CREATING CLOSED-LOOP ECONOMIES

Transitioning to a "Carbohydrate Economy"
By Turning Agricultural and Forestry Waste
Into Industrial Products

Report for Idaho, Oregon, and Washington

Prepared by:
The Institute for Local Self-Reliance
2425 18th St., NW
Washington, DC 20009
202/232-4108 (phone)
202/332-0463 (fax)

and:

The Center for Watershed
and Community Health
P.O. Box 10933
Eugene, OR 97440
541/744-7072 (phone)
541/744-6660 (fax)

January, 1998

Table of Contents

Introduction

This report examines the agricultural and forestry economies in Idaho, Oregon, and Washington, focusing on the potential for using agricultural and forestry waste as raw material for the manufacture of industrial products (e.g., liquid fuels, building materials and industrial chemicals, such as ink pigment). Transition to an economy based on waste biomass has been called a "carbohydrate economy".

The report is a component of a multi-year initiative between the Center for Watershed and Community Health of Oregon and the Institute for Local Self-Reliance of Minneapolis, MN. and Washington D.C. to identify the policies, programs and practices needed to stimulate closed-loop economic development across the Pacific Northwest.

The first chapter provides a general overview of the current availability and use of agricultural and forestry waste. The second chapter, divided into three sections by state, offers (1) a more detailed look at current industrial uses of agricultural and forestry waste in each state, (2) a review of research underway to promote the use of agricultural and forestry waste, (3) a survey of the potential for economic development in that sector, and (4) a review of the financing available to make that development possible. The third chapter draws conclusions and makes recommendations from the first two chapters. Appendix A describes the effort in Minnesota to promote the use agricultural products as a raw material for industry.

Waste-Based agriculture

In this report, particular emphasis is placed on waste-based agriculture. Waste-based agriculture refers to the utilization of agricultural residues (often viewed as waste materials including grass seed straw, wheat straw, corn cobs, rice hulls, cereal straws, etc.) from the field, and transforming them into valuable products. A simple example of this is to harvest excess corn stover from the field and process it into higher value products such as paper or absorbents. Not only do the farmers receive monetary compensation for their agricultural residues, but manufacturers can reap the benefits of using renewable, inexpensive and often environmentally-preferable raw materials for their products, thus reducing the need for virgin resources.

Fiber-based industries

Fiber-based industries are generating the most interest in waste-based agriculture at this time. Strawboard manufacturing, for one, has created an explosion of interest in the Pacific Northwest. A feasibility study is currently being prepared for a strawboard plant in western Washington, which will also look at the possibility of pulping agricultural fiber for use in paper mills.

Weyerhaeuser has been researching the possibility of pulping rye grass straw in Oregon for several years. Researchers in Oregon have expressed an interest in reviving the state's fiber flax industry for use in both textiles and paper production. Significant raw material is available for the development of many new facilities; however, financial constraints hinder their development. Fiber-based construction material manufacturing facilities range in cost from $4 million to over $50 million. Pulping facilities can approach $90 million.

Interest in fiber-based product development was shown when sixty people attended a meeting sponsored by the Washington State University Cooperative Extension Services in Spokane in November, 1996. International Resources Unlimited presented information to the participants concerning their work analyzing data to locate a strawboard plant in the Pacific Northwest. Another business group stated they were using Business Diagnostics to prepare a feasibility study for locating another strawboard plant in the region. Their mill would cost $15 million, pull fiber from a 35-mile radius and pay $35/ton for the fiber; they expect a 20 percent return on investment from this plan. Finally, Al Wong of Canada made a presentation on technology designed to pulp fiber into paper as another potential development option.

Waste-Based agriculture as a key component of a carbohydrate economy

The potential for closed-loop agricultural economic development in the Pacific Northwest abounds if one looks at industrial uses for agricultural waste-based products. The goal, however, should not just be economic development, it is to make good products by skilled, well-paid workers who are concerned about the growth and strength of the local community.

Waste-based agricultural economic development also produces environmental benefits when they are used to create a "Carbohydrate Economy". This term was coined in 1992 by The Institute for Local Self-Reliance, with their ground-breaking report titled, "The Carbohydrate Economy: Making Chemicals and Industrial Materials from Plant Matter". The vision and principles of a carbohydrate economy are as follows:

"One hundred fifty years ago most of our non-food consumer products and industrial raw materials were derived from plant matter in all its forms -- fruits, vegetables, grains, grasses, bushes and trees. The rest came from animal matter, and from inorganic (noncarbon-based) minerals like sand, iron, and other metal ores.

"Then came the discovery of fossil fuels, whose name derives from the fact that they are the fossilized remains of living matter. Live living matter, fossil fuels are organic (carbon-based) materials; they are composed primarily of hydrocarbons. But because they are dead matter, fossil fuels are called minerals: organic minerals.

"In the mid-nineteenth century, hydrocarbons began to vie with carbohydrates for materials supremacy. Coal, and later to a much greater extent petroleum, became the basic raw material of industrial economics. Industrial uses of plant matter stagnated. Research and development in the carbohydrate economy tapered off and, after World War II, virtually ceased.

"Fossil fuels replaced plant matter because they offered definite advantages. As fuels, they contain much more energy by weight and volume, making them easier to transport and store. The liquid nature of petroleum, and the ease of liquefying natural gas, allow them to be transported cheaply over long distances via pipelines, and to be more easily converted into by-product chemicals. The large-scale nature of petroleum refineries, and the attendant size of their parent corporations, enables them to afford vastly larger research and development budgets than their much smaller and more dispersed agriculture-and-forestry-based counterparts.

"By 1970, petroleum had routed carbohydrates in virtually every product category, except for paper manufacturing. Oil accounted for 70 percent of our fuels and more than 95 percent of our organic chemicals.

