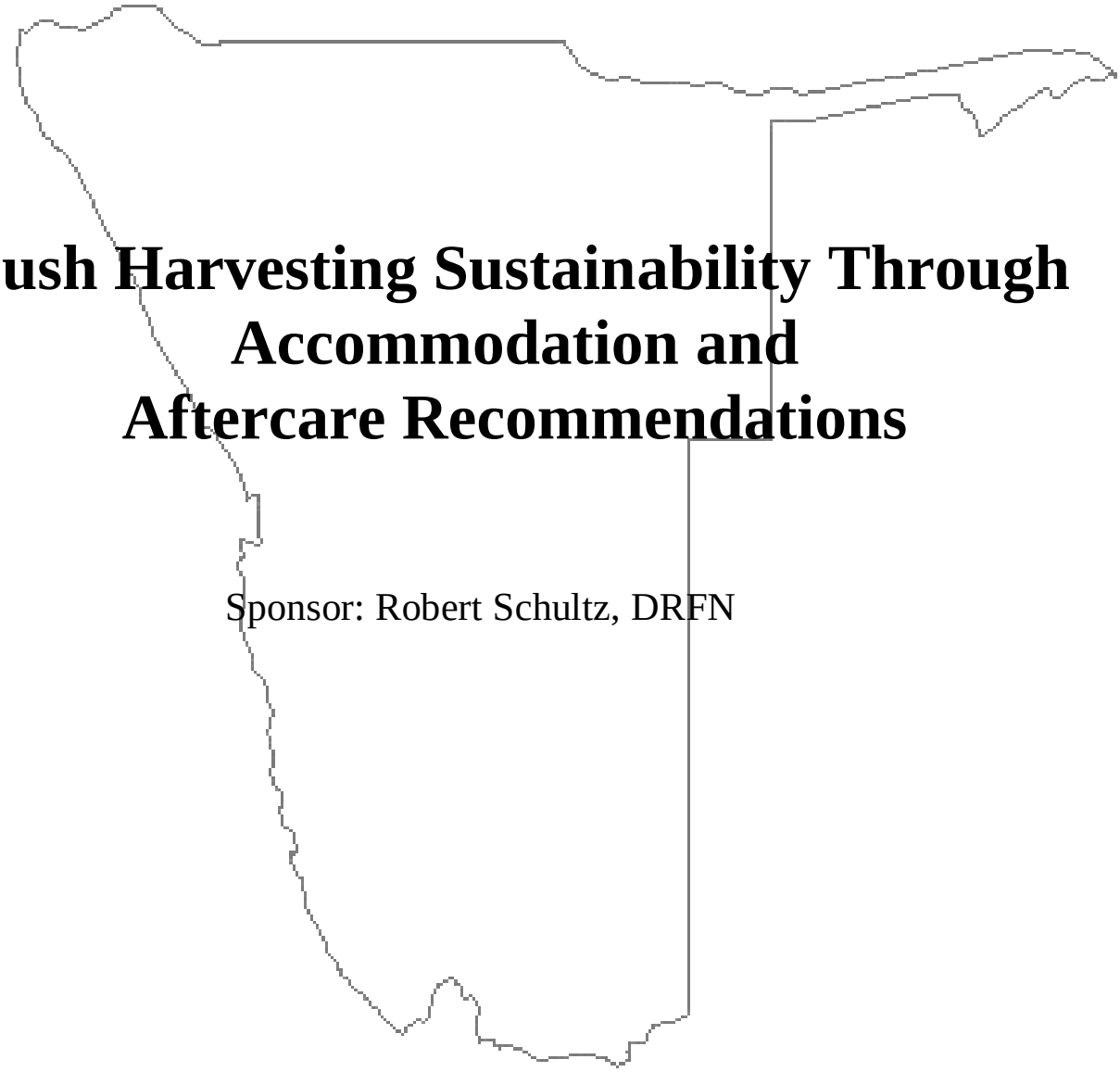

Bush Harvesting Sustainability Through Accommodation and Aftercare Recommendations

Sponsor: Robert Schultz, DRFN

Jonathan Baldiga **Kelsey Graham**

Lisa Rosenfelder **Zachery Van Ness**

Project Number:
0802
IQP Division: 49B

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Sponsor: Robert Schultz, DRFN

An Interactive Qualifying Project Report
submitted to the Faculty of the
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements for the
Degree of Bachelor of Science
by

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May 2, 2008

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Abstract

Namibia's farmland is currently overrun by invasive bush, which threatens wildlife and cattle. Our project goal was to contribute to the sustainability of a bush-to-electricity industry by designing accommodation trailers to attract and retain workers, as well as by recommending proper land aftercare systems to ensure sustainability of Namibian farmland. We developed several flexible trailer designs to comfortably house rural workers in a variety of fields. We also recommended aftercare systems that allow farmers to significantly increase their land productivity.

Acknowledgments

We would like to thank the following individuals and organizations for their effort in helping us make our project a success. First, we would like to thank the Desert Research Foundation of Namibia (DRFN) for sponsoring our project. Most importantly we would like to thank our sponsor, Robert Schultz, the head of the Energy Desk at the DRFN, who has been supporting our project since the beginning. We would also like to thank our aftercare sponsor, Claus Hager, the head of the Land Desk, who supported and challenged us with new ideas. We also extend a thank you to Detlof Van Oersten, the executive director of the DRFN, for his support and important project input. Also, we would like to thank Lucky Ganeb and Alex Moses for providing valuable input on our trailer design. Additionally, we would like to give a huge thanks to the rest of the DRFN staff for allowing us to use their work area, phones, printers, and their extensive knowledge.

Regarding those individuals and organizations outside the DRFN, we would like to thank SolarAge, specifically Helvi Ileka, for her input on energy efficiency, as well as Dr. Andreas Wienecke for his input on sanitation. Also, thank you to Dr. Bruce Brewer for sharing his knowledge on bush harvesting. For our aftercare section, a special thanks to Nico de Klerk for his vast knowledge on bush encroachment. Furthermore, a tremendous thank you to those Polytechnic of Namibia professors that attended our focus group: Dr. Andrew Conroy, Barbara Curtis, Dave Joubert, and Ibo Zimmermann. They helped tremendously with finalizing our recommendations and opening us to new ideas. Also, thank you to Klaus Kellner for his ideas on aftercare.

We would like to extend a warm thank you to the Polytechnic of Namibia for their hospitality. We would also like to thank them for allowing us the use of design software at their Engineering building for our trailer design.

Lastly, we would like to thank our professors, Professors Reinhold Ludwig and Creighton Peet. The continuous support and input that they gave to our project was invaluable.

Thank you again for all of your support.

Jonathan Baldiga
Kelsey Graham
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Zachery Van Ness

Authorship

While there was generally a primary author in most sections, every team member has reviewed and added to each section of the report. For this reason, we all hold equal responsibility for the writing and do not claim single authorship on any section. Similarly, the project work was distributed equally amongst group members.

Definitions

SME: Small and Medium Enterprises. Bush harvesting teams will be organized by these independent corporations to harvest, chip, and deliver the biomass material to the gasification plants.

Aftercare: Techniques applied to the land after harvesting; methods to discourage the regrowth of the invasive bush, while ensuring a continuous supply of biomass and biodiversity.

CCF: The Cheetah Conservation Fund. A non-profit organization in Namibia. The CCF is currently harvesting the bush for profit, using the biomass to create BushBloks to be used as wood fuel.

DRFN: The Desert Research Foundation of Namibia, our sponsoring agency.

CBEND: Combating Bush Encroachment for Namibia's Development. The umbrella project our IQP falls under, which the DRFN is currently working on.

Note: In this report, metric units are used as well as the local currency. Specifically, it should be noted that:

Tons: A "ton" is 1 metric tonne, or 1000 kg. This is equivalent to 2,200 pounds.

N$: The current exchange rate, as of 22 April 2008, is 0.129 USD: N$1 or N$7.77: 1 USD.

Hectare: 10,000 sq. meters or 2.5 acres. For visualization purposes, it is approximately the size of 2 football fields.

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Executive Summary

Three major obstacles hindering Namibia's economic development are: unemployment, the invasive bush, and an inadequate electric power supply. Unemployment in Namibia is officially recorded to be 31% (Namibia 2001 Population and Housing Census, 2002). As people migrate to cities to find jobs, innovative rural employment opportunities are needed, as two-thirds of the population lives outside of urban areas. Invasive bush encroachment is another concern because it causes substantial declines in land productivity, especially for cattle grazing lands (de Klerk, 2004). The invader bush grows in thick stands, with extensive root systems that take nutrients from the soil and reduce groundwater levels. In an already semi-arid climate, further reduction in groundwater is cause for serious concern. Finally, Namibia faces energy challenges, with nationwide power consumption significantly exceeding domestic production capabilities. As a result, half of all electricity in Namibia is purchased from South Africa (Weidlich, 2008). As South Africa also struggles with energy concerns, it has become more crucial for Namibia to generate power domestically.

Currently, the Desert Research Foundation of Namibia (DRFN) plans to address these three issues by trying to establish a bush harvesting industry through the CBEND (Combating Bush Encroachment for Namibia's Development) project. This project seeks to create an industry where groups of rural workers can independently harvest invasive bush, sell it as valuable fuel, and implement a land aftercare program to maintain sustainability of the land. CBEND promotes Namibia's development by working towards creating job opportunities, increasing land value, and establishing an independent, renewable power source.

In order for the bush harvesting industry to be sustainable, measures must be taken to ensure the long term availability of both labor and land resources. Since workers will be required to live in remote areas away from their families, extra incentives for workers to accept the jobs are needed. Additionally, as harvesting requires training and practice, measures should be taken to ensure a high worker retention rate. Meeting the farmers' desires is also important for creating a sustainable industry, since cooperation with them is crucial. Most farmers wish to implement an aftercare approach that will return the land to cattle grazing savanna. This desire needs to be met, while also promoting a healthy ecosystem. Our research aimed to promote the sustainability of the bush harvesting industry by addressing labor resources as well as the implementation of a desired aftercare program.

Our goals were two fold: 1) to contribute to the sustainability of the bush harvesting industry by identifying ways to improve the desirability of working in an arid, adverse environment, and 2) to provide recommendations for an appropriate land aftercare approach that would ensure sustainability of the land. Objectives to meet these goals included:

- Develop a list of necessary features for an accommodation trailer
- Determine cost-effective and energy-efficient technologies for the accommodation trailer to provide power, entertainment, and safety
- Create technical specifications and drawings for the accommodation trailer
- Create a spreadsheet tool to allow flexibility in the trailer design
- Select a chipping machine to complement the trailer as part of a bush harvesting operation

- Create spreadsheets to organize aftercare information for future reference
- Identify recommendations for short-, mid-, and long-term aftercare methods.

These goals and objectives address two major sustainability concerns of the CBEND project. By meeting these, we were able to contribute to the long term success of a bush harvesting industry.

We employed several methods in order to meet objectives related to the technical design of an accommodation trailer. Through expert interviews, literature review, and consultation with local businesses, we compiled the base requirements for the trailer as well as the appliances, space, and power requirements to meet the needs of rural workers living in the field. We conducted a design review with managers at the DRFN, where we received professional feedback on the preliminary design of our trailer, allowing us to modify our design as per their suggestions.

Various methods were also employed to make recommendations for techniques of proper land aftercare. By gathering information on past attempts to control bush regrowth, we were able to determine which were successful. We received many detailed suggestions on aftercare methods by contacting ecological and agricultural experts. Finally, by holding a focus group with Polytechnic of Namibia faculty, we received professional feedback on our preliminary list of aftercare methods.

Through our research, we were able to design several different accommodation trailer options. Bezêr Trailer Manufacturing provided us with an initial quote of N$241,500 for an 8 person trailer. Based on our design review feedback, we drafted several smaller design options: a 4 person trailer and an energy/storage trailer. Finally, by providing Solar Age with power requirements, we were able to get quotations on a solar power system, resulting in a complete cost analysis of our trailer designs. To accommodate this cost analysis, as well as maintain a flexible trailer design, we created a dynamic Microsoft Office Excel costing tool which allows the user to select items to include in the trailer and receive detailed cost and power breakdowns. From these breakdowns, we identified that the 8 person trailer would be the best option for an eight person harvesting team. This trailer would allow adequate sleeping quarters for each worker, as well as ample storage for personal items, food, and equipment. The final cost for this trailer design was determined to be N$260,000.

One of the most useful features of the trailer design is its flexibility and universality of design. With the aid of our dynamic costing tool, trailer designs for many different applications, such as housing workers in various fields, as well as mobile clinics and shelters, may easily be drafted. To improve flexibility even further, we recommend researching a modular trailer design, so that multiple 4 person trailers may be linked together, to easily accommodate different numbers of workers. We also recommend that the accommodation trailers be used in other fields, such as mining operations, medical clinics, and emergency shelters.

With regards to identifying an appropriate aftercare method for bush harvested areas, we determined that an herbicide is the most appropriate short-term solution. We concluded that the best herbicide to use is Picloram, which is available under the brand name Access, by Dow AgroSciences. This herbicide has proven to be effective in bush control in the past and is highly selective due to its spray application. It is also colored so that application can be monitored.

For a mid-term aftercare solution, we determined that continued application of Picloram should be used. After resprouting has occurred, Picloram should again be applied to the sprouts. Regarding a long-term solution, we investigated whether an

alternative species could be identified to replace the invasive bush by providing an alternative biofuel source, but determined this to be impractical. Furthermore, it is the general consensus of bush encroachment experts that there is sufficient bush to sustain the harvesting industry and additional sources do not need to be found. Instead, we recommend the implementation of a land restoration system, in which the farm land is returned to cattle grazing area by providing bags of mixed seeds to the farmers. This meets the farmers' demands for more grazing land, while also promoting a healthy ecosystem by lowering the risk of erosion and promoting biodiversity. Although we have made initial recommendations for aftercare methods, experimental research is needed before implementation. Specifically, long-term solutions should be studied through the creation of test plots, which will reveal the success or failure of a specific aftercare approach.

If successfully implemented, our recommended trailer design will give workers an incentive to stay with the bush harvesting profession on a long term basis. Our research into aftercare methods will provide a basis for decision making that will return large amounts of farmland to open grazing lands and thus meet the desires of the farmers.

1.0 Introduction

Sustainable development is defined by the World Commission on Environment and Development's Brundtland Report (1987) as "…development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (p. 43). In short, sustainable development allows beneficial changes to be created in the present, while keeping the impact on the future in mind. Many policies aim to improve life in developing countries. However, if the long term sustainability of the plan is not a focal point, it may fail after a few years, wasting the efforts and expenses put into the policy. In Namibia, sustainable solutions to social, environmental, and energy concerns must be implemented in order to ensure the country's future development.

Three problems currently hinder Namibia's growth: unemployment, bush encroachment, and an inadequate electric power supply. According to the 2001 Census, unemployment in Namibia is 31% (Namibian Government, 2002). The demand for employment opportunities is more urgent in rural areas, where two-thirds of the population resides. The creation of rural jobs would be an optimal opportunity to combat unemployment, since workers could stay near their homes and families, and not be forced into informal settlements around the urban areas. Invasive bush encroachment is another concern, and causes substantial declines in land productivity, principally cattle raising (de Klerk, 2004), leading to large amounts of land being deemed unusable by farmers. It was found in Uganda that the "mean annual gross income was US$49,393 per cow per annum on cleared farms compared to US$23,351 on bushy farms" (Mugas et. al, 2000, p. 64). This indicator suggests that clearing bush encroached farms can lead to an increase in land productivity. The invader bush species have also been linked to a reduction of groundwater levels, due to their dense

population and extensive root systems. In an semi-arid climate, further reduction in groundwater is cause for serious concern. Finally, Namibia faces energy challenges, with the nationwide power consumption significantly exceeding its domestic production capabilities. As a result, Namibia purchases approximately half of all electricity from South Africa (Weidlich, 2008). As South Africa struggles with its own energy concerns, it has become more crucial for Namibia to generate its own supply of power.

To combat the unemployment and bush encroachment issues, rural worker accommodations and techniques to control the regrowth of invasive species must be considered. Worldwide, people working far from their homes in rural areas are housed in various ways. In Australia, accommodation trailers are often used to house employees in agricultural industries (Australian Government, 2006). In Namibia, however, employees who maintain the nation's roads or install vast fence systems around farms are only provided with tents to sleep in, leaving them largely exposed to the harsh Namibian environment. These tents lack simple human necessities such as privacy, security, and bathing facilities, causing them to be considered undesirable (pers. com. R. Schultz, March 2008). Improving worker housing facilities will increase the desirability of bush harvesting, as well as potentially increase the productivity and worker retention rates. In order to combat the bush encroachment problem, previous research has considered various techniques of land aftercare. These aftercare techniques involve the treatment of land after the removal of bush to ensure that unwanted species do not return. Strategies include controlled fires to destroy new sprouts, the use of grazing animals such as goats, the planting of new plants, and the use of herbicides. Additionally, aftercare methods consider alternative

biomass species, which would provide future power and employment opportunities. These techniques have been used in the past with varying degrees of success.

The use of accommodation trailers, both worldwide and in Namibia, has been relatively limited. In order to create a sustainable bush harvesting industry, we determined techniques for making trailers desirable, as well as portable and financially viable. Furthermore, limited attention to aftercare research has led to unsuccessful management of harvested land in Namibia. A more successful aftercare solution needs to be identified to ensure the sustainability of the harvested land and continuation of the harvesting industry by meeting the desires of the farmers.

Currently, the Desert Research Foundation of Namibia (DRFN) is attempting to establish a bush-to-electricity industry through its project entitled Combating Bush Encroachment for Namibia's Development (CBEND). This project aims to create an industry where groups of rural workers can independently harvest invasive bush, sell it as valuable fuel, and treat the farmland so as to restore it to its original level of productivity for grazing. CBEND promotes Namibia's development by creating job opportunities, increasing land value, and establishing an independent, renewable power source. By offering desirable accommodation for workers, as well as by promoting a long term supply of biomass for energy production through a sustainable aftercare system, our contributions aimed to assist in the longevity of the bush harvesting industry.

2.0 Background

Namibia faces three major problems: unemployment, bush encroachment, and an inadequate energy supply. The DRFN has launched the CBEND project to create a bush-to-electricity power plant cycle to help alleviate unemployment while utilizing the invasive bush. In order to achieve sustainability in this industry, it is necessary for jobs to be desirable as well as to create conditions for a consistent fuel source.

2.1 Unemployment in Namibia

Colonized by the Germans in the late 19th century, Namibia has had a history of foreign occupation, conflicts, and apartheid. Namibia's people finally gained independence in 1990. Today, the country's diverse population has a new challenge: unemployment. Nationally, the officially reported unemployment figure is 31% (Namibian Government, 2002), although unofficial estimates reach as high as 40%. Even the official figure is five times the worldwide unemployment rate of 6.0% (International Labor Organization). Namibia's unemployment values are compared to other countries in Figure 1.

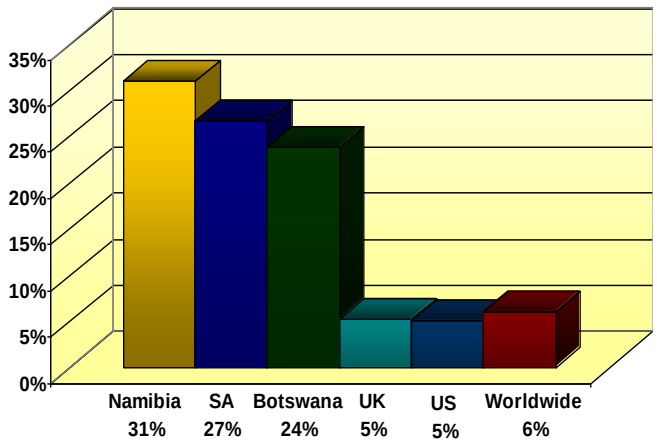

Figure 1: Comparison of Unemployment Figures of Namibia and Other Nations

(Namibian Government, 2002)

According to the 2001 Census (Namibian Government, 2002), Namibia has a population of around 1.8 million people. This relatively small population is distributed over a large area of 824,000 square kilometers, resulting in an average population density of only 2.1 persons per square kilometer. Namibia's largest urban area is Windhoek with 230,000 inhabitants, accounting for 13% of the country's total population. There are only a few additional urban areas, the largest being Rundu, which has a population of only 44,000 people. Two-thirds of Namibia's population resides in rural areas.

The lack of urbanization leaves many people without job opportunities (Namibian Government, 2002). According to the 2001 Census, nearly 70% of urban residents were involved in the work force, as opposed to only 44% of rural residents. It is apparent that urban areas have more employment options, which often results in individuals traveling to the cities for potential job opportunities. Unfortunately, job creation has not kept up with the migration rate to these areas. Furthermore, migration to cities displaces families from their native homes. If jobs were made available in rural areas, people would not have to move to cities in an often futile attempt to find work.

The unemployment rate is determined by dividing the population of Namibia over the age of 15 into two categories: those who participate in the labor force, and those who do not, as displayed in Figure 2. The labor force is not necessarily those who are employed, but rather is comprised of individuals who are physically able to work. Those outside of the labor force include students, homemakers, the disabled, the retired, and those receiving pensions. As of the 2001 Census, 69% of the labor force is employed. However, the Census defines employed as "During the seven days prior…having worked…even for one hour for pay, profit, or family gain during that

period" (p.36). Therefore, despite the fact that two-thirds of the labor force is labeled as employed, they are often idle during the majority of the week, or work for no pay for a family business. This results in only about 400,000 individuals, or 22% of the nation's total population, who work at least one hour per week, with or without pay.

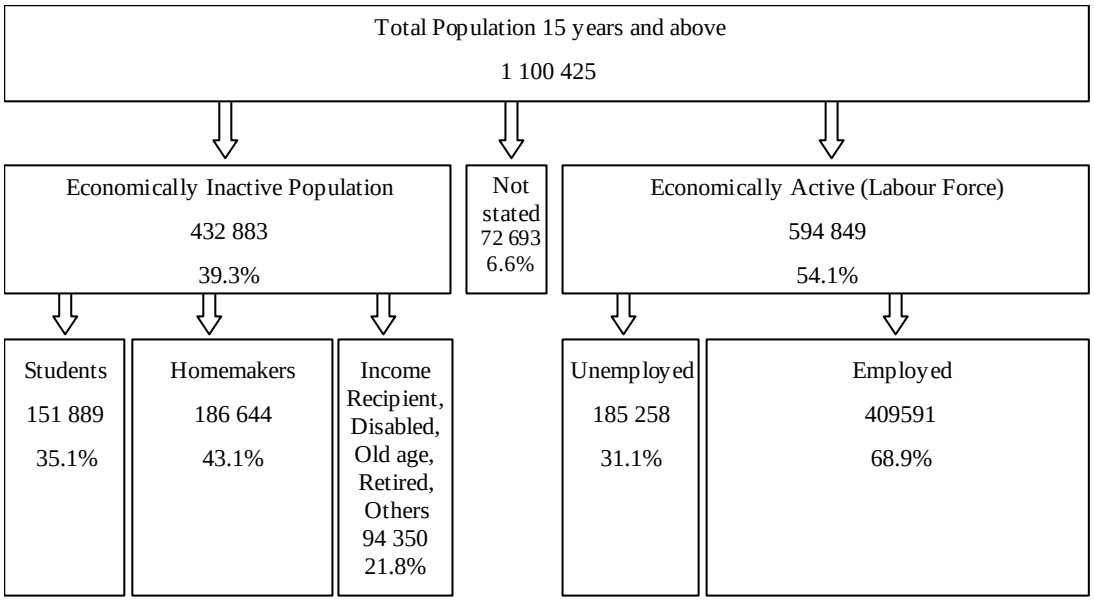

Figure 2: Population Groups Defined in the 2001 Census

(Namibian Government, 2002)

These statistics can be further detailed when breaking down the labor opportunities. The government hires approximately 20% of all employed individuals. This large number provides insight into the government's focus on job creation. Also of interest, 12% of all employed persons are unpaid family workers. Returning to the nation's employment figures (Namibian Government, 2002), only approximately 19% (350,000 people) of Namibia's population receive some type of pay for work. This results in the remaining majority of the population to be financially dependant on these people.

Based on the previous statistics, the severity of unemployment in Namibia is apparent. More specifically, the lack of income generated by individuals is prevalent. Although the government does encourage labor intensive projects, there is still a

shortage of job opportunities. Furthermore, the Census alludes to the greater need for jobs in rural areas, which would help slow the general migratory trends to urban areas. Consequently, it is important to create jobs in rural areas, where the majority of Namibia's people reside.

2.2 Bush Encroachment

Bush encroachment in Namibia currently covers an area of approximately 26 million hectares. As of 2004, the invasive bush had caused over N$700 million annually in losses to the Namibian economy (pers. com. R.Schultz, March 2008). The most prevalent species of invasive bush are *Acacia mellifera* (Black Thorn), *Acacia reficiens* (False Umbrella Thorn), *Colophospermum mopane* (Mopane), *Dichrostachys cinerea* (Sickle Bush), *Rhigozum trichotomum*, and *Terminalia sericea* (Silver terminalia). The *D. cinerea*, *A. mellifera*, and *T. sericea* grow at a density of 4,000-12,000 plants/ha. The primary encroached land is shown in Figure 3. The map also shows the densities of the bush species throughout the country.

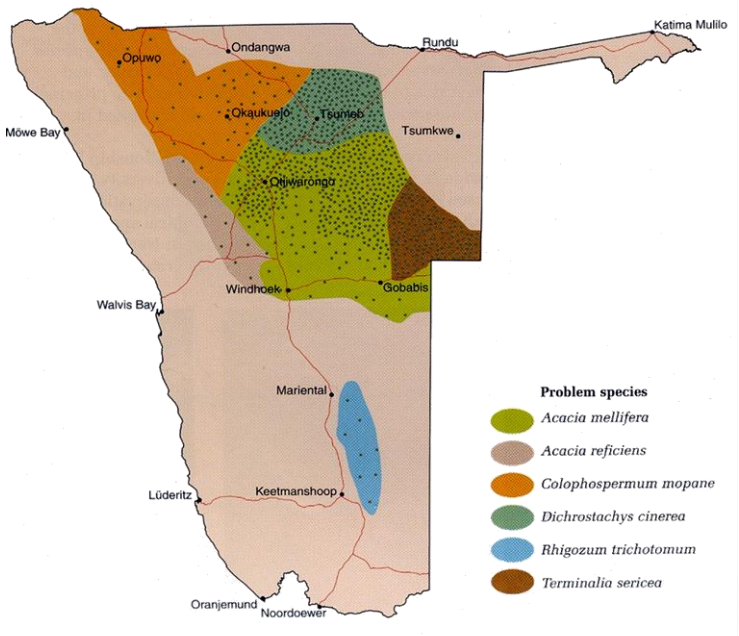

Figure 3: Invasive Bush Species in Namibia

(Schultz 2008)

The invasive bush in Namibia is detrimental to agriculture, cattle grazing, and the cheetah population. In northern and central Namibia, the invasive bush has impacted groundwater supplies in the already semi-arid environment, since the extensive root systems take water away from the native plants and grasses (de Klerk, 2004). The bush has also reduced underground water recharge from rainfall from 6% to just 0.2% (pers. com. R.Schultz, March 2008).

Cattle raising is very important to Namibia's economy and has been the predominant focus of land use in Namibia for centuries. It is essential for farmers and ranchers to have a healthy herd of cattle to sustain their livelihood. However, the invasive bush hinders the growth of grasses that cattle rely on for food, reducing the amount of land available for livestock. In the past 50 years, the commercial cattle herd has been reduced from 2.5 million to 800,000 (pers. com. R.Schultz, March 2008).

Wildlife, specifically the cheetah population, has also been affected. The cheetah hunts by sight and its attempts to maneuver through the thorny bush can scratch the corneas of the cheetah's eyes. This greatly diminishes their ability to hunt native prey. The cheetah has found a solution to this problem by hunting the cattle, which in turn results in some farmers killing the cheetah. This is of concern to the Cheetah Conservation Fund (CCF), an organization that strives to protect this threatened species. Currently, the CCF operates one of the largest farms that regularly harvest the invasive bush (Leinonen, 2007). They use the harvested material to create BushBloks, which are used as fuel for cooking and heating.

2.3 Energy Sources in Namibia

The availability of power in Namibia has been a prolonged problem in the nation's development (Weidlich, 2008). Today, the country buys as much as 50% of its annual consumed power, the majority from South Africa. Additionally, rolling blackouts and brownouts constantly plague the nation. Figure 4 shows Namibia's power consumption for the previous 10 years, as well as power produced by NamPower, South Africa (Eskom), and other sources.

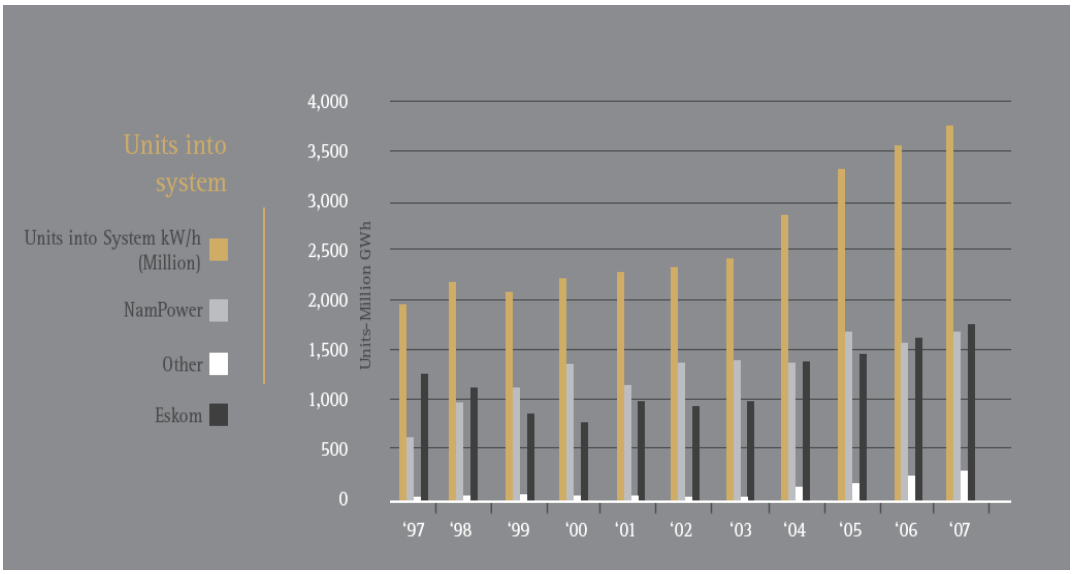

Figure 4: Namibia's Power Consumption for the Past 10 Years

(NamPower, 2008)

As shown in Figure 4, power consumption has rapidly increased since 2003, however production has shown little increase to compensate for this growth. The majority of power supplemented into Namibia has been supplied by South Africa's Eskom power company. Currently, power production in Namibia is approximately 380 MW, and energy demand is close to 600 MW. Forecasters predict a continued increase in power demand, as shown in Figure 5.

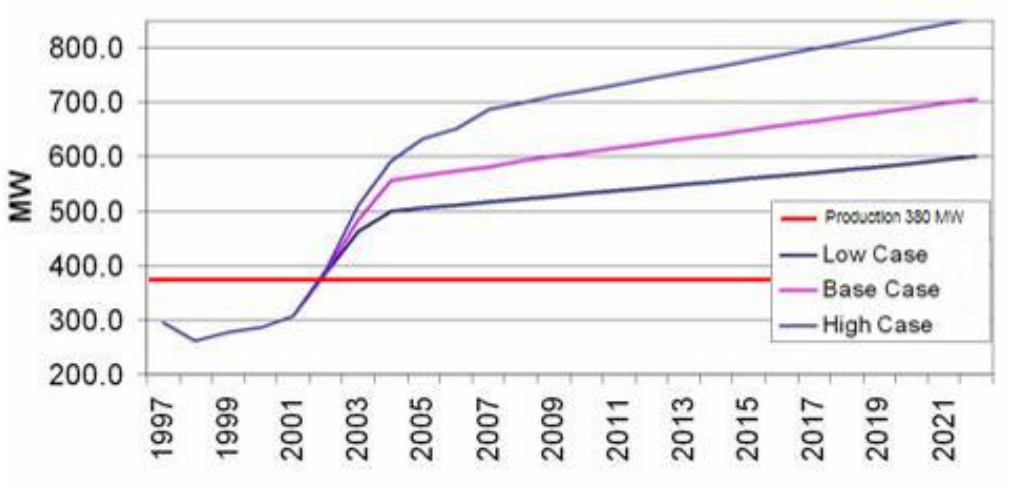

Figure 5: Namibia's Predicted Power Consumption

(NamPower, 2008)

Namibia is currently working on small-scale projects that will help alleviate the power crisis (Weidlich, 2008). Temporary diesel generators are used, though these typically cost almost three times as much to operate as coal generation. Wind generator farms are being planned for development along the coast. Unfortunately, delivering this power to interior areas still remains a costly problem. Additionally, by 2009, a N$3 billion power sharing grid with Zambia, Zimbabwe, and Botswana will help all four nations share a more reliable power supply.

Despite these developments, rural areas are often many kilometers from the power grid. The three major power plants are in relatively large urban areas. Most of the power that rural areas receive is from small solar generators. The development of biomass power plants in these rural areas will not only create more power for the entire country, but will also expand the electrical grid to areas that could truly benefit from a constant power source.

