ABSTRACT

" THE DEVELOPMENT OF A SYSTEM TO PRODUCE A MARKETABLE PRODUCT FROM CHAPARRAL AND OTHER HARDWOODS."

A new method of harvesting and converting brush and hardwoods into Charbonella (BBQ Fuel), Filter Charcoal, and Industrial Heat is described. Access is provided by a four-foot " Roadlett ". Brush is cut and bundled then allowed to dry. Bundles are loaded on a self-loading powered trailer behind a small but powerful tractor. The bundles are hauled out over the " Roadlett " to the landing where material to 2 inch diameter is processed into chunks on a Neme Chunker. Material 2-8 inches in diameter is cut to 12 inch lengths in the Rainier Shear. The chunks are hauled to an Industrial Park where they are converted to Charbonella, Filter Charcoal, and Heat for drying lumber or firewood.

June 1986

EBC COMPANY

BIOMASS UTILIZATION
WASTE WATER RESEARCH

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THE DEVELOPMENT OF A SYSTEM TO PRODUCE A MARKETABLE PRODUCT FROM CHAPARRAL AND OTHER HARDWOODS.

You don't have to be very smart to know that it is very hard to make a useful and profitable product out of brush. It is scattered all over steep rocky hills. It is hard to cut and harder to haul and no one wants it when you get it there. It is full of water and smokes when you burn it, if you can figure a way to get it in the stove. Yet this is what a group of us set out to do because we must market the hardwoods too, including the brush, if our forests and ranchlands are to be productive. It has been a long hard expensive struggle to develop the machines and the product. It is still going on so this should be considered an interim report.

This report covers work done under a grant from California Department of Forestry as well as work done by EBC Company and Manzanita Energy,Inc..

Some of the cutting and bundling of brush and trees was done by crews from Parlin Forks Conservation Camp. Some of the equipment was developed by the University of California, Forest Engineering Staff at Davis.

This report is the story of developing the machinery and equipment for producing a marketable product from chaparral and other harwoods found in the North Coast range and forest lands. This work is still going on particularly in the marketing of the two principle products, Charbonella- The Successor to Barbeque Charcoal (figure 1 & 2) and, Filter Grade Charcoal for Air and Water Filtration.

The first phase of the work proceded from March 1984 to November 1984 and is covered in the enclosed paper entitled " A System for Producing Biomass Fuel for a Multi-Use Industrial Park". This paper was presented at the Southern Biomass Energy Research Conference, March 1985, at the University of Florida. It was selected for publication in "Biomass Energy Development", Plenum Press, New York and London. This paper which is enclosed is part of this report.

Our information indicated that the Charcoal Production System we then were using costs about $500.00 per ton of charcoal produced while the best price we could get was around $160.00 per ton.

Our efforts to market bundled firewood were also unsuccessful. Since the purpose of this work is to find markets, work was halted until products with more potential were developed.

Manzanita Energy, Inc., and EBC Company continued their work in trying to find a better way to produce profitable products. Our research pointed to a machine capable of cutting brush into uniform lengths of 4-6 inches to allow for an even feed into the Kleensmoke Charcoal Kiln. We also found that a light charring of the outside of the larger pieces produced a product superior to charcoal for most types of Barbequeing, Smoking or Grilling.

The search for a machine that could cut brush to our specifications finally led to the Neme Chunker invented in Finland. The unit as manufactured was not suitable but we modified it to produce the product we wanted. It was mounted on a Chevrolet four wheel drive pickup using the rear drive shaft for power. It can still negotiate short distances using front wheel drive over reasonably good roads. The detailed description of the modified Neme Chunker is beyond the scope of this paper. . (figure 3) The unique design of the Neme Chunker does not allow it to cut brush over two inches in diameter.

This left the material beween two and eight inches to be processed into firewood or other products. We had already determined that chainsaw cutting and hydraulic or hand splitting provided the best answer for material over eight inches in diameter in this situation.

Where the tree length boles could be skidded out the best answer appeared to be an automatic shearing system called the Rainier Chomper, invented and manufactured by Warren Aikens of Rainier, Oregon. (Figure 4) This led Warren to suggest a modification of the Chomper that will

automatically shear wood from 2-8 inch diameter into lengths up to 12 inches long for firewood. (figure 4) We have named it the Rainier Shear. This Rainier Shear is currently working well. It should sell for around $10,000.00. This will provide the small firewood producer with a complete line of equipment for a modest capital investment.

Figure 5 shows the general layout of the second phase of the operation from April 22 to May 21, 1986.

When this phase started Tanoak and Madrone on 1.6 acres had been cut by the Parlin Forks crews about 16 months before. Boles over about eight inches had been cut into about ten foot lengths and the brush had been bundled. Some rot had occured in both the boles and the branches. I estimate the yield loss at 20%. Table 1 shows the approximate side slopes at 100 foot intervals.

The stumps had been left 3-4 foot high since the plan called for rooting them out when the road was built. It was noted that stump sprouting appeared less when high stumps were left. This suggests leaving high stumps when removing hardwoods as part of site preparation. This hypothosis should be checked out experimentally.

Rich Triplett and Scott White were hired with their Acutrac Tractor with powered self-loading trailer to construct about 150 feet more of four foot wide road and haul the bundles to the truck road. With a tractor operator and one helper they removed about 78 bundles in a total working time of 67 hours @ $55.00 per hour. Some of this time was devoted to equipment and system development. Scott estimates that bundles could be yarded for $20.-$23 each. (figure #6)

John Toennis and Tim Salo working as owner operators cut, split and hauled and sold, twenty-three cords. This amounts to 14.5 cords per acre They worked about 183 man hours not counting travel time or delivery time. This comes to about eight hours to the cord. They used the Pac Trac to haul the split wood out where it was loaded on their truck. (figure 7) They paid Jackson State Forest $5.00 per cord stumpage,

they of course had no experience bundling brush. The figures quoted are for a similar stand in similar topography.

If a landowner wished to remove hardwoods this is a possible scenario.

The landowner would flag out twenty acres and pay for putting in a four foot road so all trees were within about 50 feet of the road.

The firewood cutters would cut the hardwood trees and take any part of the bole they wanted (usually down to about 8" diameter) and pay the landowner $5.00 per cord stumpage.

The firewood cutters would charge $12.00 each to bundle all the branches and other slash into tight bundles about four feet in diameter and ten feet long which will weigh 800 to 3,000 lbs. per bundle. The firewood cutters could then leave the area or they could also be a part of the second phase.