"Now, just 20 years after the age of oil reached its apogee, we may be seeing the pendulum swing back in favor of a carbohydrate economy. In the 1980’s and 1990’s we discovered the disadvantages of relying on fossil fuels.

"From an environmental perspective, all kinds of pollution, from acid rain to global warming, from smog to ground water pollution have been linked to using fossil fuels.

"From a political perspective, relying on distant lands for our energy needs imposes very high national security costs.

"From an economic perspective, relying on imported raw materials when local alternatives are available weakens local and regional economies.

"The 1990’s may be witnessing a historic turn-around in the fortunes of plant matter. The comparative economics of carbohydrates and hydrocarbons is changing. Advances in the materials and biological sciences are reducing the cost of manufacturing plant matter-derived products while environmental regulations are increasing the cost of hydrocarbon-based products. Moreover, the growing environmental consciousness has prompted many customers to pay willingly a "green" premium for carbohydrate-derived, environmentally benign products.

"The potential industrial market for plant matter consists of both fuels and chemicals. The energy market is by for the larger. In 1989, Americans used 1.8 billion tons of materials for fuel: triple the tonnage of all plant matter consumed that year for food and nonfood purposes combined.

"Yet the very size of the energy market raises important environmental and social questions. if we were to substitute plant matter for a majority of our fossil fuels, what would be the impact on the U.S. and the global food supply? What would be the effect on soil erosion, on biodiversity, on water quality resulting from the increases use of fertilizers and pesticides?

"A few intermediate chemicals derived from plant matter have been in the marketplace since the beginning of this century (e.g. carbon black, adhesives). These are making new inroads into petrochemical markets. But the appearance of carbohydrate-based consumer products is a very recent phenomenon. The vast majority of these products, such as enzyme-based detergents or vegetable oil-based inks and paints or starch-based plastics, were unavailable only a decade ago. While most are still more expensive than their hydrocarbon-derived counterparts, they have already found a share of the market due to green consumerism and environmental regulations. Moreover, their price has dropped significantly in the past 5 years and promises to continue to drop in the near future.

"The carbohydrate economy is still very much in its infancy, but our research indicated that is has clearly moved beyond the birthing stage. Plant matter-derived products now have toeholds in markets from which they previously were excluded. And they have captured significant portions of other markets in which they previously had only a marginal presence.

"A renaissance of a carbohydrate economy holds great promise not only for environmental protection but also for rural economies. Increasing the demand for plant matter will raise its price, thereby increasing farmers' revenue. Moreover, plant matter, unlike petroleum, is expensive to transport. This encourages processors to locate plant matter-based manufacturing jobs in rural areas, strengthening area economies, expanding jobs, and increasing tax revenues. Policies that promote a carbohydrate economy can thus fulfill both environmental and economic development objectives.

"The struggle between carbohydrates and hydrocarbons is more that 150 years old. In the 1990's (and beyond), this competition is simply moving into another stage- a stage in which the prospects of the carbohydrate economy are brighter than ever." (ILSR, 1992: 1-2)

Social & Economic benefits of a waste-based agricultural economy

The social benefits of a waste-based closed-loop agricultural economy include strong rural economies. Because of the consolidation of agriculture and the increasing difficulties of small family farms to compete, our rural economies have been dwindling. By developing the high-value use of sustainably produced plant matter and/or agricultural

waste, rural communities would develop a viable, rooted economic base to carry them forward into the next century. The techniques and processes used in the carbohydrate economy lend themselves to small-scale production, which means the value-added processing could be locally or cooperatively owned, adding to the potential social value of such a strategy.

The economic benefits of an agricultural-based economy can be dramatic. For example, Minnesota produces 13.6 million dry tons of agricultural waste annually, the vast majority of with is corn stover. Harvested and used as pulp for the construction industry, this waste would surpass the volume of forest-wood pulp produced in Oregon (3 million tons) and Washington (5 million tons) combined. Ethanol provides another example. In only three years, from 1994 to 1997, the demand for ethanol in Minnesota jumped from 120 to 175 million gallons a year, with expectations for 1998 set at 220 million gallons; the industry has created 1400 jobs at $9-14 an hour.

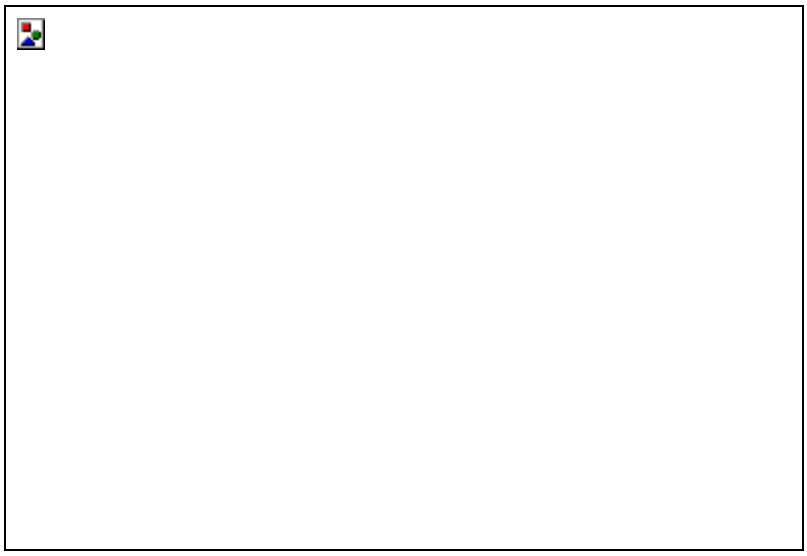
I. Available Residue

Estimating recoverable residues, either agricultural or forestry, is not an exact science; the environmental benefits of leaving residue in the field is the first priority. The residue available after environmental needs have been met can then be calculated. On the one hand, residue left in the soil maintains the soil's organic matter, provides plant nutrients, conserves moisture, and prevents soil loss from water and wind erosion. On the other hand, excess residue left in the field promotes disease, and leads to delayed or uneven germination.