The CBEND (Combating Bush Encroachment for Namibia's Development) project hopes to install a bush-to-electricity power plant in Namibia to utilize this otherwise useless invader; the hope is to develop the country's first independent power producer. A biomass plant in Namibia would help expand the national

electricity grid, bring energy to more of the population, and create job opportunities. Removing the invasive bush would allow the expansion of cattle grazing areas, encourage agriculture, and bring back the shrinking habitat for wildlife. Members of CBEND will be focusing on the structure, management, operation, and purchase of a wood gasifier. They ultimately will advise small companies that will be harvesting the invasive bush, which will to be sold to a gasification plant and turned into electricity to be added the national grid.

2.4 Housing Conditions in Namibia

Housing conditions in rural Namibia are often poor, attributed to the lack of employment, low income, and the migratory trends to urban areas (Namibian Government, 2002). In urban areas, over 20% of households reside in improvised housing (shacks) or traditional dwellings made from organic materials. In comparison, 66% of the rural population live in traditional dwellings, most of which are without basic amenities such as water and electricity. These housing statistics are displayed in Figure 6.

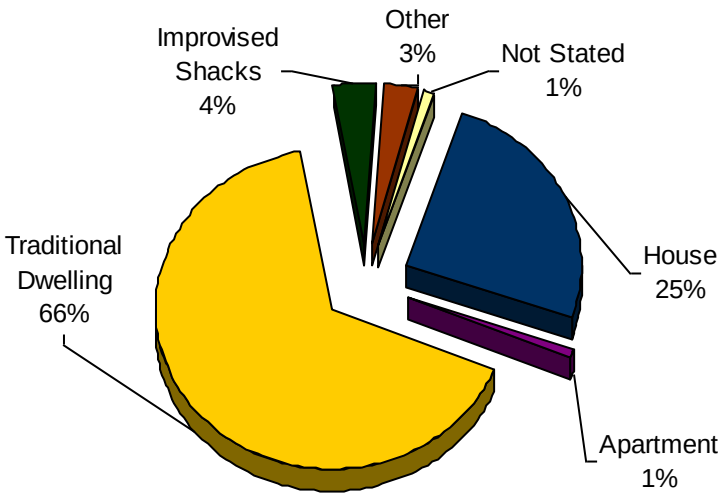

Figure 6: Rural Namibia Housing Types

(Namibian Government, 2002)

Housing construction materials are also more primitive in the rural areas. In urban Namibia, the predominant roofing material is corrugated iron, which is used extensively in improvised housing. In rural areas, thatch and grass are most commonly used for roofing. Similarly, homes in rural areas utilize sand and mud for flooring, and other organic materials, such as compost and manure, for the walls. Figure 7 shows examples of housing conditions in the informal settlement of Katutura, outside of Windhoek. Temperatures in these shacks may reach as high as 40°C in the summer heat, creating unsafe living conditions.

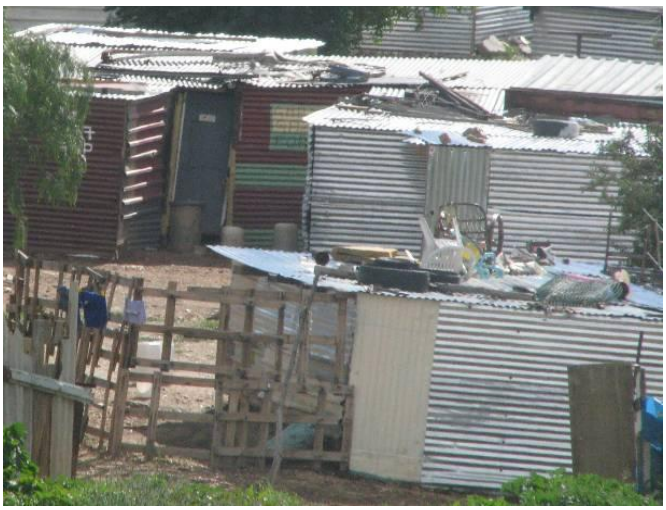

Figure 7: Improvised Shacks in Katutura, outside of Windhoek

Electricity and water availability is also less plentiful in rural areas. The predominant source of energy for cooking in these rural homes is wood and charcoal, accounting for 90% of the fuel used, whereas electricity is used in less than 5% of households for cooking. Similarly, electricity for lighting is found in only 10% of rural households. In these homes, paraffin (kerosene), candles, and wood are the primary sources of lighting. Electrical heating is almost nonexistent in rural areas, where 60% of households rely on wood and charcoal, and 30% have no source of heating. Additionally, in rural areas 20% of households have no access to safe

drinking water, and more than a quarter of the rural population must travel at least half a kilometer to acquire water.

Creating an appropriate accommodation for bush harvesting workers will increase the desirability of this occupation. It is important to keep in mind the cultural acceptance of housing, while at the same time improving upon previous housing that workers may be accustomed to. The creation of adequate housing will promote worker health, safety, and satisfaction.

2.5 Worker Accommodation

Many types of jobs, such as those in construction, agriculture, and livestock herding, require workers to spend many nights away from their homes. Proper living quarters then become a necessity. Places such as the United Kingdom (Simpson, 2008); Queensland, Australia (Queensland Development Code, 2003); and Canada (British Columbia Government, 1996) have provided temporary accommodation for workers. Important factors were considered such as suitable location, sleeping quarters, water supplies, bathing facilities, as well as food preparation and storage. In Whistler, British Columbia, Canada, the Resort Municipality of Whistler Act's Worker's Accommodation Regulation (British Columbia Government, 1996) states that housing must be provided for agriculture and construction workers.

In Leeds, United Kingdom, a large scale site accommodation was built for a group of 300 construction workers by the Konstructa Hire Company (Simpson, 2008). They constructed 12 steel, anti-vandal site buildings that incorporated extensive security measures. The buildings were built in three weeks, and were double stacked to create six, two story buildings. They included reception, offices, meeting rooms, toilets, and a canteen.

In Australia, the Rural Workers Accommodation Act was enacted in 1969 (Australian Government, 2006). This act states that agricultural and pastoral workers must have accommodation, free of charge, if they are required to live on site for more than 24 hours. Similarly, the Queensland Development Code of 2003 provides for pastoral workers' accommodation. This act specifies the necessities for a workers' on-site accommodation. The workers' accommodation must be "suitably located to provide an adequate standard of health and amenity for the workers" (Queensland Government, 2003, p. 4). The living space must be a certain distance away from the work area and any other structure having to do with the area of work.

The Queensland Development Code (Queensland Government, 2003) detailed specifications for the sleeping area: the floor area must be at least 3.15m^2 to 5.6m^2 for each worker, with a length of 3m x 2.1m. The area must be lit and have proper ventilation. It was also stressed that sleeping areas must be separated for men and women. If necessary, partitions from ceiling to floor should be installed to allow for privacy. The Queensland Development Code also stated that a sufficient water supply must be provided, at least eight liters of potable water per person per day is necessary. The Queensland provisions require one shower facility for every six workers, with a minimum floor area of 900mm x 900mm. Again, to ensure privacy, a curtain or screen should be used. If laundry facilities are to be provided, one tub for every three workers is necessary.

A store area for food and supplies is also a very important feature for any living area. However, as in the case at Australia's Nomads Cryon, it may also be required for the employees to bring their own food (Nomads Cryon, 2004). Other important features are lighting (Queensland Government, 2003), ventilation, shelving, a locking door, and insulated walls.

In Turner, Maine, (Fernandez, Fernandez, and Gayle, 1995) there is a very dense population of Hispanic migrant workers. These families live in trailers with two or three other three-person families in each. Additionally, one trailer houses 16 single men. The trailers were described as follows (Fernandez, Fernandez, and Gayle, 1995, Migrant Workers):

> The trailers we visited were very clean and neat, but the pest infestation and many safety hazards were obvious. Most trailers had broken windows and doors, leaking plumbing, defective or missing smoke detectors, holes in walls and flooring, exposed electrical wiring, frayed and torn furnishings, cockroach and rat infestation, and appliances in disrepair.

With so many people living together, it is very important to maintain hygienic conditions at all times (Queensland Government, 2003). The facilities should be maintained so as not to fall into disrepair. Additionally, proper sanitation practices should be followed, and residents should be educated on first aid.

2.6 The Aftercare of Harvested Land

Control of invasive plants has been a problem worldwide. While temporary eradication is often achieved, a proper method of aftercare must be implemented in order to prevent the return of unwanted plants. Several methods have been used, including chemical and biological control, browsers, fire, and the seeding of new plant species.

Chemical Control

An example of successful chemical control is the use of herbicides on the invasive Japanese barberry in northeastern United States. The Japanese barberry originated in Japan and was introduced to the northeastern United States in 1875 as an ornamental plant (Swearingen, 2006). It is still currently sold in nurseries across the

United States, despite its reported invasive nature. The bush is a dense, spiny shrub that grows between 0.6-2.5 meters high. The Japanese barberry persists in almost all natural habitats in the northeastern US and alters the pH, nitrogen levels, and biological activity in the soil. Additionally, it pushes out native plants and reduces wildlife habitats. White-tailed deer prefer to eat native plants rather than the Japanese barberry, giving the barberry a clear competitive advantage.

Control of the Japanese barberry is considered very important given the current lack of knowledge and its widespread use as an ornamental plant (Swearingen, 2006). The barberry has high germination and seed production rates. It can also resprout from root fragments, necessitating removal when trying to control its growth.

It was found that the most successful aftercare method for the Japanese barberry was the application of a triclopyr solution, Garlon, to the stumps after cutting down the bushes (Swearingen, 2006). This chemical prevents resprouting; however, because it is a non-specific herbicide, it needs to be controlled extremely carefully so as not to harm surrounding non-invasive plants

Browsers

Another aftercare treatment used to control resprouting of invasive plants is the use of browsers, such as goats. Previously, goats have successfully been used to control the spread of the Scotch broom species. This bush was first introduced to the continent of North America as a garden ornamental by early settlers of the Pacific Coast (Parker, 1998). From there, it spread far up into British Columbia and down into California. Currently it is rapidly moving farther into Oregon and Washington. The Scotch broom aggressively pushes out desirable native plants such as forbs,

grasses, and young trees. Therefore, it is a threat to the native animals that depend on these native plants.

Several different controls have been implemented against the Scotch broom with varying degrees of success (Parker, 1998). Using goats as a control for resprouting was found to be incredibly successful. After the bushes were initially killed using herbicides and mechanical means, the goats were allowed to graze in the recently cleared area to prevent the spread of any remaining invasive plants as well as any new sprouts. The goats were penned in using an electric fence, so that they were limited to a designated area. After the goats had consumed all the unwanted vegetation in that area, they were moved to the next area to continue the control. The use of goats had no ill effects on the surrounding vegetation, and given time, they could control a small patch of Scotch broom if it was not too tall.

Biological Control

An example of aftercare using biological control was also applied to the Scotch broom. A moth, *Leucoptera spartifoliella,* was introduced in the 1970s to destroy the remaining bush after initial eradication (Parker, 1998). However, this moth was heavily parasitic to other plants and largely ineffective in controlling the Scotch broom. A seed weevil, *Apion fuscirostre*, was also introduced in 1983 to control the plant. While the larvae did consume the seeds and assist in slowing their spread, they did not help to control the already existing plants.

Similar types of biological control of the invasive bush have also been attempted in Namibia. However, the Namibian species of bush share many of the same qualities as the Scotch broom and Japanese barberry; these hardy plants are effectively able to survive harsh conditions such as drought (de Klerk, 2004). They

also have a large seed production, which aids in their spread. Seed weevils, similar to those introduced to control Scotch broom in Oregon, were introduced in South Africa and Namibia in hopes that they would have a significant effect on the spread of the bush (Bethune, 2004). Their introduction allowed for almost 99% of the seeds to be destroyed. However, because of their aggressive seed production, the bushes were still able to survive and proliferate.

Fire

For millennia, wildfires have been crucial in maintaining the balance in ecosystems (Zouhar, 2007). Fire destroys weeds and overgrowth, adds nutrients to soil, and often encourages germination. Prescribed burning is currently considered an environmentally friendly alternative to chemical herbicides. However, there are many concerns with implementing fire as a plant control mechanism.

Harold Wiedemann (2005) identified a few specific concerns regarding prescribed burning, such as unwarranted damage to healthy plant species and erosion after the burn. Zouhar et. al. (2007) also recognized the potential risk to human life and property damage from fire. Another crucial issue with prescribed burning is the unpredictable nature of plants' reactions. Because burning may also stimulate germination, controlled burning to remove invasive plants may actually result in damaging healthy plants and encouraging invasive plants to flourish. Additionally, controlled fires do not destroy much of the plant below the ground's surface (Rice, 2005). With the invasive plants in Namibia, the extensive root system present may not be thoroughly destroyed through burning, and regrowth would be probable. A photo displaying the vast root system of a Namibian bush is shown in Figure 8. Lastly, fires create additional environmental concerns due to the generation of smoke.

In the US, prescribed burning is often banned in the spring time because of the nesting of local birds.

Figure 8: Photo of the Invasive Bush Species Vast Root System

(R. Schultz, 2008)

Planting of Non-Invasive Plants

The desire to reintroduce native species into an area taken over by invasive plants is a desirable goal around the world. In Seattle, Washington, USA, the Frink Park was overtaken by invasive weeds and shrubs (Bergendorf *et. al.*, 2001). A team of workers removed all of the invasive species and replanted native shrubs and groundcover. These bushes helped alleviate erosion problems commonly found with the removal of plants. The native plants also helped to bring back many native animals that left the area when it was overtaken with the invasive species. It was necessary for a team of workers to water the newly planted species during the first growing season, to ensure the success of the aftercare process.

2.7 Summary

Among the many obstacles to Namibia's development, bush encroachment, an inadequate power supply, and unemployment stand out as especially challenging. Although people tend to look to urban areas to provide employment opportunities, it is not realistic for a few cities to provide jobs to everyone, especially when two-thirds of the Namibian population lives in rural areas. Therefore, greater efforts need to be made to provide rural job opportunities. Regarding energy, Namibia's dependence on South Africa for power generation is not a realistic long-term solution. Although efforts such as wind farming and diesel generators have been made, Namibia could greatly benefit from using the encroaching bush, an overabundant resource, to feed the power grid. Indeed, the invasive bush has been very problematic to Namibian farmers, who rely on grazing lands to raise cattle, one of Namibia's most important resources. The CBEND project aims to address these three issues by creating a bush-to-electricity industry to provide rural jobs, restore encroached areas to productive grazing land, and use an otherwise harmful pest to provide power to an energy poor country.

3.0 Methodology

This project focused on a subset of the CBEND project, to ensure the sustainability of the bush harvesting industry. Our goal was to contribute to the sustainability of a bush harvesting system through identifying ways to make bush harvesting work an attractive occupation and by recommending an appropriate aftercare technique to manage land after bush removal. Through designing an accommodation trailer, we hoped to increase the desirability of the occupation by providing attractive housing. Additionally, aftercare methods were determined in order to ensure sustainability of the land and the harvesting system. Our objectives were addressed by establishing the following steps:

- Develop a list of necessary inclusions for an accommodation trailer
- Determine cost-effective and energy efficient technologies to include in the accommodation trailer to provide power, entertainment, and safety
- Create the technical specifications and drawings for an accommodation trailer
- Create a spreadsheet tool to allow flexibility in the trailer design, as well as to allow for future applications or modifications
- Identify an appropriate chipping machine
- Create Excel documents to organize aftercare information for future reference
- Provide recommendations for short-, mid-, and long-term aftercare methods.

The trailer was designed in order to retain trained workers by providing attractive accommodations. It was also crucial for an aftercare system to be implemented that encourages a healthy ecosystem and sustainability of the industry through meeting the desires of local farmers. These objectives are essential to creating a sustainable industry as outlined in CBEND. We utilized a number of methodologies

including informal interviews and cost-benefit analyses to attain these objectives. These methods allowed us to satisfy the parameters laid out by our sponsor, such as budget constraints and environmental concerns.

3.1 Technology Selection

In order to successfully implement our accommodation trailer design into a working bush harvesting cycle, our sponsors requested for us to select a wood chipper and a towing vehicle to pull both the chipper and trailer.

Chipper and Towing Vehicle Selection

By reviewing the documentation provided by the Research Centre of Finland (Leinonen, 2007), we were able to gather data on the chipping needs of a Namibian bush harvesting system. We consulted with chipping distributors, such as Tree-Cycle, for recommendations on different machines.

In order to determine the towing vehicle, we needed to calculate the amount of cargo the vehicle would be delivering. Bezêr Manufacturing was able to provide the load based on the weight of the accommodation trailer. A chipper distributor also provided us with the weight of the chipper machine. Past literature and discussion with our sponsors determined the mass of harvested material the truck would be carrying. The load tonnage then became one of the requirements for truck selection, along with cost and durability.

3.2 Design of the Accommodation Trailer

To determine the basic requirements that needed to be included in a trailer design, we first interviewed Robert Schultz and Claus Hager of the DRFN. We created a preliminary design based on these initial requirements. We also interviewed

Lucky Ganeb and Alex Moses, of the DRFN, who provided suggestions for non-essential items that would help make the accommodations more desirable. Ganeb and Moses, as Namibian citizens, were able to give insight into the importance of these items because they are personally aware of the needs, desires, and values of rural Namibians.

Concurrent with the research conducted on amenities, we also needed to determine trailer dimensions. Initial design specifications provided by our sponsors allowed for us to estimate the dimensions. Then, as we finalized the amenities that could be included in the trailer, we calculated exact dimensions. Through consultation with Bezêr Trailer Manufacturer in Windhoek, we established the acceptable and legal dimension constraints of the trailer. Bezêr's extensive work on trailer design provided further knowledge on what dimensions would be needed to meet our requirements.

We gathered information on products that could be included in the trailer design by visiting local vendors, as well as by contacting suppliers via the internet and phone. We focused on energy efficient technologies, since the trailer will be using a solar power source. Specifically, we contacted DB Electric to obtain prices and availability on energy efficient light bulbs. Solar Age Namibia, a local solar company that has been used in the past for energy efficient trailers at the DRFN, provided us with a detailed list of batteries and solar panels required to meet our power budget. Prices for other amenities, such as television sets, were gathered by contacting several local suppliers for prices and availability.

We also contacted Dr. Andreas Wienecke, a sanitation expert at the Habitat Research Development Centre (HRDC). Dr. Wienecke provided information on innovative, portable toilets. Because the trailer needed to be a desirable

accommodation, alternative toilet ideas were considered advantageous, especially since traditional portable toilet facilities require more space and money than we have a budget for.

We established food and water requirements through interviews with our sponsors. To establish proper storage space requirements, we determined the volume of water and food necessary for the workers.

Weekly meetings with our sponsors, Robert Schultz and Claus Hager, provided us with continued input into the design progress. This ensured that the design remained within their specifications. We gave a formal presentation of the trailer design to Dr. Detlof von Oertzen, the executive director of the DRFN, and other DRFN towards the end of the design process to obtain professional suggestions. These led to redesigns of the trailer to allow for financial accessibility.

All relevant trailer information was organized into an electronic database. Additionally, we determined that it was necessary to create a dynamic spreadsheet tool to allow future changes to be made to the design. Using online tutorials and previous Excel documents, we were able to design an effective spreadsheet.

3.3 Aftercare

Management of bush encroachment has been an ongoing challenge in Namibia, and many attempts to control it have been implemented. By gathering information on these past attempts we were able to determine which methods of aftercare needed to be explored further, and which have been unsuccessful. Additionally, as a main focus of the CBEND project is creating rural employment opportunities, we investigated aftercare methods that would allow for further income generation for the harvesting workers.

Informal interviews with our sponsors, Robert Schultz and Claus Hager, provided us with many suggestions for aftercare methods as well as gave information regarding the desires of farmers in Namibia. Different aftercare options were researched in depth with constant feedback from our sponsors. We researched biomass management options around the world and in Namibia to identify a list of potential plants that thrive in low rainfall environments, are fast growing, do not contain thorns, and grow well in the invasive bush area. It was hoped that this research would find a replacement biofuel source other than the invasive bush.

To gather further information on the subject, we contacted experts in Namibia and worldwide. We set up a focus group with several professors at the Polytechnic of Namibia in order to share and develop ideas as a group. Experts in Namibia were especially helpful since many of them have already implemented aftercare programs similar to those we were researching and therefore could provide the results of their research. One of the attendees, Dave Joubert, had written a dissertation on bush encroachment in Namibia, which was particularly useful. He and another attendee, Ibo Zimmermann, also had created a website that provides suggestions for combating the bush encroachment problem in various areas, which helped provide suggestions for short-term solutions.

We interviewed Mr. Nico de Klerk, a longstanding scholar of the bush encroachment problem in Namibia, to obtain his expert opinions on aftercare methods, particularly regarding short- and mid-term solutions. To acquire additional opinions on herbicide use, we contacted Professor Klaus Kellner, an herbicide expert from North-West University in South Africa.

The aftercare process was incorporated into the design of the trailer, in order to allow for proper storage area for the aftercare equipment. We were able to develop

recommendations for a three-step solution as well as creating an Excel spreadsheet containing all information gathered on the aftercare solutions. Furthermore, an aftercare fact sheet was created with information on the selected aftercare recommendations for more concise guidance. This fact sheet is provided in Appendix L.

4.0 Results and Analysis

To meet our goal of improving bush harvesting job desirability, we developed several accommodation trailer designs. By analyzing the relative benefits and disadvantages, we were able to select one recommendation. Additionally, we created a user friendly dynamic costing tool with Microsoft Office Excel to assist in further design changes.

Through our research and expert interviews, we compiled a list of land aftercare methods, outlining the effectiveness and concerns associated with each. Through careful analysis we were able to recommend one aftercare solution as the most appropriate for Namibian farmers.

4.1 Trailer Design Results and Discussion

In Namibia, the majority of field workers are housed in tents during the week. These tents do not provide entertainment, protection from the weather, and are considered temporary housing. In order to retain trained workers for bush harvesting, we designed accommodation trailers that would provide workers with beds, television access, refrigeration, and storage space. Through creating more permanent housing opportunities, it is hoped that the desirability of the occupation will rise, therefore increasing worker retention rates.

We developed trailer designs based on input from our sponsors, other DRFN employees, background research, as well as input from Bezêr and Solar Age, the two companies which will be manufacturing the trailer and installing a solar array system. By analyzing the different ideas provided by these sources, we finalized several trailer designs and identified one as the most appropriate solution for bush harvesting.

While only one design was recommended, each trailer has potential for use in various applications.

4.1.1 Amenities Determination

To determine the necessary amenities to include in the trailer design, we interviewed Lucky Ganeb and Alex Moses, two Namibian residents. They provided many suggestions for amenities to include relating to entertainment, sanitation, energy efficiency, and cooking.

Entertainment

Ganeb and Moses suggested the inclusion of entertainment, such as a radio, CD player, or PC, while Robert Schultz of the DRFN suggested a television with DVD player. Entertainment would increase the desirability of the job while boosting morale. The low-stress atmosphere resulting from entertainment will hopefully help to keep good interpersonal worker relationships, contributing significantly to a healthy work environment.

Toilet Options

Through our interview, we also learned that having access to a toilet near the trailer was a necessity in order to ensure job desirability as well as to avoid snakes and other dangerous animals that are commonly found at night. We consulted Dr. Andreas Wienecke, a sanitation expert at the Habitat Research Development Centre (HRDC), on ideas for a mobile toilet system. In our informal interview, he presented options for mobile, clean, dry toilets. Two options that might work best in a mobile environment were the UDS (Urine Diversion System), and the pit toilet. While the UDS separates solids and liquids, collecting solid waste in a biodegradable bag, the

pit toilet simply consists of a hole in the ground and a portable plastic toilet above it. The relative advantages of each toilet are listed in Table 1. Because of the high cost of biodegradable bags, and the ease of implementation of the pit toilet, we decided to go with the simpler option.

Table 1: Pit vs. UDS Toilet

Toilet Type	Advantages	Disadvantages
Pit Toilet	• Cheap • Lightweight • Small	• Need to dig pit • Possibility of Odors • Less sanitary
UDS Toilet	• No Odors • No Set-up	• Requires Bio-Degradable Bags (must be imported) • Larger than Pit Toilet

Energy Efficiency

Another important consideration offered by Ganeb and Moses was the use of energy efficient technology, such as the wind turbine, wood efficient stove, and solar box cooker, in order to meet a low power budget. Following up on this, we consulted with DB Electric, an electronics store in Windhoek, to compile a list of energy efficient and traditional light bulbs. These options are summarized in Table 2.

Table 2: Lighting Options

Item	Cost per Item (N$)	Power Requirements
Eurolux 13W Bulb (EE)	$28.00	13 W
Eurolux 18W Bulb (EE)	$50.00	18 W
Osram 14W Bulb (EE)	$19.50	14W
Eurolux 45W Bulb	$240.00	45W
Eurolux 85W Bulb	$263.00	85W
Major tech Work light, 2x26W	$360.00	2x 26W

Ganeb and Moses also provided options for energy-efficient cooking. Figure 9 shows the Vesto wood efficient stove.

Figure 9: Vesto Stove, a Wood-Efficient Stove

(New Dawn Engineering)

4.1.2 Trailer Specifications

Based on our amenities research, we designed an 8 person accommodation trailer. After feedback from DRFN executives, we developed three additional designs: the 4 person open air, 4 person partitioned, and the storage trailer. Each of these designs is discussed below, with Table 3 summarizing the advantages and disadvantages of each. Additionally, technical drawings of each design may be found in Appendix C. It should be noted that the final costs of the trailer are current estimates from the original quotation received from Bezêr, and we recommend to the DRFN to follow up with the manufacturing company to receive more accurate quotations for these configurations.

Table 3: Advantages and Disadvantages of Different Trailer Designs

Design	*Advantages*	*Disadvantages*	*Cost ($N)*	*Daily Energy Consumption*	*Peak Power*
8 Person	• Inside Living space	• Not accessible to SMEs	N$260,000	3.09 kWh	951 W
4 Person	• More accessible to SMEs • Inside living space	• Greater Per Man Cost	N$210,000	2.93 kWh	878 W
Storage Trailer(Custom)	• Cheapest Design • Custom design	• No inside living space	N$167,000	2.87 kWh	865 W
Storage Trailer (Standard)	• Cheaper and quicker production	• Not customizable	N$154,000	2.87 kWh	865 W

8-Person, Open Space Trailer Design

This trailer design incorporates sleeping accommodation for eight harvesting workers along with daily amenities that allow for bathing and cooking. The trailer is 5.3 meters long and 2.3 meters wide, with additional storage space over the trailer hitch. The height of the trailer is 2.4 meters, and the floor to ceiling height inside is 2.0 meters. The interior of the trailer is not partitioned, allowing for adequate air circulation, walking space and flexibility in the utilization of this space. Additionally, next to each bed is an 80cm by 20cm window to allow air flow in the trailer. The slender design of the windows increases security, since they are too small for criminals to break and enter. This design features four permanent bunk beds in the front half and four foldable bunk beds in the rear. The advantage to the permanent bunk beds is the added storage capacity underneath, while the foldable beds allow for workspace inside the trailer. In the rear of the trailer, the door folds downwards to act as a ramp, eliminating the need for stairs.

Inside the trailer is storage space for items sensitive to the environment. Each worker has access to a private storage locker that holds approximately 28 liters.

Cabinets are located towards the center of the trailer and are used for food storage as well as electronic control components. The design also includes a large, energy efficient 225 liter chest freezer.

One major characteristic of the 8 person accommodation trailer design is the utilization of exterior space. Ample storage is located below the floor, as well as over the trailer hitch. The partitioned storage space allows for the separation of possibly toxic herbicides from food preparation equipment, yet the shelving is adjustable to allow for flexibility in storage. Attached to the external wall of the trailer is a large table, which folds down to provide work space a table for eating. Additionally, a fold-up awning is located above the table, providing shade during the day. On the opposite side of the trailer, a shower curtain folds out of the side to provide privacy while using the gravity-fed shower. Solar panels are located on the roof of the trailer to generate power.

After presenting this trailer design to DRFN employees, the largest concern was that small and medium enterprises (SMEs) may not see the benefit in spending an additional large amount of capital on worker accommodations. They expressed concern that SMEs would be forced to reduce wages to accommodate better living conditions for workers. Given the choice, they argued, workers would rather receive higher wages to support their families than nicer accommodations.

4 Person, Open Space Trailer Design

Robert Schultz and the DRFN suggested a less expensive 4 person trailer option, so as to be more affordable SMEs. This trailer design is very similar to the 8 person trailer, but much shorter. The trailer is designed to accommodate only four people, though the included amenities are the same. The trailer is 3.3 meters long,

with extra storage space located over the trailer hitch, 2.3 meters wide, and 2.4 meters high, excluding the wheel height. Similar to the 8 person design, the interior floor to ceiling height is 2 meters, where the remaining space below the floor is dedicated to storage. The layout of the trailer is also similar to the 8 person counterpart, although the four foldable beds and workspace in the rear of the trailer are omitted. However, the interior storage space and chest freezer remain. Additionally, the exterior components are similar, though the solar power system is smaller due to the lower power demands.

Even though the trailer is reduced in size, it should be noted that the amount of area available to each worker is larger than that of the 8 person trailer. However, since items such as the chest freezer and television remain, with half the amount of people, the cost per worker of the trailer is higher.

4 Person, Partitioned Rooms Trailer Design

Another concern brought to our attention from the design review was that of personal space, as these harvesters would be working and sleeping alongside each other for extended periods of time. Therefore, we considered a partitioned trailer design, where each worker would sleep in his individual room. However, after preliminary design sketches, we determined that the partitioned rooms were too small to be comfortable. Each room is only 1.2 meters wide, enough space for a bed and a small aisle.

Because this trailer is comparable in size to the 8 person design, the per person cost is nearly double that of the 8 person trailer. Due to the associated costs and tight space, we determined that this design was unfeasible and unrealistic. Robert Schultz agreed that although the partitioned space would allow for additional privacy, the

tight compartments would not be attractive to the harvesting workers. Due to these limitations, we did not look into this design further.

Storage Trailer Design

Because of concerns involving SMEs and their desire or ability to purchase a large trailer, we decided to create a trailer design that was less expensive than previous models, yet was still able to provide some basic amenities. The large storage trailer was designed to supplement the current tent accommodations by providing freezer space, power, and dry storage space for food and personal items.

The resulting trailer is 1.5 meters long, with additional storage space over the trailer hitch, 1.2 meters wide, and 1.2 meters high, excluding wheel height. The included chest freezer allows for food storage, and is on a rolling platform to allow access from outside of the trailer, creating storage space above the freezer. Similarly, batteries for power storage are located over the axle, and slide out for access. The remaining trailer space is devoted to storage for equipment, food, and items such as chairs. The equipment is separated on one half of the trailer to prevent possible contamination of food and personal items.

In addition to the custom storage trailer manufactured by Bezêr, we also discussed the possibility of a standard storage trailer, manufactured by a South African company, Venter. The pre-fabricated trailers provide SMEs with a cheap and available solution for storage. Additionally, many models already exist on the market to fit various needs. We specifically looked into the Hawker trailer. This trailer is 2.13 meters long, 1.53 meters wide, and 2.1 meters high. This design allows for adequate storage space, including space for a chest freezer. However, custom work

may be required to install shelving, a shade awning, and a work table. Additionally, a solar power system would need to be installed.

Although the storage trailers will not provide sleeping quarters inside, it is still an important design for better accommodating rural workers. Currently, the largest qualm with residing in tents is the lack of provisions. By providing workers with refrigeration, entertainment, and electricity, it will lessen the burden of living in the bush for extended periods of time. Though sleeping inside a trailer may be the ideal solution, smaller storage trailers would still be invaluable to workers, as they would provide amenities the workers will need. These storage trailers may also be implemented as a starting point to improving worker conditions, with the eventual hope of implementing larger accommodation trailers on a wide scale.

4.1.3 Bezêr Manufacturing

Bezêr, a trailer manufacturing company in Windhoek, provided us with a base quotation for the original 8 person trailer. This price included the manufacturing, beds, double axle design, solar power system, trailer hitch, and air brakes. Including 15% VAT, the cost of the trailer was quoted at N$241,500.

After designing three possible trailers, we formally requested a quotation on each design, itemized in order to allow for future changes. In this request, we provided a thorough breakdown of each component for the three different designs. Unfortunately, Bezêr Manufacturing did not return a quotation in time for discussion in this report. We recommend that the DRFN acquires the quotations for accurate figures.

4.1.4 Solar Age

Solar Age Namibia provided us with recommendations on energy efficient refrigeration as well as power generation equipment. After selecting the features to be included in the original 8 person trailer, we determined that 5.8 kWh of energy was necessary. Solar Age reported that for this power demand, 14 solar panels were needed, with each panel being 1.4 x 0.64 meters.

After reanalyzing the power consumption of the trailer designs, we scaled down the daily energy demands for each trailer: the 8 person required 3.1 kWh, and the 4 person required 2.9 kWh. From these energy demands, we contacted Solar Age to request new quotations on these systems. Unfortunately, Solar Age did not return quotations to us in a timely manner; we again recommend to the DRFN to follow up with Solar Age to receive the updated quotations.