In the second phase the Acutrac Tractor with a helper would then return and yard the bundles to the roadside for $23.00 per bundle.

This would put the total price per bundle at the roadside at $35.00 each or about $70.00 per ton.

Economic Analysis; There are 10 variables in this calculation that determine the cost and benefits of this operation.

These are the variables;

BENEFITS:

a. $_____ per acre for removal of hardwoods including brush.
b. Sale of Charbonella at ___per pound and Filter Charcoal at ___ per pound.

c. Filter Charcoal at __per therm for drying firewood or operating a greenhouse or other uses.

d. per cord stumpage for firewood cut.

COSTS:

a. __per ton paid to firewood cutters for bundles.
b. __per ton paid to Acutrac crew for yarding bundles to the roadside.
c. __per ton for Neme Chunker and Rainier Shear operation at the roadside.
d. __per ton for hauling to Biomass Industrial Park.
e. __per ton for operation of the Kleensmoke Kiln producing Charbonella and Filter Charcoal.
f. __per __for other operating costs of the firewood dryer and greenhouse.

James Engineering Company is creating a program for the computer that will combine all of these variables to determine the economic feasibility for various situations.

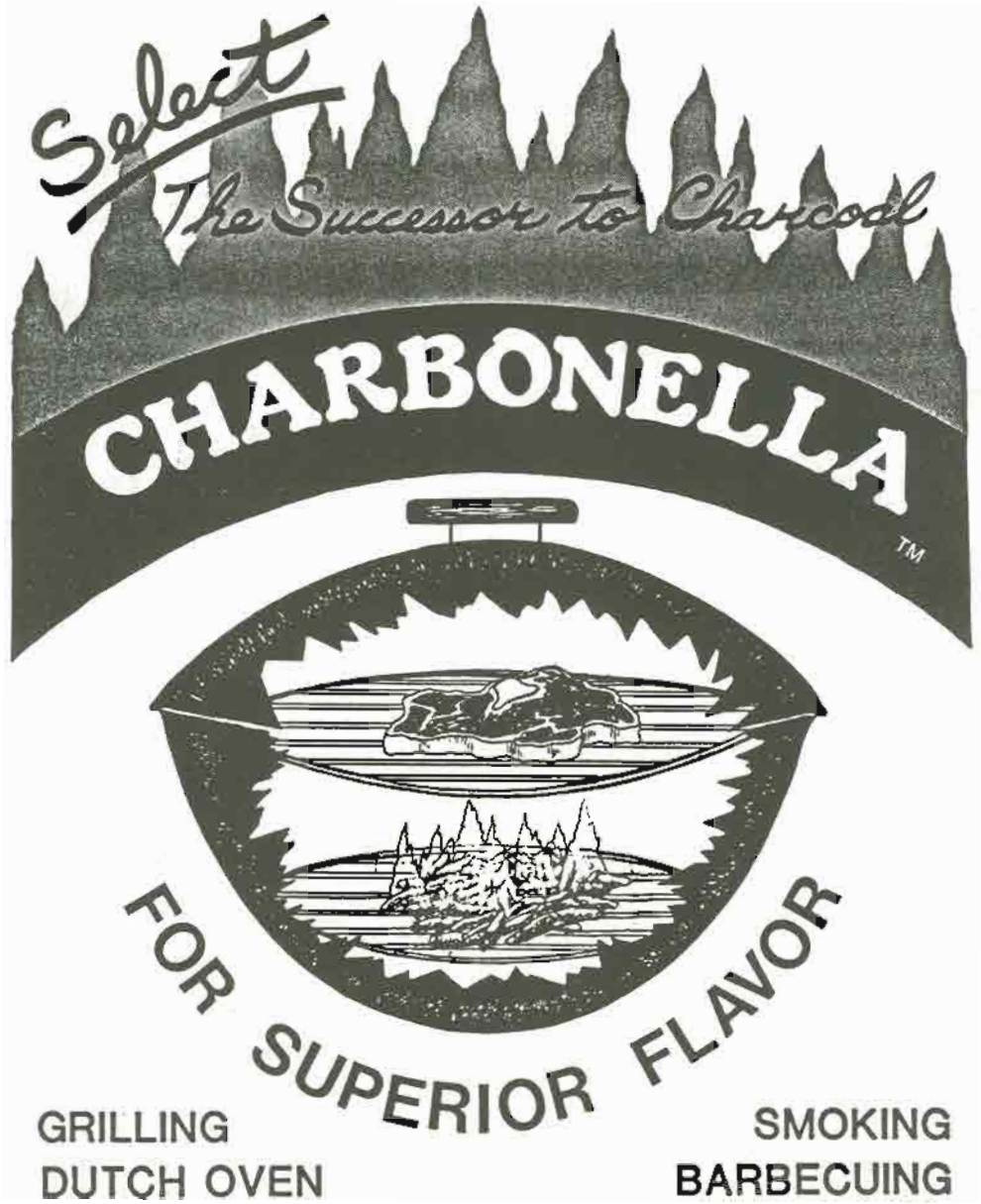
If we put the figures of the present operation into the program, the cost per acre cleared appears high. The most important figures is the price we can get for the Charbonella and Filter Charcoal. At this writing these are unknown. It should be obvious that many improvements can be made in the equipment, the training and experience of the people and the system. It would have been hard to predict the success of the airline industry if you were riding in the planes of the 30's and 40's.

Finally look at the photos (figure 8) or better yet walk down our four foot road. This is much like the community forest at Basil, Switzerland that I visited years ago where dozens of hikers were enjoying the same area where light cable logging was going on which included removal of the branches.

TABLE I

DISTANCE FROM NORTH END FEET	SIDE SLOPE %	4 FOOT ROAD GRADE %
0	55	
100	35	-2
200	30	-5
260	15	ROAD FORKS
300	37	-18
400	40	-5
600	40	+12
700	35	-22
730	END OF TEST AREA	

FIGURE 1



CHARBONELLA ™ is a balanced blend of lightly charred chaparral fired in a unique patented kiln.

100% NATURAL PRODUCT

NO ADDITIVES LIGHTS EASILY
EVEN HEAT UNIQUE FLAVOR

NO STARTING FLUID REQUIRED

MANUFACTURED BY

MANZANITA ENERGY INC.