Agricultural residue

As shown in Figure 1, significant amounts of deliverable agricultural residue are available in the Pacific Northwest.

Figure 1. Agricultural Residue



These estimates in Figure 1 were derived by (1) estimating the amount of residues that can be harvested without soil loss or soil nutrient loss, and (2) reducing these estimates in half to provide a realistic number for the amount of residues that might potentially be harvested.

Agricultural residue in the region is currently not being utilized. It is generally left on the field in its entirety or if removed, is typically landfilled. If harvested the residue could be used for a wide variety of industrial purposes including construction materials, paper, plastics, fuels, cosmetics, absorbents, and intermediate chemicals.

Forestry Residue

The forestry residue data presented in Figure 2 below was calculated by the U.S. Forest Service based upon survey data provided by primary wood processors. These values fluctuate directly with timber production, which varies from year to year. Figure 2 shows forestry residues generated in each state and their current reported usage.

Most forestry residue is used by burning the wood for heat and power; however, production of new products from these residues would be possible if wood processors were to receive a higher value from wood waste by making construction materials or other industrial products. In Washington and Oregon, between 1 and 2 million tons of forest residues are used each year for fuel.

No matter what strategy is used, great care must be given to ensure that more than sufficient amounts of biomass are left in the forests for ecological reasons and that use of the biomass does not spur demands for more wood extraction. The long term ecological health of the forests must be the *top priority*.

II. STATE PROFILES

IDAHO

Idaho's population ranks 42nd in the nation (1,133,000 in 1994). In 1990, the federal government owned 62% of the land in Idaho. The state's major industries are manufacturing, agriculture and tourism. Agriculture makes up 10.5% of the state's gross product at $2 billion a year.

The principal crops for Idaho are:

Crop	1994 Production
Potato	134 million cwt
Sugarbeets	5.6 million tons
Barley	54 million bushels
Onion - summer storage	5.5 million cwt
Hops	6.2 million pounds
Wheat - all	100 million bushels
Lentils	935,000 cwt

Industrial Uses for Idaho's Crops

Potatoes and wheat are major crops, and the full utilization of these crops has been the focus of several companies. Waste materials from these two crops can be turned into construction materials, fuels, biodegradable plastics, absorbents, and paper. Waste sugars from sugarbeet operations can also be converted into a variety of chemicals including ethylene glycol and propylene glycol.

Idaho's Companies of Interest

Idaho has a number of companies using agricultural residues for industrial uses. These include:

J. R. Simplot, one of the world's largest french fry processors makes ethanol with the waste material from potatoes. They sell it on the open market, as well as use it internally to fuel vehicles.

International Absorbents makes superabsorbants with wheat starch. They are used for a variety of things including cleaning up chemical spills.

Bon Terra makes erosion control mats. The erosion control mats are used in road construction, flood repair, forest fire repair, coal reclamation and landfills. The mats are made with wheat straw and coconut fibers. The straw is purchased from local producers when possible. The mats meet tough federal standards for use in government funded construction projects.

Innovative Biosystems makes soil amendments and pesticides. This product uses the residues as a carrier for the active ingredient, microorganisms with anti-fungal properties. This company is in the very early stages of production. They are currently doing contract production for two companies at undisclosed volumes. One company is marketing the product as a soil amendment, and the other is waiting for pesticide registration for the product.

National Products International makes a line of skin and body care products with potato starch as a main ingredient. They do mostly direct sales. All of the manufacturing, sales, and office work is conducted by the five-person staff. They have recently expanded into health foods. Non-Periel in Blackfoot, Idaho is their starch supplier.

Techni-Chem Corporation uses ligna sulfate, which is extracted from pine tree bark, to produce a product used to deoxygenate water in boilers to reduce corrosion. They also use a small quantity of lanolin (50-100 pounds/year). Gross sales were $700,000 in 1996, 95% of which resulted from direct sales. The company is privately held and received no government or foundation grants for start-up. They have indicated an interest in expanding.

A.E. Stanley Manufacturing Company and **Penford Products** make industrial potato starch used in the paper industry.

Research Efforts

Biodiesel. Several people at the University of Idaho are researching biodiesel. The technology has been developed, and demonstration projects are underway. Demonstration projects in Yellowstone National Park and with the Idaho Department of Natural Resources have given the researchers some publicity; however, widespread use of biodiesel is not expected at the time due to the unfavorable economics. Biodiesel currently wholesales for $3.50-$4.00 per gallon, compared with approximately $0.70 for diesel fuel. Further research is being conducted on alternative feedstocks, such as yellow mustard and waste vegetable oils from food processing. Less expensive production procedures are also being investigated. Promoting the fuel for use in environmentally sensitive areas such as Yellowstone is keeping the research and small-scale production going.

Potato and wheat starch. A USDA research project conducted at the University of Idaho investigated the use of potato and wheat starch for the production of packaging and soil solarization films. One use for this technology could be as a packet for spices that could be added to cooking water where it would dissolve and release the spices. An

application for the film is as a cover for newly planted crops to trap heat. The technology needs further refinement because the films still degrade too quickly.

Financing Efforts

There are no financial programs specifically targeting value-added agricultural processing within the state; however, federal AARC Center and SBA assistance is available to businesses in the region, as well as to traditional lending institutions.

Idaho has a state-funded Small Business Development Center to assist small businesses and manufacturers with business plans and market analyses. The Small Business Development Center is very good at reaching rural areas and assisting cottage industries with expansion.

OREGON

Oregon's population ranks 29th in the nation (3,086,000 in 1994). Agriculture makes up 4% of the state's gross product at $2.6 billion per year.

