

WOOD FIBER FEASIBILITY STUDY

AN EXPLORATION OF SUSTAINABLE AND PROFITABLE
OPPORTUNITIES FOR THE WOOD FIBER THAT IS GENERATED
THROUGH SCHEDULED PLANTATION THINNINGS



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Presented To:

Planting Empowerment

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I. EXECUTIVE SUMMARY

As part of the MIT Sloan Entrepreneurs in International Development Club (SEID), a team of four MIT students [Justin Butler (MBA 2011), Adam Rein (MBA 2010/HKS), Lily Russell (MBA 2011) and Andreas Wallendal (MIT 2011)] (The Team) worked with Planting Empowerment (PE) to research profitable alternatives for the use of wood fiber that is generated from periodic thinnings.

Given 1) the relatively long, 20-25 year harvest schedule for timber plantations, and 2) the current practice among all plantations in Panama to leave unwanted wood fiber to rot, PE was eager to find a sustainable use for the wood fiber that could generate returns prior to saw timber harvesting. For every 11 trees planted, PE expects to earn revenue from 5 at harvest, with no option for unsellable wood fiber except to leave it to rot. Multiply this by the thousands of hectares of teak plantations in Panama and there is an attractive resource of unutilized wood fiber. The team's investigation has shown that PE can turn this otherwise neglected fiber into a valuable commodity.

Biochar, fertilizer, handicraft/furniture, a biomass power plant and selling to industrial fuel consumers (ie paper and pellets) were among the alternatives considered. In order to evaluate each objectively, the following criteria were used: revenue potential, upfront capital, fit with PE's mission, market demand, and ease of implementation.

Recommendation: The most attractive use for PE's wood waste was determined to be the production of biochar. Biochar has the advantage of multiple potential end uses: (A) sell directly to the agricultural market, (B) use as an input to produce organic fertilizer to sell to market, or (C) use as an input to produce organic fertilizer for PE's plantations or Arimae's upcoming nursery. The capital requirement for biochar production of a 10 HA thinning is two 55 gallon barrels, an investment of about \$1,000. Organic fertilizer production would require an additional \$500 investment for certification and legal fees.

We recommend that PE would profit most by using biochar as an input to organic fertilizer to sell into the market. The biochar produced from a ten hectare, year four thinning is estimated to produce roughly 8,000 pounds of fertilizer with a potential revenue of \$26,000. The second best option is to sell biochar direct to market, with potential revenues between \$5,000 and \$15,000 for a ten hectare, year four thinning (depending on biochar prices), yielding a 20-30% profit margin. Biochar or fertilizer revenues would roughly double with each addition thinning in years 8, 12, and 20, as the amount of wood fiber not suitable for commercial use also doubles each thinning. A fertilizer business has the additional benefit of scaling by purchasing wood fiber from neighboring plantations when needed. One full-time employee would be required to gather wood fiber for the production biochar, and another employee would be needed part-time for the production of fertilizer.

The other potential options do not appear viable at this time. There is no clear market for industrial fuel in Panama – the only identified paper industry does not utilize wood fiber and, though highly supported by all stakeholders, there is no pellet industry. The biomass power plant was ruled out given expected capital costs of \$1.5-3M per MW and a report from the Ministry of Environment stating that a biomass

plant was not commercially viable at a scale less than 5MW – the size of the Santa Fe plant. Finally, no handicraft or furniture market was found that would purchase four-year-old teak wood at scale.

II. OVERVIEW OF THE CHALLENGE

During January 5-15, 2010 the Team traveled to Panama and met with PE, indigenous landowners, the indigenous communities with whom PE collaborates, other forest products companies, sawmill operators, fertilizer producers, the Ministry of the Environment (ANAM), forest managers and other relevant stakeholders. In addition to alternative uses for the wood fiber a few tertiary issues were raised, including: collaboration among plantations for co-cropping research; cooperation to create a domestic wood processing industry for furniture and/or wood drying; impact of continuous yearly planting schedule; land rights priorities among the indigenous communities and ANAM's hesitancy towards working with the indigenous communities.