Willits • Covelo, California

NET WEIGHT
LBS
KGS

PRODUCT OF CALIFORNIA USA

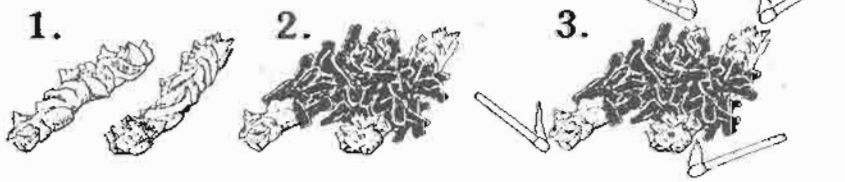
FIGURE 2

CHARBONELLA™

Gourmet Barbeque Fuel

INSTRUCTIONS

1. Twist newspaper into small rolls.
2. Make a pyramid of CHARBONELLA™ on top and light.
3. For added flavor begin cooking when flame is present.
4. Don't let it burn down completely - add more CHARBONELLA™ as needed.



NO STARTING FLUID REQUIRED

FIGURE 3

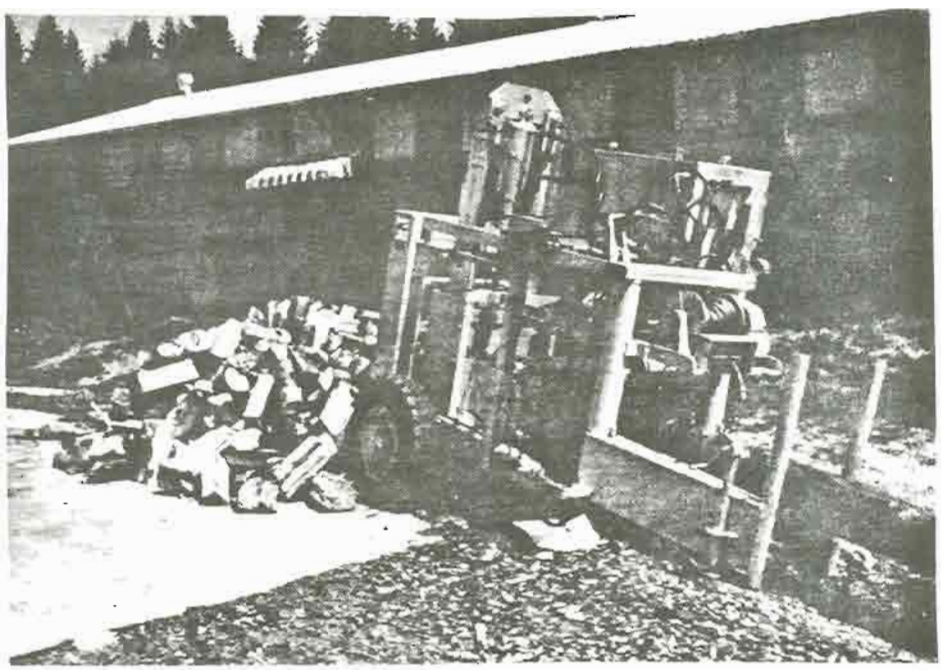
NEME CHUNKER

The branches are fed under the rotating knives. As the chunks accumulate they are shoveled into the tote box. The production machine would have a conveyor.

The Boscoe Cutter for producing 12 inch long firewood would be fed by the same operator.

Figure 4

The Rainier Shear cuts firewood from pieces up to 8 inches in diameter.



The Rainier Chomper shears tree length logs up to 18 inch diameter into firewood automatically.