Oregon's principal crops are:

Crop	1994 Production
Peppermint	3.21 million pounds
Hops	13.7 million pounds
Potatoes - fall	27.5 million cwt
Barely	9.5 million bushels
Wheat - all	58.6 million bushels
Ryegrass Seed	413 million pounds
Onions - storage	10.3 million cwt.
Strawberries	70.2 million pounds

Oregon is the number one producer in the nation of Christmas trees, grass seed, hazelnuts, peppermint and cranberries.

Currently, 40% of Oregon's products leave the state after value-added processing; however, the national average is 54%. Presently, most of Oregon's grains leave the state before any processing is done, and most of the grain is sold overseas.

Oregon Governor John Kitzhaber has set a goal for the state to breach this gap, and the state's Department of Agriculture has appointed a staff person to promote industrial development by expanding existing processing facilities and creating new ones. The Department of Agriculture, in fact, has researched whether Oregon's legal structure has impeded setting up value-added food processing facilities in the state. No such impediments were found (the issue was raised because an individual incident had been repeated so often that it indicated there might be a large problem).

Industrial Uses for Oregon's Crops

Oregon's agricultural wastes can have a variety of industrial uses. Wheat straw can be transformed into construction materials, paper and other absorbent products. Grasses can also be used for construction materials, such as blown insulation, as well as pulped into paper.

Oregon's Companies of Interest

Structural Straw Products, **Inc.** is making construction materials from straw.

Universal Pulping has patented a process for converting agricultural residues, including rice straw, rye grass, corn stalks, and wheat into pulp for paper, as well as cellulose, lignin and hemicellulose-based chemicals. They are currently working with North Carolina State University's Department of Wood and Paper Sciences to scale-up the process to a commercial level.

International Resources Unlimited (IRU) is a consulting group focusing on alternative raw material exploration for industrial uses, including agricultural residues.

Living Tree Paper Company produces paper from a combination on non-wood fiber and recycled wastepaper. Their product Tradition™ paper is a blend of 10% hemp, 10% esparto grass, 60% agricultural byproducts and 20% post-consumer recycled fibers.

Potential Industrial Uses

Meadowfoam is a winter-spring annual wildflower native to northern California and Oregon. It produces an oil seed which has a very long strand fatty acid oil. This makes it useful as a replacement for several petroleum products in areas where sperm whale oil traditionally has been used, for example, cosmetics. Meadowfoam uses only about 20% of the herbicides and 25% of the fertilizer applied to normal grass seed in the Willamette Valley. It requires no fungicides compared to the 3-4 applications of grass seed. It also

provides a greater return to farmers than grass seed. It therefore has environmental and economic benefits compared to grass seed and can be a useful rotational crop in the valley. A breeding program as well as agronomic, seed processing and product development programs have been ongoing at Oregon State University. The process of bringing the plant from its wild state into a production crop has taken 30 years. In 1995, 3,000 acres were planted, and the 1996 estimates are from 8,000 to 10,000 acres planted. The entire crop is being raised under contract at this time.

At present, the oil is being sold into the cosmetics industry; however, the oil has significant advantages in the ink, plasitcizer and lubricant markets. In the ink industry there is the potential to lower the amount of pigment used. Pigment costs $30 per pound, whereas the estimates for the oil is expected to be at $5 per pound at market maturity.

There is an effort by a Portland group to develop an ethanol production facility in the state. They are looking at using food processing waste as a raw material, and sell it to Portland distributors to meet the oxygenated fuel mandate in the metro area.

Research Efforts

Daniel J. Brose of D.J. Brose Engineering in Bend is researching a process for developing **onion oil products**. They received a Phase I SBIR grant in 1993. The Treasure Valley of southwestern Idaho and eastern Oregon produces about one-third of the total annual US storage onion crop. Prior to shipment, onions are sorted to remove those that do not meet mandatory specifications for size, shape and appearance. The onions that do not meet standards, the "culls," represent about 20% of the harvest, and until recently were dumped on farm land. Farmers are no longer allowed to dump the onions due to possible disease spreading, and they must find a new way to dispose of the culls. This is an example of public policy driving private research.

A **Food Innovation Center** is being started jointly by Oregon State University and the Oregon Department of Agriculture. It’s mission will be to advance the opportunities for value-added in the food processing industry in Oregon and the Pacific Northwest. Construction for the state-of-the-art facility is approximately 18 months away and it will be fully equipped for developing products and product concepts. They will do packaging, as well as marketing research. There was no need for scale-up facilities, but for more detailed production information.

Flax, which is not an agricultural waste but rather an alternative fiber crop, is used to make rope, paper and linen for textiles. Historically, Oregon grew flax up until the late 1950's. Currently, flax is being researched as a possible replacement wood in the paper and construction industries and as a rotation crop for grass farmers. Researchers at Oregon State University are working on the agronomic and processing issues associated with reviving the industry. Currently, the infrastructure for processing the material no longer exists. The real question is whether the crop could be grown economically considering the infrastructure needs to be rebuilt. The cost of the infrastructure is from

$2-15 million depending on how far you want the material processed toward yarn for textiles.

WASHINGTON

Washington's population ranks 15th in the U.S. (5,343,000 in 1994). Agriculture makes up 3.7% of the state's gross product at $4.9 billion per year.

Washington's principal crops are:

Crops	1994 Production
Apples	2,850,000 tons
All Wheat	134 million bushels
Barley	14.335 million bushels
Fall Potatoes	88.9 million cwt.
Green Peas for Process	2.432 million cwt.
Dry Edible Peas	1.409 million cwt.
Spearmint Oil	1.46 million pounds

The state produces 73% of the nation's hops, 66% of the spearmint oil, and 62% of the dry edible beans. It produces over 35% of the pears, concord grapes and sweet cherries, over 50% of the apples and over 65% of the red raspberries.