The mission and goals of Planting Empowerment (PE) presents unique challenges that require unique solutions. By choosing operating methods that aim to empower indigenous Panamanians, PE faces some problems that other companies in the teak business do not, specifically a higher cost of capital.

As the teak business cycle is relatively long (20-25 years from planting to harvest), it presents significant risks and discounted valuations of investments. If PE could develop a way to create revenue before the 25-year time horizon, it could significantly reduce risks faced by investors, and increase the valuation of its investments.

One possible method for creating revenue streams before the 25-year harvest is to make use of material removed from the plantation during thinning cycles. The amount of waste created during the thinning process is significant, and determining the best possible use for it has been the focus of our study.

Wood created from thinnings in the first eight years is not suitable for standard uses of 25-year-old teak. Several alternative uses for this fiber have been identified, and each encompasses its own challenges and rewards. For example, this material can be used as a fertilizer feedstock, used for handicrafts by the indigenous community, or converted to pellets for use in wood burning stoves. A complete list of identified opportunities is presented in the Market For Wood Fiber Summary Diagram on page 5.

In order to objectively evaluate each of these opportunities, the following criteria were used: revenue potential, upfront capital, fit with PE's mission, market demand, and ease of implementation. The use of these categories aims to methodically analyze each opportunity relative to PE's current financial, social, and organizational conditions.

These conditions present significant opportunities and challenges that need to be incorporated in the evaluation of prospective fiber usage schemes. PE would like to maximize their revenue from these waste streams with minimal upfront capital. Due to a history of previous work with indigenous peoples, PE has a unique opportunity to leverage valuable relationships to develop new programs involving the use of thinning material. A main disadvantage, however, is PE's remote management structure. All

management is located in the US, with only plantation workers permanently in Panama, which may add significant complexity to the implementation of new projects.

Overall, PE faces a need to create revenue streams before the 25-year harvest event. One possible opportunity for revenue creation is the use of material from thinning in various applications. Each of the possible uses for this material, however, presents its own positives and negatives based on the nature of the use, and the current state and mission of PE. We have identified what we believe to be the most feasible options for PE, and have evaluated them in an objective manner, keeping in mind PE's mission of creating financial gains while maintaining a social mission.

III. MARKET FOR WOOD FIBER, "DESECHOS"

Use of Wood Fiber	Revenue Potential	Initial Capital	Fit with PE mission	Market Demand	Ease to Implement
1. Biochar-Mkt	Med-Low	Low	Med	Med	Easy
2. Organic Fertilizer	Med	Low	High	Med	Med
3. Handicraft/Furniture	Med	Low	Med	Low	Med
4. Biomass	High	Very high	Med	Med	Hard
5. Pellets	Med	Med	Med	Low	Med
6. Paper	Low	None	Low	Low	Easy

A. Biochar

It is possible to turn the wood fiber produced from thinning into biochar. Biochar is charcoal that is produced from the heating of biomass in the absence of air. Biochar can be used as fuel for cooking food, as a heat source, or as a method to sequester carbon, or as a fertilizer additive.

The benefits of adding biochar directly to soils are many¹: i) Suppressed methane emission, ii) reduced nitrous oxide emission by half, iii) reduced leaching of nutrients, iv) stored carbon in a long-term stable sink, v) reduced soil acidity, vi) reduced aluminum toxicity, vii) increased soil aggregation due to more fungal hyphae and arbuscular mycorrhizal fungi, viii) improved soil water handling characteristics, ix) increased soil levels of available Ca, Mg, P and K, x) increased soil microbial respiration and biomass, xi) increased nitrogen fixation in legumes.