FIGURE 5

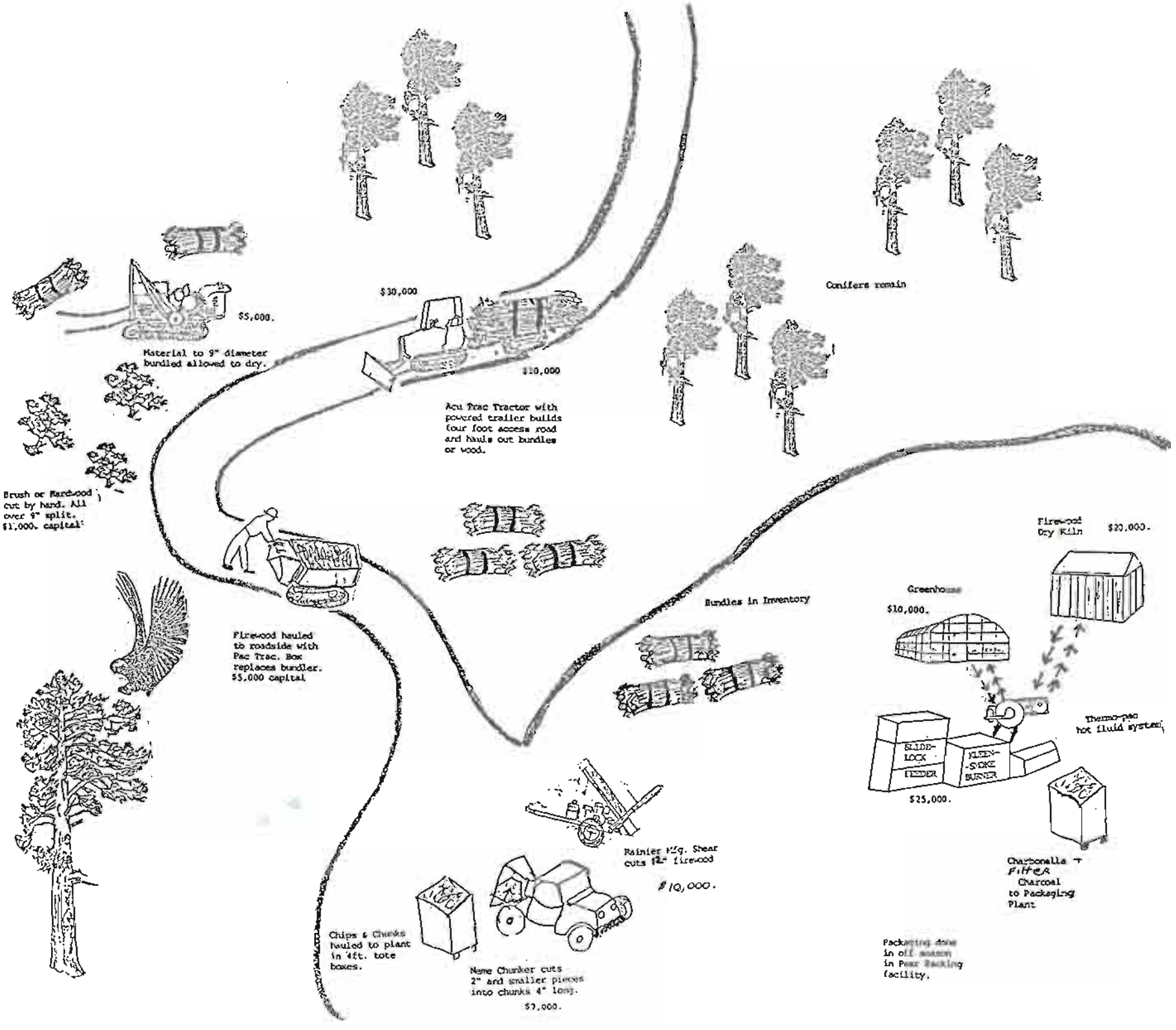

$5,000.
Material to 9" diameter bundled allowed to dry.
$30,000
$10,000
Acu Trac Tractor with powered trailer builds four foot access road and hauls out bundles or wood.
Conifers remain
Brush or Hardwood cut by hand. All over 9" split. $1,000. capital
Firewood hauled to roadside with Pac Trac. Box replaces bundler. $5,000 capital
Bundles in Inventory
Firewood Dry Kiln $20,000.
Greenhouse
$10,000.
SLIDE-LOCK FEEDER
KLEEN-STOKE BURNER
$25,000.
Thermo-pac hot fluid system
Charbonella Filter
Charcoal to Packaging Plant
Rainier Mfg. Shear cuts 12" firewood
$10,000.
Chips & Chunks hauled to plant in 4ft. tote boxes.
Nemo Chunker cuts 2" and smaller pieces into chunks 4" long.
$7,000.
Packaging done in off season in Pear Packing facility.

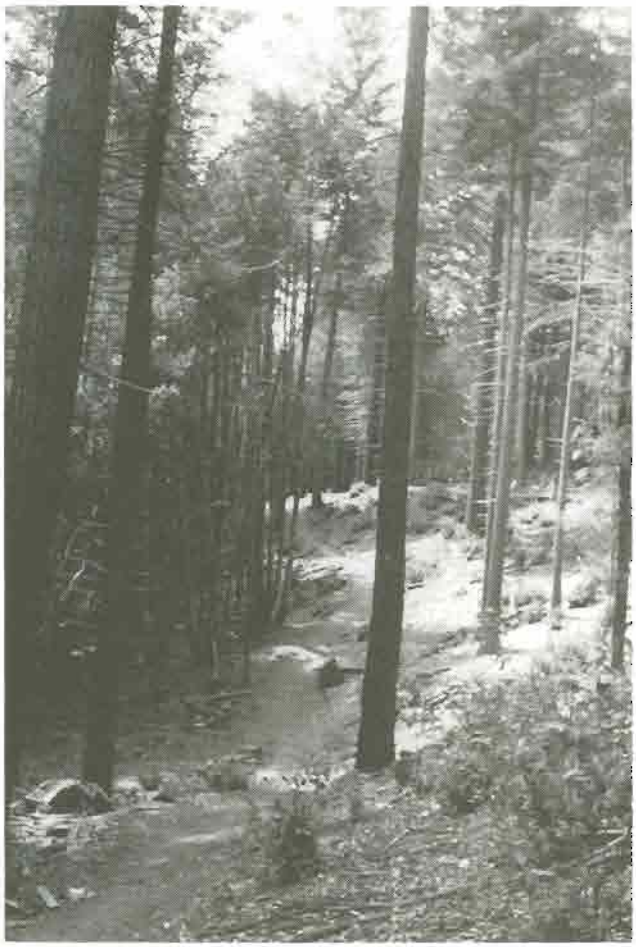
FIGURE 6

THE ACUTRAC WITH SELF-LOADING POWERED TRAILER LOADING A BUNDLE. NOTE, THE STRAPS CROSS HAULING THE BUNDLE. IT IS CAPABLE OF LOADING AND HAULING 4,000 POUNDS.

FIGURE 7

PAC TRAC HAULING OUT FIREWOOD THAT HAS BEEN CUT AND SPLIT BY HAND. THIS PAC TRAC CONVERTS EASILY INTO THE BRUSH BUNDLER. THE LOAD HERE WEIGHS ABOUT 700 POUNDS

FIGURE 8



This is looking North through the 1.6 acre plot after removal of the bundles. The four foot road will provide access for management and recreation. The stump sprouts show heavy browsing by deer.

FIGURE 9

The Kleensmoke Charcoal Kiln processes chunks into Charbonella and Filter Charcoal. The conveyor (A) automatically loads the Slide Lock Feeder(B) which loads the Kleensmoke Kiln (C). Glowing charcoal falls into conveyor (D) into dry quenching system. The clean hot gases pass through heat exchanger (E) which preheats the combustion air to 600° F. The hot gases (750°F) are colected in pipe (F) which leads to firewood drying area. (Not Shown)

A SYSTEM FOR PRODUCING BIOMASS FUEL FOR A MULTIUSE INDUSTRIAL PARK

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ABSTRACT

This paper describes a system for cutting and bundling slash or brush into one ton bundles using a low-cost brush bundler. The bundles, about 1.2 m (4 ft) by 4 m (13 ft) long, are strapped with steel strapping and allowed to dry for 1-3 months. The bundles and logs are hauled over a four-foot wide "road" by a small but very powerful tractor connected to a powered trailer. The combination can carry two ton loads up a 40% grade. The bundles and logs are loaded onto a self-loading trailer with a unique cross-haul system.

At the semi-portable Biomass Center, the bundles are segregated to:

1. Brush to 15 cm (4 in) diameter is made into charcoal

2. Wood 15-35 cm (4-9 in) into chips or firewood

3. 35 cm (9 in) and larger into logs or firewood

The heat from the charcoal production is used to dry the chips or firewood. The dry chips can then be shipped to permanent Multiuse Industrial Parks where a permanent system can supply energy for cogeneration and better uses.

Keywords: Brush Bundles Charcoal Chips Multiuse Industrial Park

The burning of wood is actually a sequence of events. As wood is heated, free water and burnable gas are driven off along with particulates (smoke). This leaves a burning char which burns clean and hot. In our Kleensmoke Inverse Pile Burner this sequence takes place in a long horizontal refractory tube (see Figure 1). The new material is pushed under the burning char so the particulates and gases are completely burned as they pass upward through the char. By overfeeding the burner, the burning char falls out with the ashes. The ashes are separated and the char is dry quenched in a water cooled auger.