Value-added agriculture is not a high priority in the state; the state government and state officials have not made the issue a priority. Their focus has been on controlling urban growth, and improving the business climate in the state. Waste, however, is a hot issue for the state. State officials seem to be slow in picking up the concept of using waste as a raw material.

Industrial Uses of Washington’s Crops

Washington’s wheat straw can be used to make construction materials and paper. Sugar wastes from the state’s fruit operations can be used to manufacture ethanol. Vegetable oils can also be used to make a variety of products from cosmetics and personal care uses, to industrial uses such as inks, dyes, paints, lubricants, and cleaners. Agricultural resides and wood wastes can also be composted for a variety of uses from individual gardens to community projects.

Washington's Companies of Interest

International Lubricants Inc. is located in Washington. They produce a range of automotive lubricants from various vegetable oils including rapeseed and crambe.

Washington is home to the **Earthcycle Materials Exchange**. The Exchange is a national electronic posting site for buying and selling industrial by-products and raw materials which are no longer needed by the company which purchased them. They have categories for a huge range of products including agricultural by-products. The site is accessible through the World Wide Web.

The **Mutual Materials Brick Factory** in eastern Washington has given some of their land to Bio-Energy Enterprises. Bio-Energy will use the land to build a straw-fed methane plant that will produce methane to fuel the brick factory. Potting soil will also be produced as a by-product and sold. They expect to be in production by fall of 1998.

Inland Technologies manufactures industrial cleaning solvents derived from citrus fruits. Their products are sold to printing, automotive, metal finishing, aerospace, and electronics industries, as alternatives to hazardous petroleum-based cleaning solvents.

Pabst Brewing produces fuel-grade ethanol from their brewery waste. Their plant capacity is currently 1 million gallons per year, however they typically produce between 0.5-0.75 million gallons/year, which is sold directly into the market.

Georgia Pacific Company produces ethanol from wood pulp. Their capacity is 7 million gallons per year.

Potential Industrial Uses

Domtar of Canada is looking at locating a wheat straw pulping facility in eastern Washington.

Western Washington raises large amounts of wheat which could provide the raw material for **strawboard** plants. The Washington Association of Wheat Growers is developing plans to build up to four plants in Washington over the next several years. The first plant will be in Pasco. Construction of this facility could start in late 1997. The technology they plan to use produces boards which are not a high enough quality for furniture, but work well for construction applications.

Financing Efforts

Ecotrust and **ShoreTrust** are making loans to environmentally friendly businesses on the Long Beach Peninsula in Washington (Ilwaco, Washington). They have $2.5 million to invest (from grants and related investments) in high-risk economic development projects. A separate $5.3 million in "deposits" is available from EcoDeposits, which offers nationally marketed, FDIC-insured savings, checking and money market accounts. The intent is to set up a new bank as an offshoot of ShoreTrust in the region. They are still in the process of raising the capital for the new bank. Additional information on Ecotrust is in the Oregon section of this report.

Other U.S. Companies Utilizing Agricultural and Forestry Wastes

Agriboard Industries L.C. (Fairfield, IA) produces construction boards from wheat straw.

Clean Green Polymers (Golden Valley, MN) makes polymers from corn and wheat starch.

Litter-Mate, Inc. (Fergus Falls, MN) makes wheat-based cat litter.

PrimeBoard Inc. (Wahpeton, ND) manufactures wood substitutes for building materials from wheat straw.

Zeneca BioPolymers (Wilmington, DE) makes resins for packaging applications from the fermentation of sugarbeets, cereal crops and other agricultural sources.

Xylan-Xymax (Nevada) has a patented process which steam explodes just about any source of cellulose (wheat straw, old newspaper, kenaf, switchgrass, etc.) and then mixes these fibers in a twin-screw exturder with polypropylene or polyethylene resins and forms any manner of construction shapes. The resins can be provided by recycled plastics.

Insul Holz-Benton International, IHBI (Windsor, SC) uses waste woodchips incorporated into cement to make a building block that has a higher insulation value than standard concrete block. The wood is treated with a mineral solution that prevents it from rotting. The company sells licenses to manufacturers who want to use the wood chip treating technology and/or the building block process.

Natural Fiber Composites, NFC (Baraboo, WI) makes plastic composites for the automotive industry from waste wood and plastic.

III. Conclusions/Recommendations

Overall, the region has significant potential to use agricultural and forestry waste as feedstock for a closed-loop carbohydrate economy. Raw materials are available locally. Entrepreneurial spirit in the region is strong. Technical assistance is available in the region, although some locations offer better support than others. And the rural population has moderate underemployment and unemployment rates (some more so than others).

The following is a list of areas where moderate efforts could result in significant gains for the regional economies:

1. Begin to promote closed-loop waste-based agriculture and forestry opportunities

as key components of developing a "carbohydrate economy."

As a first step, an agriculture/government/academic-based committee or

task force should be formed to identify the steps necessary to stimulate these

enterprises. The mission of this task force could include:

• Developing a targeted revolving loan fund for special low-interest loans for

this sector;

• Identifying and bringing together the necessary technical assistance providers;

• Hosting a trade fair to promote the waste-based agricultural products already made in the region and elsewhere in the U.S.;

• Encourage the formation of agricultural cooperatives as a means for farmers to pool their waste streams;

• Liaison with construction industry to determine specifications for products made from renewables;

• Establish demonstration projects with renewables, such as a school or community building; the focus would be on using green and local raw materials.

In addition, some specific projects that should be encouraged such as:

• Thermotech Inc., as an example of value-added to organic matter, could be encouraged to utilize the organic waste shipped from Portland to the Waste Management Inc. landfill.