However, the most applicable use for PE is as an additive to fertilizers. When used in fertilizer, biochar can significantly increase the effectiveness of fertilizer (estimations of up to 10% more efficiency). Discussions with fertilizer producers in Panama indicated that there is a market for biochar for use in fertilizers that is worth pursuing. One major agricultural producer reported that he would pay up to

¹ <http://biochar.pbworks.com/>

\$0.75 per pound of biochar for his organic fertilizer operation, although the international market price in the U.S. is roughly \$0.25 per pound.² The consumption for one producer is estimated to be 3,000 lbs/yr. During a normal biochar process, 15% or more of the weight input is converted to biochar as an output. Assuming that PE's four year thinning will yield 9.7 cubic meters of wood fiber per hectare³, PE's revenues are estimate to be between \$5,000 and \$15,000 for PE. This revenue would come from selling biochar directly into the fuel or organic fertilizer market in Panama.

Creating biochar is a relatively simple process, requiring minimal capital investment in equipment, and small amounts of simple labor. Details of the biochar process are available later in this report.

B. Fertilizer

Our team has identified organic fertilizer production as a potential source of supplementary revenue for timber plantations. Some companies in Panama have already shown that a small-scale operation can save on costs and, more importantly, be profitable. Organic fertilizer requires low upfront capital as the ingredients can be obtained for free (plus transport) or at a low-cost. The main ingredients for organic fertilizer are chicken/horse manure, rice husks, soil or black soil, and can be supplemented with phosphorus rock, lime, sulphur and molasses. Microorganisms can also be grown in the fertilizer; collecting microorganisms can increase costs, but it can also significantly increase the retail value. These ingredients and additives can be combined in certain amounts to create fertilizers that are optimal for certain purposes.

The main barriers to overcome for fertilizer are:

- Locating a reliable source of chicken or horse manure at a reasonable price, including transportation costs.
- Collecting or purchasing and breeding microorganisms for enhancement of soil
- Experimenting and testing different combinations to find optimal mix
- Certification process, to enable retail of fertilizer

The profit opportunity for fertilizer appears high. As described in detail on page 18, the total costs of fertilizer production are estimated to be about \$4.00 per bag, while a bag will sell for \$7.50, according to local producers. A revenue model is available below:

Sacks Produced / Week	200
Lbs / Sack	45
Cost / Sack	\$4.50
Revenue / Sack	\$7.50
Profit / Sack	\$3.00

² <http://www.biochar-us.org/>

³ Zanin, Daniella. "Feasibility of Teak Production for Smallholders in Eastern Panama."

Profit / Yr (40 wks / yr)	\$26,520.00
Total Production (lbs)	8,000.00

C. Handicraft/Furniture

Desechos were too small to be converted to lumber to make handicrafts or furniture. The thinned trees after 7 years can have substantial diameters ranging from 10-20 centimeters. However, sawmills are not currently set up to deal with these smaller sizes and too much of the tree would be lost to the blade thickness to make furniture milling a viable option. These trees also are younger so the wood is mainly sapwood, which is not sought after and does not finish well, again not making it suitable for handicraft or furniture manufacture.

D. Biomass power plant

Evidence from other countries show the potential for a profitable small-scale biomass combined heat and power (CHP) power plant. This option had three major benefits: the highest potential revenue stream, a local power plant using bunker diesel fuel that could be a good target, and added environmental benefits from reduced GHG emissions.

Biomass would be challenging to implement for four reasons

- Capital and operational cost equals \$1.5-3.0 million per MW (IEA 2009)
- Business plan would require the sourcing of large quantities of biomass from other plantations. We did not find value a middleman could add in sourcing this biomass. Nor do we think it fits with PE's model.
- Implementation too difficult, requiring cooperation of power plant firm, local government, and other plantation owners
- Local workers have no technical expertise regarding the power plant

E. Industrial fuel customer (paper, pellets) direct or through sawmill

Wood pellets are a type of wood fuel, generally made from compacted sawdust. Pellets are a high efficiency, clean fuel. They are extremely dense but must be produced from a low moisture content feedstock below 10%.