This sequence produces clean heat in the 1140 C (2000°F) range while also producing charcoal that is around 90% carbon. This charcoal producing equipment shown in Figure 2 is semi-portable with its own power system. We call this our Satellite Biomass Conversion System or Biovertor. It produces cut dry firewood, charcoal and dry chips from the bundles of brush. Any sawlogs are sorted out here and sent to sawmills.

Charcoal is used for making barbeque briquets and chunks. Charcoal can also be used for air and water filtering as well as other industrial processes.

GETTING WOOD TO THE BIOVERTOR

The trouble with wood is that it grows on hills and other areas that make it difficult to harvest. About 40% of the tree is brush and limbs. When freshly cut it contains about 50% water, which not only reduces the caloric value but causes smoke. If wood is chipped green, it is difficult to dry the chips because wood is such a good insulator and catches fire if not properly controlled. It is difficult and expensive to haul, particularly from the stump to the roadside. A high percentage of the biomass in the forest is in the form of brush which must be harvested and disposed of. Wood harvesting equipment is expensive to buy and maintain and can be used only during daylight and the dry season. Wood harvesting is hazardous which greatly increases the cost of workmans' compensation. Heavy logging equipment cannot be used in many areas because of silvicultural needs and state regulations.

THE WOOD HARVESTING SYSTEM

This paper describes a system that overcomes many of the difficulties by producing a variety of products using small, efficient units of production. To do this we set up a number of guidelines.

1. The entire tree or bush had to be removed and marketed.

2. Higher value species would be left for accelerated growth. In many situations this means that we would be paid to remove the material.

3. The equipment had to be within the means of an owner-operator as much as possible. This means more jobs for semi-skilled workers working as independent operators.

4. It must be able to harvest material on slopes up to 35%.

5. The brush and limbs had to be unitized for hauling and storage.

6. The material should dry in the woods to reduce moisture and transportation costs.

7. The system should provide the opportunity to sort the components for the highest profit markets.

8. The Biovertor installations must be semi-portable since the unprocessed material does not load or handle easily and is not readily hauled on public roads.

9. The Biovertor should sort and convert the material into higher value products that can easily be stored, handled or transported to the central Biomass Industrial Park or to other markets.

THE REDWOOD REGION

The Redwood Region is small but the silvicultural problems get national attention. The system we have developed meets very stringent environmental requirements.

The Redwood (Sequoia sempervirens) grows principally with Douglas Fir (Pseudotsuga taxifolia) and Tanoak (Lithocarpus densiflora) on rugged coastal mountain ranges in Northern California. Slopes range up to 60%, soils erode easily and the average rainfall of about 55 inches comes mainly from November to April. Tanoak sprouts from the stump and, along with other hardwoods, aggressively take over the site. This has lead to herbicide spraying as a method of control.

CUTTING THE MATERIAL

We have used gas powered circular brush saws which cut fast but have considerable maintenance. The hydraulic chain saw and shears powered by the Brush Bundler engine are slower cutting but much more reliable. There are more companies making hydraulic and air tools for the orchard and tree service industry. Many can be made to work in cutting brush and slash.

Pieces over about 10 cm (4 in) are cut with a gas chain saw with a 75 cm (30 in) bar.

It is important to note that the actual cutting takes only 10-20% of the total operation of cutting and stacking brush. We need something like compressed air or DC electricity that can create and store energy then deliver it in short bursts.

BUNDLING THE SMALL MATERIAL

After cutting the brush and stems, they must be either processed on the spot or transported to a place where they can be converted into a useable product. Our yarding system can haul a bundle weighing about 1 metric ton (2240 lb). These bundles are usually around 1.2 m (4 ft) diameter x 4 m (13 ft) long. It is difficult to find a landing area big enough for a chipper and a chip van. Standard chip vans cannot negotiate our logging roads. If a portable chipper is to be used, it must be set up near the main highway.

About four years ago, we began work on finding a method for compressing brush into a bundle that could be loaded, transported and stored easily. We worked with a number of hydraulic clamping and tieing systems

that showed promise but were either too slow or clumsy or both.

The current Burton Brush Bundler, Model BB 900, Figure 3 meets all of the parameters that we set out to meet. It is mounted on the Pac Trac 900 all-terrain vehicle which enables it to operate on slopes up to about 40%. On steeper ground it must operate off the four foot wide road built by the Acutrac Tractor.

The Model BBT 4 fits on a standard three-point hitch that is on almost all farm tractors. The hydraulic power comes from the tractor system. This works well on level ground and enables the farmer or rancher to generate income in the off season while clearing his land of brush. Unfortunately, this system only works on slopes up to about 10%.

The operation is as follows. The Burton Brush Bundler is positioned adjacent to the brush or trees being cut. The lower nylon straps are pulled out about 8 m (25 ft) and laid on the ground. Two steel straps are also pulled out and laid down. As the brush is cut into pieces that can be handled, it is piled on top of the straps making a pile about 8 m (25 ft) long, 2 m (6 ft) high and about 4 m (13 ft) wide. The upper nylon straps are now pulled out and connected to the lower straps. Hydraulic power now tightens the nylon straps with a pull of about 1600 kg (3500 lb) making a bundle about 1.2 m (4 ft) in diameter by about 4 m (13 ft) long. The steel straps are then connected, tightened and sealed. The nylon straps are then released and the cycle repeated.

The bundles weigh from 700-1800 kg (1500 to 4000 lb) depending on the type of material. Two men can produce 3/4 to 2 bundles per hour depending on terrain and type of cover.

It is important to note here that the cutters can always be working in a cleared area since the bundles take about 1/4 the space of piled brush. In some cases the firewood is cut and split from the boles at this point. Split wood dries much faster than round wood. In other cases everything that can be handled by hand is put in the bundles. At this point it is best to let the bundles dry for one to two months. In this time the small, under 18 cm (4 in), branches with the leaves dry to 17%-25% moisture in the dry summer months and to 35-40% in the winter due to so-called transpiration drying. Larger material dries much more slowly unless it is cut in short lengths and split. This on-the-spot drying increases fuel value and cuts transportation costs. It is, of course, possible to yard the bundles out immediately.

YARDING AND ACCESS

The bundles cannot be skidded like logs because the steel straps catch on stumps. This difficulty was overcome by devising a self-loading trailer that was connected to the powerful little Acutrac Tractor.

The Acutrac Tractor is the invention of R. A. Triplett of our area and is manufactured in Canada. It has a hydrostatic drive which delivers power to two drive sprockets in each track. It has a unique five-way tilt dozer blade which enables it to build a 1.2 m (4 ft) road through steep terrain at the average rate of about 91 m (300 ft) per hour.