2. Support the growth of strawboard manufacturing facilities. Manufacturing construction materials from agricultural fibers requires from 20,000 tons to

180,000 tons of straw per year per facility. At these input levels, the potential for new construction material manufacturing facilities in the region ranges from 3 large facilities to 250 small facilities. Job creation from these facilities is more difficult to estimate. One specific facility currently operating uses 3,600 ton per year per shift of straw and employs 35 in a single shift setup.

3. Support waste-to-ethanol facilities as an excellent use of local resources to drive the transportation industry. For example, the Oregon Cherry Growers are seeking an alternative disposal methods for the brine from the cherry processing, which can be fermented into ethanol. A processing facility that would meet their needs would produce up to one million gallons of ethanol per year.

4. Insure that there is adequate technical assistance for start-up companies in the region. Marketing, business planning and financial proposal writing assistance should be available to all entrepreneurs.

5. Support the Oregon State University value-added food center. Food processing wastes are excellent raw materials for industrial products. The same technologies used for food processing are used by industrial operations and having regional experts available would benefit a wide variety of industries.

6. Support the possibility of meadowfoam as an industrial crop. There is currently no infrastructure present to foster its growth. There are no crushing facilities in the Pacific Northwest, the closest is in Bakersfield, CA or Phoenix, AZ. A processing facility would cost approximately $3-5 million to build and would employ 30-40 people year round. Funding for continued long-term research is also lacking.

7. Support development of other new crops such as flax. These new crops can have additional benefits in reducing pesticide and herbicide use by breaking the weed cycle when used in rotation with other cash crops. The Willamette Valley alone has the potential for 500,000 acres of flax. The industry should also develop uses for the toe (or short fibers), which has been used in Europe for molded car panels. Other crops such as kenaf and industrial hemp, should also be considered.

8. Consider a transition program for forest product workers to become biorefinery operators. There is some overlap in skills needed by biorefineries and the timber industry. The most obvious is the need to move large qualities of material with heavy equipment and process large volumes.

9. Support alternative uses of grass seed straw. Research is being done in the use of grass seed straw for blown insulation and other products. These should be supported on both economic and environmental grounds.

Appendix A. Minnesota's Homegrown Transportation Fuel Industry

Minnesota's campaign on behalf of ethanol may be the most comprehensive effort by any state to support an agricultural-manufacturing industry focused in a specific sector.

Ethanol is an automobile fuel that is made from many kinds of crops and wastes (e.g., corn, wheat, potatoes, whey, wood, sugarcane, etc.). It is most often used in an 8-10 percent blend with gasoline. Ethanol was used in automobiles at the turn of the century and again before World War I and still again in the 1930s and during World War II. After World War II the fuel ethanol market disappeared.

In 1978, the federal government enacted an excise tax credit for ethanol fuels. The tax was raised twice in the 1980s and lowered in 1990 to its present level of 5.4 cents per gallon of gasoline. If ethanol is a 10 percent blend, this translates into a tax incentive for ethanol of 54 cents per gallon.

The federal excise tax exemption made ethanol economically competitive with gasoline. But ethanol still had to make it into the marketplace. This required convincing automobile manufacturers not to void their warranties if car owners used ethanol blends, and persuading gasoline stations to dedicate a pump to ethanol blends, and convincing motorists that ethanol did not degrade engine performance. Achieving these three goals took more than ten years. Indeed, until 1987, the vast majority of ethanol was sold through independently owned gas stations.

Minnesota, as with most corn producing states, viewed ethanol as a potentially important vehicle for increasing farm income. Initially, its goal was to increase the consumption of ethanol inside the state. Later, the state goal was to maximize production of ethanol inside the state. And coupled with the goal was a strategy to encourage a large number of locally and cooperatively owned ethanol facilities.

The state's involvement in ethanol began in 1980 when it enacted a state excise tax exemption for ethanol blenders of 4 cents per gallon of gasoline. In 1982, the state offered a tax exemption to school buses (amended in 1985 to read "school vehicles") and local government vehicles that purchased ethanol in bulk. This exemption was extended in 1991 to include non-bulk purchases by state and local government fleets.

The federal and state excise tax exemptions helped to create a rapidly growing market for ethanol by the mid-1980s. But, such incentives did little to create an in-state manufacturing capacity because ethanol could be produced more cheaply in Archer Daniels Midlands' very large refineries in Illinois and Iowa.

To encourage homegrown ethanol industry, in 1985 Minnesota lawmakers altered the ethanol incentive program. Half of the 4-cent tax exemption was converted into a producer payment of 20 cents per gallon for ethanol produced with the state. This money came from the general fund. The other half of the ethanol incentive remained a state excise tax exemption, which reduced state highway revenues.

Minnesota offered the 20-cent producer payment only for the first 15 million gallons produced annually. This was largely done because of limited available funds, but the result was to encourage numerous small- and medium-sized plants rather than one or two very large ones. This in turn created a very competitive industry and also an industry with significant political influence.

The producer payments are scheduled to cease in 2010. In 1994, as a result of a statewide oxygenate mandate that virtually guaranteed a large internal market for ethanol (see below) the legislature phased out the so-called pump credit of two cents beginning that year. That credit will completely end as of October 1997. In 1997, producer payments to Minnesota ethanol plants is about $17 million.

Environmental Incentives

The 1990 federal Clean Air Act required urban areas with excessive carbon monoxide emissions to add 2.2 percent oxygen to their gasoline during the winter months beginning in October 1991. The Twin Cities was subject to this requirement but not rural Minnesota. The Clean Air Act also required that urban areas with excessive ozone levels add 2.7 percent oxygen year round. No area of Minnesota has been subject to this requirement.

In 1991, to reduce pollution and encourage a wider market for ethanol, Minnesota created its own oxygenate mandate. A minimum oxygen content of 2.7 percent was required for all gasoline sold in the Twin City metropolitan area year round beginning in October 1995, and statewide year round beginning in October 1997.