4.2 Trailer Selection

Although each of the trailer designs has its benefits, not all are applicable for bush harvesting. Specifically, since the harvesting teams will consist of eight laborers, it would be more cost effective to utilize an 8 person trailer, rather than the 4 person option. Additionally, farmers prefer to have hired workers to be in a central location while on their farms, rather than scattered in tents. Therefore, we recommend that the bush harvesters be housed in an 8 person trailer configuration. This would cost the SME approximately N$260,000. However, this capital will be used to treat workers more fairly, resulting in content workers, which would lead to higher productivity and worker retention. In an undesirable job such as bush harvesting, it is important to have minimal worker turnover rates in order to keep

training costs low and productivity high. The utilization of an accommodation trailer with protected sleeping quarters will increase the desirability of this occupation, as well as help ensure the sustainability of the industry. Two technical drawings of the final recommended trailer are given below in Figures 10 and 11.

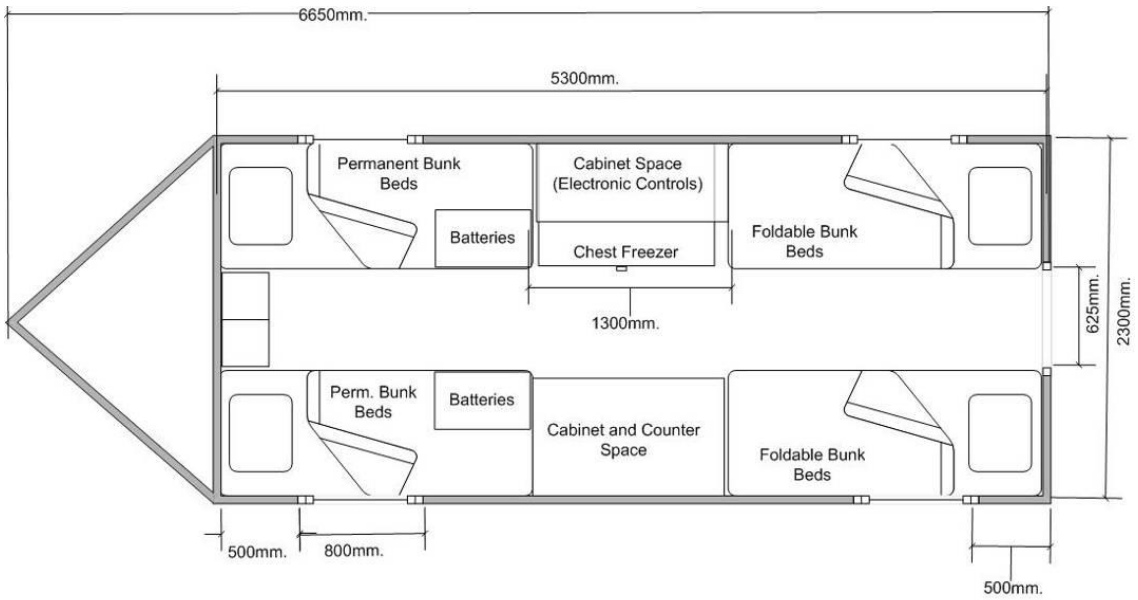

Figure 10: Top View of the Recommended Accommodation Trailer

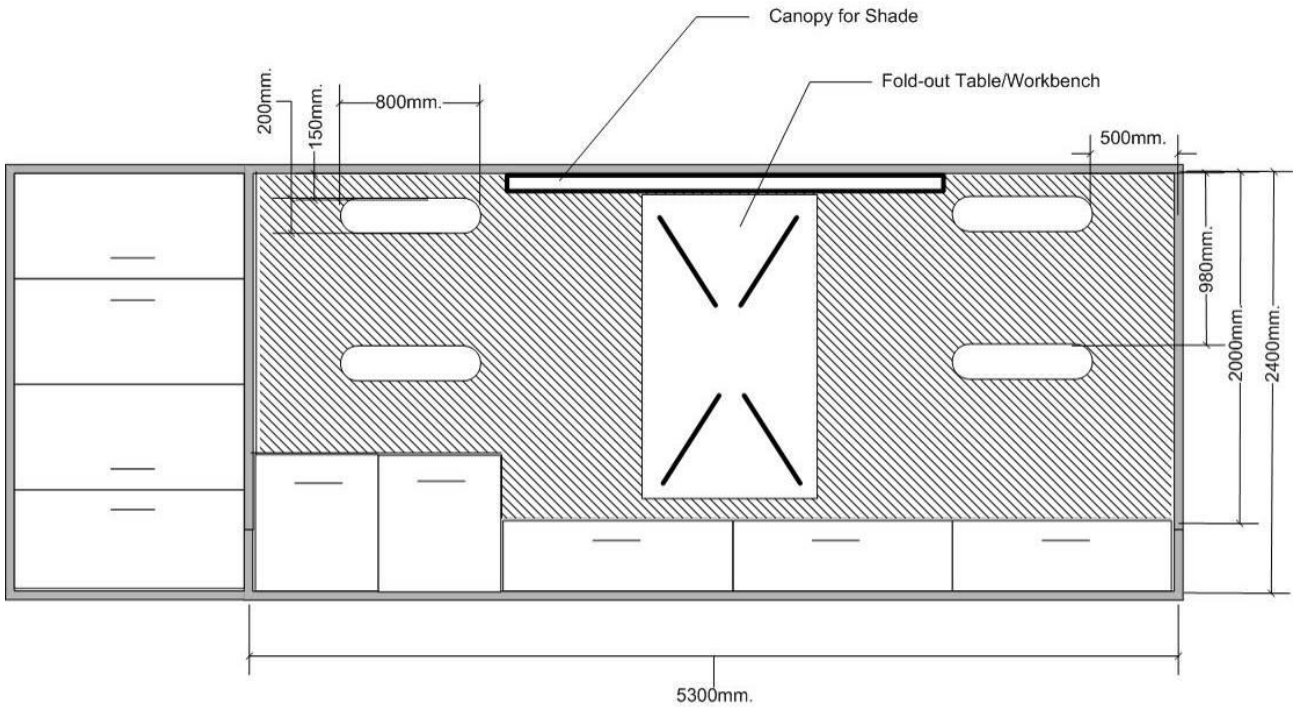

Figure 11: Side View of the Recommended Accommodation Trailer

The important advantage to the 8 person trailer design is its flexibility. The storage space was created to be flexible, to allow for numerous of uses. Additionally, the workspace inside the trailer provides shelter during poor weather. It is also important to note that the exterior of the trailer was utilized for workspace and cooking space, which allows for an overall smaller trailer, saving money.

The flexibility of all the trailer designs is an important aspect. Although we determined that the 8 person trailer was most effective for a bush harvesting team, each trailer has potential uses in other applications. While designing the trailers, we determined that it was necessary for trailers to have numerous uses, which would allow for their flexibility. This would allow SMEs to purchase accommodation trailers and use them in different applications if one endeavor fails, resulting in less capital loss. Creating a trailer design that may only be used for bush harvesting will lock SMEs into the growing industry, which may not deem financially viable.

Additionally, each trailer provides rural workers with better accommodation than current conditions. The live-in trailers provide shelter, allowing workers to abandon their tents that provide little protection from the elements. However, each trailer design, including the storage trailers, provides basic amenities that are currently lacking from tent accommodations. These trailers provide refrigeration to preserve food, electricity to provide lighting for safety, and entertainment relieving workers from the idle nature of their jobs.

Although these trailers were designed for bush harvesters working in rural areas, they will hopefully be implemented in a variety of applications. The bush harvesting system should be considered a model for all of Namibia's worker accommodation. The current tent accommodations across Namibia do not provide workers with sufficient provisions. Widespread implementation of accommodation

trailers would treat workers with greater respect, creating healthy environments and allowing for higher productivity and retention rates.

4.3 Chipper Selection

Through conversation with Shaughn Frost from Tree-Cycle, a South Africa Chipper Distributor, we were able to research various chippers for bush harvesting. He recommended that a disc style chipper be utilized, because it is more efficient at shredding harder woods (such as the invasive bush), as well as more fuel efficient than the drum style chippers. He specifically suggested the Bandit model 200XP or 250XP with Caterpillar engines. Both of these options are able to handle 300mm material, suitable for the invasive bush. The different engine options for these models are summarized in Table 4.

Table 4: Comparison of Chipper Types and Engines

Chipper Model	*Capacity*	*Hopper Dim.*	*Engine*	*Horsepower*	*Cost ($N)*
Brandit Model 200+: RCO668-247	300 mm	737 x 889 mm	Caterpillar Diesel 2054C	86 HP	$198,880.00
Brandit Model 200+: RCO670-249	300 mm	737 x 889 mm	Caterpillar Diesel 3054ET	115 HP	$211,040.00
Brandit Model 200+: RCO672-251	300 mm	737 x 889 mm	Caterpillar Diesel 3054C	130 HP	$218,640.00
Brandit Model 200+: RCO674-253	300 mm	737 x 889 mm	Caterpillar Diesel 3054E	140 HP	$220,560.00
Brandit Model 250: RCO668-247	300 mm	737 x 1626 mm	Caterpillar Diesel 2054C	86 HP	$216,320.00
Brandit Model 250: RCO670-249	300 mm	737 x 1626 mm	Caterpillar Diesel 3054ET	115 HP	$228,480.00
Brandit Model 250: RCO672-251	300 mm	737 x 1626 mm	Caterpillar Diesel 3054C	130 HP	$236,080.00
Brandit Model 250: RCO674-253	300 mm	737 x 1626 mm	Caterpillar Diesel 3054E	140 HP	$238,000.00

The key difference between the 200XP and 250XP models is the machine size. The 250XP model has a larger feed opening, increasing the overall capacity. Additionally, the feed wheel in the 250XP model is larger, further increasing the capacity. Each model also has a variety of available engines. The main difference between each engine is the output horsepower. In general, the higher the horsepower, the quicker the brush may be chipped. Each of these chippers is appropriate for bush harvesting, however more research should be conducted to determine the necessary power.

4.4 Dynamic Costing Tool

As the CBEND project progresses, equipment, worker team size, and other aspects of the bush harvesting system may change. Hence, one static recommendation for a complete trailer design may not be appropriate. To address this, we have developed an interactive spreadsheet tool that allows the user to customize the trailer design by choosing from different appliance and design options. The dynamic nature of this tool allows the DRFN, or any other organization, to adjust our final recommendation to suit future project specifications. This tool is also expandable, so that the user can add technology and appliances to suit specific needs. This allows for the design of a trailer for other applications, such as a mobile medical clinic or emergency housing during natural disasters.

The costing tool has a database containing information on each appliance. This information is organized in categories according to appliance type, in order to allow the user to easily find and expand appliance options. The tool also has an interface which allows the user to select different items from drop down menus. Based on these decisions, the tool then outputs detailed cost and power breakdowns.

Data Input

The data input screen allows the user to choose from different options. Figure 12 shows a part of the input screen which allows the user to change lighting options. Beneath each input box is a hyperlink to allow the user to easily access the database, where they may add more appliances and information for expandable use.

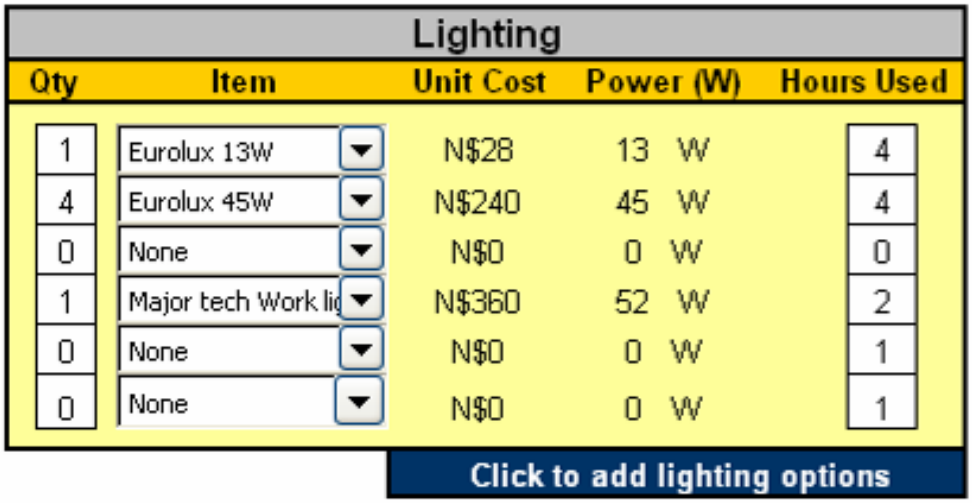

Figure 12: Lighting Input Box from Spreadsheet Tool

Scrolling down allows the user to change other options relating to water and personal storage, power tools, refrigeration, and entertainment. Any changes made can then be saved under a certain configuration name, as shown in Figure 13. This allows several different configurations to be saved and loaded for different applications.

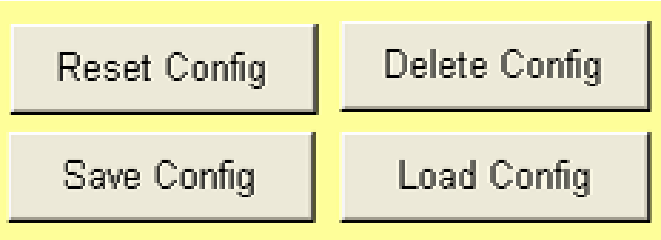

Figure 13: Save and Loading Buttons from Spreadsheet Tool

Data Output

Based upon input data, the dynamic costing tool gives a detailed breakdown of costs, as shown in Appendix D. The cost breakdown immediately shows which items have been selected and how much they cost. The user can see which categories of appliances are the most expensive, and where costs can be reduced. Additionally, the

preconfigured formatting allows the user to immediately print the cost breakdown for use at budget meetings or for filing.

Similarly, the spreadsheet generates a power breakdown, as shown in Appendix E. This breakdown details the power consumption of each device. This automatically generated list is ideal for providing information on power needs to companies such as Solar Age Namibia.

Other Features

The spreadsheet tool is designed for simple user input. The box setup allows a visual approach, contrasting from the typical spreadsheets Excel is often used for. Navigation buttons are provided on the top of each screen to allow the user to easily travel between different worksheets. Additionally, a small walkthrough tutorial exists, accessible by another button. This tutorial allows users to receive a brief introduction to each screen, and the available functionality.

Another feature is the visual display features for graphically representing data. As configurations are stored, bar graphs for cost, daily energy consumption, and peak power use are generated to compare the various configurations. This allows the user clear comparison between the different configurations. Additionally, two pie charts are configured to display the cost breakdown as well as the peak power breakdown.

4.5 Aftercare

In order to ensure the sustainability of the harvesting industry, proper harvesting techniques and aftercare methods need to be used to satisfy the farmers. If the desires of the farmer are not met, the industry will not succeed due to lack of cooperation. Furthermore, proper techniques need to be followed to promote a healthy ecosystem. If too much bush is harvested at one time, the land will lack biodiversity, which allows species to become invasive. With this in mind, we researched methods to encourage healthy harvesting of land and techniques to be implemented post-harvesting that will satisfy farmers.

Through research and interviews, we compiled many aftercare options. These options were then compared using Excel tables. After discussing these choices with experts, we selected the final techniques for recommendations.

4.5.1 Short-term options

A short-term solution would be implemented immediately after harvesting the invasive bush. This stage of the aftercare process is important for preparing the land for the implementation of long-term techniques. Furthermore, this stage would be implemented by the harvesting laborers, increasing their potential for profits.

Herbicides

Herbicides have been used for years to control invasive bush in Namibia. While this aftercare method has had varying degrees of success, it is one of the best options for a short-term solution to bush encroachment. The most commonly used herbicides in Namibia to combat the invasive bush are located in Table 5.

Table 5: Common Herbicidal Products for Bush Control in Southern Africa

(Kellner, 2008)

Chemical Trade Name	*Active ingredient*	*Active Ingredient(s)Content (pure)*	*Type of Formulation*	*Supplier/ Distributor*
Access	Picloram (potassium salt)	240 g/ l	SL	Dow AgroSciences/ Ecoguard Distributors
Bromacil G10	Bromacil	100 g/ kg	GR	Sanachem
Buschwacker	Bromacil	800 g/ kg	WP	Enviro Industries
Garlon 4	Triclopyr (butoxyl ethyl ester)	480 g/ l	EC	Dow AgroSciences/Efekto
Hyvar X	Bromacil	800 g/ kg	WP	DuPont
Hyvar XG10	Bromacil	100 g/ kg	GR	DuPont
Molopo(old Graslan 20P/ Grazer GG)	Tebuthiuron	200 g/ kg	GG	Sanachem
Molopo SC (old Reclaim/ Grazer SC)	Tebuthiuron	500 g/ l	SC	Sanachem
Savana 500 SC	Bromacil/ Tebuthiuron	250 g/l / 250 g/l	SC	Sanachem
Tordon Super	Picloram (iso octyl ester)/ triclopyr (butoxyl ethyl ester)	120/ 240 g/ l	OL	Dow AgroSciences
Ustilan 10 GR	Ethidimuron	100 g/ kg	GR	Bayer
Ustilan 20 GG	Ethidimuron	200 g/ kg	GG	Bayer
Ustilan 70 WP	Ethidimuron	700 g/ kg	WP	Bayer
Abbreviations: EC = Emulsifiable Concentrate, SC = Suspension Concentrate, SL = Soluble Concentrate, GG = Macro Granule, GR = Granule, OL = Oil Miscible Liquid, WP = Wettable Powder				

In Namibia, chemical control of the invasive bush is carried out by aerial application as well as by hand (MET, 2008). Both methods have been effective, and the method of application is generally based on the amount of area needing to be covered, funds available, and availability of a labor force. Aerial applications tend to

be less labor intensive, while more expensive than hand spraying; however, when treating large amounts of land, aerial application can be the more cost effective option. This research also determined that using herbicides as an aftercare method increased net income of livestock farmers by more than 700% in some areas.

It is estimated that the density of grasses in an area after herbicidal aftercare will increase by 200-400% (MET, 2008). This translates into approximately a N$56 financial gain per hectare after this aftercare treatment has been applied. Furthermore, using herbicidal treatment is relatively fast and can be selective, if applied by hand. Herbicides can remain effective at suppressing seedling regeneration for up to five years.

Dave Joubert, a professor in the Department of Nature Conservation at the Polytechnic of Namibia, created a bush management website that provides detailed suggestions for specific bush encroachment situations (Joubert et. al., 2007). This website can be used by answering questions about the encroachment problem in a specific area. The design of the questionnaire is laid out in a flow chart in Appendix O. After completing this questionnaire for the northern region, the area targeted for bush harvesting by the DRFN, three herbicide solutions were suggested: Molopo SC (spray application herbicide), Molopo GG (aerial application herbicide), and Savanna SC (spray application herbicide). The advantage of using a handheld spray such as Molopo SC or Savanna SC is that the applier can be more selective. Additionally, Molopo SC, out of the two, is less expensive. However, if there is high clay content in the soil, Molopo SC is not as effective as Savanna SC. The use of spray application was suggested because the harvesters could easily implement it, and it is also less expensive than aerial application

Nico de Klerk, a longstanding scholar of the bush encroachment problem in Namibia, also found that herbicides are very effective in combating bush encroachment. Furthermore, an environmental impact survey was conducted by the Ministry of Environment and Tourism on herbicides used in Namibia, which concluded that there are no significant toxic residues or water and meat quality concerns (pers. com. with Nico de Klerk, March 2008). However, de Klerk did note that mid-term and long-term solutions need to be put in place as well, to ensure that regrowth will not occur.

During the focus group discussion on aftercare, the effectiveness of herbicides was analyzed. The herbicide Picloram (commercial name: Access) was suggested by Mr. Ibo Zimmermann of the Polytechnic of Namibia, and was then generally agreed upon by others in the group. Some advantages to Picloram are that it is delivered via a hand held sprayer, is applied to the stumps, and is colored, so that progress can be monitored and over application can be avoided. It has been proven to kill the majority of invasive bush species, yet does not damage surrounding vegetation (pers. com. with I. Zimmermann, April 2008). Based on these characteristics, it is believed that Picloram would be the most effective and cost efficient herbicide to be used.

There are also disadvantages to using herbicides as an aftercare treatment (MET, 2008). While herbicides are effective in killing unwanted plants, the treated plants have shown a resistance to decay and decomposition, which can hinder the growth of other plants in that area. Furthermore, herbicides must be properly stored on site, and a separate space must be made for storage if transported in the accommodation trailers.

A compilation of herbicides that we focused on during research is provided in Appendix H. By organizing the research in this manner, the benefits and

disadvantages of different herbicides are readily apparent. After analyzing the different choices and taking into consideration the different expert suggestions, we recommended Picloram as the short-term solution, due to its known success on invasive bush species and its efficient application method.

Pruning

Pruning is a method where the branches are removed from the bush, rather than harvesting the entire plant. This method prevents heavy resprouting after harvesting and eases future harvesting by encouraging the bushes to grow outward (pers. com. with Dave Joubert, March 2008). It is also important to note that the harvested branches need to be more than 2.5 cm in diameter to be useful for charcoal production, and that harvesting a thorny bush with 10 to 20 stems can be incredibly difficult. By pruning, one takes only the useful branches, leaving smaller ones to continue growing for future harvesting.

Concerns with implementing a pruning technique are that harvesters will not be properly trained or willing to implement this system. It would be beneficial for them financially to shred the whole plant during the first harvest as opposed to just a few branches. Furthermore, if only branches are shredded, there will be problems trying to meet the same quota of biomass. With these concerns in mind, we do not suggest this system as an aftercare method; however, it is recommended to research this idea further.

4.5.2 Mid-term options

Mid-term aftercare techniques occur at approximately one year after the land has initially been harvested. The focus of mid-term options is to control the unwanted regrowth of the invasive bush.

Browsers

Animals, such as goats and cattle, have been used in Namibia in an attempt to control bush encroachment (MET, 2008). It was found that goats alone decreased the bush by 70.1%, and cattle alone decreased the bush by 62.8%. However, when goats and cattle are used together, the quantity of bushes decreased by 77.8%. Since the cattle prefer to eat the grasses, the goats are forced to eat more bushes due to competition for grasses. An advantage to using only goats, however, is that grass species increase by 1.95-3.6%.

There are also disadvantages to using goats. The purchase and upkeep of goats can be expensive, and many farmers may not find the investment feasible. Nico de Klerk agreed with these sentiments, and added that while using browsers could be successful in combating the bush, goats would not be a suitable solution in the long run. While it is possible to use browsers as a bush control mechanism, a great number of goats would be needed to control the whole harvested area. The MET (2008) found that "goats can be introduced successfully to utilize and control regrowth as a follow-up to other methods like the application of herbicides, felling/stumping, and controlled or accidental fires... [however]...grazing pressure needs to be at a level where the growth is kept low" (p. 238). To keep grazing pressure high, a large amount of goats are necessary, which is costly.

It was found by the Ministry of Environment and Tourism (MET, 2008) that when given the option, few farmers use browsers because "they are difficult to manage, it is expensive (in respect of herding or fencing), and there is the constant risk of theft and predators" (p. 238). Additionally, browsers that have been feeding on bush are less valuable because their diet is not ideal for meat production. Most farmers would not want to invest in such an expensive endeavor, especially with high levels of theft and attack by predators. Due to these many negative attributes, we do not recommend browsers for use in an aftercare program.

Herbicides

Herbicides may also be used as a mid-term bush control solution. After a short-term solution has been implemented, most of the regrowth will have been prevented. However, because of the plants' vast root system or improper application, resprouting may still occur. Herbicides can then be applied to the sprouts, and regrowth of the bushes will be halted. Due to the success of Picloram on the invasive bushes, this herbicide was also chosen to be recommended as the mid-term solution.

Pruning

Pruning, by nature, is a continuous solution. If pruning was employed as a short-term solution, it would be required to continue into the mid-term time period as well. Pruning may also be used as a mid-term solution in conjunction with another short-term solution. After initial regrowth is stopped through herbicides, the remaining regrowth could then be controlled by pruning. This would keep a source of harvestable bush in the area, and would also make the bushes easier to chop down. However, it is unlikely that enough biofuel could be produced from simply pruning,

which is why this method was not recommended for implementation. More research should be done, however, to confirm this hypothesis.

Veld fires

We also considered the use of fire to control invasive bushes in Namibia. To ensure an effective burn, a minimum of 1,500 to 2,000 kg of grass per hectare is necessary (MET, 2008). However, in areas of high bush densities, these levels of grass do not exist, and therefore, veld fires should be used as a mid-term solution and not a short-term solution. Furthermore, while fires have an initial kill rate of about 90% for plants up to 2 m in height, many of the invasive bushes are taller than this. The damaged bushes will generally resprout, because their extensive root systems would not be destroyed through burning.

Another reason for implementing veld fires as a mid-term solution in conjunction with a short-term solution is that veld fires are most successful when used during the regrowth period. Fire prevents seed production, and suppresses the growth and establishment of new seedlings (MET, 2008). While veld fires are not as successful at killing fully grown trees, they have been proven effective at killing new seedlings.

Veld fires have proven successful in the past; however, there is concern that it would be difficult convincing neighbors to work together in this endeavor, and thus proper control would be difficult to attain (pers. com. with Nico de Klerk, March 2008). Without proper control of a veld fire, a dangerous situation could emerge that would damage property and wildlife habitats. Veld fires are generally considered undesirable by neighboring farms, due to the risk of spreading to their land, making persuading farmers in the area relatively difficult. In Namibia, not enough information

is available on proper fire control to provide to farmers, and there are no "fire teams" available for hire to properly implement a veld fire. Furthermore, the use of veld fires is time and season dependent. Therefore, it would be a consistently good mid-term solution, because the conditions must be ideal (pers. com. with Dave Joubert, April 2008). Due to these concerns regarding control and timing, the implementation of veld fire as a mid-term solution is not suggested for use as an aftercare solution.

4.5.3 Long-term options

Long-term options are important for ongoing sustainability of the land and the harvesting industry by meeting the desires of the farmers. The selected long-term option must also promote a healthy ecosystem. We considered several options, including: planting biofuel plants, continuing with a pruning system, and implementing a land restoration system.

Planting biofuel plants

After short and mid-term solutions have been implemented, it is hoped that a long-term solution for the harvested land can be found. This could be accomplished by planting another non-invasive species in the harvested area to replace the bush as a fuel source. This new species would then remain in that area as the sustainable source for energy, since it would not share the same undesirable characteristics as the invasive bush. Through research and communications with plant and biomass experts, we developed a list of plants that could be introduced in the harvested areas, and analyzed the options based on several characteristics. This information is located in the table in Appendix N.

Through research and communications, *Acacia senegal* showed promise as a possible solution. It is a high value cash crop for its gum production, is non-invasive,

and native to Namibia. However, there is some apprehension regarding biomass potential because the plant currently grows rather sparsely and does not have a very high frost tolerance. Due to these concerns, we recommend that a test plot be implemented to determine the success of *Acacia senegal* in harvested areas.

Digitaria eriantha also showed promise as a solution. It is a good choice for restoration and can be used as fodder (animal feed); however, concerns remain on the subject of its biomass potential. If it was not used for biomass, it would be more beneficial to have a mix of native grasses instead.

The other plants researched were ruled out as biofuel options for various reasons. These plants were either non-native, invasive, had low biomass potential, or would not grow well in the proposed area. For this reason, planting a different plant to replace the bush was not chosen as an aftercare method.

Test plots are a valid way to show whether a method is successful or not. Test plots have been created for *Acacia senegal* (pers. com. D. Joubert, April 2008), but more time is needed to discover if it is successful. However, if the test plots are successful, this aftercare method should be considered. Additionally, although a continuous supply of biomass is necessary to achieve a sustainable bush-to-electricity industry, the current quantity of invasive bush in Namibia is large enough to provide adequate power to Namibia. However, we recommend that extensive research and study be conducted to determine how many years the current invasive bush could produce power, and precisely how long it takes the invasive bush to regrow to a harvestable height.

Pruning

Due to the nature of pruning, it may also be considered as a long-term option. Instead of cutting down entire bushes at a time, only large branches would be taken and used for fuel. This would ensure that there is always a fuel source. However, the primary concern with this method is that enough biofuel will not be produced. Furthermore, this system would require harvesting teams to be closely monitored in order to make sure they are indeed pruning, as opposed to cutting down entire bushes. For these reasons, pruning was not recommended as an aftercare method.

Land restoration system

This system focuses mainly on satisfying the desires of the farmers: to have their land returned back to cattle grazing area (pers. com. with Nico de Klerk, March 2008). This desire is met through the land restoration system. To return the land to cattle grazing area, bags of native grass seeds would be provided to the farmers after harvesting is complete. Native grasses help to lower erosion problems as well as provide fodder for the cattle. After successful short- and mid-term aftercare programs, the grass will grow unhindered by the invasive bush. However, one disadvantage to this program is that it requires the farmer to spread the seed, since the grasses must be planted during the proper season. As an incentive to use the seeds, it is recommended that the entire aftercare program, including the seeds, be a required cost in addition to the basic harvesting price. Ideally, if the farmer has already bought the seeds, they would use them. Properly educating farmers about land restoration and maintaining a healthy ecosystem, through use of small education programs or pamphlets brought by the harvesters, would help to ensure the success of this system. We believe that this aftercare system is the healthiest for the land by returning it to cattle grazing.

Furthermore, while this system does not promote a continuous supply of biofuel, it is the general consensus of bush encroachment experts in Namibia that there is enough invasive bush in existence to sustain the industry. Therefore, we recommend that a land restoration system be implemented as a long-term solution.

4.5.4 Recommended Aftercare Solution

In implementing an aftercare system, it is necessary for it to be desirable to the farmer. Farmers will not be interested in buying an aftercare program unless is meets their needs. Due to this fact, the land restoration system was chosen to allow the land to be returned to cattle grazing. The land restoration system is also the most beneficial to the land because it promotes a healthy ecosystem and biodiversity. It also increases the profit yield of the land by providing additional cattle grazing area.

The land restoration system needs to be kept in mind while harvesting. During the harvesting period, at least 400-600 bushes per hectare need to be kept to maintain a healthy ecosystem (pers. com. with Nico de Klerk, March 2008). This is important to prevent erosion and promote biodiversity in the area. Therefore, restrictions on clear cutting need to be strictly enforced.

The short-term solution that would be implemented in this system would be the application of Picloram herbicide. This herbicide has proven to be the most effective in test plots and is effective on the majority of invasive bush species (pers. com. with Ibo Zimmermann, April 2008). It also requires only one dose per stump (MET, 2008). The use of Picloram would also be the mid-term solution implemented approximately one year after harvesting. This would help prevent any future regrowth.

The only concerns with using Picloram are that it is a toxic chemical, however low, and the harvesters would need to be trained on proper application and safety

measures. Important safety information and application methods can be found in Appendices I, J, and K. If proper application procedures are followed and safety measures are taken, there should be no concerns in regard to worker health or the environment. Furthermore, this program aids in creating additional employment opportunities, which is an important goal of the CBEND project. The harvesting teams would be responsible for gathering seeds from the native grasses in the fall to provide to the farmers as part of the land restoration system. This would increase the amount of work the harvesting teams are responsible for and hopefully bring them additional income.

5.0 Conclusions

We concluded that the 8 person trailer would be the ideal accommodation for the bush harvesting application, as these teams typically consist of eight workers. A trailer would provide a ventilated, safe environment – a vast improvement over the tents currently in use. The bathing, entertainment, cooking, and lighting amenities provided will contribute to satisfactory worker conditions, which will hopefully create a more sustainable labor force for this industry. Although there are concerns that this design may not be financially accessible to SMEs, we feel that it is the best solution for the workers, and well worth the efforts required to purchase it.

To allow for a flexible trailer design, dependent on a predetermined budget and number of workers, we developed an Excel spreadsheet tool. This tool allows the DRFN, or any other interested company, to input requirements for the trailer, such as refrigeration or lighting, and obtain the detailed cost and power breakdowns generated. From the initial results, the items can be scaled down to fit a specified budget.

In order to ensure land sustainability and meet the desires of the farmers, it was also necessary to consider methods to treat the land after harvesting. We conducted several interviews with experts on invasive bush to brainstorm aftercare methods. Our sponsors requested a three step plan including short-, mid-, and long-term solutions. Based on results from a focus group conducted with bush encroachment experts at the Polytechnic of Namibia, we determined that an herbicide was the best choice for the short-term solution, specifically Picloram. This herbicide has proven to be effective in bush control in the past, is highly selective due to its spray application, and is colored so that application can be monitored. For a mid-term

solution, we decided that Picloram should be re-applied after the one year resprouting period. This will ensure that regrowth of the invasive bush does not occur.

The long-term solution we recommend is to implement a land restoration system. In this system, the land is returned to cattle grazing area. Bags of mixed grass seeds will be given to the farmers. Native grass will help prevent erosion and promote a healthy ecosystem. Furthermore, it will increase the profitability of the land by allowing cattle to return to the area.

Although a lot of information was gathered during this project, there is still much more that can be done. In order to complete the CBEND project there are several issues that must be addressed, such as future research in aftercare. Recommendations for further research, studies, and future IQPs follow in the next chapter.

6.0 Recommendations

It is important to keep in mind that our trailer design and aftercare recommendations are theoretical in nature. Due to this, we recommend future research to solidify the practical implementations of these ideas. We have outlined solutions to potential problems that may arise. Through the use of our deliverables, such as the dynamic costing tool and aftercare spreadsheets, the DRFN will be well equipped to handle such problems.