High-efficiency wood pellet stoves and boilers have been developed in recent years, offering combustion efficiencies of over 90%. Wood pellet boilers - having limited control over the rate and presence of combustion compared to liquid or gaseous-fired systems - are better suited for hydronic systems (use of water for heat transfer) due to the system's greater ability to store heat. A huge export market to the UK has, in recent years, defined the pellet industry, but there is increasing export potential to the US.

A pellet plant would be an ideal customer for wood fiber at large scale. Although one saw mill interviewee mentioned a potential pellet factory in Panama City, further interviews demonstrated that

this option is often talked about but there is no tangible customer. This could remain a potential partnership in the future if a manufacturer does arise. Furthermore, ANAM strongly supported the feasibility of a pellet plant.

Pulp and paper manufacturers can use wood fiber as a heat source to produce pulp and to dry paper. One saw miller implied that he sold a truckload of wood fiber for minimal profit to a paper mill in Panama City. We identified one paper plant in Panama City: Papelera Ismeña and potentially Kimberly-Clark, both located near the Tocumen airport. In an interview with Papelera Ismeña we learned that they only produce tissue and toilet paper. The raw materials for this recycling operation are newspaper, writing paper and fiber and do not include raw wood. One opportunity for PE could be as a middleman and sell to a saw miller who would then sell to the paper manufacturers. This is likely to earn minimal revenue, have little additional benefits, and require ownership of a truck for transport. Furthermore, serving as a middleman does not align with PE's community and partnership based model.

F. Other Discarded Alternatives: Wood chips, firewood, wood ash, ink

Firewood:

Firewood is normally sold by the cubic meter ($1 \text{ m}^3 = \sim 0.276$ cords). Final harvest wood is rarely used for firewood, as it is more valuable as saw timber. Firewood may be economically sound for the small diameter wood produced from thinnings, particularly because smaller diameter stems are desirable because they reduce the need for splitting. However firewood markets, transportation and processing are all hurdles.

Wood Chips:

To produce firewood the entire usable stem is removed and processed into firewood. By contrast, the most efficient and cost-effective way to deliver fiber for pellets, paper or biomass is to chip the fiber for delivery. There is currently no chipping infrastructure because there is no developed biomass or pellet market.

Wood Ash:

One by-product of wood burning is wood ash, which in moderate amounts is a fertilizer (mainly potash), contributing minerals, but is strongly alkaline as it contains potassium hydroxide[5] (lye). Wood ash can also be used to manufacture soap, but there is no major soap manufacturer in Panama.

Ink:

There is a possibility of using teak leaves to make specialty ink that could be sold in gift stores. This would likely support an operation at PE scale but not be viable at multi-plantation scale. Research showed that the most common tattoo ink comes from the jagua fruit, stemming from the Genipa Americana tree, common in Brazil. Ink from teak leaves is used to paint clay crafts. The most common use appeared to be in cooking, similar to the banana leaf in India. This is unlikely to be a major revenue source. However, might be an interesting form of business to be run by the indigenous communities.

IV. PLANTING EMPOWERMENT RECOMMENDATIONS

Due to ease of production and significant revenue potential, the Team agrees that making biochar or fertilizer are the best options for Planting Empowerment's waste streams. Because of the relatively small scale of operations and the minimal shipping infrastructure in remote Panama, sending the wood fiber to other facilities for processing will be cost and logistically prohibitive.

A. Implementing a Biochar Process

Using the material from thinnings for biochar will involve the decomposition of the wood fiber into basic elements at temperatures near 300C. Biochar is relatively easy to implement, and at a basic level involves packing a steel drum with the wood fiber, and heating with an external fire.