This four-foot road has many advantages.

. . . . . It is wide enough to haul out the bundles and logs.

. . . . . It is wide enough to hike or ride horses on but too narrow for four wheelers.

. . . . . The cut bank and fill are low enough so there is access to the road almost anywhere in steep country.

. . . . . There is little soil disturbance so healing is rapid.

. . . . . Later, it provides access for fire control or animal husbandry at a fraction of the cost of 3 m (10 ft) roads.

. . . . . In the opinion of some authorities, it could be used in some areas now closed to regular logging.

At first we used the brush bundler to cross haul the bundles up onto the powered trailer behind the Acutrac. This led to installing the bundler winches permanently on the Acutrac trailer. This combination resulted in a system that could load a bundle weighing up to about 1800 kg (4000 lb) in three minutes. The tracks under the trailer are powered by hydraulic motors supplied by the tractor's system. Hence, the tracks are steered by the operator and produce additional traction. It is impressive to see a tractor weighing about 2400 kg (5300 lb) with the powered trailer behind taking an 1800 kg (4000 lb) load up a 32% slope. This important step made the whole system practical. (Figure 6)

At the roadside, the bundles are dumped on the ground or cross-hauled onto a fifth-wheel trailer mounted on a heavy duty four-wheel drive pickup. If the bundles and the logs are on the ground, they can be loaded on the fifth-wheel trailer with a permanently mounted cross-haul system. Logs up to 1 m (39 in) diameter and 4 m (13 ft) long have been loaded and hauled in on the powered trailer. If there is room, a portable chip producing system can be set up at the roadside and everything that is suitable can be chipped.

The Bureau of Land Management has used the Acutrac with powered trailer to haul hay into remote areas for erosion control.

THE SEMI-PORTABLE CHARCOAL PRODUCER

The bundles of brush and wood should be processed close to the woods where they are developed since it is difficult to make bundles into a full load for a large truck. This allows the operator to convert the low value brush into high value charcoal, dry chips or firewood for transport to the larger Biomass Multiuse Industrial Park.

This Biovertor System, see Figure 2, consists of a Kleensmoke Inverse Pile Burner specially modified for producing charcoal from material up to 10 cm (4 in) diameter. To do this, the brush is fed in at one end which pushes the burning material along a specially constructed refractory burner. There are three holes in the bottom. This allows the burning char to drop into a conveyor which leads to an auger which is water cooled. Cooled exhaust from the diesel generator is piped into the water cooled auger. This combination completely quenches the char. The charcoal is then ready for sale to a briquetting company for filtration, toxic gas filtering and other uses.

This charcoal making process also produces heat at about 1140 C (2000°F). This heat can be used for a number of purposes such as drying

firewood, drying chips or generating power for on-site use or for sale. In the installation shown in Figure 3, the heat is used for drying firewood. This is done in a 6.8 m (20 ft) long "oven" with a conveyor bottom. This firewood can be bundled or boxed for the supermarket trade.

It would be possible to chip the larger pieces and dry them with the heat from the charcoal process. These chips could be sold to large cogenerators or be used in the automatic chip fired burners.

MARKETING THE ENERGY

Most biomass to energy systems have been designed to generate electricity for sale to the utilities. Various laws and tax incentives have been set up to accomplish chis. Many studies have shown that the minimum practical size for cogeneration alone is about 5 MW with most being built in the 8-15 MW range. In mountainous country with few good roads, the large demands for fuel in one location means long hauls.

Remember, chips made from green material have 800 cal/kg (3000 BTU's/pd) while chips at 15% moisture have 1800-2000 cal/kg (7-8000 BTU's/pd).

This work indicates that the easiest and cheapest way to get dry chips is to allow drying in the bundle. The heat from the charcoal process can be used in a chip dryer if necessary. The dry firewood and charcoal can more easily bear the cost of transportation to market which is generally in the urban areas.

THE BIOMASS FIRED MULTIPURPOSE INDUSTRIAL PARK

Willits is a town of 3,500 population, 150 miles North of San Francisco. In 1950, there were 22 sawmills in the valley and no other industry. Now, there are only 3 sawmills, but there are at least eight companies making everything from computer parts, to large hydraulic cylinders, to toilets, to automatic paint machines and several others. In addition, studies have shown that we need cold storage for the fishing and wine industry and other agricultural crops. The Biomass Multiuse Industrial Park can meet many of these needs. Almost all small towns near the woods could do the samething.

In every city the most expensive single installation and almost the biggest power user is the sewage treatment plant. There is also a desperate need to dispose of solid waste preferably through recycling.

Almost all industries and service organizations require heating and cooling and waste disposal. Many such as laundries, lumber drying, tire recappers and greenhouses require heat at different times and at different levels. Figure 4 shows one possible configuration that could be set up around almost any sewage treatment plant or other industrial site.

It is beyond the scope of this paper to go into more detail on how this industrial park could be organized and funded. It could probably best be done as a joint public-private enterprise.

At present we have all of the components described here operating though not full time. This makes it difficult to produce reliable economic data. There are several reasons for this. We are attempting to develop higher markets such as the bundled firewood, charcoal and other products. We don't have firm prices for these. Some of our equipment such as the system we use for cutting the bundles into 63 cm (16 in) lengths is in the prototype stage which means high production costs which

must be absorbed in this venture capital phase.

The following are the approximate list prices for the various pieces of equipment.

	List Price
Burton Brush Bundler Mounted on the Pac Trac Walk Behind All-Terrain Vehicle	$ 5,000
Acutrac Tractor with Blade	30,000
Acutrac Powered Trailer with Self Loader	10,000
Kleensmoke Biovertor System Complete with Charcoal Quencher, Power Generator and Drying Oven	75,000
Bundle Cut-Off System for Cutting Bundles into Short Lengths	40,000 Est.
Bird Wood Splitter	4,000

The current costs in our area for clearing land of slash as for precommercial thinning range from $100 to $700 per hectare ($200 to $1500 per acre) with a good average for hand clearing at around $250 per hectare ($600 per acre). The actual green weight figures for material removed are around 20 tons/hectare (40 tons per acre).