6.1 Trailer Recommendations

One important aspect that remains before implementing a trailer design is worker feedback. By interviewing rural workers, the social acceptance of these trailers can be verified. Based on their feedback, design changes to more amiably suit cultural norms may easily be implemented with the help of our dynamic costing tool. Therefore, we recommend that workers be interviewed to determine whether they would like to live in accommodation trailer, and whether our designs would be acceptable to them.

To assist this further research, we have supplied the DRFN with cardboard models of the 8 person and 4 person accommodation trailers, as shown in Appendix F. These can be brought out in the field and used as a visual to talk to workers regarding the desirability of living in an accommodation trailer. Information on the importance of adequate housing, as opposed to a slightly higher salary will also need to be obtained.

Although originally designed for eight person harvesting teams in the field for five days, the accommodation trailers have numerous potential uses. The 8 person trailer was ideal for harvesting teams, as it creates ample accommodation for workers. However, some farmers, as well as uranium mine operations, have expressed interest

in smaller versions of the trailers, housing only four laborers. The rugged landscape makes towing larger trailers difficult and expensive and bigger trucks would be required. The mobility of a smaller trailer would allow accommodation anywhere on the farmland accessible by vehicle. Also, the sizeable storage space would provide for various applications of the trailer. The solar power system is capable of powering lights, a refrigerator, as well as power tools necessary for various types of work.

In addition to the utilization of 4 person trailers on farms, these trailers would also be suitable in numerous other applications. Suggestions for future research and implementation are:

- Namibia Roads Construction Company (RCC)
- Mobile Medical and Testing Clinics
- Mobile Education and Awareness Trailers
- Emergency or Temporary Shelters

The flexible design of the trailer allows for various uses. Although similar trailers have been utilized in the past for these applications, the trailers we designed are unique because they may be implemented in a wide variety of ways. This would allow businesses and governments to invest in similar trailers and use them as needed.

A final recommendation is looking into a modular design of trailers. Since there may be a greater demand for 4 person trailers, a modular trailer should be designed to allow two such trailers to be linked together. Although currently the 4 person trailer costs more per occupant than the 8 person trailer, if the trailers are mass-produced, smaller trailers may become more cost effective. Additionally, in some scenarios, companies may have numerous 4 person trailers because different operations require varying numbers of workers. A modular trailer design would allow for flexibility in its uses.

6.2 Dynamic Spreadsheet Tool

One major advantage of our trailer design concept is its flexibility. Our dynamic costing tool allows this flexibility by creating different design configurations based on user input. To ensure maximum functionality of this tool, we recommend further product information be included in the database. Because the current data may limit possible designs, the spreadsheet tool was designed to allow for the addition of extra data. Specifically, as this spreadsheet was designed for use with the harvesting trailers, there is a need for information on other appliances. Therefore, if used in designing a medical clinic, additional information would need to be added.

6.3 Aftercare recommendation

Important aspects to keep in mind when choosing an aftercare program:

- A manager should be onsite to oversee proper harvesting. This will help to ensure biodiversity remains in the area and that proper harvesting and aftercare techniques are being used.
- Small twigs and other biomass should be left in areas of high density harvesting. Leaving behind some biomass is important for a healthy ecosystem.
- The desires of the farmers who own the harvested land should always be considered. If the aftercare system that is recommended is not something the farmer would like, they may not help to implement it, and it may not be successful.
- Introducing an alien species is highly discouraged. The introduction could lead to further invasive plant problems. Also, most alien species have a higher

demand for water, which would drain the already scarce ground water in the area.

- It would be best to pay the harvesters per hectare cleared rather than the weight of harvested biomass. This will help to discourage clear cutting, which does not promote a healthy ecosystem.

We suggest that the DRFN implement our recommended aftercare solutions in a small test plot. This is especially important for herbicides. Detailed research on the environmental impact of Picloram is not readily available in Namibia. Therefore, test plots and further research on the herbicide is recommended before widespread use. Furthermore, while Picloram is known to kill the majority of the invasive plants, it may not be the best choice for all soil conditions. Therefore, every harvesting area should be researched thoroughly to make sure that the correct herbicide is being used. This can be done with small test plots at each harvesting area before the aftercare program is put into place. Furthermore, the Excel spreadsheet on herbicides in Appendix H can be used to guide herbicide selection.

Specifics on the make up of the grass seed mixture supplied to the farmers will depend on additional research on the area that is being harvested, such as soil quality, frost level, and rainfall. Native grasses vary based on region. It is crucial to survey the area that will be harvested for native grasses, and collect the seeds during the correct season to be provided to the farmers.

Further research also needs to be conducted to ensure the sustainability of the harvesting industry. Most bush encroachment experts in Namibia believe that the invasive bush is so plentiful, that harvesting for electricity production will not completely eradicate it. However, more research should be done on this topic. If it is

found that the bush is not a sustainable resource with the recommended aftercare system, it is possible that areas of farms should allow the bush to regrow after harvesting. Those areas could then be reharvested 20-30 years after the first harvest (pers. com. with Dave Joubert, April 2008).

In addition to letting the bush regrow, other aftercare programs to promote the industry's sustainability should be looked into. Further research into potential high biomass yielding plants should be conducted as well as looking into the option of pruning. Potential biofuel plant research can be continued from the compiled information gathered on this topic, found in Appendix N. Pruning may be a good option to maintain sustainability if harvesters only prune the trees for biomass and leave the main trunk (pers. com. with Dave Joubert, April 2008). This system would then provide fuel for the next harvest in that same area. However, the question still remains as to whether or not pruning will provide the harvesting teams with enough biomass to make a continued profit. Further research could provide useful elucidation on this topic.

Since this project focused on aggregating information on aftercare methods, no test plot experiments have been conducted, and so the effectiveness of the recommended aftercare program cannot be guaranteed. For this reason, continuation of research before implementation is crucial. The provided Excel documents on aftercare research should prove particularly important if changes need to be made to the program due to unforeseen problems. However, through thorough research and implementation of test plots, a solution should be found.

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Appendices:

Appendix A: The DRFN

Project Sponsor Information: The Desert Research Foundation of Namibia

The Desert Research Foundation of Namibia (DRFN, 2007) began as a small research station in 1963 called The Desert Ecological Research Unit (DERU). The DERU became the prominent research foundation for the Namib Desert. In 1990, the same year Namibia gained independence, the DERU became known as the DRFN. Today the organization continues to use its knowledge of the Namib Desert to facilitate the development of the country.

The DRFN is an independent, non-governmental research organization, which aims to, "enhance decision-making for sustainable development through research, training and consultancy in the country's land, water and energy sectors" (DRFN, 2007, Mission). While this mission is broad, it focuses on providing opportunities for communities, villages, and individuals who are struggling with the harsh environment to improve their lifestyles.

The DRFN is divided into three sectors, the land, water, and energy desks (DRFN, 2007). The energy and land sectors are currently focusing on finding a solution to the Northern Namibian invasive bush problem, which encroaches on agriculture, cattle grazing, and natural habitats. A current system for harvesting the bush is either inefficient or does not exist. The DRFN has a rich history of providing environmental evaluations as well as education and teaching programs**.** Their experience will help guide the people of Namibia to solve the invasive bush problem in an independent and sustainable manner.

The DRFN is managed according to the M8, a group made up of directors from various divisions within the organization (DRFN, 2007), while the policy of the foundation lies with a Board of Trustees. The activities of the DRFN fall into four basic categories: community based programs; research, synthesis, and networking; environmental impact assessments; and environmental education and awareness. There are many post-doctoral researchers, graduates, post-graduates, field assistants, diplomats, volunteers, and laborers, all working to make the organization's projects possible. There are approximately 35 permanent employees working for the DRFN, with other part-time assistants and volunteers focusing on specific projects.

Although the DRFN is a non-governmental organization, they are often consulted by the government for policy making and to provide recommendations for both the public and private sectors to encourage sustainable development (DRFN, 2007). The DRFN is currently working on the CBEND project, which aims to solve the bush encroachment problem. The bush encroachment project is funded by the National Planning Commission Secretariat, the European Commission, the Namibia Agriculture Union, and the Namibia National Farmers Union. Additionally, the foundation is working alongside the Namibia Women's Association, the Electricity Control Board, NamPower, the Ministry of Lands, and the Ministry of Agriculture-Directorate of Forestry to help find a solution to the invasive bush problem.

The DRFN prides itself in finding solutions to the problems of the Namibian people (DRFN, 2007). Their knowledge and experience in the land and energy sectors will help provide a solution to the bush encroachment problem and create a viable power source for Namibia. Through their education and programs, they strive to not only solve the problem today, but also to ensure its continuation into tomorrow.

Appendix B: Contact Information

1. **Amwele, Hilma**
   Background: Professor Hilma in the Department of Agriculture at the Polytechnic of Namibia. She provided valuable aftercare suggestions.

   Contact: Landline: 061 207 2173
   Email: hamwele@polytechnic.edu.na

2. **Bezuidenhout, Johny and Dudley**
   Background: Johny and Dudley are the manager and cost estimator, respectively, of Bezêr's Trailer and Body Craft Company. Bezêr is the trailer manufacturer that will be used to make the trailer. They provided a cost-analysis of the trailer as well as suggestions for design.

   Contact: Landline: 061 21 6274/87
   Email: johny@bezers.com and dudley@bezers.com
   Cell: 081 124 1398 (Johny)
   081 129 0424 (Dudley)

3. **Brewer, Bruce, Ph.D**
   Background: Dr. Brewer works for the Cheetah Conservation Fund and is in charge of the CCF BushBloks project. He has also been the general manager since 1998.

   Contact: Landline: 067 30 6225
   Email: brucebrewer@Bushblok.com
   cheeta@iafrica.com.na
   babrewer@ix.netcom.com
   Cell: 081 124 7799

4. **Conroy, Andrew B., Ph.D**
   Background: Dr. Conroy is a Fulbright from the University of New Hampshire lecturing in the Department of Agriculture at the Polytechnic of Namibia. Dr. Conroy provided information on aftercare programs.

   Contact: Landline: 061 207 2710
   Email: aconroy@polytechnic.edu.na
   Cell: 085 555 3470

5. **Curtis, Barbara**
   Background: Mrs. Curtis worked at the NBRI, specifically on the Namibian Tree Atlas project. Currently she works at the Polytechnic of Namibia in the Department of Nature Conservation as a lecturer. She provided insight into possible native plants to replace the invasive bush after it is cleared out by the harvesting teams and attended our focus group.

   Contact: Landline: 061 207 2188
   Email: bcurtis@polytechnic.edu.na
   Cell: 081 222 8686

6. **DB Lighting**
   Background: DB Lighting is a lighting store located in Windhoek that carries a line of energy efficient light bulbs. We visited the store to get prices for lighting in the trailer.

   Contact: Landline: 061 27 1890

7. **Frost, Shaughn**
   Background: Employee at South Africa's Tree-Cycle, a Chipper distributor. He has worked with other Namibian organizations to recommend appropriate chippers for the thorny bush.

   Contact: Landline: 27 21 930 4555
   Mobile: 082 338 8951
   Fax: 27 21 930 4216
   Email: info@tree-cycle.co.za

8. **Ileka, Helvi**
   Background: Member of the Management team at Solar Age Namibia who provided a cost breakdown for installing solar panels given the amount of power the trailer will demand. Solar Age will install the energy system on the trailer upon its completion.

   Contact: Landline: 061 215 809
   Email: Helvi@solarage.com
   Fax: 061 215 793

9. **Jankowitz, Willem, Ph.D**
   Background: Professor in the Department of Nature Conservation at the Polytechnic of Namibia. He provided valuable aftercare suggestions.

   Contact: Landline: 061 207 2031
   Email: wjankowitz@polytechnic.edu.na

10. **Joubert, Dave**
    Background: Mr. Joubert is a lecturer in the Department of Nature Conservation at the Polytechnic of Namibia. Mr. Joubert has done extensive research into the invasive bush in Northern Namibia, specifically on the *Acacia mellifera*. Mr. Joubert created the Chameleon Bush Encroachment Wiki program available online that give suggestions for aftercare programs. He also provided suggestions through communications.

    Contact: Landline: 061 207 2462
    Email: djoubert@polytechnic.edu.na

11. **Kellner, Klaus**
    Background: Prof. Kellner has been teaching at North-West University in South Africa in Terrestrial Plant Ecology since 1988. He specializes in degradation and desertification of the arid- and semi-arid rangelands, as well as the

restoration and rehabilitation of degraded rangelands. He also created the EcoRestore program through the North-West University including the "Bush Expert" online program which provides valuable information on how to manage bush encroachment. Prof. Kellner provided valuable suggestions on aftercare programs as well as information on further contacts.

Contact: Landline: +27 18 299 2510
Email: klaus.kellner@nwu.ac.za

12. **de Klerk, Nico**

Background: Mr. de Klerk worked for the Ministry of Environment and Tourism, specifically researching the effect of bush encroachment on Namibia. Mr. de Klerk provided valuable information on what types of aftercare have been used in the past and their success rates.

Contact: Landline: 061 25 1853
Cell: 081 128 3432

13. **Smith, Elaine Sjalome**

Background: Ms. Smith is the Manager of Research and Development for the Namibia Agricultural Union. She provided contact information on farmers who currently implement aftercare systems.

Contact: Landline: 061 237 838/9
Email: elaine@agrinamibia.com.na

14. Wienecke, Andreas, Ph.D

Background: Dr. Wienecke works for the Habitat Research and Development Centre in Windhoek. He is an expert on environmentally friendly dry toilets. He was contacted about possible toilets to implement in the trailer and provided suggestion for a portable, small, dry toilet as well as ideas for privacy.

Contact: Landline: 061 26 8211 or 061 26 8200
Email: awienecke@hrdc-na.iway.na

15. Zimmermann, Ibo

Background: Professor in the Department of Agriculture at the Polytechnic of Namibia. He provided valuable aftercare suggestions and attended our focus group.

Contact: Landline: 061 207 2461
Email: izimmermann@polytechnic.edu.na

Appendix C: Request for Proposal to Bezêr Manufacturing

DRFN
Jon Baldiga
jbaldiga@wpi.edu; nbt08@wpi.edu
18 April 2008

Request for Quotation

Bezêr's Trailer & Body Craft cc

The Desert Research Foundation of Namibia (DRFN) is determining options for accommodation trailers used by bush harvesters. The purpose of these documents is to provide Bezêr Manufacturing specifications on possible design configurations, as well as necessary components. Included in this packet are three possible trailer designs:

- 8 Person live-in trailer
- 4 Person live-in trailer
- Storage trailer (0 occupancy)

Each design should meet the following specifications:

- Any and all road requirements- must meet all legal guidelines for trailers, including, but not limited to, braking system, warning lights, weight and size requirements
- Equipped with a hitch for towing
- Sturdy for use on dirt roads
- Able to support weight of chest freezer, beds, persons (if applicable), and light harvesting equipment

Additionally, the trailer must be able to support a solar power system, though Bezêr will not be responsible for the installation of said system.

- Able to house a solar power system, including any necessary components
- Able to support weight of solar system on roof
- Able to support battery storage (six, 12kg batteries), preferably over the axle(s)

The three designs are further detailed below, with specific requirements and items to be included in the design.

We would like a quotation for each one of these designs, preferably itemized in order to see the costs of each feature (such as storage space, cabinets, etc). This will greatly help us as we finalize our design.

Thank you in advance for providing these quotations!

Sincerely,
Jon Baldiga

8 Person Live-in Trailer

This design is intended to house 8 employees. Overall the trailer is 5.3 meters long, 2.3 meters wide, and 2.4 meters high (excluding wheel height). Additionally, over the trailer hitch, extra storage space should be included. Inside the trailer, the floor to ceiling height is 2 meters, where the remaining 400 mm is storage space below the floor. The following components should be implemented:

- 4 Permanent Bunk Beds
- 4 Foldable Bunk Beds
- Cabinet space
- 8 Windows
- Door in the rear
- Folding Table fixed to the outside
- Extendable Awning for shade
- Collapsible shower curtain and shower head
- Partitioned storage space with adjustable height shelving

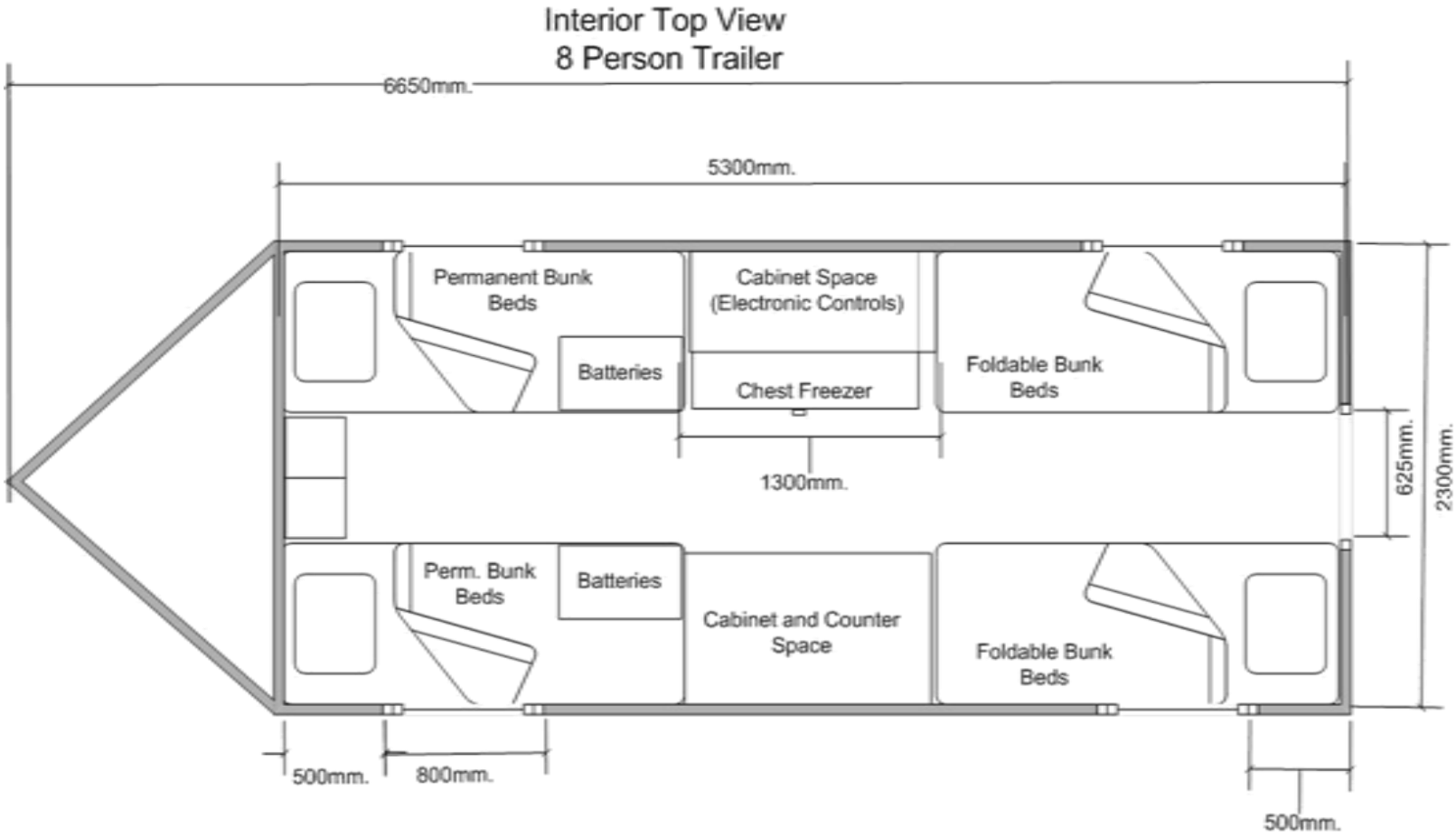


Figure 14: 8 Person trailer top view

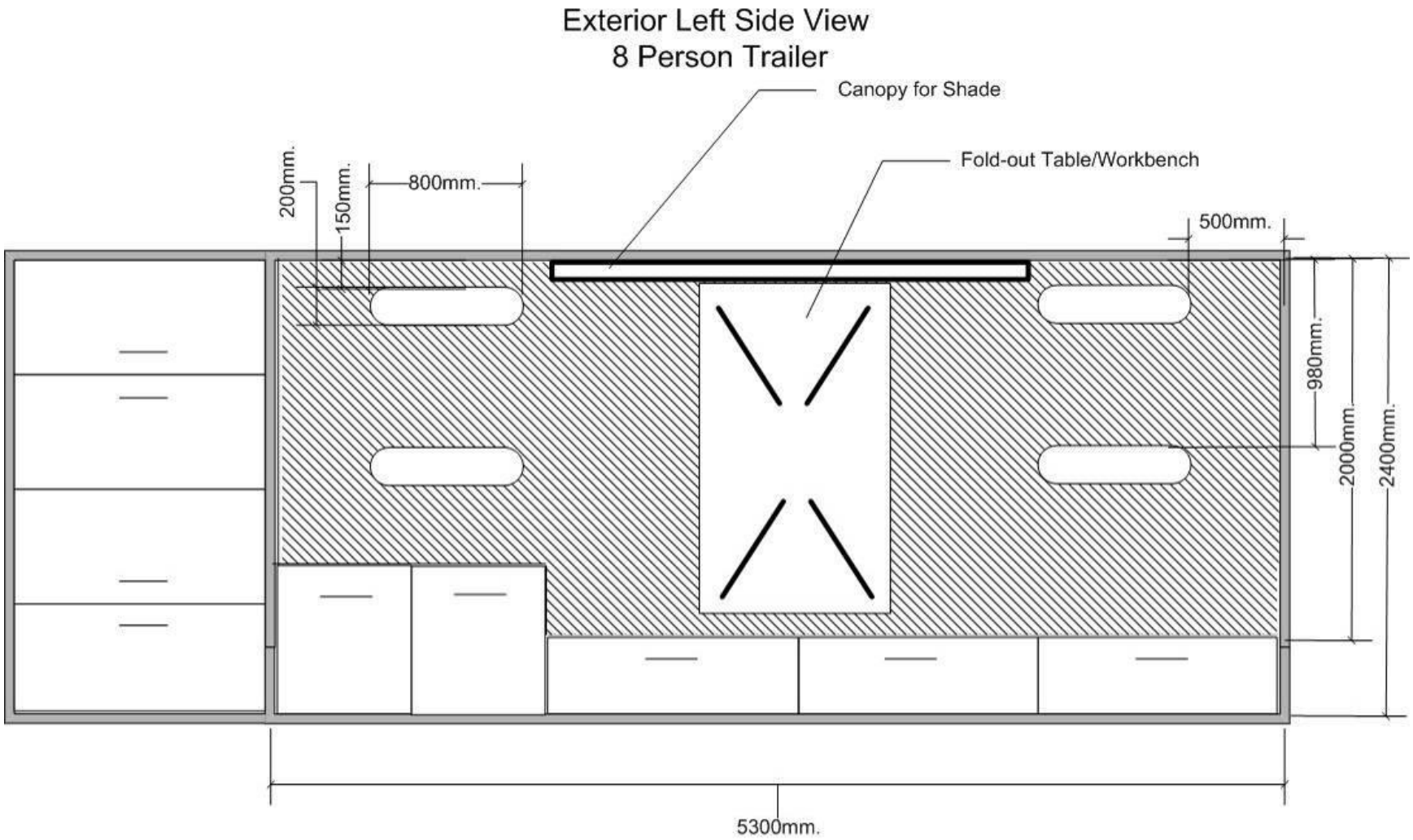


Figure 15: 8 Person trailer exterior left side view

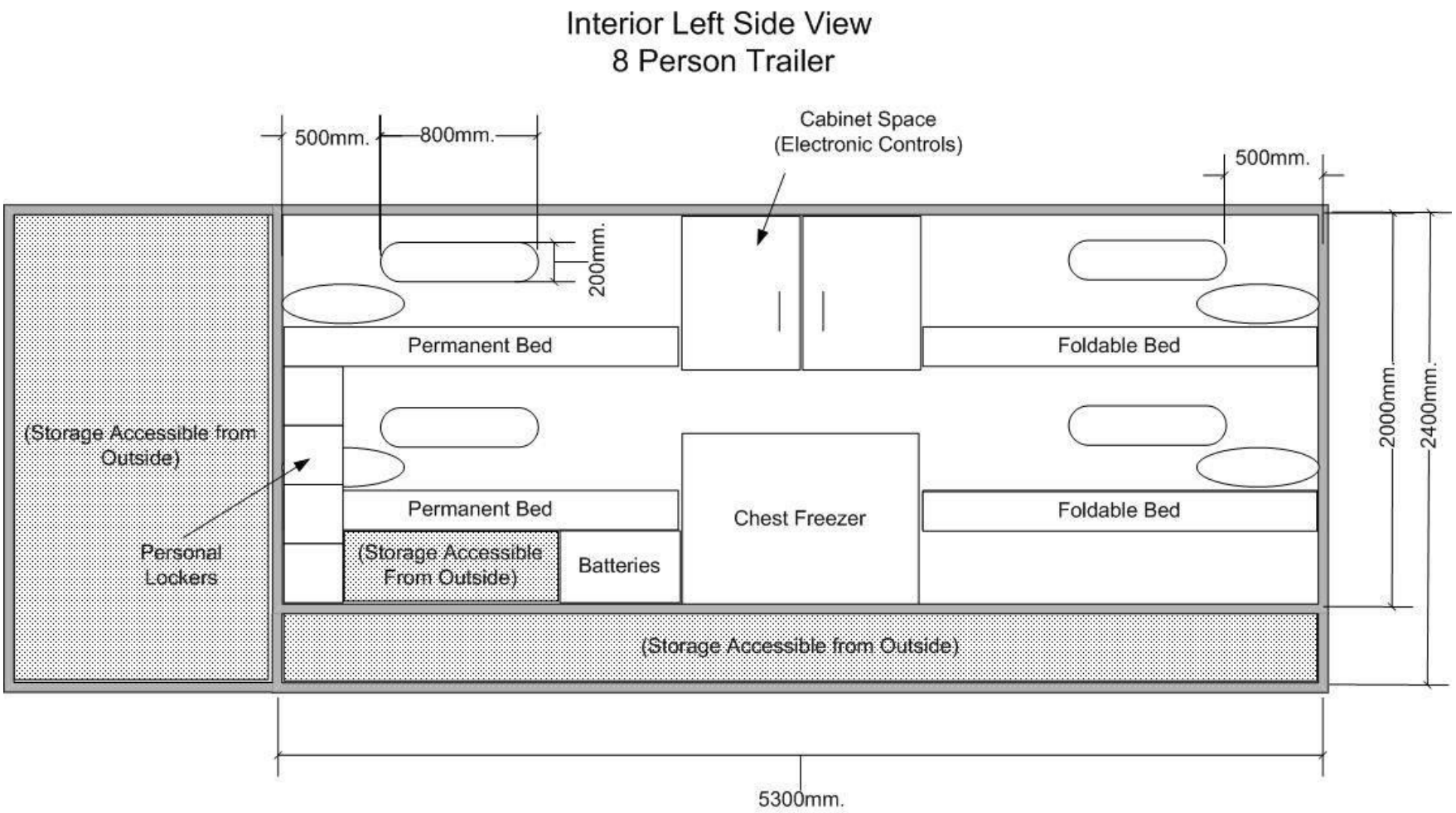


Figure 16: 8 Person trailer interior left side view

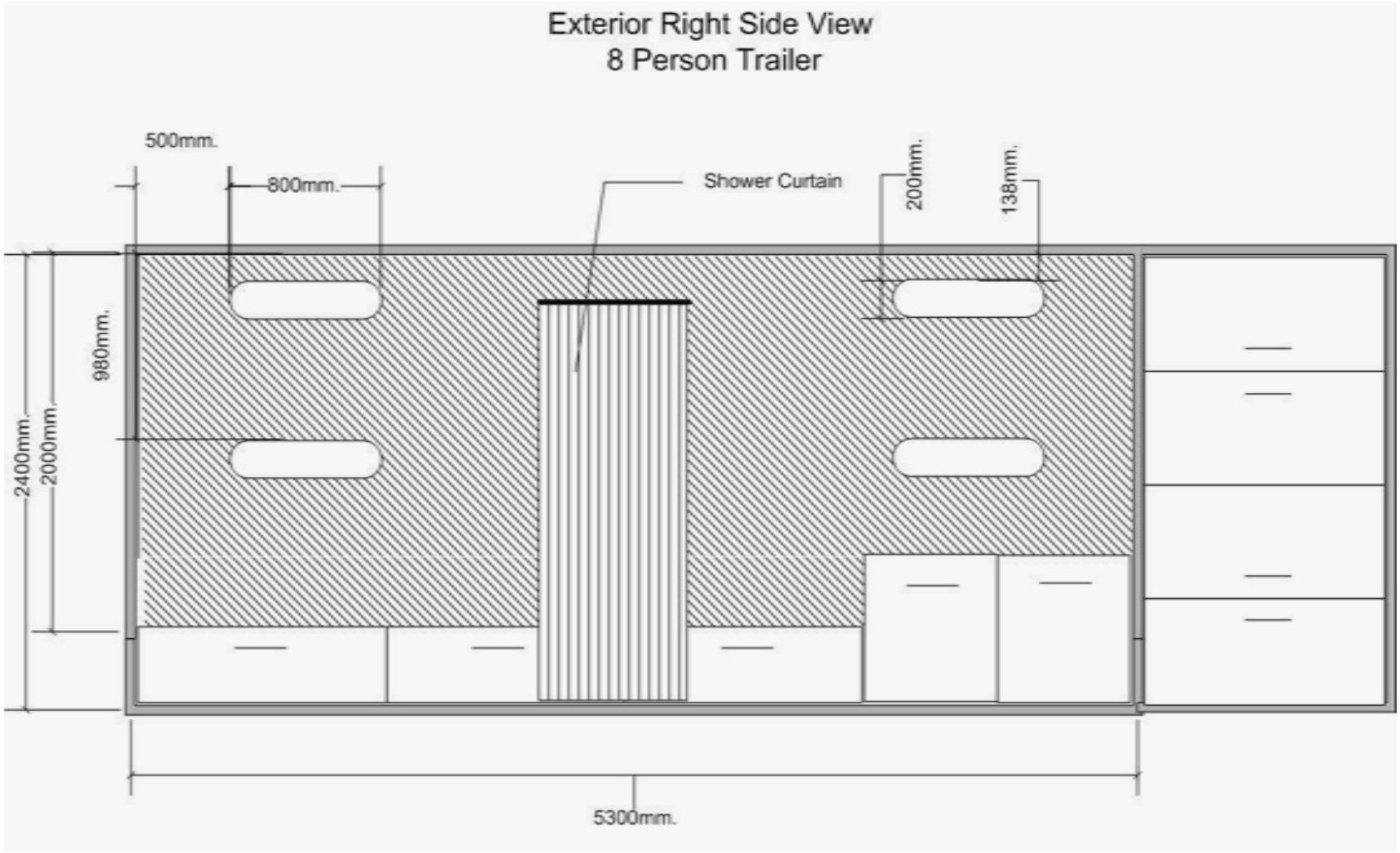


Figure 17: 8 Person trailer exterior right side view

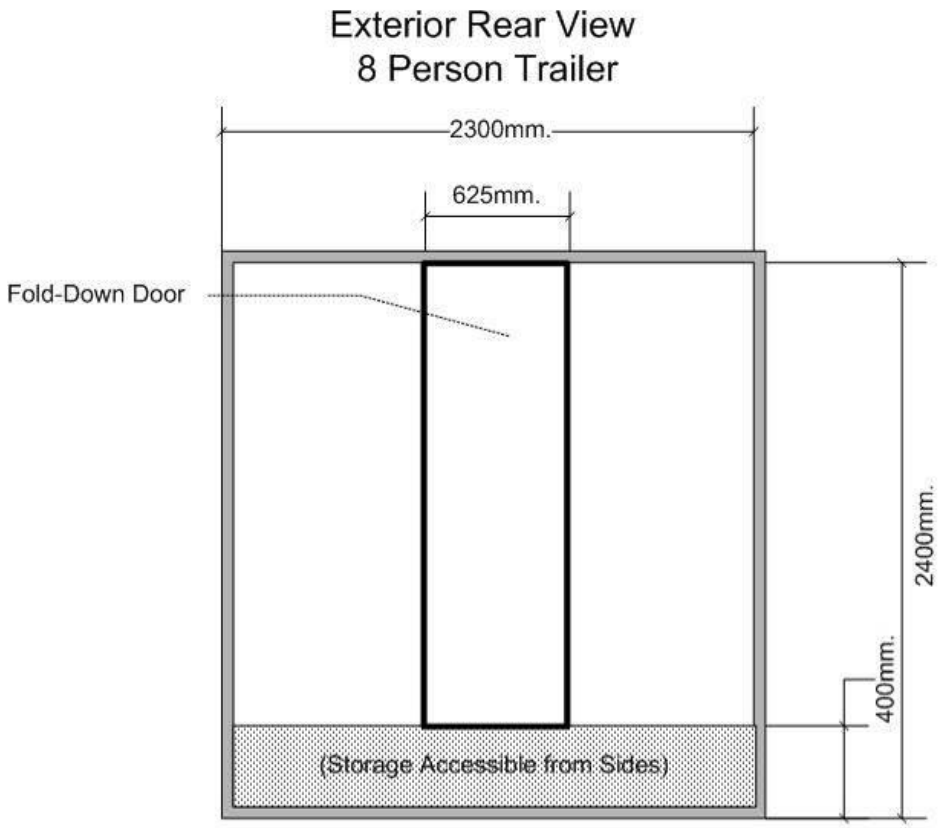


Figure 18: 8 Person trailer exterior rear view

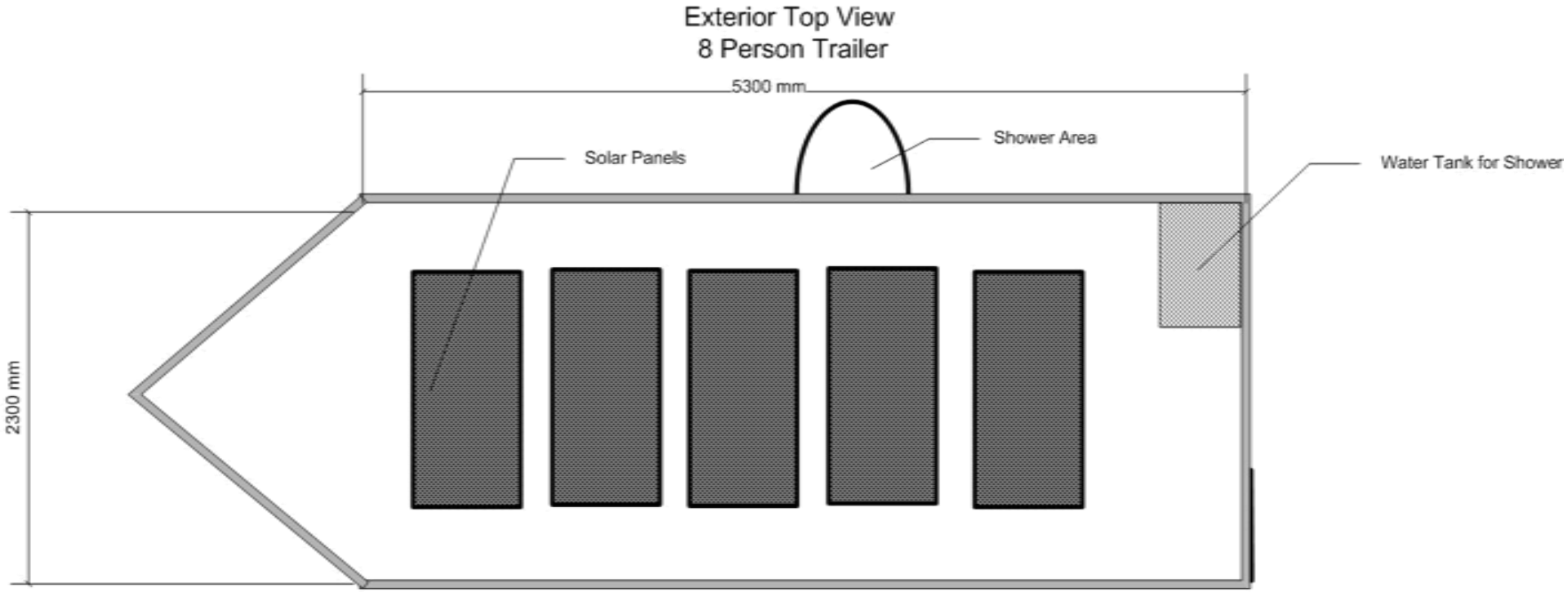


Figure 19: 8 Person trailer exterior top view

4 Person Live-in Trailer

This design is intended to house 4 employees. It is nearly identical to the 8 Person design, just smaller in length. Overall the trailer is 3.3 meters long, 2.3 meters wide, and 2.4 meters high (excluding wheel height). Additionally, over the trailer hitch, extra storage space should be included. Inside the trailer, the floor to ceiling height is 2 meters, where the remaining 400 mm is storage space below the floor. The following components should be implemented:

- 4 Permanent Bunk Beds
- Cabinet space
- 4 Windows
- Door in the rear
- Folding table fixed to the outside
- Extendable awning for shade
- Collapsible shower curtain and shower head
- Partitioned storage space with adjustable height shelving

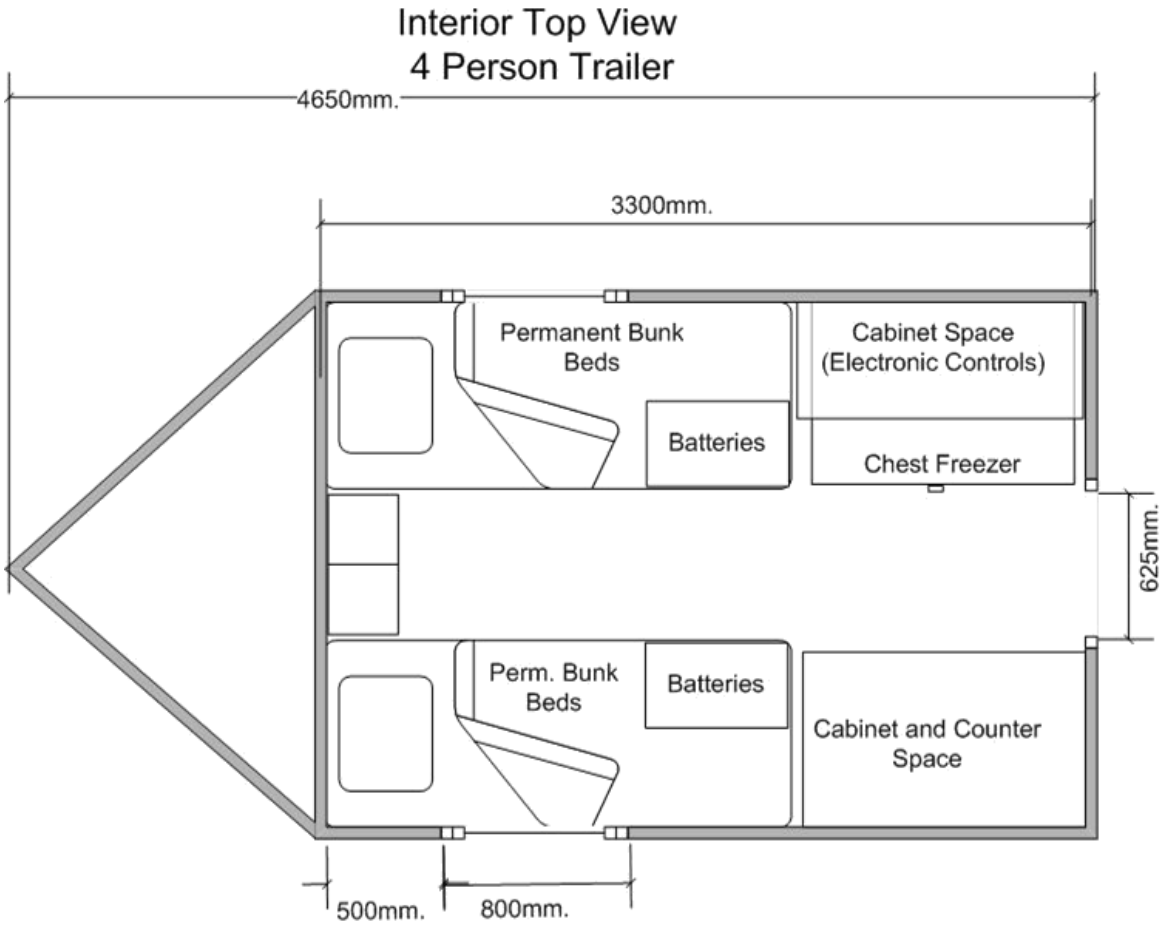


Figure 20: 4 Person trailer interior top view

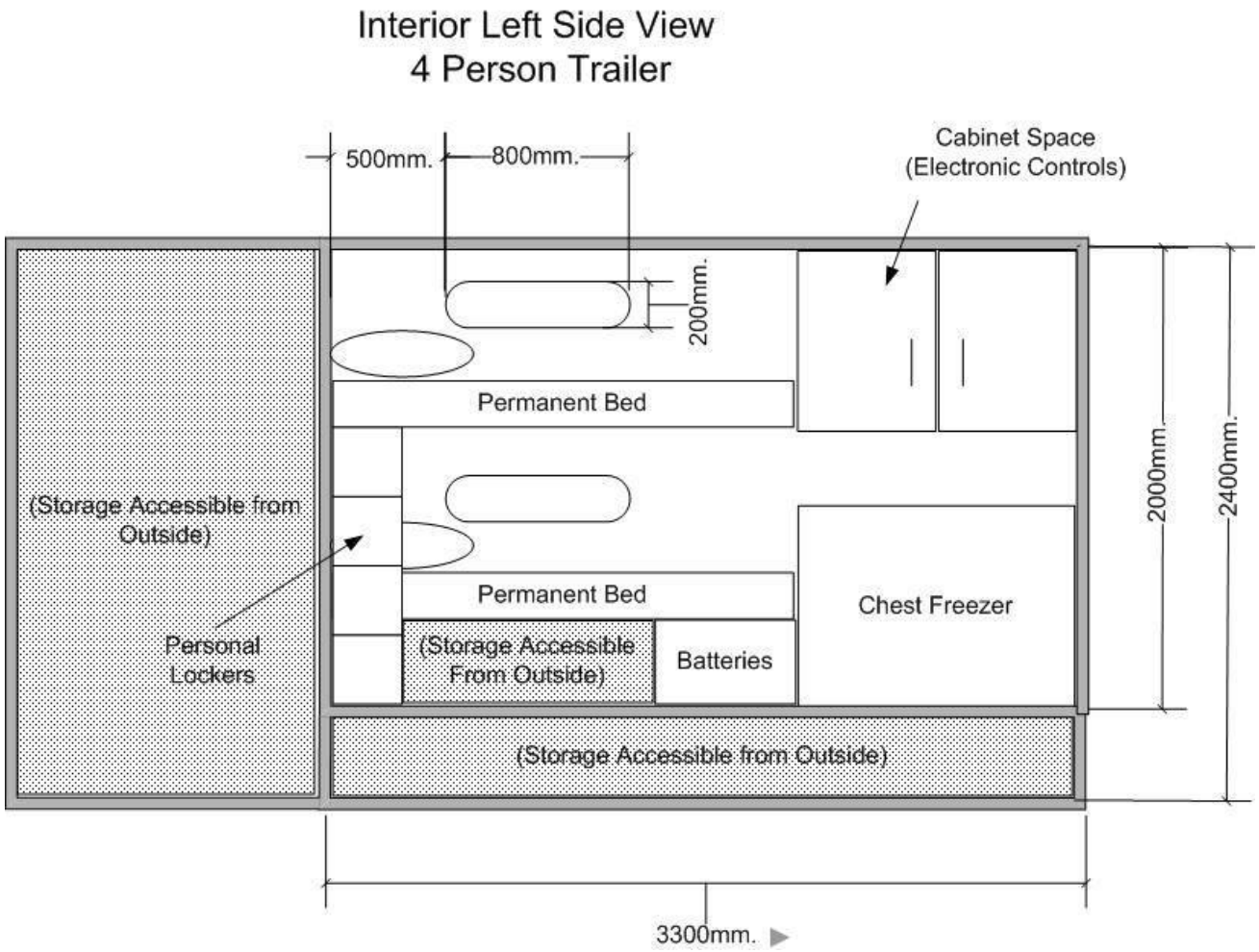


Figure 21: 4 Person trailer interior left side view

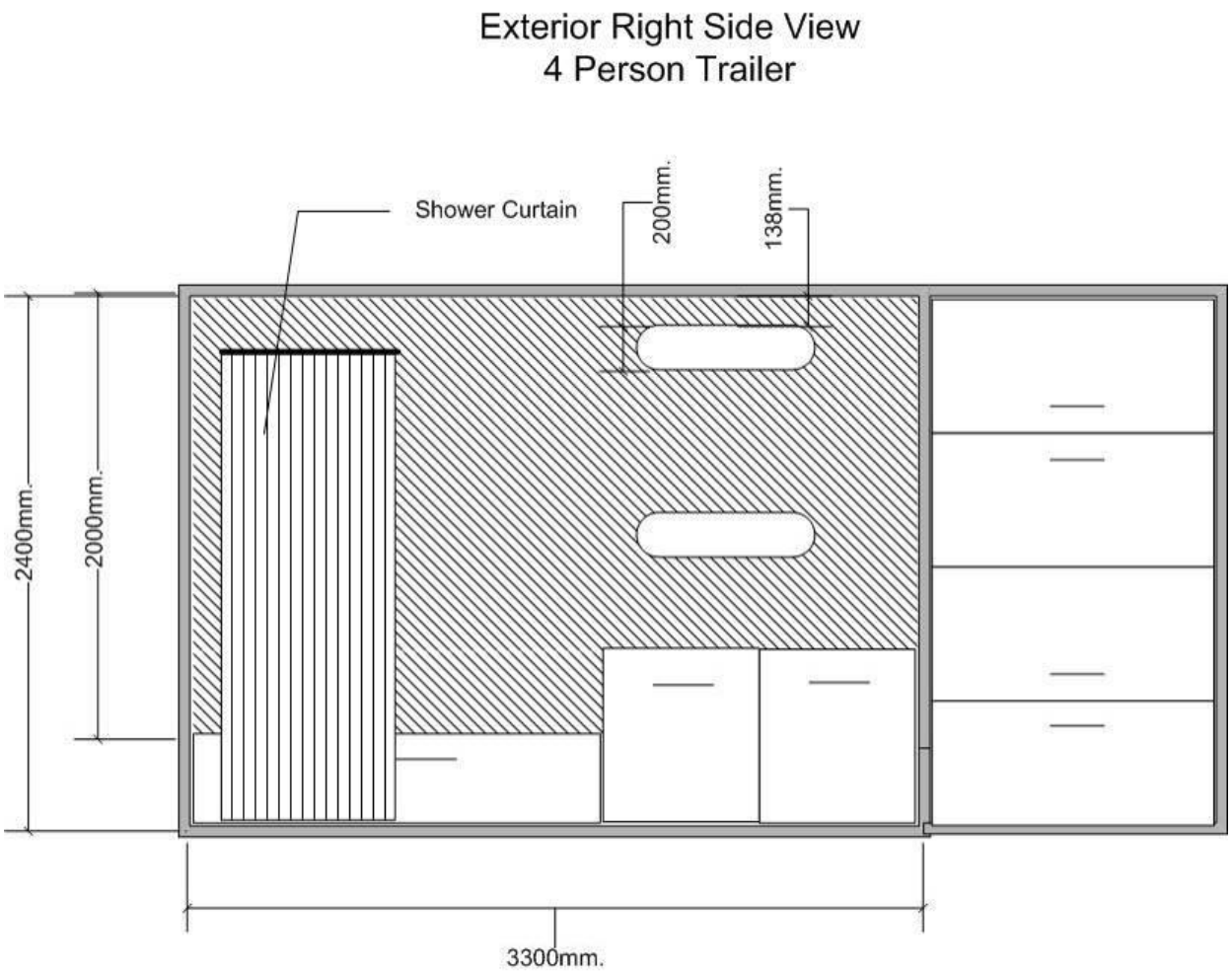


Figure 22: 4 Person trailer exterior side view

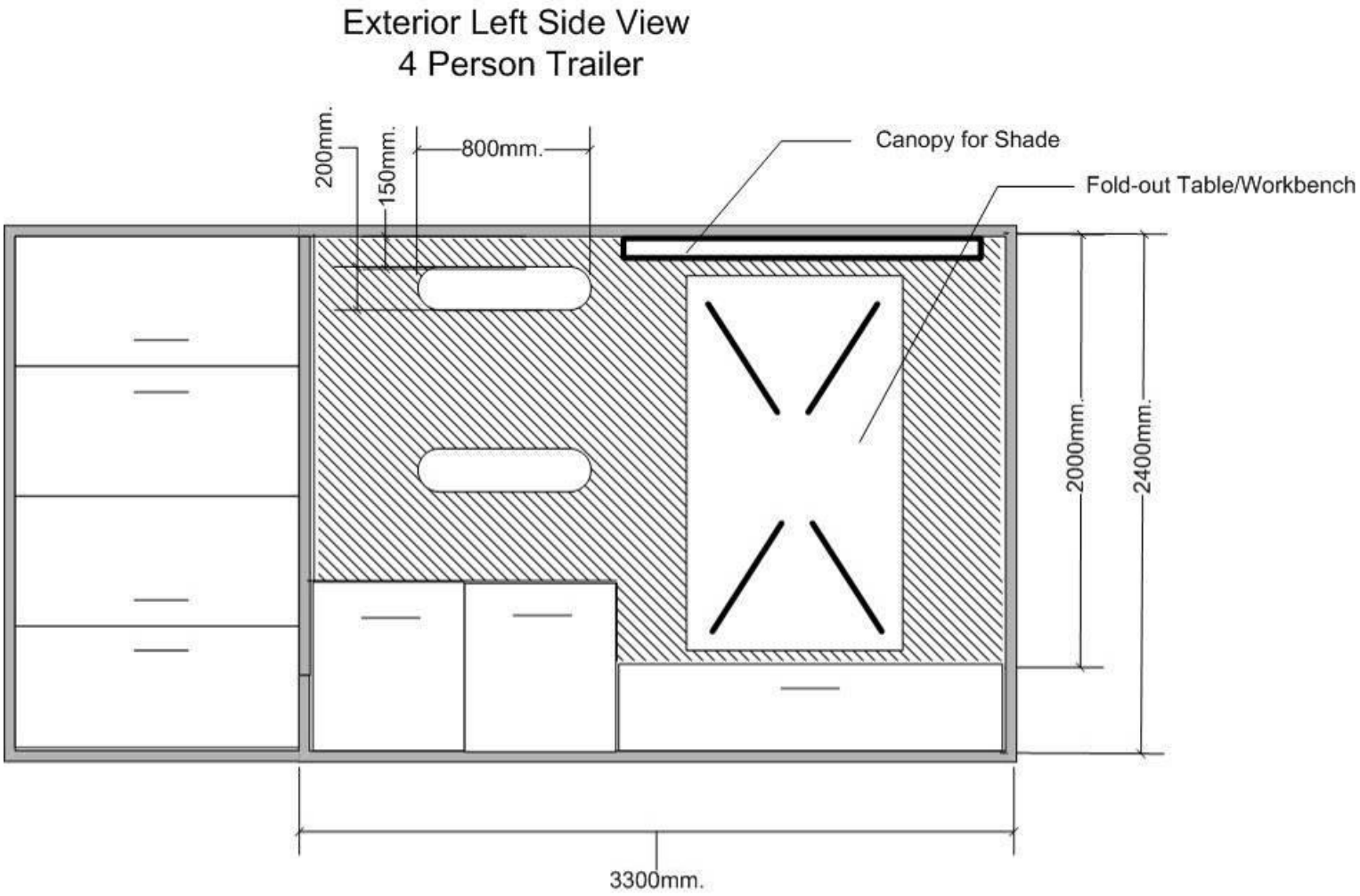


Figure 23: 4 Person trailer exterior left side view

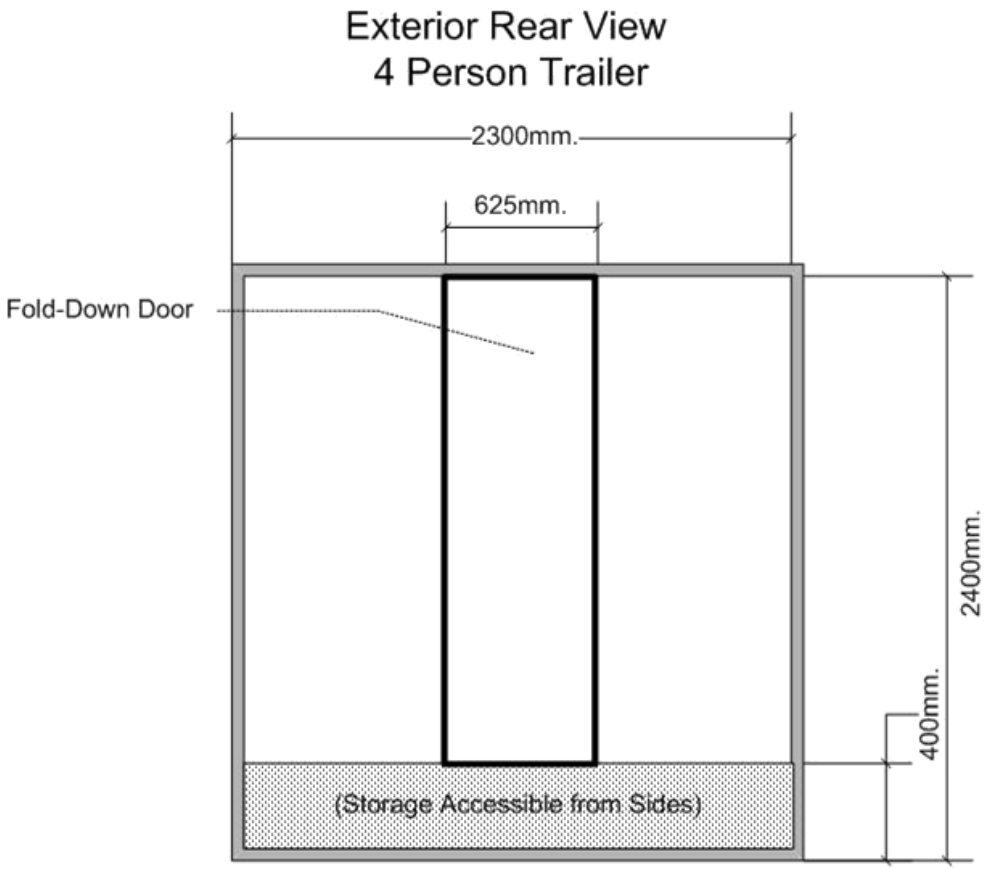


Figure 24: 4 Person trailer exterior rear view

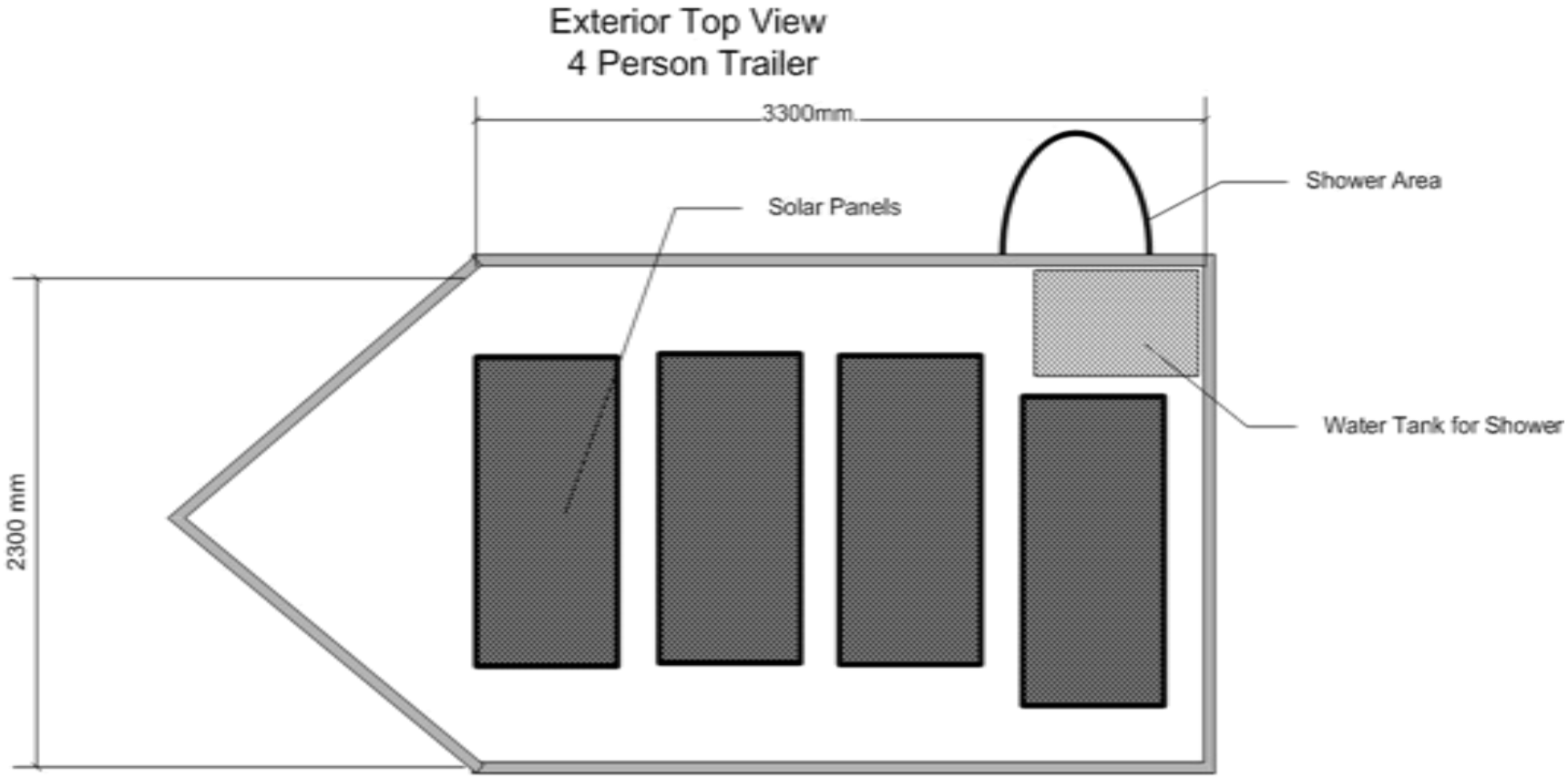


Figure 25: 4 Person trailer exterior top view

Unoccupied Storage Trailer

The storage trailer is designed to accommodate any storage needs of the workers for a week. The trailer is 1.5 meters long, with additional storage over the hitch, 1.2 meters wide, and 1.2 meters high. The following components should be implemented:

- Extendable awning for shade
- Collapsible shower curtain and shower head
- Partitioned storage space with adjustable height shelving
- Space for a large chest freezer in the rear (W119 x D66.5 x H87.6 cm)
- Rollers underneath freezer to allow freezer to slide out of trailer to open
- Rollers underneath battery storage to allow battery access

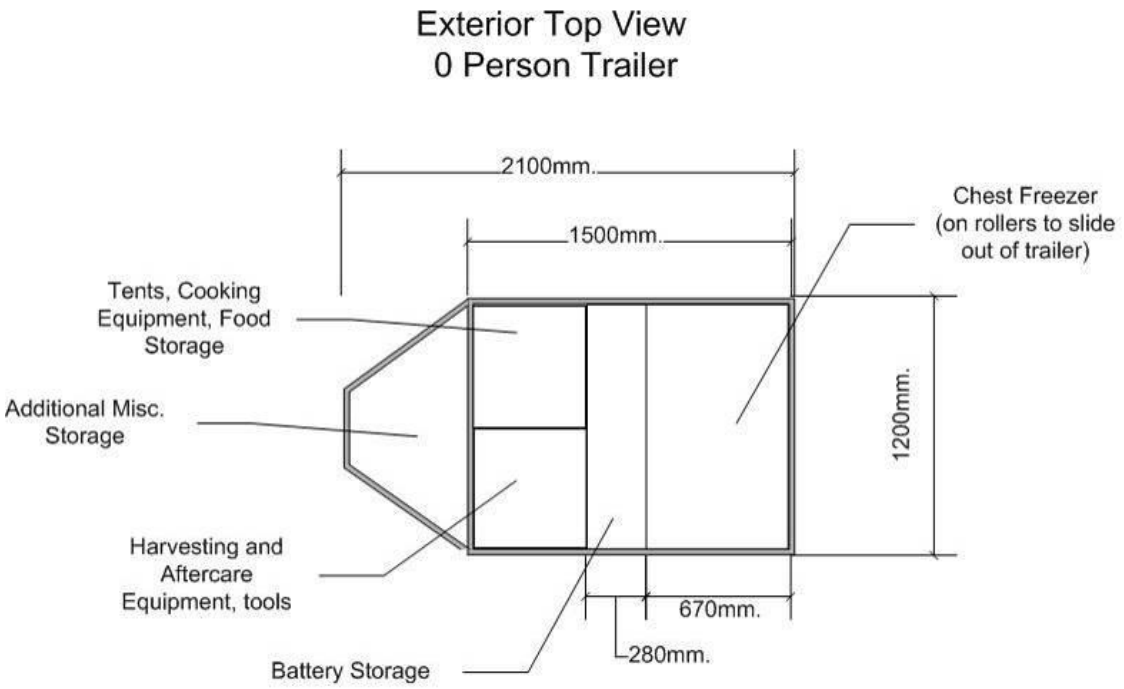


Figure 26: 0 person trailer exterior top view

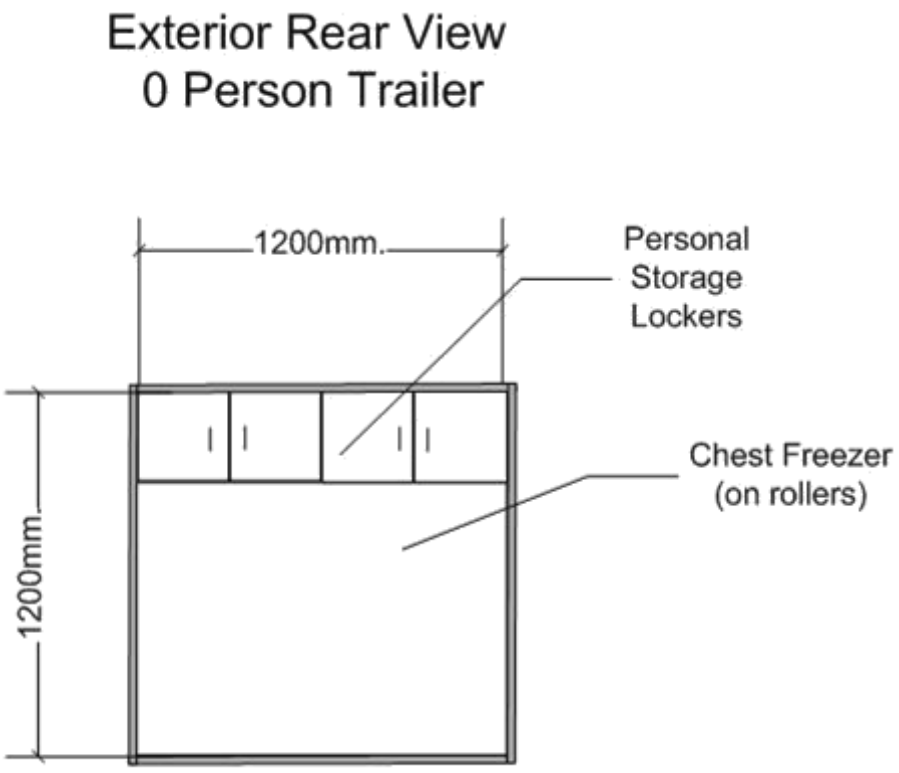


Figure 27: 0 person trailer exterior rear view

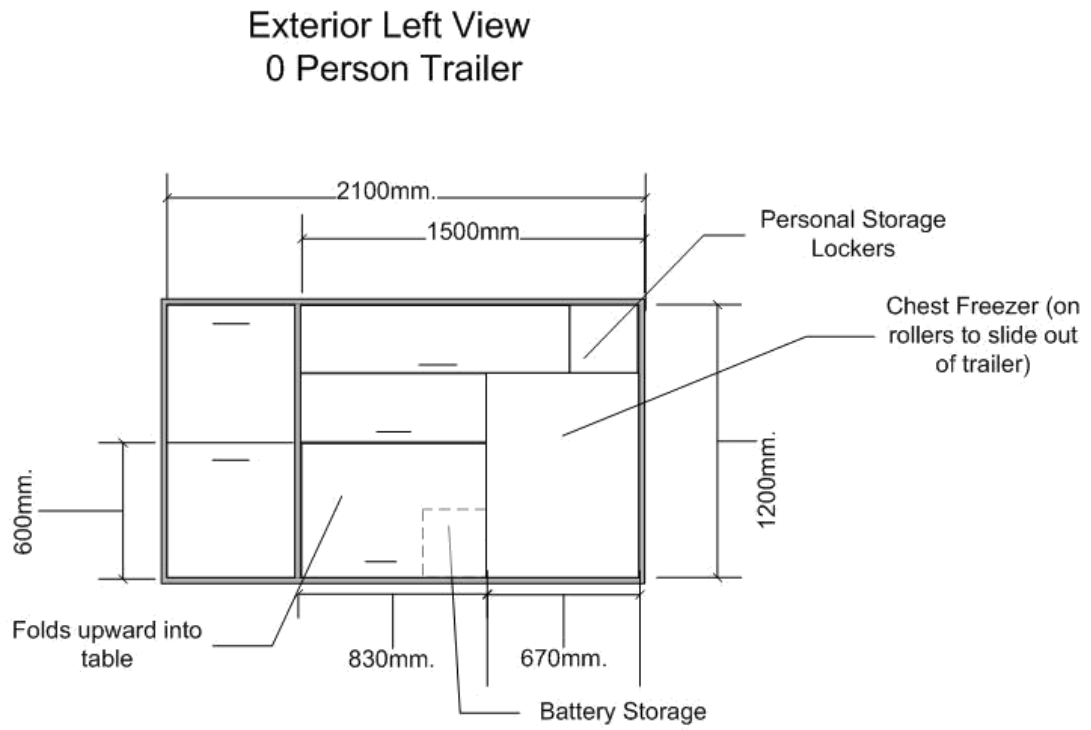


Figure 28: 0 Person trailer exterior left view

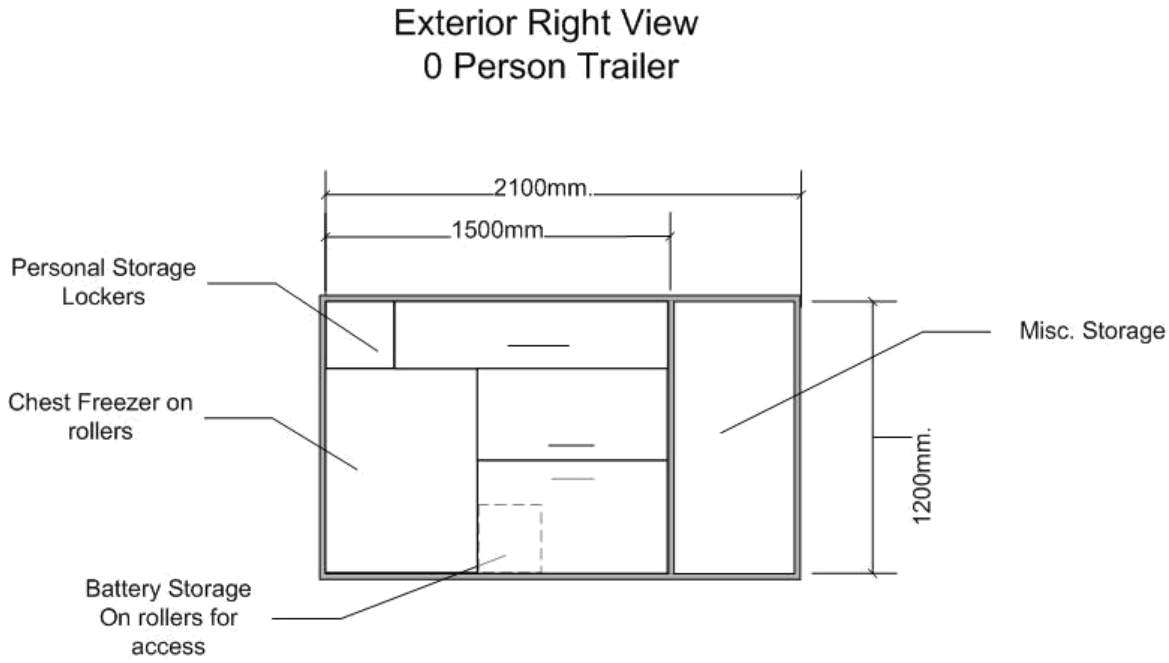


Figure 29: 0 Person trailer exterior right view

Appendix D: Dynamic Spreadsheet Cost Breakdown Output Screen

Table 6: Dynamic Spreadsheet Cost Breakdown Output Screen

Category	Item	Cost Per Item	Quantity	Total Cost
				N$367,190.84
Base Trailer Price		*N$240,000.00*	1	**N$240,000.00**
Power System	818 W			**N$107,433.14**
Total Amenities Cost				**N$19,757.70**
Lighting				**N$1,348.00**
	Eurolux 13W	*N$28.00*	*1*	*N$28.00*
	Eurolux 45W	*N$240.00*	*4*	*N$960.00*
	Major tech Work light, 2x26W	*N$360.00*	*1*	*N$360.00*
Water				**N$3,989.22**
	Okahandja 500 Liter Transport	*N$1,329.74*	*3*	*N$3,989.22*
Refrigeration				**N$8,392.00**
	Freezer: SunDanzer DCF165	*N$8,392.00*	*1*	*N$8,392.00*
Personal Storage				**N$3,200.00**
	80012SV-U	N$400.00	8	**N$3,200.00**
Entertainment				**N$1,543.68**
Television	*Sylvania 15" LCD HDTV/DVD Combo*	*N$1,543.68*	*1*	*N$1,543.68*
DVD Player	*Toshiba S-D4000*	*N$400.00*	*0*	*N$0.00*
Seating				**N$572.80**
	Apex Camping Stool ST-G-140	*N$71.60*	*8*	*N$572.80*
	None	*N$0.00*	*0*	*N$0.00*
Cooking				**N$232.00**
	Vesto	*N$232.00*	*1*	*N$232.00*
Power Tools				**N$480.00**
	Northern Industrial Bench Grinder 1/2	*N$480.00*	*1*	*N$480.00*