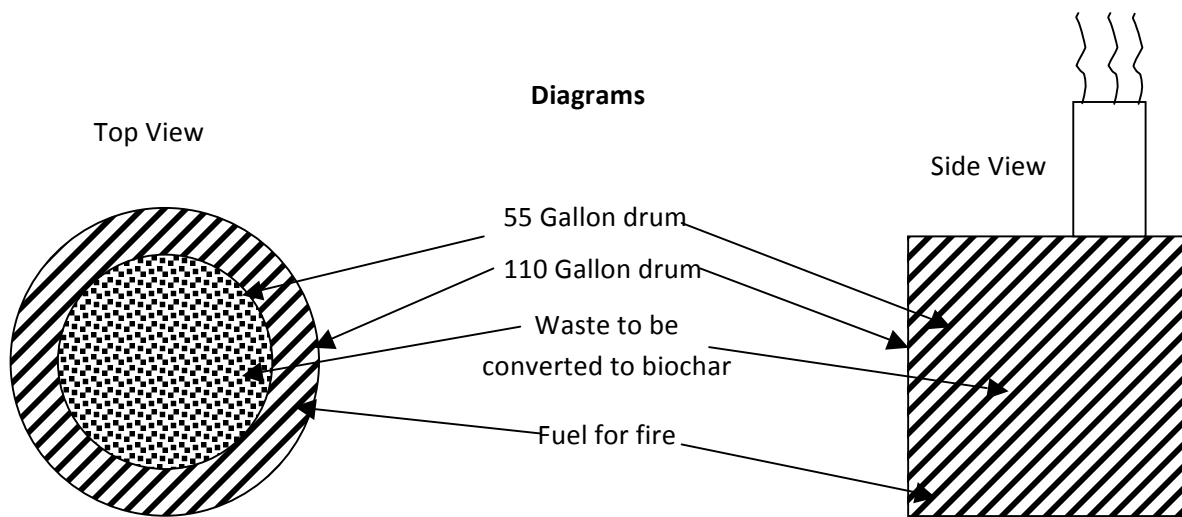
Although there are several methods for making biochar the suggested implementation method is outlined below. Other methods involve higher priced steel units (i.e., RE:char or the scale demonstrated here: <http://www.youtube.com/watch?v=nzmpWR6JUZZQ>), but these options were cost-prohibitive. Another option is simply burning the wood in a large pit, but this method is more labor-intensive, less efficient, and worse for the environment. Our recommendation involves a homemade steel drum:

1. Place a 55 gallon steel drum inside of a 110 gallon over pack steel drum.
SAFETY PRECUATION: BE SURE TO LEAVE VENTILATION HOLES IN 55 GALLON DRUM TO ALLOW ESCAPE OF GASSES
2. Fill 55 gallon drum with waste used to create biochar. Waste should be chopped into pieces no larger than 8" in any direction. A well packed container is show in Figure 1.
3. Fill gap between drums with wood debris and other fuel for fire
4. Light fuel – cover 110 gallon drum.
5. Let burn for 4-5 hours
6. Collect biochar

A video explanation of this process is available here:

<http://www.youtube.com/watch?v=RXMUmy8PpU&feature=related>

Item	Use	Price	Possible Source
55 Gallon Stainless Steel Drum	Pyrolysis Container	68\$	Global Industrial.com
110 Gallon OverPack Drum	External Combustion Chamber	\$350	Spill911.com
Metalbestos 8" x 36" Stove Pipe	Exhaust Flue	90\$	Ventingpipe.com



*RE:Char is a nascent and fairly interesting operation. Jason Aramburu is a recent graduate and has been getting a lot of media attention. RE:Char is making systems that are probably too cost-prohibitive for PE. However, Jason is looking for strong partnerships.



A well packed biochar container

B. Implementing an Organic Fertilizer Process

The second option for PE would be to implement an organic fertilizer operation.

The first stage would involve securing sources for the separate ingredients and additives. However, PE could opt for one of two different paths with fertilizer.

- The most basic organic fertilizer includes carbon-enriched soil (terra preta or black soil, or regular soil enriched with biochar – see above), rice husks and chicken manure.