The oxygen mandate could be satisfied by using either ethanol or MTBE. MTBE, a product derived from natural gas and petroleum, claims two-thirds of the national market for fuel oxygenates. But except for a small amount of MTBE produced by the Koch Refinery and reportedly sold in Wisconsin, ethanol is the oxygenate of choice in Minnesota.

The state's oxygen requirement virtually guarantees an in-state market of some 200 million gallons of ethanol by 1998. Speaking in September 1994, Governor Arne Carlson announced, "Our goal has to be that we will no longer import any ethanol. We'll produce everything we need here in Minnesota." In 1995, the Minnesota legislature established a goal of 220 million gallons of ethanol produced in the state.

Ethanol Education Programs

In the mid 1980s ethanol experienced a severe setback when gas stations began to put up signs saying, "Alcohol Free Gasoline" and motorists stopped purchasing ethanol out of fear that it was harming their cars. Demand plummeted.

There were indeed some problems related to ethanol at the time. Gas station operators were not familiar with its characteristics, especially its ability to absorb water and thus

they did not clean out tanks sufficiently and in some cases water got into gas tanks. But car engines were much more affected by two simultaneous changes occurring aside from the use of ethanol. The phase-out of leaded gasoline led to dramatic changes in the composition and variability of gasoline. And the introduction of electronic fuel-injection systems increased car engines sensitivity to fuel composition. The interaction of these two factors led to widespread problems throughout the country.

The need for technical assistance and public education of consumers, mechanics and service-station operators led the legislature, in 1987, to appropriate $100,000 per year to the Commissioner of Agriculture for ethanol promotion and education.

This funding was used to establish the Minnesota Ethanol Commission, whose members include ethanol producers, service station operators, oil companies, environmentalists, regulatory agencies, corn growers, farm groups and representatives from the Department of Agriculture. As ethanol plants began to develop, the Commission provided a forum for the sharing of information regarding technologies and financing and markets. The Commission worked with the industry and the Minnesota Pollution Control Agency to speed up the permitting process for ethanol plants.

The state appropriation was also used to develop a telephone hotline for consumers, and to hire Larry Johnson, popularly known as the Ethanol Answer Man.

In 1992, the state legislature provided $150,000 for an oxygenated fuel public outreach and training program. In 1993, an additional $200,000 was appropriated to the Department of Agriculture for continued ethanol education and promotion.

Minnesota Ethanol Production

Minnesota's first ethanol plant was build in the early 1980s by the Kraft company of Melrose as part of its cheese plant. Kraft converted whey, a byproduct of the cheese-making process, into about 500,000 gallons of ethanol a year.

The state's first significant ethanol plant opened in 1987 in Marshall. The wet-mill facility, which also produced corn syrup, High Fructose Corn Sweetener, corn oil, industrial carbon dioxide, corn starch and corn meal, was owned by 3,000 corn farmers who comprised the Minnesota Corn Processors. Later MCP expanded to over 5,000 members and built a second biorefinery in Columbus, Nebraska.

As of mid 1997, six ethanol plants are operating in Minnesota. The four that are cooperatively owned--by some 7,500 farmers--produce 90 percent of the state's ethanol output. Three more plants will be open by late 1997, and perhaps another three by late 1998. Two-thirds will be cooperatives. Several are investor owned and others are limited liability partnerships between investors and cooperatives. In 1996, a Minnesota limited

liability corporation, a partnership of one investor owned ethanol plant and two cooperatives was established to marked ethanol fuel.

As of 1997, about 10 percent of Minnesota's grain farmers are shareholders in an ethanol plant.

In 1991, Minnesota processed about 2 percent of its corn instate. By 1993, this rose to 5 percent, and by 1997 to 10 percent. By 2000, the figure could be more than 15 percent, rivaling that of Iowa.

In 1996, Minnesota initiated an "E85" program to promote ethanol as a primary fuel. The Department of Public Service has provided grants of $40,000 to four cities, which the cities match with $20,000 of their own money. The funds will be used to purchase three flexible-fuel vehicles--vehicles that can run on ethanol and/or gasoline in any blend--and one control car. Currently several dozen E85 cars are operating on Minnesota roads and six refueling stations. With the recent announcement by Ford of the availability of Taurus' that can run on any combination of ethanol and gasoline and cost less than conventional Taurus', cooperative purchasing strategies have been developed by one ethanol cooperative in partnership with the state.

Loans and Grants

In 1993, the state legislature appropriated $1 million to the Rural Finance Authority to provide loans to agriculture-manufacturing plants. The legislature appropriated another $1.475 million to this fund in 1994 and $350,000 in 1995.

In 1994, state legislators established the "Value Added Agricultural Product Processing Revolving Loan Fund" to help new farmers purchase stock in crop-processing cooperatives. The fund, received $250,000 and another $200,000 in 1995.

Assessing the Results

Minnesota's ethanol strategy has been remarkably successful, both in terms of creating a market and in developing an in-state industry. However, the program is dependent on the continuation of federal tax incentives which are set to expire in the year 2000 and which have come under a vigorous attack by Representative Bill Archer, Chair of the House Ways and Means Committee.

In 1997, the Minnesota legislative auditor evaluated Minnesota's ethanol program. The auditor noted that ethanol plants "typically have become one of the larger employers in the cities where they have been built. Moreover, the plants offer relatively high paying jobs." Producer payments in 1997 of about $17 million led to the creation of about 1400 jobs in an ethanol industry with a pay scale of $9-14 per hour. On a cost per job created, the program ranked very high. In addition the corn growers that own the ethanol plants received about $30 million in additional income.