Appendix E: Dynamic Spreadsheet Power Breakdown Output Screen

Table 7: Dynamic Spreadsheet Power Breakdown Output Screen

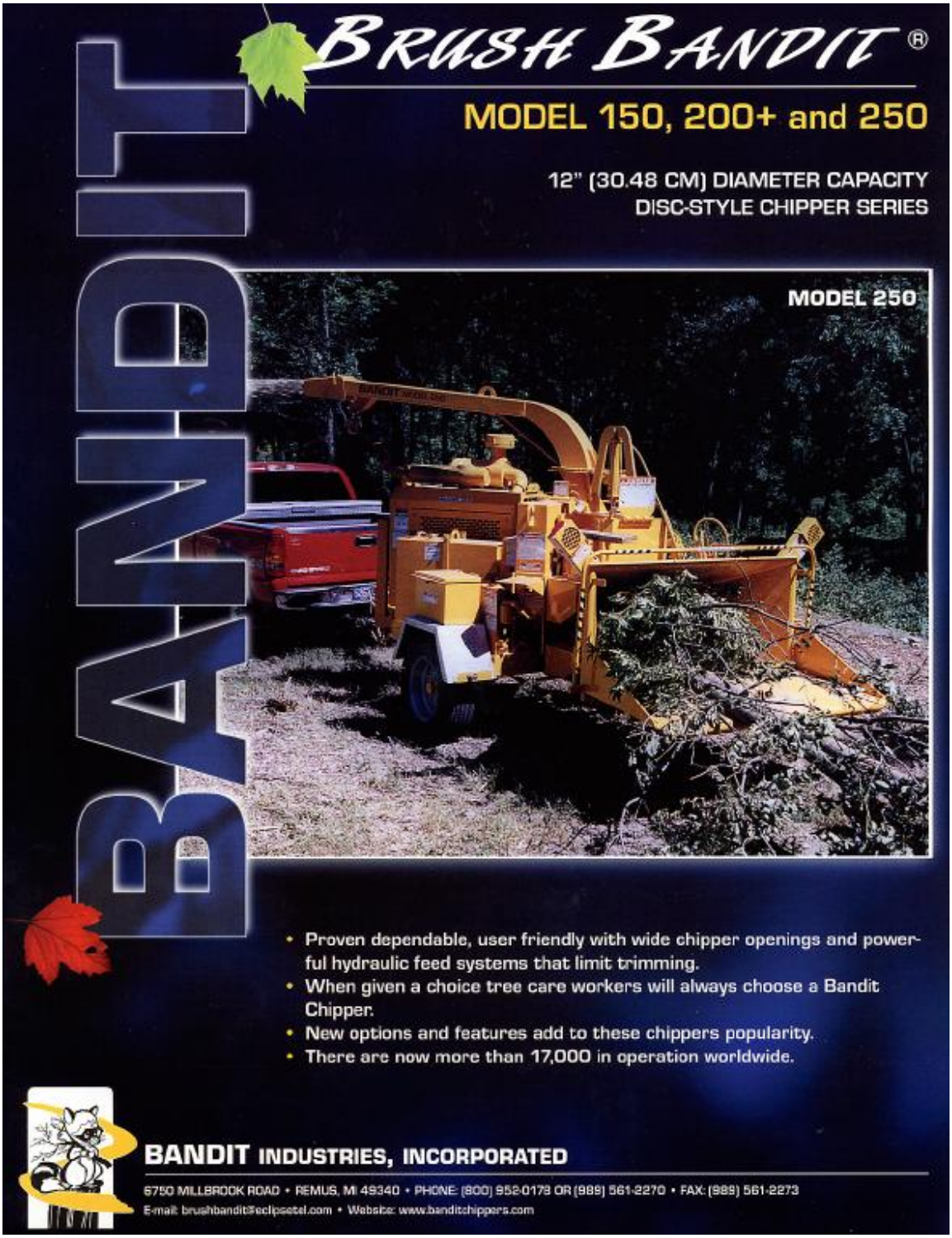
Category	Item	Power Each	Anticipated Usage	Quantity	Daily Energy Consumption	Peak Power
				TOTAL:	**3.20 kWhrs**	**1184 W**
Lighting					**0.93 kWhrs**	**338 W**
	Eurolux 13W	*13 W*	*5.00 hrs/day*	*2*	*0.13 kWhrs*	26 W
	Eurolux 45W	*45 W*	*4.00 hrs/day*	*2*	*0.36 kWhrs*	90 W
	Eurolux 85W	*85 W*	*2.00 hrs/day*	*2*	*0.34 kWhrs*	170 W
	Major tech Work light, 2x26W	*52 W*	*2.00 hrs/day*	*1*	*0.10 kWhrs*	52 W
Refrigeration					**0.77 kWhrs**	**96 W**
	Freezer: SunDanzer DCF165	*96 W*	*8.00 hrs/day*	*1*	*0.77 kWhrs*	96 W
Entertainment					**0.09 kWhrs**	**44 W**
	Sylvania 15" LCD HDTV/DVD Combo	*44 W*	*2.00 hrs/day*	*1*	*0.09 kWhrs*	44 W
Power Tools					**0.93 kWhrs**	**466 W**
	DewaltDW756 6" Heavy Duty	*466 W*	*2.00 hrs/day*	*1*	*0.93 kWhrs*	466 W
Personal Outlets					**0.48 kWhrs**	**240 W**
	Outlets for Employeee Use (Shavers, Etc)	*15 W*	*2.00 hrs/day*	*16*	*0.48 kWhrs*	240 W

Appendix F: Trailer Models to Gauge Worker Interest

Figure 30: 8 Person Trailer Model

Figure 31: 4 Person Trailer Model

Appendix G: Bandit Chipper Brochure



Bandit Takes the Time and Expense Out of Tree Removal

- **Less chain saw trimming.** Limbs are crushed, compressed and pulled into the powerfully aggressive hydraulic feed system.
- **Chips regardless of tree length.** The hydraulic feed system has the more than enough power to pull in tree length material.
- **Chip several pieces at one time.**

PROVEN DEPENDABLE FEED SYSTEMS

- Top and bottom feed wheels have bearing support on both ends.
- Heavy-duty tapered coupling provides a trouble-free method of attaching the hydraulic motor to the feed wheel shaft.
- Top wheel is carried in a trouble free slide box with replaceable wear strips that should last the life of the chipper.
- Easy climb spring tension feed system applies tension directly down on the material.

Optional Quad Wheel Feed System

(see options section of this brochure)

The Model 250 pictured here and on the cover is the ultimate 12" chipper. This high production unit features a bigger opening and a more powerful feed system compared to the 150 and 200+

The Model 200+ (pictured above) built like the Model 150 but with a heavier frame, a faster feed rate and some standard features that are options on the 150.

HEAVY-DUTY CHIPPER AND FE SYSTEM ARE THE KEY TO LO TERM RELIABILITY

- Chipper disc - 40" x 2" thick.
- Solid knife pockets - no split or staggered k pattern.
- 4" chipper shaft.
- Heavy-duty chipper base with 1/2" steel fr plate and 1/2" gussets supporting the anvil ar

LOADS CHIP BOXES TO THE MA WHILE LIMITING PLUGGING REDUCE TRIPS TO THE DUMP SITE

- Thrower style fan blades at each pocket maximize chip discharge velocity prevent plugging while minimizing air flow blow back. To further reduce blow back, be to vent your chip boxes.

EASY TO OPERATE

- Wide profile sloping infeed hopper is ideal sliding big, heavy material. This greatly red the effort needed to feed long materials as we brush.
- Reversible feed system, controlled at inf hopper by wrap around control bar.

FOR MORE INFORMATION CONTACT US BY PHONE: (800) 952-0178 OR (989) 561-2270 • FAX: (989) 561-2273

Dress Up Your Chipper

A GOOD LOOKING, BRIGHT, DURABLE PAINT FINISH

January 2000 brought about many changes in the Paint Department. We moved into a state-of-the-art wash room and paint kitchen, began priming all Bandit products with Korlar Dupont Epoxy primer, and began painting them with NPC chemical coating water based paint (best water based paint available). A paint finish with Dupont Imron 5000 is available for an additional charge.

Pickled steel absorbs paint extremely well and is used in the construction of all Bandit Chippers. all chippers receive a phosphorized bath using a Fremont Industries phosphorizing Wash System prior to the application of the primer. After painting, the units proceed to a heated drying area where they remain for a minimum of 24 hours before the application of decals.

FIVE STANDARD PAINT COLORS ARE OFFERED AT NO ADDITIONAL CHARGE:

Traditional Bandit Yellow, Construction Yellow, Safety Orange, Green and White.

DRESS UP YOUR CHIPPER WITH SPECIAL PAINT AND RIM OPTIONS

The paint choices listed above are available at no additional charge. you may choose other colors for a nominal fee.

All standard Bandit 12" chippers are equipped with replaceable aluminum fenders. The fender area takes the most abuse from materials being thrown from the towing vehicle. Aluminum fenders hold up well, look sharp with any paint color, and are easy to replace if damaged. optional aluminum and chrome rims as well as baby moon hub caps are offed to add some flare to your chipper's appearance.

THE CHIPPERS RIDE ON DURABLE RUBBER AXLE SUSPENSION

All Bandit 12" chippers utilize the proven torflex axle system that features rubber material inside the axle to absorb shock and vibration. The torflex axles provide a very quiet ride without the use of hangers or springs. This axle is extremely durable and comes with a 5-year warranty from the Dexter Axle Company.

E-mail: brushbandit@eclipsetel.com • Website: www.banditchippers.com

Unique Features And Options

TO BETTER PROCESS LIMBY MATERIALS, SELECT THESE OPTIONS

Supersized Feed Wheel

Moveable Side Feed Wheel

Unique Features and Options • Unique Features and Options

FULLER CHIP BOXES MEAN FEWER TRIPS TO THE DUMPING STATION

MAXIMIZE CHIP BOX LOADS OR SPREAD THE CHIPS OVER THE SITE WITH BANDIT'S 360° HEIGHT ADJUSTABLE AND SWIVEL DISCHARGE OPTIONS.

Unique Features and Options • Unique Featur

QUAD WHEEL FEED SYSTEM

The Best Feed System Ever Developed for a Chipper

- Wood feeds easier.
- Limbs compress better.
- Nearly doubles the feed wheel surface area that rides on the wood.
- Quad wheel feed system includes 2 bottom horizontal feed wheels and 2 top wheels that are set on a diagonal to the bottom wheels. Each set of wheels are driven from a 63 cu. in. hydraulic motor.
- Material need only touch the feed wheels and is pulled into the chipper including maximum diameter logs and chunk wood. Large material reaching the first top rollers raises it along with the second top feed wheel. The wood does not need to be pushed into the feed system to get the top wheels to raise.

BRING BIG TREES AND PILES OF BRUSH INTO THE CHIPPER WITH THE HYDRAULIC WINCH OPTION

Pulls heavy material and piles of brush to the feed system. The winch greatly reduces hand carrying of material while reducing the need to cut and trim. The winch is a great tool for dragging material from tight or restricted areas that are not accessible to the chipper.

CRUSH LIMBS AND BRANCHES WITH THE HYDRAULIC LIFT CYLINDER

The hydraulic lift cylinder raises the top feed wheel to assist in feeding larger diameter materials and is used to apply down pressure on the top wheel for crushing limbs and branches. The lift cylinder can also be used to raise and lock the top wheel to gain access to the area between the feed system and disc. Those not selecting the lift cylinder can use the hand crank tongue jack to raise and lock the top feed wheel.

Increase Production

MAXIMUM PRODUCTION WITH LIMITED PREPARATION DUE TO WIDE CHIPPER OPENING AND AGGRESSIVE FEED SYSTEM

Powerful feed wheels pull and crush material entering the feed system, allowing crotchy and forked limbs to be chipped with ease.

Chipper opening is 17" wide on the Model 150 and 200+. The Model 250 has a large chipper opening and a wider 64" less restrictive infeed hopper. The chipper opening on the Model 250 is 12 percent wider (19-1/4" wide) than the 150 and 200+ Models.

The economically priced Model 150 (pictured above) is compact and lighter weight than the other 12" models to accommodate smaller towing vehicles. (Shown with customized options.)

Feed wheels close to the chipper disc are located within 3-3/4" of the chipper disc at the closest point on the 250 and 8" on the 150 and 200+.

Chipper knives pull and lift. The position of the chipper knife in the disc and the angle of the disc forces a chipping action that pulls and lifts to assist the feed system in pulling wood into the chipper.

LOW KNIFE MAINTENANCE COSTS

- Hinged chipper hood for easy access to the knives.
- Long lasting 1/2" knives are reversible, resharpenable, and specially treated to stay sharp up to 3 times longer than a standard heat treated knife.
- Four-sided anvil easy to adjust.
- Knives are a fraction of the cost of those used in competitors chippers.
- Knives are common in size and offered by several knife manufacturers.

TOUCH UP KNIVES IN THE CHIPPER WITH THE KNIFE SAVER

The Knife Saver™ will put an edge back on the knives while they are in the chipper. Badly worn or severely knicked knives can not be restored with the Knife Saver™. Sharp knives are essential to make the chipper perform properly. Chipping with dull knives reduces production, reduces chip quality, increases vibration and fuel consumption. The Knife Saver™ will get you through jobs quicker and allows you to change knives in your maintenance shop.

Appendix H: Potential Herbicides for Aftercare

Table 8: Potential Herbicides for Aftercare

Aftercare: Herbicides												
Method	**Name of product**	**Active chemical**	**Application process**	**Method of control**	**Target plants**	**EPA toxicity class**	**Human toxicity level**		**Wildlife**			**Half-life**
							Toxicity category	**Toxicity concerns**	**Mammals:**	**Birds:**	**Aquatic:**	
Herbicide	Molopo SC, Molopo GG	Tebuthiuron	SC: hand held spray GG: Aerial	inhibits photosynthesis	broadleaf and woody weeds, grasses and brush	III CAUTION	Low	Very low toxicity on all counts except Oral: Moderate toxicity	moderately toxic	practically nontoxic	slightly toxic	12-18 months
	Aqua-Kleen, Barrage, Lawn-Keep, Malerbane, Planotox, Plantgard, Savage, Salvo, Weedone, and Weedtrine-II	2,4-D	hand held spray or as a dry compound.	synthetic growth hormone	broadleaf leaves	III DANGER-POISON	slight to moderate toxicity	lightly toxic orally, but toxicity class I-highly toxic by eye exposure	slight to moderate toxicity	slightly toxic to wildfowl and slightly to moderately toxic to birds.	highly toxic to fish	7 days
	Access	Picloram	hand held spray		woody plants, broadleaf weeds	III CAUTION	slight toxicity	moderate toxicity to eyes, mildly toxic to skin	slight toxicity, no apparent effect on cattle	practically nontoxic	moderately to slightly toxic to fish	2 months
	Borea, Bromax 4G, Bromax 4L, Borocil, Cynogan, Hyvar X, Hyvar XL, Isocil, Krovar, Rout, Uragan, Urox B, and Urox HX	Bromacil	hand held spray or as a dry compound.		perennial grasses, brush	IV Dry: CAUTION Liquid: WARNING	dry: practically non toxic, liquid: moderately toxic	irritation of skin, eyes and respiratory tract	dry: practically non-toxic, liquid: moderately toxic	practically nontoxic	slightly toxic to practically nontoxic	60 days
	Garlon, Turflon, Access, Redeem, Crossbow, Grazon and ET	Triclopyr	hand held spray		woody and broadleaf plants	III DANGER or CAUTION	slightly toxic	can effect liver and kidneys after extended exposure	slightly toxic	slightly to practically nontoxic	practically nontoxic	30-90 days

Appendix I: Directions for ground application of Access Herbicide

DIRECTIONS FOR USE - USE ONLY AS DIRECTED

TIMING OF APPLICATION

GIFBLAAR

For optimum control apply **ACCESS 240 SL** only when the CURRENT SEASON'S GROWTH IS FULLY DEVELOPED, but before the leaves start to turn yellow in the early autumn.

In this respect it is recommended that spraying should not be undertaken before November, by which time most of the new stems will have emerged and produced mature leaves.

Spraying earlier in the spring, when most of the new growth present consists of recently emerged stems with immature leaves, will result in unsatisfactory control.

Do not apply **ACCESS 240 SL** if more than 25 % of the foliage has been destroyed by caterpillars or other insects.

Any regrowth found in the second season after the application should be resprayed.

When spraying old stems which have not yet produced leaves also spray surrounding soil for at least 30 cm from stem.

OTHER SPECIES

Apply **ACCESS 240 SL** only on actively growing plants and when soil moisture is favourable to plant growth.

Apply only when the trees are in the correct stage of development, as indicated below

- only spray trees of which leaves have fully developed.
- spray only on healthy and vigorously growing trees.
- spray only on trees with full foliage cover.
- do not apply to wet foliage.
- do not spray following a late frost.
- do not spray target plants when drought signs are evident or showing signs of stress.

B. GROUND

a) Knapsack Application

Avoid fine droplet size - use a knapsack sprayer with a solid cone nozzle, eg. Spraying Systems TG1 (or equivalent type) that will ensure an even coverage of the target area.
Maintain a constant pressure of between 200 - 250 kPa.
Maintain a distance of approximately 50 cm from the target for best coverage.

b) High Volume Application (Only with a foaming agent)

Use a motorized pump capable of applying pressures of 1,000 - 1,200 kPa - use a Spraying Systems Foamjet FJ 0006 aspirating nozzle, (or equivalent type.) Add commercially available foaming agent, (eg. Ecoguard's HERBIFOAM), as a temporary spray application marker.

c) General

Apply as a complete cover spray to leaves and stems.
Use only on actively growing plants, up to 2 metres in height, with full leaf cover.
Apply sufficient spray mixture to wet foliage till just before the point of run-off.
Do not apply if rain is likely within 3 hours.
Do not apply to wet foliage.
Do not apply is wind velocity exceeds 15 km/h (as measured by handheld wind recorder approved by the Registrar : Act No. 36 of 1947). The difference between the wet and dry bulb readings on a whirling hygrometer must not exceed 8 ºC.

CUT STUMP TREATMENT

- Apply preferably immediately after felling but definitely within 3 hours.
- **ACCESS 240 SL** should not be applied to the stump if surface is wet from rain or dew.
- Apply with a knapsack, as a coarse spray using solid cone nozzle tips (eg. Spraying Systems TG-1, Delavan CE 1 or equivalent type) at 100 kPa, low pressure.
- Do not exceed spray height of 20 cm above target. Do not apply if wind velocity exceeds 15 km/h (as measured by handheld wind recorder). The difference between the wet and dry bulb readings on a whirling hygrometer must not exceed 8 ºC.
- Apply according to directions in the table below.

C. **CUT STUMP APPLICATION**

BUSH/SHRUB SPECIES	RATE/100 ℓ WATER	REMARKS
Acacia dealbata (Silver wattle)	1,5 ℓ	See DIRECTIONS FOR USE above. **Add 500 mℓ ACTIPRON SUPER/100 litre spray mix.** Apply to low cut stumps (10 – 20 cm high) preferably with a single cut surface. Apply to complete cut surface of stumps with a diameter or less than 10 cm. Where multiple stumps are present, all cut surfaces must be treated. For bigger stumps apply to the cambial region (sapwood) of the cut surface. In all cases, apply until the point of run off. A follow-up spray as a coppice application may be required.
Acacia mearnsii (Black wattle)	1,5 ℓ	
Acacia saligna (Port Jackson)	2.0 ℓ	
Chromolaena odorata (Paraffin bush)	1.0 ℓ	
Eucalyptus duneii	3.0 ℓ	
Eucalyptus macarthurii	3.0 ℓ	
Eucalyptus smithii	2.0 ℓ	
Eucalyptus grandis	1.5 ℓ	
Lantana camara (Lantana)	1.0 ℓ	
Melia azedarach (Syringa)	2.0 ℓ	
Populus canescens (Grey poplar)	2.0 ℓ	
Solanum mauritianum (Bugweed)	1.0 ℓ	
Ulex europaeus (Gorse)	2.0 ℓ	

BUSH/SHRUB SPECIES	RATE/100 ℓ WATER	REMARKS
Acacia erubescens (Blue thorn)	2.0 ℓ	**Add 2.0 ℓ ACTIPRON SUPER / 100 ℓ spray mix.** Apply to low cut stumps (10 - 20 cm high). Apply to complete cut surface until the point of run-off. A follow-up spray as a coppice application may be required.
Acacia karroo (Sweet thorn)	2.0 ℓ	
Acacia mellifera (Black thorn)	2.0 ℓ	
Acacia tortilis (Umbrella thorn)	2.0 ℓ	
Colophospermum mopane (Mopane)	2.0 ℓ	
Dichrostachys cinerea (Sickle bush)	2.0 ℓ	
Terminalia sericea (Transvaal silver leaf)	2.0 ℓ	

(Dow AgroSciences, 2003)

Appendix J: Material Safety Data Sheet for Access Herbicide

MATERIAL SAFETY DATA SHEET

Dow AgroSciences

Emergency Phone: 1800-033-882 (24 hrs)
Dow AgroSciences Australia Ltd.
Frenchs Forest NSW 2086

ACCESS* HERBICIDE

Effective Date: 18 April 2007
Product Code: 44504

1. PRODUCT AND COMPANY IDENTIFICATION:

PRODUCT: Access* Herbicide

PURPOSE: Herbicide

COMPANY IDENTIFICATION:

Dow AgroSciences Australia Ltd.
ABN 24 003 771 659
Level 5, 20 Rodborough Road,
Frenchs Forest NSW 2086

Customer Service Toll Free Number:
1800 700 096
(Mon-Fri, 8am–5pm EST)
Emergency Telephone Number:
1800 033 882
(24 hours) (EMERGENCIES ONLY)

Transport Emergency Only Dial 000

2. HAZARDOUS IDENTIFICATIONS:

EMERGENCY OVERVIEW

HAZARDOUS SUBSTANCE. NON-DANGEROUS GOODS

Classified as hazardous sccording to the criteria of NOHSC
Not Classified as Dangerous Goods for Land Transport

Potential Health Effects:
Irritating to eyes and skin. May cause lung damage if aspirated. Inhalation may irritate respiratory system.

RISK PHRASES:

R65:	Harmful: may cause lung damage if swallowed.
R20/21/22:	Harmful by inhalation, in contact with the skin and if swallowed.
R36/38:	Irritating to eyes and skin.
R50:	Very toxic to aquatic organisms.

SAFETY PHRASES:

S2:	Keep out of the reach of children.
S3/9/49:	Keep only in the original container in a cool, well-ventilated place.
S20/21:	When using do not eat, drink or smoke.
S23:	Do not breathe vapour or spray.
S24:	Avoid contact with skin.
S62:	If swallowed, do not induce vomiting: seek medical advice immediately and show the container or label.
S61:	Avoid release to the environment. Refer to special instructions (sections 6, 7, 13).

3. COMPOSITION/INFORMATION ON INGREDIENTS:

Ingredient	CAS #	Content
Triclopyr Butoxyethyl Ester	064700-56-7	30.7 %w/w
Picloram Isooctyl Ester	026952-94-5	16.4 %w/w
Diethylene glycol monoethyl ether	000111-90-0	10-20 %w/w
Aromatic hydrocarbon solvent	64742-94-5	30-50 %w/w

4. FIRST AID:

Consult the Poisons Information Centre (131126) or a doctor in every case of suspected chemical poisoning. Never give fluids or induce vomiting if a patient is unconscious or convulsing regardless of cause of injury. If breathing difficulties occur seek medical attention immediately.

EYE: Hold eyes open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, and then continue rinsing eyes. Call the Poisons Information Centre or doctor for treatment advice.

SKIN: Take off contaminated clothing. Rinse skin immediately with plenty of water for 15-20 minutes. Call the Poisons Information Centre or doctor for treatment advice.

INGESTION: Immediately call the Poisons Information Centre or doctor. Do not induce vomiting unless told to do so by the Poisons Information Centre or doctor. Do not give any liquid to the person. Do not give anything by mouth to an unconscious person.

INHALATION: Remove to fresh air; if effects occur, consult a physician.

NOTE TO PHYSICIAN: The decision of whether to induce vomiting or not should be made by an attending physician. If lavage is performed, suggest endotracheal and/or esophageal control. Danger from lung aspiration must be weighed against toxicity when considering emptying the stomach. No specific antidote. Treatment of exposure should be directed at the control of symptoms and the clinical condition of the patient.

5. FIRE FIGHTING MEASURES:

FLASH POINT: 73°C (PMCC)

COMBUSTIBLE: C1

FLAMMABLE LIMITS
LFL: 0.9%
UFL: 6.0%

EXTINGUISHING MEDIA: Carbon dioxide, dry chemical, foam, and/or water fog.

FIRE AND EXPLOSION HAZARDS: Combustible liquid. Moderate risk of an explosion from this product if involved in a fire. If product is involved in a fire it may produce toxic and corrosive mixtures in confined spaces.

FIRE-FIGHTING EQUIPMENT: Wear safety boots, non-flammable overalls, gloves, hat, goggles, and self contained breathing apparatus. All skin areas should be covered. Ensure that no spillage enters drains or water sources.

HAZCHEM: 2X

6. ACCIDENTAL RELEASE MEASURES:

ACTION TO TAKE FOR SPILLS/LEAKS: DO NOT touch or walk through spilled material. Wear a face shield or goggles, overalls buttoned to neck and wrist, chemical resistant gloves and boots. Stop leak when safe to do so. Dike area and prevent entry into waterways, and drains. **Small spills/leaks:** Absorb with material such as sand, soil or sawdust. Collect spilled product and place in sealable container for disposal. Spill residues may be cleaned using water and detergent. Contain and absorb wash water for disposal. Absorb and collect washings and place in the same sealable container for disposal. Dike the area of large spills and report them to Dow AgroSciences at 1800-033-882.

7. HANDLING AND STORAGE:

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE:

HANDLING: Keep out of reach of children. Harmful if swallowed or inhaled. Causes eye and skin irritation. Avoid contact with eyes, skin and clothing. Users should wash hands before eating, drinking, chewing gum, using tobacco, or using the toilet.

STORAGE: Store in tightly closed original container in a cool, dry well-ventilated area out of direct sunlight when not in use. Do not store with food, feedstuffs, fertilizers and seeds. See product label for further handling/storage precautions relative to the end use of this product. Reduce stacking height where local conditions can affect packaging strength.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION:

These precautions are suggested for conditions where the potential for exposure exists. Emergency conditions may require additional precautions

EXPOSURE GUIDELINES: Picloram isooctyl ester: None established. For the acid, NOHSC TWA 10 mg/m^3. Triclopyr acid: Dow AgroSciences Industrial Hygiene Guide is 2 mg/m^3 as acid equivalent, Skin.

A "skin" notation following the exposure guideline refers to the potential for dermal absorption of the material including mucous membranes and the eyes either by contact with vapors or by direct skin contact. It is intended to alert the reader that inhalation may not be the only route of exposure and that measures to minimize dermal exposures should be considered.

ENGINEERING CONTROLS: Provide general and/or local exhaust ventilation to control airborne levels below the exposure guidelines.

RECOMMENDATIONS FOR MANUFACTURING, COMMERCIAL BLENDING, AND PACKAGING WORKERS:

EYE/FACE PROTECTION: Use chemical goggles

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SKIN PROTECTION: When prolonged or frequently repeated contact could occur, use protective clothing impervious to this material. Selection of specific items such as face shield, boots, apron, or full-body suite will depend on operation.

RESPIRATORY PROTECTION: Atmospheric levels should be maintained below the exposure guidelines. When respiratory protection is required for certain operations, use an approved air-purifying respirator. The following should be effective types of air-purifying respirators: organic vapour cartridge.

APPLICATORS AND ALL OTHER HANDLERS: Refer to the product label for personal protective clothing and equipment.

9. PHYSICAL AND CHEMICAL PROPERTIES:

APPEARANCE: Brown liquid
ODOUR: Aromatic
SOLUBILITY IN WATER: Insoluble
pH: 4.4 (1% solution)
VAPOR PRESSURE: 375 mmHg @ 38°C (solvent); Picloram IOE negligible; Tricopyr BEE 10 x 10˚5. mm Hg @ 33 °C
BOILING POINT: 183 – 210°C (solvent)
SPECIFIC GRAVITY: 107 g/mL @ 20°C
% VOLATILE BY VOLUME: Expected to be low @100°C

10. STABILITY AND REACTIVITY:

STABILITY: Combustible. Stable under normal storage conditions.

INCOMPATIBILITY: (specific materials to avoid) Acid, base and oxidizing materials

HAZARDOUS DECOMPOSITION PRODUCTS: Nitrogen oxides and hydrogen chloride may be formed under fire conditions.

HAZARDOUS POLYMERIZATION: Not known to occur.

11. TOXICOLOGICAL INFORMATION:

POTENTIAL HEALTH EFFECTS: This section includes possible adverse effects, which could occur if this material is not handled in the recommended manner.

EYE: May cause moderate eye irritation. Corneal injury is unlikely. Effects likely to heal readily.