- A more scientific approach combined with the addition of sulphur, phosphorus rock, lime and possibly microorganisms and molasses (a food source for the microorganisms) could yield more complex organic fertilizer with a higher retail value.

(A) Basic Fertilizer

- For the basic formula use a mix of black soil, rice husks and chicken manure
- For nursery use; 75% manure with rice husks and soil making up the rest
- For plantation use; 75% black soil with rice husks and manure making up the rest
- This process is extremely basic and, once mixed, requires no further attention
- There is no real market for this basic fertilizer apart from PE's own use
- The black soil here can be made from biochar
- Cost of \$4 dollars per sack (cost of black soil and chicken manure)

(B) Complex Fertilizer

Other producers have already begun the process of developing a certified fertilizer with the use of microorganisms. According to our research, they are implementing the best practices for fertilizer production. Biochar would be the one additive we found that could improve their fertilizer. Below we have outlined their process; however they are still testing different mixes. Also, it is important to remember that different regions of the country need different fertilizer mixes. For example in Darien it is common to use less rice husks.

- Mix: 800 sacks (15gl/sack)= (approx.) 400 chicken manure, 400 horse manure (rice husks are included as part of the chicken manure), 8 quintales lime, 2 quintales sulfur, 8 quintales phosphorous rock, 20 quintales ashes, 20 gallons microorganisms, 5 gallons molasses.
- 15 day fermentation with rototiller everyday
- 10 gallons of microorganisms applied with pump
- Microorganisms: microrisa/mycorrhiza, root fungus, anaerobic condition for 40 days
- Costs: manure free with \$50 for truck pick-up (less than hour drive), \$35/barrel for molasses. \$1.25 total cost/sack. \$7.50 retail.
- Certification Process
 1. Sample
 2. Lab to test mineral content (1-1.5 month long process)
 3. Registro Comercio: Once you have the formula you want, register with MIDA
 - a. MIDA does field analysis (bring sample). 2-3 months
 - b. Need to bring documentation
 - i. There are several stamps/certifications from technical consultants, sanitation consultants, ATF, lawyer, regent
 - ii. Need both product and company to be registered

Market

- Basic Organic Fertilizer is being sold in Darien for about \$2.00 per small bag
- Others price their more complex fertilizer at \$7.50 per large bag
- Some market data suggests a demand of 3000 sacks/month. Huge opportunity is in export (but this carries much stricter processing guidelines. i.e. fertilizer can not touch ground)

It does not make sense for PE to enter the market with a basic organic fertilizer as this is selling for about \$2 dollars for a small sack (a small sack is from sight approximately half the size of a regular sack), while others are spending \$4 dollars per sack to make their own basic fertilizer. A basic fertilizer, however, could be used by PE or sold to local plantations directly.

More complex fertilizers need a lot more attention and many more steps are involved but there are larger profits to be realized. The main boundaries here are the certification process, which takes time and costs about \$200, plus legal fees, in addition to the collection/purchase and breeding of the microorganisms.⁴

C. Implementing an Industrial Fuel Process

PE's lowest capital cost option would be to try to sell its wood fiber for use in a paper or pellet factory. Assuming a market develops, transportation will be the key to economic viability. There are two marketing/transportation options:

(A) Sell the wood fiber to a broker-middleman such as Junior, the sawmill employee. This is the lowest effort, lowest capital cost and lowest revenue option. The key benefit would be in Junior supplying a truck for transport. Optimistic estimates only yield \$100 of revenue per truckload, while it would cost \$60 for transport (assuming truck rental and fuel). After accounting for the labor of loading the truck, this option would be nearly profit neutral with no other labor or environmental benefits.

(B) Sell the wood fiber direct to a paper mill (currently no buyer identified) or future pellet factory. This would require sufficient volume of wood and either in-house or hired transportation, but would eliminate a brokerage fee and thus yield more revenue.

⁴ http://www.howtogardenadvice.com/soil_prep/make_biochar.html