The auditor's report raised concerns about the proliferation of relatively small ethanol plants because such plants may produce ethanol at a higher cost per gallon than larger plants. He expressed concern about the reliance on a federal tax incentive scheduled for termination in the year 2000. The report tracked, on a monthly basis, the economics of ethanol production from January 1994 through October 1996 and concluded that ethanol profits per gallon fluctuated dramatically, from a lower of negative 25 cents per gallon in April 1996 to a plus 55 cents per gallon in September 1996. The report concluded that without the 20 cent per gallon producer credit and the federal tax credit, only in 11 out of the 34 months tracked would producers make a profit.

The auditor also concluded that the use of ethanol increased the price of gasoline in Minnesota by 1-2 cents per gallon. The Minnesota Department of Agriculture responded in a letter to the auditor that historically Minnesota gasoline prices were higher than surrounding states and that because of the tax incentives, ethanol is lower in price than other oxygenate, octane enhancing fuel additives and should lower the price of gasoline. The Department of Agriculture also noted that because of ethanol's high octane levels, oil refineries could produce a sub-octane gasoline. This would lower production costs by about 3/4 of a penny a gallon and if passed onto Minnesota motorists would just about equal the producer payments Minnesota gives to Minnesota ethanol producers.

The costs of producing ethanol have continued to drop as a result of improved manufacturing efficiencies. However, the cost of ethanol depends on the cost of corn and corn prices have been trending higher.

Corn mills that produce ethanol also produce other byproducts. MCP's wet mill produces more than half a dozen end products while the more numerous but smaller dry mills produce distiller's grains (DDGS), and animal feed, and ethanol. Dry mills inside and outside of Minnesota have worked to increase the market value of DDGS. One ethanol plant has explored extracting corn oil, a common practice in wet mills but not in dry mills.

In mid 1996 the high price of corn plus low byproduct prices caused the shutdown of some of the ethanol capacity in Minnesota and a substantial amount of the ethanol capacity nationwide. With the expansion of the MCP plant and the opening of the ProGold plant, new supplies of High Fructose Corn Sweetener came on the market and prices plummeted. By 1997 MCP had lost a reported $120 million and in the summer of 1997 Archer Daniel Midlands purchased a 30 percent share of MCP. In return for its equity investment ADM will receive a 30 percent share of MCP's profits but has no voting rights and no seats on the Board of Directors. This relationship could strengthen MCP's marketing capacity. It is unclear what effect it will have on the rest of Minnesota's ethanol sector.

Unless the price of gasoline rises substantially or the costs of producing ethanol drop substantially, a continuation of tax incentives will be necessary for ethanol to continue to compete with MTBE or other gasoline additives. One can expect production costs to drop incrementally. A maximum 10-15 cent per gallon reduction in costs is possible given

recent yield increases demonstrated in federal labs. Production costs would probably have to drop by 30-40 cents per gallon for ethanol to compete without federal tax incentives.

Currently ethanol's federal tax incentives are less than those provided to electric or natural gas vehicles and are comparable to those provided to wind turbines. Nevertheless one can expect continued pressure on ethanol's incentives.

Several companies are seriously pursuing a cellulose-to-ethanol production process. This process may be able to produce low cost ethanol if the facility relies on cellulosic wastes and is located in a part of the country where suppliers would be willing to pay a high disposal fee. This is unlikely to be the case in Minnesota.

The price of ethanol, including federal and state tax incentives is about 15 cents a pound. This is a relatively low valued product. At least one company, Arkenol, has been pursuing the possibility of establishing a cellulosic based ethanol plant in Minnesota that would have as its primary product butanol, a much higher priced intermediate chemical. International Polyol Chemical Inc. has just opened a South African plant that uses a patented bioreactor process to convert the sugars extracted from sugar cane into commodity chemicals like ethylene glycol and propylene glycol, whose price begins at about 20-30 cents a pound and is expected to begin construction on a U.S. facility by the end of 1997. The facility would produce volumes comparable to those produced by Minnesota's ethanol plants.

Minnesota's ethanol enterprises are, in fact, small biorefineries. Just as oil refineries extract the maximum value from a barrel of crude oil, so these biorefineries are trying to extract the maximum value from a bushel of corn. The addition of ethanol to their product line is an attempt to increase the value added from corn. These value-added pursuits could in the future move the ethanol plants into the intermediate chemical market or into making use of the cellulosic components of corn.

Summary: Minnesota's Ethanol Program

Minnesota's effort to develop ethanol represents a long term coherent effort that marries legislative, regulatory, public education, fiscal and financial elements. By 1997 all small and medium sized ethanol plants were in operation, with the vast majority owned by over 7500 Minnesota farmers, about 10 percent of all Minnesota grain farmers. The plants had created over 1400 direct jobs with a pay scale of $9-14 per hour. The ethanol plants were producing 8-10 percent of Minnesota's automotive transportation fuel and that state had an embryonic network of cars and refueling stations that allowed vehicles to operate with up to an 85 percent ethanol mixture.

Minnesota has sufficient agricultural materials to be completely self-sufficient in homegrown transportation fuels. However, the ethanol industry is dependent on a federal tax incentive that could well disappear in the year 2000. Only since the early 1990s has the federal government aggressively pursued R&D strategies to lower the costs of ethanol production and only since about 1994 has the industry begun aggressive efforts to

increase the value of dry mill byproducts. Both these efforts may pay off in significantly lower ethanol costs in the near future. However, unless gasoline prices or MTBE prices increase substantially between now and then, if the federal tax incentive disappears it is likely that most if not all of Minnesota's ethanol production would shut down. There is some evidence that converting cellulosic rather than starch materials to ethanol could substantially lower its production costs, but no commercial plant is yet doing so. Another strategy for Minnesota's ethanol producers would be to improve the value-added aspect of their manufacturing plants by producing higher value intermediate and specialty chemicals from starch rather than relatively low value fuels.