.d, para. 4).</p>
<p>Buckles and Clasps</p>	<p>BioPlastic “Terratek® SC” (Green dot Bioplastics, n.d, para. 1)</p>	<p>“The Terratek® SC line of starch biocomposites provides effective solutions to meet growing demand for eco-friendly, biobased goods.” (Green dot Bioplastics, n.d, para. 1)</p>
<p>Buckets (Seedling bags)</p>	<p>Hemp “Hempton” (Hemp Fabric Lab, n.d.).</p>	<p>“Hemp’s tensile strength is eight times that of cotton fibre which accounts for its historical use in sails and rope for the British and American Navies. It is an exceptionally durable and strong ecofriendly fabric.” (Simplifi Fabric, n.d, para. 9).</p>

**Appendix – J Approval Forms**

**IDSN 4502**  
SENIOR LEVEL THESIS TWO

Humber ITAL / Faculty of Applied Sciences & Technology  
Bachelor of Industrial Design / WINTER 2021  
Catherine Chong / Sandro Zaccolo


**CRITICAL MILESTONES: APPROVAL FOR CAD DEVELOPMENT & MODEL FABRICATION**

<b>Student Name:</b>	Cristian / Loria
<b>Topic / Thesis Title:</b>	Sustainable Tree Planting

**THESIS DESIGN APPROVAL FORM**

Thesis design is approved to proceed for the following:	<input checked="" type="checkbox"/> CAD Design and Development Phase
<b>Comment:</b> Initial CAD progress well as of reading week/March 10th, continue with detailing and refinement.	

Thesis design is approved to proceed for the following:	<input checked="" type="checkbox"/> Model Fabrication Including Rapid Prototyping and Model Building Phase
<b>Comment:</b> Design development progress well as of reading week/March 10th, once CAD is completed, can move forward to model fabrication from week #9 onward.	

<b>Instructor Signature(s):</b>	
	
<b>Date:</b>	10th March 2021