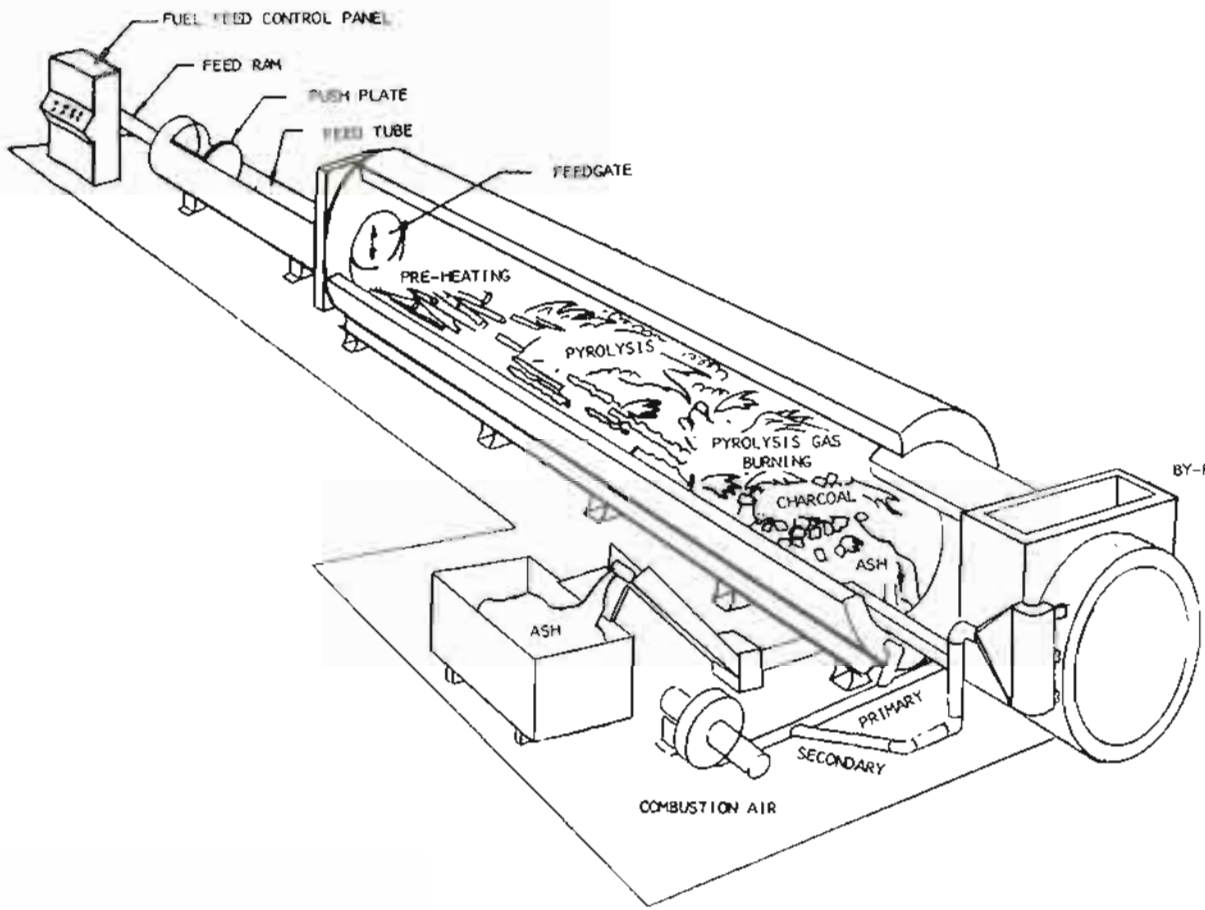
This makes any economic analysis site specific and rather meaningless at this point.

It is hoped that this paper will stimulate others to find a better way to create products and jobs for our forest communities from the renewable resources that surround them.

KLEENSMOKE, INC. - INVERSE PILE BURNERS*

KLEENSMOKE, INC. INVERSE PILE BURNERS USE LIGNEOUS AND ORGANIC WASTES TO PRODUCE LOW-COST, HIGH-TEMPERATURE HEAT. EXIT GASES ARE FREE OF UNBURNED HYDROCARBONS, HAVE VERY LOW PARTICULATE LOADINGS, AND ARE WITHOUT SO_X FROM THE FUEL. THE BURNER COMBINES FUEL PREHEATING, PYROLYSIS, HIGH-TEMPERATURE GAS BURNING, AND ASH REMOVAL IN A SINGLE-CELL, HORIZONTAL COMBUSTION CHAMBER. THE MECHANICAL ADVANCEMENT OF FUEL FROM THE FEED TUBE THROUGH THE COMBUSTION CHAMBER PERPETUATES THE THREE-PHASE BURNING. INHERENT ASH IS PUSHED TO A DISCHARGE PORT WHERE IT EMPTIES INTO A DISPOSAL CONTAINER. PROPORTIONAL CONTROL OF PRIMARY AND SECONDARY COMBUSTION AIR MAINTAINS A UNIFORM HEAT FLUX. PRIMARY AIR IS PREHEATED IN THE REFRACTORY WALLS MAINTAINING CONTROLLED TEMPERATURE AS IT IS INTRODUCED TO THE COMBUSTION CHAMBER THROUGH OVERFIRE JETS. SECONDARY AIR PROVIDES ADDITIONAL OXYGEN FOR COMBUSTION OF PARTICLES AND HYDROCARBONS, AND FOR SUPPLYING COOL AIR TO STABILIZE THE HEAT FLUX.

*PATENT AWARDED



DISCHARGE CONNECTION TO A HEAT RECOVERY UNIT, E.G.

STEAM GENERATOR

HEAT EXCHANGER

NOTE: A MODEL 0032

68" ID BY 32' LONG
30" FEED PORT; 48" DISCHARGE PORT
REFRACTORY CONCRETE RATED AT 2500°F
HEAT RELEASE RANGE: 5MM TO 50MM BTU/HR