SKIN: Prolonged contact may cause skin irritation with local redness. Prolonged or frequently repeated skin contact is unlikely to result in absorption of harmful amounts. Prolonged or frequently repeated skin contact may cause allergic skin reactions in some individ uals. The LD_{50} for skin absorption in rabbits is >2000 mg/kg.

INGESTION: Low toxicity if swallowed. The oral LD_{50} for rats is >2000. If aspirated (liquid enters the lung), may cause lung damage or even death due to chemical pneumonia.

INHALATION: Excessive exposure may cause irritation to upper respiratory tract (nose and throat). The aerosol LC_{50} for rats is >5 mg/L for 4 hours.

SYSTEMIC (OTHER TARGET ORGAN) EFFECTS: Excessive exposure may cause liver, kidney and blood effects. Signs and symptoms of excessive exposure may be anesthetic or narcotic effects.

CANCER INFORMATION: Picloram and triclopyr did not cause cancer in laboratory animals. The solvent contains naphthalene, which has caused cancer in some laboratory animals. An increase in lung tumors was observed in female, but not male, mice exposed to naphthalene by inhalation for two years. Limited oral studies in rats were negative.

TERATOLOGY (BIRTH DEFECTS): For triclopyr and picloram, birth defects are unlikely. Exposures having no effect on the mother should have no effect on the fetus. Did not cause birth defects in animals; other effects were seen in the foetus only at doses which caused toxic effects to the mother. The solvent did not cause birth defects or any other foetal effects in laboratory animals.

REPRODUCTIVE EFFECTS: Picloram, in animal studies, has been shown not to interfere with reproduction. Triclopyr, in laboratory animal studies - effects on reproduction have been seen only at doses that produced significant toxicity to the parent animals.

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MUTAGENICITY: For the components tested, animal genetic toxicity studies were negative. For triclopyr and picloram, in-vitro genetic toxicity studies were negative.

12. ECOLOGICAL INFORMATION:

ENVIRONMENTAL DATA:

MOVEMENT & PARTITIONING:
Based largely or completely on information for triclopyr and picloram.
Bioconcentration potential is moderate (BCF is between 100 and 3000 or Log Pow 3 and 5).

DEGRADATION & PERSISTENCE:
Based on information for triclopyr.
Based on the stringent test guidelines, this material cannot be considered as readily biodegradable; however. these results do not necessarily mean that the material is not biodegradable under environmental conditions.
The photolysis half-life in water is 6.6 days.
Based on information for picloram.
The photolysis half-life in water is 70.6 minutes.
The photolysis half-life in soil is 115 days.
The hydrolysis half-life is 18.4 hours to 61.5 days.

ECOTOXICOLOGY:
Based on information for triclopyr BEE.
Material is highly toxic to aquatic organisms on an acute basis (LC_{50} or EC_{50} is between 0.1 and 1 mg/L in most sensitive species).
Based on information for picloram.
Material is moderately toxic to aquatic organisms on an acute basis (LC_{50} or EC_{50} is between 1 and 10 mg/L in most sensitive species).

13. DISPOSAL CONSIDERATIONS:

DISPOSAL METHOD: If wastes and/or containers cannot be disposed of according to the product label directions, disposal of this material must be in accordance with your local or area regulations. This information presented below only applies to the material as supplied. The identification based on characteristic(s) or listing may not apply if the material has been used or otherwise contaminated. It is the responsibility of the waste generator to determine the toxicity and physical properties of the material generated to determine the proper waste identification and disposal methods in compliance with applicable regulations. If the material as supplied becomes a waste, follow all applicable regional, national and local laws and regulations.

14. TRANSPORT INFORMATION:

ROAD AND RAIL TRANSPORT: Not classified as dangerous goods for the transport by road and rail according to the criteria of the Australian Dangerous Goods Code (ADG 6).

SEA AND AIR TRANSPORT: Classified as dangerous goods for transport by sea and air in accordance with the International Maritime Dangerous Goods Code (IMDG) and the International Air Transport Association (IATA) Dangerous Goods Regulation.

UN No: 3082
Class: 9
Packing group: III
SHIPPING NAME: ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S. (triclopyr). Marine Pollutant

15. REGULATORY INFORMATION:

APVMA APPROVAL NUMBER: 46640

POISON SCHEDULE: 6

16. OTHER INFORMATION:

Glossary
ACGIH: American Conference of Governmental Industrial Hygienists.
AIHA WEEL: American Industrial Hygiene Association's Workplace Environmental Exposure Level.
BCF: Bioconcentration Factor - a measure for the characterization of the accumulation of a chemical in an organism. It is defined as the concentration of a chemical in an organism (plants, microorganisms, animals) divided by the concentration in a reference compartment (e.g. food, surrounding water).
Dow AgroSciences Industrial Hygiene Guideline: An internal company standard based on an 8 hour TWA.
EC_{50}: median effective concentration. Statistically derived concentration of a substance in an environmental medium expected to produce a certain effect in 50% of test organisms in a given population under a defined set of conditions.

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Explosive Limits - The range of concentrations (% by volume in air) of a flammable gas or vapour that can result in an explosion for ignition in a confined space.
K_{oc} - the organic carbon partition coefficient (mL soil water /g organic carbon).
LC_{50} - Lethal Concentration 50%. A concentration of chemical in air or water that will kill 50% of the test organisms.
LD_{50} - Lethal Dose-50%. The dose of a chemical that will kill 50% of the test animals receiving it.
NOHSC: National Occupational Health and Safety Commission of Australia now the Office of the Australian Safety and Compensation Council.
OSHA: American Occupational Safety and Health Administration.
PEL: Permissible Exposure Level, a maximum allowable exposure level by law.
pH - Measure of how acidic or alkaline a material is using a 1 - 14 scale. pH 1 is strongly acidic and pH 14 strongly alkaline.
Polymerisation - a chemical reaction in which small molecules 9monomers) combine to form much larger molecules (polymers). A hazardous polymerisation reaction is one that occurs at a fast rate and releases large amounts of energy.
P_{ow} - The octanol-water partition coefficient is the ratio of the concentration of a chemical in octanol and in water at equilibrium and at a specified temperature. Octanol is an organic solvent that is used as a surrogate for natural organic matter. This parameter is used in many environmental studies to help determine the fate of chemicals in the environment.
STEL: Short-Term Exposure Limit. A term used to indicate the maximum average concentration allowed for a continuous 15 minute exposure period.
TLV: Threshold Limit Value, an exposure limit set by a competent authority
TWA - Time Weighted Average. The average concentration of a chemical in air over the total exposure time - usually an 8 hour work day.

References

AS/NZS 1715-1994 Selection Use and Maintenance of Respiratory Protective Devices.
ASNZS 1716 - 1994 Respiratory protective devices.
Australian Dangerous Goods Code
NOHSC Hazardous Substances Information System.

Replaces version dated: 4 April 2007
Sections amended: 9

FOR FURTHER PRODUCT INFORMATION CALL DOW AGROSCIENCES CUSTOMER SERVICE REPRESENTATIVES TOLL FREE 1800 700 096 DURING BUSINESS HOURS.

This MSDS has been compiled using publicly available information, information provided by suppliers of ingredients used in the product and internal studies on the product and/or its ingredients.

THIS MSDS SUMMARISES OUR BEST KNOWLEDGE OF THE HEALTH AND SAFETY HAZARD INFORMATION OF THE PRODUCT AND HOW TO SAFELY HANDLE AND USE THE PRODUCT IN THE WORKPLACE BASED ON PUBLICLY AVAILABLE AND INTERNALLY AVAILABLE INFORMATION. EACH USER SHOULD READ THIS MSDS AND CONSIDER THE INFORMATION IN THE CONTEXT OF HOW THE PRODUCT WILL BE HANDLED AND USED IN THE WORKPLACE INCLUDING IN CONJUNCTION WITH OTHER PRODUCTS. IF CLARIFICATION OR FUTHER INFORMATION IS NEEDED TO ENSURE THAT AN APPROPRIATE RISK ASSESSMENT CAN BE MADE, THE USER SHOULD CONTACT THIS COMPANY. THE RESPONSIBILITY FOR PRODUCTS SOLD IS SUBJECT TO OUR STANDARD TERMS AND CONDITIONS, A COPY OF WHICH IS SENT TO OUR CUSTOMERS AND IS ALSO AVAILABLE ON REQUEST.

(Dow AgroScience, 2007)

Appendix K: Product Label for Access Herbicide

POISON

KEEP OUT OF REACH OF CHILDREN
READ SAFETY DIRECTIONS BEFORE OPENING OR USING

Dow AgroSciences

Access*

Herbicide

ACTIVE CONSTITUENTS:	240 g/L TRICLOPYR present as the butoxyethyl ester
	120 g/L PICLORAM present as the isooctyl ester
SOLVENTS:	389 g/L LIQUID HYDROCARBON

GROUP I HERBICIDE

For selective control of a wide range of woody and noxious weeds in commercial and industrial areas, public lands, fence lines and pastures, by basal bark and cut stump applications as specified in the Directions For Use.

Dow AgroSciences Australia Limited A.B.N. 24 003 771 659
20 Rodborough Road FRENCHS FOREST NSW 2086
www.dowagrosciences.com.au
CUSTOMER SERVICE TOLL FREE 1-800 700 096
* Trademark of Dow AgroSciences

DIRECTIONS FOR USE

RESTRAINTS

DO NOT add water to Access Herbicide.

DO NOT apply to weeds which may be stressed (not actively growing) due to prolonged periods of extreme cold, moisture stress (water-logged or drought affected), poor nutrition, presence of disease, or previous herbicide treatment as reduced levels of control may result.

DO NOT apply to charcoal coated or wet stems as this can repel the diesel mixture.

See GENERAL INSTRUCTIONS - APPLICATION section for application method details.

AGRICULTURAL NON-CROP AREAS, COMMERCIAL AND INDUSTRIAL AREAS, FENCE LINES, FORESTRY, PASTURES AND RIGHTS-OF-WAY.			
WEEDS CONTROLLED	**WEED GROWTH STAGE**	**RATE /60 L DIESEL**	**CRITICAL COMMENTS**
Acacia spp. including: Black wattle Brigalow Hickory wattle Mimosa bush Mulga Sally wattle Silver wattle	**Basal bark method:** Plants with stems up to 5 cm basal diameter.	1 L	Ensure all stems on multi-stemmed varieties are treated. Delay treatment until all regrowth on bulldozed or ploughed land has had time to emerge to a height of at least one metre. Root suckering wattles will need follow-up treatment.
African boxthorn	**Cut Stump method:** Plants up to and in excess of basal bark size. Apply immediately after cut is made.		Treat all stems on multi-stem plants.
Algaroba (*Prosopis* spp.)			
Angophora spp. regrowth			
Australian blackthorn			This species may become dormant so should not be treated during winter.
Bitterbark			Regrowth from roots may occur.
Broadleaf privet		2 L	
Brush box			Treat single stemmed seedling plants only.
Cacti including: Common pest pear Harrisia cactus Prickly pear Snake cactus Tiger pear Tree pear		1 L	Apply as an overall spray, wetting all areas of the plant to ground level.
Cockspur thorn			
Corkwood wattle			Basal bark application only. Species with old, rough bark require more thorough wetting than smooth barked species. Some regrowth may still occur.
Corymbia spp.			
Ellangowan poison bush			
Eucalyptus spp. regrowth			
False sandalwood			
Green cestrum			
Grevillea spp.			
Groundsel bush			

AGRICULTURAL NON-CROP AREAS, COMMERCIAL AND INDUSTRIAL AREAS, FENCE LINES, FORESTRY, PASTURES AND RIGHTS-OF-WAY.			
WEEDS CONTROLLED	**WEED GROWTH STAGE**	**RATE /60 L DIESEL**	**CRITICAL COMMENTS**
Guava	**Basal bark method:** Plants with stems up to 5 cm basal diameter.	2 L	Regrowth may occur from roots of the main tree.
Hard milkwood		1 L	
Hawthorn			
Heartleaf poison bush			
Honey locust			
Kiteleaf poison	**Cut Stump method:** Plants up to and in excess of basal bark size. Apply immediately after cut is made.		
Leucaena			
Limebush			Treat single stem plants only.
Lantana			
Narrow leaf hop bush			
Needlewood			
Oleander			
Parkinsonia			
Punty bush			
Red ash (white myrtle)			
Rubbervine			
Swamp box		2 L	Treat single stemmed seedling plants only.
Sweet briar		1 L	Do not treat during winter.
Tea trees			
Turpentine			
Turpentine bush			
Whitewood			
Wild orange			Basal bark treatment only.
Wild peach			
Wild Rosemary			
Wild tobacco tree			Cut stump treatment only.
Wilga			
Yellow bells (*Tecoma* spp.)			Some root suckering may occur.

AGRICULTURAL NON-CROP AREAS, COMMERCIAL AND INDUSTRIAL AREAS, FENCE LINES, FORESTRY, PASTURES AND RIGHTS-OF-WAY.			
WEEDS CONTROLLED	**WEED GROWTH STAGE**	**RATE /60 L DIESEL**	**CRITICAL COMMENTS**
Camphor laurel	**Basal bark method:** Plants with stems up to 10 cm basal diameter.	1 L	Species that become dormant should not be treated during winter.
Peppercorn tree (*Schinus molle*)			Basal bark method only.
Prickly acacia			
Sisal hemp	**Cut Stump method:** Plants up to and in excess of basal bark size. Apply immediately after cut is made.		Basal bark method only.
Tree of Heaven			Species that become dormant should not be treated during winter.
Willow		4 L	Cut stump method only. Complete control may not occur due to the multi-stem growth of plant and difficulty treating all stems.
Chinee apple	**Basal bark method:** Plants with stems up to 15 cm basal diameter. **Cut stump method:** Plants up to and in excess of basal bark size. Apply immediately after cut is made.	1 L	

NOT TO BE USED FOR ANY PURPOSE, OR IN ANY MANNER, CONTRARY TO THIS LABEL UNLESS AUTHORISED UNDER APPROPRIATE LEGISLATION.

FOR NATIVE VEGETATION

Use of Access on native vegetation must be done in accordance with STATE and/or LOCAL legislation.

WITHHOLDING PERIOD:

The use pattern of this product is such that no withholding periods are required.

GENERAL INSTRUCTIONS

MIXING

Access herbicide is designed for use with diesel distillate only. It will NOT mix with water.

Quarter fill the spray unit or mixing container with diesel and add the required amount of Access. Add the remaining diesel and shake or agitate thoroughly to mix the contents. Only mix sufficient chemical for each day's work, mixing periodically.

Dilution Table for one part Access in 60 parts diesel:

Amount of Access Herbicide	Volume of diesel added after Access
17 mL	85 mL
255 mL	1.7 L
fill to 1 L	fill to 5 L
fill to 15 L	fill to 100 L

COMPATIBILITY

Access is compatible with diesel and should not be used or diluted with any other chemicals.

GENERAL APPLICATION

Apply only with hand-directed equipment such as a pneumatic sprayer. The use of diesel as a herbicide carrier may affect the rubber seals in some sprayers. To avoid this, use sprayers, which use Viton® seals and fittings.

Spray equipment should be used at low pressures, up to 200 kPa, to avoid splashing.

Ensure all stems on multi-stemmed varieties are treated. Delay treatment until all regrowth on bulldozed or ploughed land has had time to emerge to a height of at least 1 metre.

Species that lose their leaves e.g. sweet briar; or become dormant, e.g. Australian blackthorn or camphor laurel, should not be treated during winter.

Species with old, rough bark require more thorough wetting than the smooth barked species.

DO NOT apply to charcoal coated or wet stems as this can repel the diesel mixture.

Basal Bark Application Method

Liberally spray the bark around the stem from ground level to 30 cm high, wetting thoroughly to the point of runoff (unless otherwise stated).

Cut Stump Method

Stems should be cut less than 15 cm above ground level.

Immediately apply Access/diesel mixture **liberally** to the **freshly** cut stump by spraying the cut surface and sides of the stem.

CLEANING SPRAY EQUIPMENT

Rinse water should be discharged onto a designated disposal area or, if this is unavailable, onto unused land away from desirable plants and watercourses.

After completion of spraying, use a degreaser such as Caltex Kwik-D-Grease® to remove traces of diesel from the sprayer. Rinse tank and spray through nozzles thoroughly with water to remove degreaser.

After the above, quarter fill the tank with clean water and add a alkali detergent, (e.g. liquid SURF®, OMO®, DRIVE® at 500 mL/100L of water or the powder equivalent at 500 g/100L of water). If using a concentrated laundry detergent use 250 g (or mL)/100 L water.

Do not use chlorine based cleaners.

Shake the water around the sprayer and spray the solution through the nozzles to thoroughly clean the lines and nozzles. Rinse well with clean water to remove detergent.

To clean brushes and container, spray liberally with degreaser. Hose off thoroughly with water and repeat using detergents (see above).

DO NOT use this equipment for any other purpose.

RESISTANT WEEDS WARNING

GROUP I HERBICIDE

Access Herbicide is a member of the pyridines group of herbicides. The product has the disrupters of plant cell growth mode of action. For weed resistance management the product is a Group I Herbicide.

Some naturally occurring weed biotypes resistant to the product and other disrupters of plant cell growth herbicides may exist through normal genetic variability in any weed population. The resistant individuals can eventually dominate the weed population if these herbicides are used repeatedly. These resistant weeds will not be controlled by this product or other Group I Herbicides.

Since the occurrence of resistant weeds is difficult to detect prior to use, Dow AgroSciences accepts no liability for any losses that may result from the failure of Access Herbicide to control resistant weeds.

Strategies to minimise the risk of herbicide resistance are available. Contact your farm chemical supplier, consultant, local Department of Agriculture, or local Dow AgroSciences representative.

PROTECTION OF CROPS, NATIVE AND OTHER NON-TARGET PLANTS

Treat target weeds only. DO NOT allow mixture to contact non-target species.

DO NOT use on land to be cultivated for growing sensitive plants. Legumes, vines, vegetables, cotton, tomatoes, ornamentals, coniferous species and many other broadleaf plants are highly susceptible to Access during both growing and dormant periods.

Picloram, one of the active ingredients in this product, can remain active in the soil for extended periods depending on soil type, rainfall, temperature, humidity, soil moisture and soil organic matter.

DO NOT move soil, which has been sprayed, to areas where desirable plants are to be grown.

DO NOT apply when the treated soil may be washed to areas growing, or to be planted with desirable plants.

DO NOT apply close to, or on, areas containing roots of desirable plants, or sites where surface water from heavy rain can be expected to run off to areas containing, or to be planted to, susceptible crops or plants.

PROTECTION OF LIVESTOCK, WILDLIFE, FISH, CRUSTACEANS AND ENVIRONMENT

DO NOT contaminate streams, rivers or waterways with the chemical or used containers.

Alongside waterways treat only noxious weeds and poisonous plants.

STORAGE AND DISPOSAL

Store in the closed, original container in a cool, well-ventilated area. Do not store for prolonged periods in direct sunlight.

DO NOT store near food, feedstuffs, fertilisers or seed.

Triple rinse empty containers with diesel before disposal. Add rinsings to spray tank. Do not dispose of undiluted chemicals on site.

The method of disposal of the container depends on the container type. Read the STORAGE AND DISPOSAL instructions on the label that is attached to the container.

SMALL SPILL MANAGEMENT

Wear protective equipment (see SAFETY DIRECTIONS). Apply absorbent material such as earth, sand or clay granules or cat litter to the spill. Sweep up material for disposal when absorption is completed and contain in a refuse vessel for disposal (see STORAGE AND DISPOSAL section). If necessary, wash the spill area with an alkali detergent and water and absorb as above the wash liquid for disposal.

SAFETY DIRECTIONS

- Harmful if swallowed.
- Will irritate the eyes, nose, throat and skin.
- Repeated exposure may cause allergic disorders.
- Avoid contact with eyes and skin.
- Avoid inhaling vapour or spray mist.
- When opening the container and preparing spray and using the prepared spray, wear cotton overalls buttoned to the neck and wrists, a washable hat and elbow-length neoprene gloves and a face shield or goggles.
- If product on skin, immediately wash area with soap and water.
- If product in eyes, wash it out immediately with water.
- After use and before eating, drinking or smoking, wash hands, arms and face thoroughly with soap and water.
- After each day's use wash gloves, face shield or goggles and contaminated clothing.

FIRST AID

- If poisoning occurs, contact a doctor or Poisons Information Centre. (Phone: Australia 13 11 26)
- If in eyes, hold eyes open, flood with water for at least 15 minutes and see a doctor.

MATERIAL SAFETY DATA SHEET

Additional information is listed in the Material Safety Data Sheet for Access Herbicide, which is available from Dow AgroSciences on request. Call Customer Service Toll Free on 1-800 700 096 or visit www.agrosciences.com.au

NOTICE

Seller warrants that the product conforms to its chemical description and is reasonably fit for the purposes stated on the label when used in accordance with the directions for use. No warranty of merchantability or fitness for a particular purpose express or implied, extends to the use of the product contrary to label instructions, or under off-label permits not endorsed by Dow AgroSciences, or under abnormal conditions.

APVMA Approval No. 46640/0906

* Trademark of Dow AgroSciences
® Registered Trademarks

IN A TRANSPORT EMERGENCY ONLY
DIAL 000
FOR POLICE OR FIRE BRIGADE

EMERGENCY RESPONSE (ALL HOURS)
RING FROM ANYWHERE IN AUSTRALIA
1-800 033 882
(LOCAL CALL FEE ONLY)

drumMUSTER eligible container

(Dow AgroSciences, 2008)

Appendix L: Aftercare Fact Sheet

AFTERCARE

Land restoration system

- Return land to cattle grazing area
- Create a healthy, sustainable ecosystem

Objectives of land restoration system

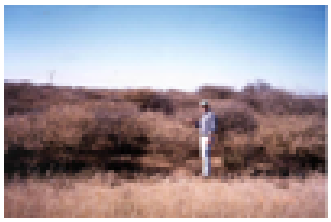
- During harvesting, leave 400-600 bushes per hectare for biodiversity
  - Require implementation of aftercare system after harvesting is complete to promote a healthy ecosystem
- Include bags of mixed grass seeds in purchase of aftercare system

Aftereare system breakdown

Short-term

- Picloram herbicide (brand name Access)
- Apply to low cut stump (10-20cm high)
  - Apply to cut surface until run-off
    - Rate/100ℓ water: 2.0ℓ

Dow AgroSciences
Access®
Herbicide



Mid-term

- Reapply Picloram herbicide to sprouts after resprout period (~1yr)
- Apply as a complete cover spray to leaves and stems until just before point of run-off
- Do not apply to wet foliage or if rain is likely

Long-term

- During fall, harvesters gather mix of local grass seeds
  - Bags of grass seeds are a required purchase with aftercare system
    - If during the correct season, farmers can hire harvesters to lay down seeds

Appendix M: Alternative short-term/mid-term aftercare options.

Table 9: Alternative short-term/mid-term aftercare options

Short Term/Mid Term Aftercare Methods		
Method	**Percent of trees cleared per hectare**	**Time of application**
goats	70.10%	after regrowth is complete ~1yr
goats and cattle	77.80%	after regrowth is complete ~1yr
cattle only	62.80%	after regrowth is complete ~1yr
veld fire	90%	after regrowth is complete ~1yr

Appendix N: Long-term aftercare plant options

Table 10: Long-term aftercare plant options

Long Term Aftercare Methods								
Plant	Invasive?	Annual biomass potentia	Other uses	Native to Namibia?	Soil requirement	Annual rainfall requirements	Frost toleranc	Internet source
Agave americana	yes	some plants reach up to 100kg in 3 years	tequila-like products	no	Well-drained. Loam or sand.	infrequent water demands	good	http://www.desert-tropicals.com/Plants/Agavaceae/Agave_americana.html
Bromus rubens L	yes		little value, poses threat to livestock	no	shallow dry soil or poor textured, clayey soil	100 mm and 250 mm of precipitation	poor	http://tncweeds.ucdavis.edu/esadocs/documnts/bromrub.pdf
Opuntia ficus-indica (prickly pear cactus)	yes		gum, oil, candles, food source, fuel	no	light (sandy) and medium (loamy) soils and requires well-drained soil.		good	http://www.ibiblio.org/pfaf/cgi-bin/arr_html?Opuntia+ficus-indica
Acacia senegal *	no	annual running 0.5–5 m3/ha wood	gum	yes	dry rocky hills, in low-lying dry savannas	250–360 mm	poor	http://www.winrock.org/fnrm/factnet/factpub/FACTSHA_senegal.html
Leucaena leucocephala	yes	2-6 t/ha	fodder, firewood, construction poles and sand binding	no	well-drained soils with pH above 5.5	650-1,500 mm prefers subhumid to humid climate	poor	http://www.tropicalforages.info/key/Forages/Media/Html/Leucaena_leucocephala.htm
Centrosema pascuorum	yes	4-9 t/ha	hay	no	wide range of soils, from sand to heavy clay and from slightly acid to alkaline soils (pH 5-8.5).	700-1,500 mm	poor	http://www.tropicalforages.info/key/Forages/Media/Html/Centrosema_pascuorum.htm
Macroptilium atropurpureum	no	5-8 t/ha under good conditions	high quality silage	yes	ravelly, sandy, and loamy soils (rarely clays) low tolerance of salinity.	800 mm-1,600 mm, drought tolerant	good	http://www.tropicalforages.info/key/Forages/Media/Html/Lotononis_bainesii.htm
Digitaria eriantha *	no	average is 10-20 t/ha, but may exceed 30t/ha	grazing, hay or silage. Suitable for cut-and-carry	yes	sands and sandy loam soils	300-1,300 mm	very good	http://www.tropicalforages.info/key/Forages/Media/Html/Digitaria_eriantha.htm
Neonotonia wightii	rarely	3-8 t/ha	hay and silage	surrounding countries	wide range of soils from red sands to heavy black clays, well drained	550-1,650 mm	tolerable	http://www.tropicalforages.info/key/Forages/Media/Html/Neonotonia_wightii.htm

Long Term Aftercare Methods

Plant	Invasive?	Annual biomass potentia	Other uses	Native to Namibia?	Soil requirement	Annual rainfall requirements	Frost toleranc	Internet source
Stylosanthes fruticosa	no	6 t/ha	improving fertility of fallow areas	yes	sandy well-drained alkaline soils	350-1,500 mm	poor	http://www.tropicalforages.info/key/Forages/Media/Html/Stylosanthes_fruticosa.htm
Stylosanthes scabra	potentially	10 t/ha under ideal conditions	cut-and-carry	no	infertile, acid, friable or hard-setting, sandy-surfaced soil	700-1,600 mm, extremely drought resistant	good	http://www.tropicalforages.info/key/Forages/Media/Html/Stylosanthes_scabra.htm
Stylosanthes viscosa	potentially	1.5 t/ha		no	mostly acid, often on sandy or sandy loam soils of sedimentary or granitic origin, but also on clays and clay loams, weel drained	1,000-1,750 mm	poor	http://www.tropicalforages.info/key/Forages/Media/Html/Stylosanthes_viscosa.htm
Chloris gayana	rarely	10-25 t/ha	hay, pasture	surrounding countries	well-structured loams and clays of volcanic origin, it grows on most well drained soils,	500-1,500 mm	good	http://www.tropicalforages.info/key/Forages/Media/Html/Chloris_gayana.htm
Lablab purpureus	no	4 t/ha	pulse crop and fodder legume	yes	deep sands to heavy clays, provided drainage is good, and from pH 4.5-7.5.	650-3,000 mm, drought resistant	very poor	http://www.tropicalforages.info/key/Forages/Media/Html/Lablab_purpureus.htm
Sesbania sesban	rarely	20 t/ha/year	green manure and a source of cut and carry forage	surrounding countries	wide range of soils from loose sands to heavy clays	500-2,000 mm, grows best with periodic waterlogging	tolerable	http://www.tropicalforages.info/key/Forages/Media/Html/Sesbania_sesban.htm
Stylosanthes hamata	no	17 t/ha DM in pure stands,	permanent pasture, hay	no	infertile, acid, sandy surfaced soils, onto more alkaline soils	500-2,000 mm	poor	http://www.tropicalforages.info/key/Forages/Media/Html/Stylosanthes_hamata.htm
Urochloa mosambicensis	rarely	1–8 t/ha	permanent pasture, hay	surrounding countries	lighter textured soils from sands to clay loams	800–1,000 mm	poor	http://www.tropicalforages.info/key/Forages/Media/Html/Urochloa_mosambicensis.htm
Urochloa oligotricha	no	6 t/ha	pasture	yes	range of soil textures from sands to clays	(400–) 600–1,000 (–1,500) mm, moderately drought tolerant	good	http://www.tropicalforages.info/key/Forages/Media/Html/Urochloa_oligotricha.htm
Cenchrus ciliaris	yes	2-9 t/ha	pasture, hay, silage	yes	sandy soils, sandy loam, loam, clay loam and red earth soils.	300 and 750 mm	good	http://www.tropicalforages.info/key/Forages/Media/Html/Cenchrus_ciliaris.htm
Prosopis cineraria	failed to propogate when introduced in Namibia	2.9 M^3/ha	wood, food, fodder	no	coarse, sandy, often alkaline soils	150-400 mm, extremely drought tolerant	slightly tolerant	http://www.winrock.org/fnrm/factnet/factpub/FACTSH/P_cineraria.html

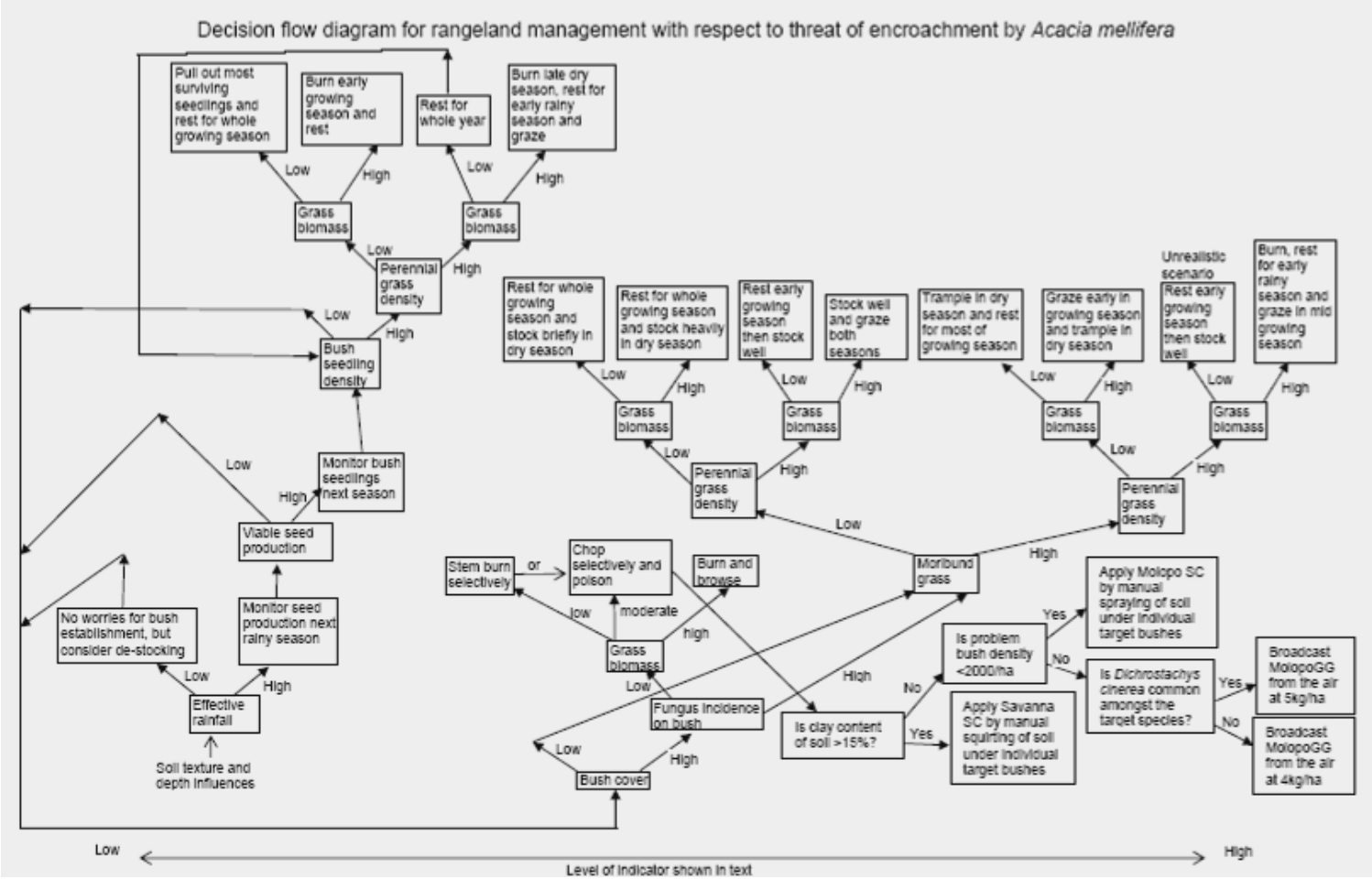


Figure 32: Decision flow diagram for Acacia mellifera

Appendix P: Biomass Power Plants

With oil prices across the globe skyrocketing, and renewed concerns for the environment and CO_2 emissions, biomass power plants have become an attractive solution to the energy needs for many countries. Numerous biomass power plants utilize gasification. Gasification is a technique used to convert the carbon in bio-materials into a gas mixture consisting of carbon monoxide, hydrogen, methane, and carbon dioxide (Irons, 2008). Gasification is a more efficient process than direct combustion because more energy is extracted. During gasification, the biomass releases CO_2 into the atmosphere, however this amount is equal to or less than the amount absorbed by the plant during its growth period. Therefore, the process is carbon neutral (Bookhart, 2003).