KLEENSMOKE, INC.
222 Franklin St.
Willits, Ca 95490
(707) 459-6219

SCALE 130 | APPROVED BY | DRAWN BY RB

DATE 12/81 | REVISED

GENERAL DESCRIPTION

DRAWING NUMBER 3501

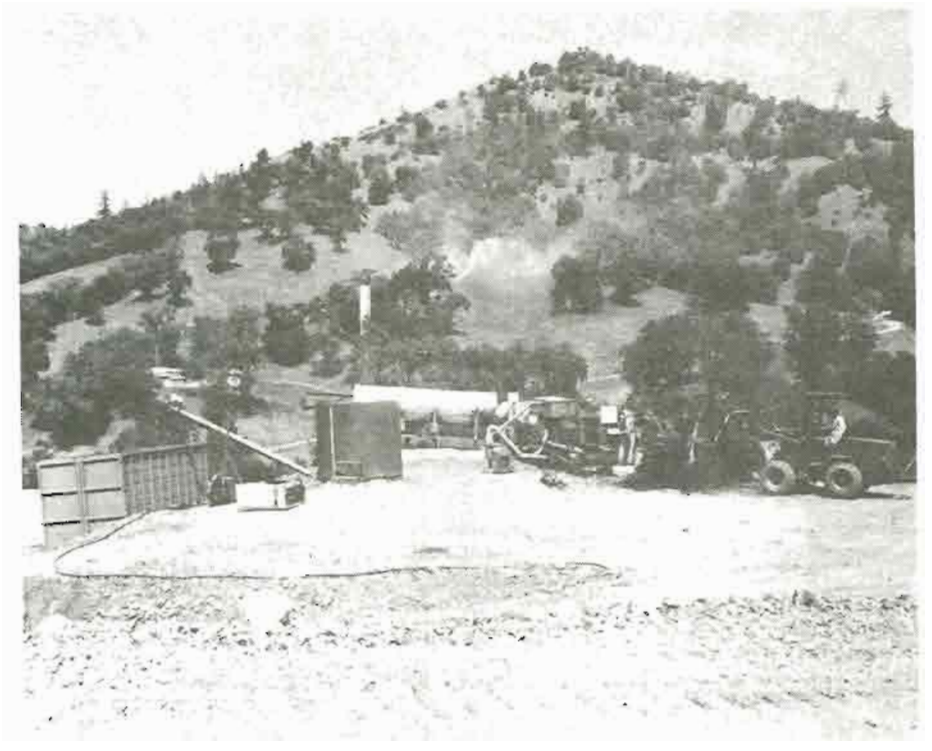
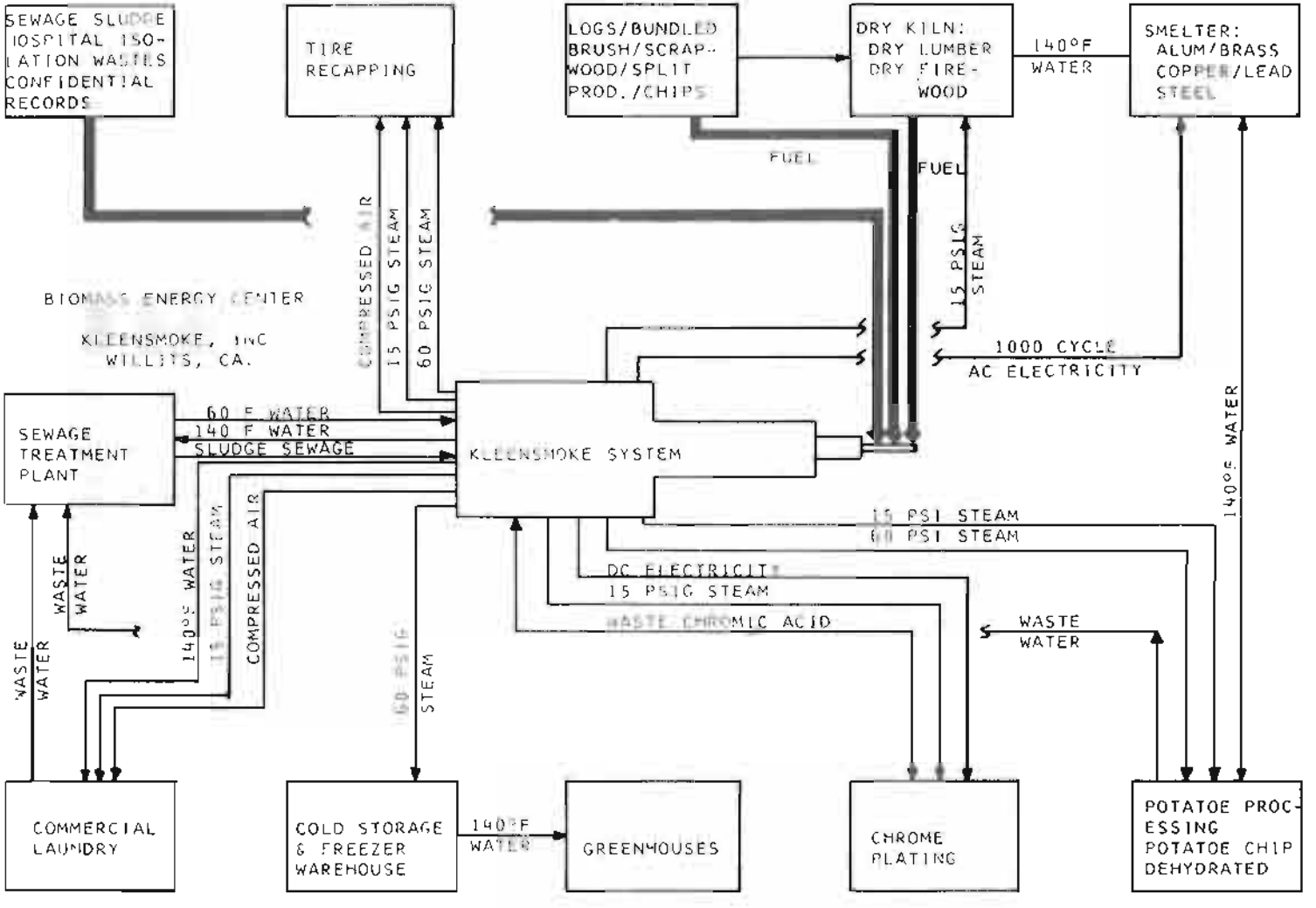


Fig. 2. Semi Portable Biovertor Installation. Brush is fed into the modified Kleensmoke Burner at the right. The char drops out and is quenched and conveyed into the box. The Firewood Kiln is in the background.

Fig. 3. The Burton Brush Bundler mounted on a Pac Trac walk behind vehicle. Brush is piled on the straps on the ground then pulled up to make a 1.2 m (4 ft) diameter bundle.



Biomass Energy Center, Kleensmoke, Inc., Willits, CA.

Fig. 5. Douglas Fir stand with hardwoods removed and bundled. The uncleared area is in background.

Fig. 6. The Acutrac Tractor with powered self loading trailer carrying a bundle out over a 1.2 m (4ft) road. The Redwood Forest is about 55 years old. The removal of the hardwoods releases the redwoods.

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