The US, as well as countries such as Bangladesh (Perlack et al., 1995), Brazil, the Philippines, Sweden, and Finland (Biopact, 2008), have implemented successful biomass systems. In these countries, plants convert crops, animal wastes, wood, municipal wastes, and aquatic plants into energy. Fifteen percent of the world's energy supply comes from biomass (Perlack, 1995). In industrial countries biomass only accounts for 3% of primary energy, however in developing countries biomass supplies 35%. In industrial countries this energy is primarily used for heat and electricity, while in developing countries it is used more for cooking and heating. There is a growing movement in developing countries, however, towards the creation of electricity.

Appendix Q: Harvesting Technologies Worldwide

The harvesting of woody biomass for use as an energy source has taken place in many countries. The challenges and opportunities faced in these areas may be instructive when attempting to integrate such systems in Namibia.

One challenge of short rotation forestry, a method of growing and harvesting forest biomass, is the abundance of variables including crop height, spacing density, operating season, and reproduction methods (Mattsson & Mitchell, 1995). These ever-changing sets of circumstances make it difficult to identify a single harvesting machine that is effective and appropriate in all circumstances.

Another item to consider when investigating harvesting technology is its impact on soil (Mattsson & Mitchell, 1995). Heavy machinery, if used on soft, wet ground, has the potential to cause serious, long-term ecological damage to a harvesting site. Low pressure ground equipment may be needed in many areas. In the case of short rotation forestry, plantations would have to be designed with broader pathways to accommodate wide tire machines.

An alternative way of gathering woody biomass is by using forest residues, the byproducts of the forestry industry (Mattsson & Mitchell, 1995). Since the use of large scale forestry technology can be expensive, smaller, inexpensive machinery is often more economical for the removal of small woody biomass. Single grip harvesters, for example, are excellent at removing small forest residues and laying them aside to dry.

It is estimated that, in the case of forest residue collection, transportation accounts for 20-40% of the total delivered fuel cost (Mattsson & Mitchell, 1995). Clearly, efficient transportation methods are needed. Chipping the wood fuel before transportation increases transport density, but can create problems if the chips need to

be stored for an extended period of time. Allowing sufficient drying of the wood before transport is another way to increase density and reduce cost.

Swedish research has also found that transportation costs make the production of wood chips for fuel too expensive as a competitive resource when compared with traditional power sources (Berg, 2003). One way to increase efficiency is to compact forest residue into composite residue logs (CRLs), such as those shown in Figures 16 and 17 (Andersson, 2000). Wood Pac and Fiberpac are two companies that have produced equipment that can efficiently compress branches and forest residues into log shaped bales, which are easier to transport and handle. These CRLs have diameters of approximately 0.75m, length of up to 3m, and weigh between 400–600kg. When burned in a biomass power plant, Andersson has shown that each log is capable of producing over 1MWh of energy. One reason CRLs are an attractive method, is that conventional round wood transport technology may be utilized to transport them. The Wood Pac unit was found to produce about 15 CRLs per productive hour, while the Fiberpac 370 produced 20-30 CRLs per hour. Figures 16, 17, and 18 below show the creation and transport of the Composite Residue Logs.

Figure 33: Composite Residue Logs being easily handled and transported

(Andersson, 2000. 119)

Figure 34: The Fiberpac 370, used to efficiently create CRLs

(Andersson, 2000, 118)

After transport, the CRLs can then be chipped at the heating plant, which is cheaper than on site chipping solutions. However, chipping remains the "bottleneck" in the harvesting system. Technology still needs to be developed to determine the best way to chip CRLs (Andersson, 2000). Large drum chippers can be used for high productivity at low chipping costs, but they are very sensitive to contaminants, creating expensive repair costs.

Figure 35: A Bruks 1004 CT drum chipper used to chip CRLs

(Andersson, 2000. 120)

Another example of a machine that bundles forest residue into CRLs is the Timberjack SA FB370 model (Cuchet & Roux, 2003). A cage, open at both ends, is fed with raw, unbundled residue in one end, which is compacted, fed through, and then tied at the other end. The bundling machine is mounted on a forwarder, for easy mobility. Trials in France suggest that it is easy to produce CRLs with this equipment from the forest residues on maritime pine, poplar, chestnut and hornbeam stands. One challenge is the moisture content of the wood. Dry branches tend to break under the strain of tying strings, creating loose bundles. One solution to this problem is to bundle as soon as possible after harvesting. Another concern is the use of biodegradable strings, which are much easier to dispose. Unfortunately, they are more expensive and have a shorter life expectancy.

An important factor to consider when harvesting wood products is greenhouse gas emission; this includes the generation of CO_2, CO, and NO_x. A study conducted by Berg and Karjalainen (2003) compared two studies, in Finland and Sweden, in

terms of the emissions of greenhouse gasses from forest harvesting and secondary transportation. A formula was constructed to aide in the comparison:

$$E = EF + A \quad (1)$$

where E is the amount of greenhouse gas emissions in grams per unit of performance, EF is the emission factor in grams per kg of fuel, A is amount of energy consumed or distance traveled for a given activity. All three terms are dependent on the type of fuel, the performance, the method used, and emission control.

Many different factors were taken into account such as terrain, tree-type, harvest size, and distance traveled (Berg & Karjalainen, 2003). Nordic brand harvesters were mainly used in both countries. Finland used small tractors adapted for forest work for forwarding, while Sweden used small forwarders. In Finland distances are greater, thus additional transportation is needed to move the machinery, while in Sweden the distances are short enough for machines to be moved by their own means. After harvesting, the land must be scarified, meaning the forest floor must be broken and disturbed for regeneration to occur. Emissions were found to be less in Sweden than in Finland. Sweden has a larger growth per area, which results in lower emissions per harvested unit. The actual variations in operations, vehicles, engines, and fuels all must be considered when determining emissions levels.

Appendix R: Harvesting Technology in Namibia

Namibia needs an effective harvesting solution in order to halt encroachment on agricultural land, provide stable employment for native workers, and provide economical, environmentally friendly energy for an energy poor country. The Cheetah Conservation Fund in Namibia has a partly mechanized harvesting system (Leinonen, 2007) consisting of felling, gathering, drying, chipping, and transporting phases. In this system, teams of 4-8 men use axes to clear brush. Four men in compiling crews then manually drag the bushes to a strip road for drying. A team of eight men transport the dried limbs into a chipper that feeds into a trailer, which is then transported a distance of 50km to the Bushblok plant.

The Research Centre of Finland (Leinonen, 2007) reviewed the current Namibian methods of bush harvesting. They looked into different technologies and their effectiveness in felling brush. Based on their research, they devised a new mechanized harvesting system, which involves felling bush with a skid steer or rotary saw, gathering with skid steer or grapple fork, chipping with a mechanized chipper, and finally transporting by road using tractor trailers. The Research Centre calculated the costs of the new mechanized system to be 24% lower than the current system at the CCF. Chipping and road transport costs were also significantly reduced. However, the Centre also found that harvesting wood chips for a 5MWe power plant requires 231 workers with the current CCF system while the new system would require only 29 workers. The ratio of workers in the CCF system to the new system remains nearly the same for 10MWe and 20MWe power plants. Hence, while the new mechanized system is efficient at removing the most bush for the smallest cost, it is counterproductive to the goal of increasing employment. According to Robert

Schultz and the DRFN, the hand axes will be recommended for the CBEND project as felling equipment in order to ensure a large sustainable harvesting industry.

A survey done by the Steward Scott Namibia Consulting Engineers discovered that 35% of farms that clear the invasive bush do so using manual techniques (de Klerk, 2004). Manually removing the bush is highly labor intensive and thus creates job opportunities. Stumping is a technique that removes the bush above the ground through the use of axes, mattocks, handsaws, or chainsaws. Since most bushes will regrow if they are only stumped, an aftercare system for the rest of the bush must be implemented. For mechanical removal of the root system one can also use mattocks and axes; however, this is highly labor intensive and other aftercare methods such as herbicide are more likely to be used when removing more than one bush at a time. Stumping was previously done by a rotating saw attached to the back of the tractor. However, this method was abandoned due to difficulty sawing the thick bush such as the Black thorn and for safety reasons.

A Holt machine was used to flatten the Black thorn, but it was inefficient at flattening species of bush with thinner stems (de Klerk, 2004). The Holt machine allowed the "opening up" of particular areas of thick plant growth, however it raised costs due to follow up treatment from shoots sprouting from the stumps of flattened plants.

The de Klerk study (2004) proposed to thin the bush by 25%, or every fourth tree, every five years. This would ensure that the bush-to-electricity harvesting system would be a sustainable enterprise. In areas that were intensely harvested (greater than 50%), the leaf, flower, and seed production increased due to lowered competition among species. De Klerk also found that the best season to harvest *C. mopane* is in winter (May-August), because in the spring, the new leaves are a source of food for

browsing wildlife (de Klerk, 2004). In harvested areas, regrowth is expected with varieties such as *Dichrostachys cinerea* and *Acacia mellifera*. If proper follow-up treatment (chemicals, goats to eat shoots, etc.) is not taken, the bush will grow back to an even greater extent.

An efficient manner of removing bush is the bulldozing of the bush encroached area (de Klerk, 2004). However, problems will arise if the topsoil is disturbed, because that provides an ideal environment for new seedlings. In de Klerk's study, a D6 Caterpillar tractor with a bulldozer blade was used to clear areas with Black thorn and other plants. This technique of bush removal was deemed too expensive for individual farmers. However, this method would be useful to clear land in order to produce crops.

Table 12 provides insight into the selection of eight bush harvesters, as well as the expected harvesting land per person.

Table 11: Land Cleared by 8 Person Harvesting Team

Labour performance criteria	Result
Average number of workers	8
Total number of working days	67
Total area treated (manual application of chemicals)	900 ha
Total person days (8 x 67)	536
Area cleared per day per worker	1.68 ha

(MET, 2008, p. 137)

Appendix S: Social Labor Issues in Namibia

Women in Agricultural Labor

Women in Namibia have recently experienced major changes both in terms of their influence in politics and in the workplace. In the Namibian Constitution, which was passed in 1990, equality for all persons before the law was established (Bauer, 2001). Specifically, discrimination on the grounds of gender was prohibited. This was a significant change for the women of Namibia, who previously held limited power and were unequal before the law. A policy of affirmative action for women was also set up in Namibia soon after the country's independence; electoral law now requires that 25% of candidates in local elections be women. In 1996, the Married Persons Equality Act was passed, which placed married men and women equal before the law.

In agriculture, women have always been a key to success. It was found that in the Owambo regions of Namibia, women are twice as likely to work in the fields as men (Girvan, 1995). Men generally take jobs involving higher levels of technology, replacing animal-drawn plows with modern equipment. Post-independence, women are becoming increasingly more responsible for livestock, making decisions for seed selection and field preparation. However, in almost all Namibian rural communities, men still hold the power in agriculture; women are expected to harvest for the purpose of feeding their families, but not to contribute to the income. Many women farm both individual plots to feed their family, as well as family plots, which are controlled by men, to make a profit. Women are entitled to sell produce on a small, informal scale, but anything larger than that is controlled by the husband. Efforts by the government have been made, however, to try to increase the amount of control held by women in agriculture.

The level of agricultural skills held by women is of high importance, since they have been responsible for the actual field work involved in harvesting for years. Given that women are socially accepted in the agricultural workforce, they may be a potential workforce for the harvesting jobs. However, given the living situation the harvesters will be staying in, it is unknown if a women's quarters could be provided.

HIV/AIDS

The effect of HIV/AIDS on Namibia has been devastating. The exact specifics on the levels of infection in the country are not available due to the stigma of the disease (Susser, 2007), though the accepted statistics report a 19.9% infection rate. The percent of the population tested for the disease is surprisingly low. While most Namibians know the disease exists, it is not customary to be open about having the disease. In general, only rumors exist about the possibility of the disease being the cause for countless numbers of deaths. Therefore, when dealing with the disease in terms of labor, HIV/AIDS is generally ignored and asking possible hires if they are infected may not be socially accepted.

The disease has a large impact on the quality of labor in Namibia. It is not customary to ask people about their health conditions. Therefore, potential employees could have HIV/AIDS without the employer's knowledge. This could affect their ability to work at a labor intensive job by lowering their ability to do physical labor. Furthermore, absenteeism will increase due to personal sickness, death, or sickness of friends and family. To compensate for the impact of the disease on the work force, different working solutions should be considered to insure a more reliable output of product.

Appendix T: Safety in Agriculture

Work in agriculture related fields has a high potential for personal injury. Strains, sprains, hearing loss, chemical poisoning, skin disorders, cancers, respiratory issues, and heat stress are only some of the issues faced by workers (OSHA, 2008).

To avoid strains and sprains, (OSHA, 2008) workers must maintain good posture, shift weight while working for long periods of time, and stand with feet a shoulder width apart, if possible. Also, to maintain back health, the back must be kept straight while squatting, and should be limited in use. It is important to stretch and rotate tasks. Employees should be in good physical shape, making sure they get enough sleep and take breaks during the day (Georgia Farm Bureau, 2008)

Employers are also responsible for safety precautions (OSHA, 2008). They should make sure that all equipment is maintained in order to ensure tools are in working order. The lights, tires, brakes, etc. should be checked regularly on all machinery (Georgia Farm Bureau, 2008). Employers should train employees in work methods and safety, ensure that supervisors know that people are using equipment properly, and provide instructions for emergency situations.

Ear protection is a necessity to protect workers' hearing (OSHA, 2008). Proper maintenance of equipment is also important to reduce noise levels. If employees use chemicals, protective clothing and gloves should be worn. One should avoid contacting the chemicals and then touching the skin or eyes.

It is important to protect the skin in agricultural work (OSHA, 2008). Skin cancer is a danger when working in the sun for long periods. Proper attire and sun-block should be worn to avoid overexposure to harmful radiation. Certain types of dermatitis such as contact dermatitis, heat rash, and those resulting from insect and

plant irritants can occur. These can be prevented by avoiding contact with irritants as well as by washing frequently. It is important to maintain personal hygiene (Cyr and Johnson, 2008), especially at the end of the day. Work clothes should be removed, hands and face should be washed before eating, and a shower should be taken each day.

Dehydration is a concern when working in heat. In a few hours a person can loose up to 6% of his/her body weight. A loss of just 2 to 3 percent can cause blood circulation to slow, leading to discomfort, thirst, rising body temperature, and increased pulse rate. Heat cramps, dizziness, headaches, excessive sweating, and extreme weakness are all signs of heat exhaustion. Heat stroke can also occur, causing the body to stop sweating, resulting in a rapid increase in body temperature. If untreated, the person can lose consciousness, convulse, or even die. Employers can avoid these situations by educating workers on the dangers of heat, by providing adequate water and shade, and by having a person certified in first aid on each team.

Appendix U: Effective Communication and Teambuilding

The harvesting laborers will be required to live in accommodation trailers during the work week since they will be operating in sparsely populated rural areas. This unique arrangement, in which the employees both work and live together, must be treated with care. Specifically, it is important for the managers to stress effective communication in order to create harmonious teams. Bernard Erven from Ohio State University has published numerous documents on managing dairy farms (2008). Two specific papers of interest for the harvesting managers are "Overcoming Barriers to Communication" and "Building a Dairy Farm Team." A summary of Erven's ideas and the application for the harvesting teams follow, while the full papers may be found in Appendices V and W, respectively.

Namibia's diversity is one of the country's unique aspects. The different ethnic groups all speak various languages and dialects; although they often communicate amongst themselves in English or Afrikaans. However, communication between different individuals is a key issue in both work and living environments (Erven, 2008). Even if people are fluent in a second language, they may miss certain phrases or slang terms that others use. Regardless of language barriers, Erven identifies other obstacles to effective communication, such as unclear messages, poor listening skills and interruptions, as well as communicating over the wrong "channel." For example, important, detailed messages should be in writing, while it may be more appropriate to deliver short instructions verbally. Erven also stresses the importance of open feedback while communicating, because it verifies the content of the message, as well as provides opportunities for clarification.

Proper communication is imperative for the harvesting teams. During the work day, individuals will need to receive tasks from the managers, as well as discuss

with each other effective techniques to harvest each day. Furthermore, conflicts will undoubtedly arise while sharing accommodation facilities; therefore, it is important for channels to be in place to address concerns to each other, as well as to the managers of the team. The harvesting team managers should be trained in certain basic communication techniques, as suggested by Erven. Additionally, managers should stress proper communication to employees, and be open to feedback from the laborers.

The bush harvesting laborers will all be working together on a daily basis to harvest the quota of biomass in order to provide appropriate supplies to the power plants. Therefore, effective teamwork is necessary. Bernard Erven defines a team as individuals who work together toward a common goal (2008). This goal cannot be reached by single workers, but rather the individuals need to complete the tasks together as a team. Erven finds that teamwork has a number of advantages when dealing with complicated tasks, such as efficiency in completing goals, mentoring inexperienced workers, and comradery. These are specifically essential when working and residing together. A successful team will rely on each other for support, as well as provide enjoyment in monotonous tasks. Managers are advised to encourage team work while harvesting bush, which will result in more productivity and less conflict.

To create a sustainable industry, laborers should be properly trained in their work, as well as in first aid. Regardless of the methods used for harvesting, all machinery and equipment is dangerous due to the sharp blades and heavy equipment. Therefore, proper education is essential for providing all workers with a safe occupation. Additionally, without proper training, the bush harvesting industry would

remain undesirable. With continued training, laborers will become more comfortable working, and fewer injuries will occur.

Appendix V: Overcoming Barriers to Communication

OVERCOMING BARRIERS TO COMMUNICATION

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Ohio State University

Communication plays a major role in employer-employee relationships on farms. It also affects the relationships among family members on the management team. Although effective communication does not guarantee success of a farm business, its absence usually assures problems. A communication problem may soon become a crisis or it may linger on for years.

More specifically, communication influences the effectiveness of the hiring and training of employees, motivation of employees, providing daily instructions, performance evaluations and the handling of discipline problems. These are the obvious roles of communication. Communication also affects the willingness of employees to provide useful suggestions. Employees feel a part of the business requires communication. In fact, for employees to make the important evolution from "workers" to "working managers" requires effective communication between supervisors and employees.

Employees typically are hesitant to state their goals, their concerns and their disappointments. Of course, an employee may be a complainer and share views to the point a supervisor silently begs for less "communication." Much more common is the need to better understand what an employee is "really thinking."

This paper is about improving communication skills. Removing barriers to communication is one of the easiest ways to improve communication. Removing these barriers starts with an understanding of a communication model. This paper should help managers think about their own communication skills and the way they communicate day-to-day back home.

Communication Model

The process starts with a **sender** who has a **message** for a **receiver**. Two or more people are always involved in communication. The sender has the responsibility for the message.

The sender's message travels to the receiver through one or more **channels** chosen by the sender. The channels may be verbal or non-verbal. They may involve only one of the senses, hearing for example, or they may involve all five of the senses: hearing, sight, touch, smell, and taste. Non-verbal communication, popularly referred to as body language, relies primarily on seeing rather than hearing.

The sending of a message by an appropriate channel to a receiver appears to have completed the communication process or at least the sender's responsibility. Not so! After sending the message, the sender becomes a receiver and the receiver becomes a sender through the process of **feedback**. Feedback is the receiver's response to the attempt by the sender to send the message. Feedback is the key to determination by the sender of whether or not the message has been received in the intended form. Feedback involves choice of channel by the receiver of the original message. The channel for feedback may be quite different from the original channel chosen by the sender. A puzzled look may be the feedback to what the sender considered a perfectly clear oral instruction.

Effect on the receiver completes the communication process. Effective communication is the original sender having the desired effect on the receiver. Communication at its best minimizes misunderstanding between sender and receiver. The sender cannot transplant a message or idea. Ineffective communication means there was no effect on the receiver or the effect was unexpected, undesired and/or unknown to the sender.

This simplified version of a complex process can be a powerful tool for thinking about one's communication skills, diagnosing communication problems and developing plans for improvement of communication. The good news about communication is that improvement is usually possible. The bad news is that perfection in communication escapes everyone.

Barriers to Communication

Problems with any one of the components of the communication model can become a barrier to communication. These barriers suggest opportunities for improving communication

1. **Muddled messages** - Effective communication starts with a clear message. Contrast these two messages: "Please be here about 7:00 tomorrow morning." "Please be here at7:00 tomorrow morning." The one word difference makes the first message muddled and the second message clear.
   Muddled messages are a barrier to communication because the sender leaves the receiver unclear about the intent of the sender. Muddled messages have many causes. The sender may be confused in his or her thinking. The message may be little more than a vague idea. The problem may be semantics, e.g., note this muddled newspaper ad: "Dog for sale. Will eat anything. Especially likes children. Call 888-3599 for more information."

   Feedback from the receiver is the best way for a sender to be sure that the message is clear rather than muddled. Clarifying muddled messages is the responsibility of the sender. The sender hoping the receiver will figure out the message does little to remove this barrier to communication.

2. **Stereotyping** - Stereotyping causes us to typify a person, a group, an event or a thing on oversimplified conceptions, beliefs, or opinions. Thus, basketball players can be stereotyped as tall, green equipment as better than red equipment, football linemen as dumb, Ford as better than Chevrolet, Vikings as handsome, and people raised on dairy farms as interested in animals. Stereotyping can substitute for thinking, analysis and open mindedness to a new situation.

   Stereotyping is a barrier to communication when it causes people to act as if they already know the message that is coming from the sender or worse, as if no message is necessary because "everybody already knows." Both senders and listeners should continuously look for and address thinking, conclusions and actions based on stereotypes.

3. **Wrong channel** - "Good morning." An oral channel for this message is highly

appropriate. Writing "GOOD MORNING!" on a chalkboard in the machine shed is less effective than a warm oral greeting. On the other hand, a detailed request to a contractor for construction of a farrowing house should be in writing, i.e., non-oral. A long conversation between a pork producer and a contractor about the farrowing house construction, with neither taking notes, surely will result in confusion and misunderstanding. These simple examples illustrate how the wrong channel can be a barrier to communication.

Variation of channels helps the receiver understand the nature and importance of a message. Using a training video on cleaning practices helps new employees grasp the importance placed on herd health. A written disciplinary warning for tardiness emphasizes to the employee that the problem is serious. A birthday card to an employee's spouse is more sincere than a request to the employee to say "Happy Birthday" to the spouse.

Simple rules for selection of a channel cause more problems than they solve. In choice of a channel, the sender needs to be sensitive to such things as the complexity of the message (good morning versus a construction contract); the consequences of a misunderstanding (medication for a sick animal versus a guess about tomorrow's weather); knowledge, skills and abilities of the receiver (a new employee versus a partner in the business); and immediacy of action to be taken from the message (instructions for this morning's work versus a plan of work for 1994).

4. **Language** - Words are not reality. Words as the sender understands them are combined with the perceptions of those words by the receiver. Language represents only part of the whole. We fill in the rest with perceptions. Trying to understand a foreign language easily demonstrates words not being reality. Being "foreign" is not limited to the language of another country. It can be the language of another farm. The Gerken house may be where the Browns now live. The green goose may be a trailer painted red long after it was given the name green goose. A brassy day may say much about temperature and little about color.

   Each new employee needs to be taught the language of the farm. Until the farm's language is learned, it can be as much a barrier to communication as a foreign language.

5. **Lack of feedback** - Feedback is the mirror of communication. Feedback mirrors what the sender has sent. Feedback is the receiver sending back to the sender the message as perceived. Without feedback, communication is one-way.

   Feedback happens in a variety of ways. Asking a person to repeat what has been said, e.g., repeat instructions, is a very direct way of getting feedback. Feedback may be as subtle as a stare, a puzzled look, a nod, or failure to ask any questions after complicated instructions have been given. Both sender and receiver can play an active role in using feedback to make communication truly two-way.

Feedback should be helpful rather than hurtful. Prompt feedback is more effective that feedback saved up until the "right" moment. Feedback should deal in specifics rather than generalities. Approach feedback as a problem in perception rather than a problem of discovering the facts.

6. **Poor listening skills** - Listening is difficult. A typical speaker says about 125 words per minute. The typical listener can receive 400-600 words per minute. Thus, about 75 percent of listening time is free time. The free time often sidetracks the listener. The solution is to be an active rather than passive listener.

   One important listening skill is to be prepared to listen. Tune out thoughts about other people and other problems. Search for meaning in what the person is saying. A mental outline or summary of key thoughts can be very helpful. Avoid interrupting the speaker. "Shut up" is a useful listening guideline. "Shut up some more" is a useful extension of this guideline. Withhold evaluation and judgment until the other person has finished with the message. A listener's premature frown, shaking of the head, or bored look can easily convince the other person there is no reason to elaborate or try again to communicate his or her excellent idea.

   Providing feedback is the most important active listening skill. Ask questions. Nod in agreement. Look the person straight in the eye. Lean forward. Be an animated listener. Focus on what the other person is saying. Repeat key points. Active listening is particularly important in dealing with an angry person. Encouraging the person to speak, i.e., to vent feelings, is essential to establishing communication with an angry person. Repeat what the person has said. Ask questions to encourage the person to say again what he or she seemed most anxious to say in the first place. An angry person will not start listening until they have "cooled" down. Telling an angry person to "cool" down often has the opposite effect. Getting angry with an angry person only assures that there are now two people not listening to what the other is saying.

7. **Interruptions** - A farm is a lively place. Few days are routine. Long periods of calm and quiet rarely interrupt the usual hectic pace. In this environment, conversations, meetings, instructions and even casual talk about last night's game are likely to be interrupted. The interruptions may be due to something more pressing, rudeness, lack of privacy for discussion, a drop-in visitor, an emergency, or even the curiosity of someone else wanting to know what two other people are saying.

   Regardless of the cause, interruptions are a barrier to communication. In the extreme, there is a reluctance of employees and family members even to attempt discussion with a manager because of the near certainty that the conversation will be interrupted. Less extreme but serious is the problem of incomplete instructions because someone came by with a pressing question.

8. **Physical distractions** - Physical distractions are the physical things that get in the way of communication. Examples of such things include the telephone, a pick-up truck door, a desk, an uncomfortable meeting place, and noise.

These physical distractions are common on farms. If the phone rings, the tendency is to answer it even if the caller is interrupting a very important or even delicate conversation. A supervisor may give instructions from the driver's seat of a pick-up truck. Talking through an open window and down to an employee makes the truck door a barrier. A person sitting behind a desk, especially if sitting in a large chair, talking across the desk is talking from behind a physical barrier. Two people talking facing each other without a desk or truck-door between them have a much more open and personal sense of communication. Uncomfortable meeting places may include a place on the farm that is too hot or too cold. Another example is a meeting room with uncomfortable chairs that soon cause people to want to stand even if it means cutting short the discussion. Noise is a physical distraction simply because it is hard to concentrate on a conversation if hearing
is difficult.

Facilitating Communication

In addition to removal of specific barriers to communication, the following general guidelines may also facilitate communication.

1. Have a positive attitude about communication. Defensiveness interferes with communication.

2. Work at improving communication skills. It takes knowledge and work. The communication model and discussion of barriers to communication provide the necessary knowledge. This increased awareness of the potential for improving communication is the first step to better communication.

3. Include communication as a skill to be evaluated along with all the other skills in each person's job description. Help other people improve their communication skills by helping them understand their communication problems.

4. Make communication goal oriented. Relational goals come first and pave the way for other goals. When the sender and receiver have a good relationship, they are much more likely to accomplish their communication goals.

5. Approach communication as a creative process rather than simply part of the chore of working with people. Experiment with communication alternatives. What works with one person may not work well with another person. Vary channels, listening techniques, and feedback techniques.

6. Accept the reality of miscommunication. The best communicators fail to have perfect communication. They accept miscommunication and work to minimize its negative impacts.

Summary

Communication is at the heart of many interpersonal problems faced by farm employers. Understanding the communication process and then working at improvement provide managers a recipe for becoming more effective communicators. Knowing the common barriers to communication is the first step to minimizing their impact. Managers can reflect on how they are doing and make use of the ideas presented in this paper. When taking stock of how well you are doing as a manager, first ask yourself and others how well you are doing as a communicator.

Appendix W: Building a Dairy Farm Team

Building A Dairy Farm Team

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Would anyone doubt that a successful dairy farm requires a team effort? Silly question? Not at all. Most dairy farms have groups of people or collections of individuals rather than teams. Success does not demand a team approach. A farm manager who prefers a team approach faces a tough test of patience, people skills and communication.

Team Basics

A dairy farm can have a team of people, a group or just a collection of individuals. The differences among the three are important:

Team: Several people who ***work together*** as a ***cohesive unit*** to achieve specific, shared goals.

Group: Several people who have common goals but work ***independently*** without depending on each other for their success.

Individuals: Several individuals who work ***independently*** to accomplish their individual goals without depending on each other for their success.

There are good reasons for dairy farm managers to form teams. Successful teams are likely to help managers accomplish the following:

1. Efficiency in use of farm resources

2. Complementarity of skills brought to the team by its members

3. Reinforcement of goals, standards, procedures and rules

4. Mentoring of newer and less skilled team members by other team members

5. Esprit de corps from team members personally enjoying each others' company and the team's accomplishments

6. Peer pressure to help meet team goals and to correct performance deficiencies

7. Monitoring of performance at both the individual and team level

However, people sometimes have understandable reasons for resisting teamwork:

1. Previous negative experiences with attempts at teamwork

2. Fear of the risk that goes with commitment to a team effort

3. Management's failure to develop an atmosphere of trust in a team's ability to be good for both the farm and individuals

4. Some people not fitting well into a team environment, e.g., perfectionists, scorekeepers, grudge carriers, loners and procrastinators.

Stages of Team Development

A dairy farm group goes through several stages before becoming a highly efficient and effective team. The stages are:

1. Forming

2. Storming

3. Initial Integration (norming)

4. Total Integration

5. Dissolution

Teams go through these stages at different rates and in different ways. Most will go through all five stages provided they don't stall at an early stage and cease to function.

Note carefully! We are describing a process uncommon in group work. Teamwork is easy rhetoric. The practice of teamwork challenges even the most experienced dairy farm managers. Some farm managers look for "top down" shortcuts. Some scoff at the time necessary to turn a group of people into a team. However, for those who understand the principles and then work hard at implementation, the payoffs can justify the effort.

We turn now to the characteristics typically associated with each of the five stages in the team development process.

1. Forming
   - Members become acquainted
   - Members learn about goals and tasks of the team
   - Members evaluate work associated with and benefits of the team relative to career and personal needs
   - Most everyone exhibits good behavior and courtesy
   - Leader identified
   - Preliminary plans made for the next steps
   - Members enjoy a good and seemingly easy start

2. Storming
   - High emotion

- Conflict may occur during long and seemingly inefficient meetings
- There is a lot of "behind the bosses' back" and "behind the leaders' back" kind of grumbling
- High emotion characterizes some of the interaction among team members
- Doubts based on previous negative experiences cause people to be cautious
- Doubts emerge about ability to deliver all that is expected
- Writing a mission statement and/or goals is stressful and leads to additional statements about differences of opinion
- Outcome finally is to push ahead with a sense of some important progress has been made but that there is much still to be accomplished

3. Initial Integration (norming)
- Team begins to function cooperatively
- Rules of acceptable conduct, or norms, are established
- Team needs begin to take precedent over individual needs
- Hostility ceases
- Mission statement and detailed goals are completed
- Individuals begin to experience benefits of close cooperation with others on the team
- Sense of closeness and group purpose emerges
- Team has some major successes

4. Total Integration
- Major successes continue
- Conflict is rational
- Creative tension regularly reappears
- "What next?" is a compulsive question
- Team struggles with how to handle changing membership
- Successes are widely recognized
- Members are concerned more about the team than their own successes
- Team is well organized; meetings are short and efficient

5. Dissolution
- No team goes on indefinitely
- Teams that have functioned well sense when change, new members and "mission accomplished" have taken members back to the forming stage.

Cultivating Team Performance

Neither the farm manager nor outside cooperators, e.g., veterinarians, can accept responsibility for team performance. Each team is responsible for its own performance. However, the following guidelines for team members, managers and cooperators can help cultivate team performance:
1. Establish urgency. Have a driving cause, issue or need.

2. Pay particular attention to early planning meetings and actions. Remember that most groups never reach the norming stage of team development.

3. Set some clear rules of behavior. Those rules will vary team to team. Examples include: holding all scheduled team meetings, starting meetings on time, volunteering to help each other with disagreeable jobs, saying thank you, and not talking about problems with neighbors and friends.

4. Set and seize upon a few performance-oriented tasks and goals. Make them SMART: **S**pecific, **M**easurable, **A**ttainable, **R**ewarding, and **T**imed.

5. Challenge each other with fresh facts and information.

6. Spend lots of time together. There is no substitute for a team caring about its members and each team member caring about the welfare of the team. Celebrate birthdays, go to a baseball game together, have frequent team meetings, and have a daily "coffee break" together.

7. Exploit the power of positive feedback, recognition and reward. Celebrating successes is time well spent.