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Opportunities in Grass Straw Utilization: An Alternative Viewpoint



Agricultural Experiment Station
Oregon State University

**OPPORTUNITIES IN
GRASS STRAW UTILIZATION:
AN
ALTERNATIVE VIEWPOINT**

by

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PREFACE

The research report OPPORTUNITIES IN GRASS STRAW UTILIZATION was prepared by CH₂M-Hill in conjunction with Oregon State University, and published in February 1991. It was prepared for the Oregon Economic Development Department (OEDD) and the Oregon Department of Agriculture (ODA) with funding provided by the Center for Applied Agricultural Research (CAAR), the Oregon Seed Council, and the grass seed commissions. It provides a preliminary economic screening of production and market use potentials for grass straw, and conditions necessary for its use. At present the only substantial commercial market for grass straw is as livestock forage, a weak and limited market in which straw itself has no positive market price. Yet straw is a technically viable fiber source in a number of potential markets. The issue is that straw has not been competitive with existing raw material fiber sources in such markets where cheap wood fibers from the PNW timber industry historically have dominated. The report takes a look at current markets to see if economic conditions have changed enough for straw to become a competitive fiber source and if so, to see what other barriers, if any, preclude its adoption.

The Executive Summary of the report ranks market opportunities by likelihood for commercial adoption and/or expansion. Measured judgement was used by authors of the report in arriving at the rank ordering. What is clear is that potential markets for straw have improved over the past decade. However, such improvement still leaves straw as only a marginally competitive substitute for existing wood fiber raw material sources and only under specific conditions. The specific conditional requirements are largely technical in nature and will require resolution even before economic feasibility criteria are met.

Differences arose among authors in assessing the seriousness of some technical obstacles, predicting the time required to surmount the technical problems and the nature of future market conditions and circumstances influencing further straw utilization. Foretelling the future is itself a risky venture. Some authors of the February report believed it important to present an alternative interpretation of project findings. To serve that role, an alternative ranking is presented in this report of grass straw utilization adoption potentials and factors likely to influence the nature and extent of their adoption.

An important element of this alternative viewpoint is that future project efforts to enhance the commercial use of grass straw should not be conducted without detailed and deliberate feasibility analysis on a case by case basis, thereby minimizing the risk of commercial failure. This is an important responsibility in committing both public and private funds.

The alternative rank ordering of straw market use potentials treated here is listed as follows:

Most likely near term straw use options

- Animal Feed
- Hydromulch and Specialty Mulch Products
- On-farm Composting

Straw use expansion when wood fiber prices (hog fuel, sawdust and wood chips) increase another 25-50 percent

- Pulp/Paper
- Panelboard

Long-term expansion (at least a decade away) requiring an 80-100 percent increase in natural gas prices, or a near-doubling of PNW power sale rates, and significant straw combustion problems (slag) solved

- Boiler Fuel Supplement
- Power Plant (existing)
- Power Plant (new)

Unknown or Unlikely Straw Use Expansion

- Commercial Compost and Potting Medium
- Chemical Markets
- Home Stove Fuel

Clarification of this alternative ranking is the subject of this interpretative report which serves to substitute for the Executive Summary found in the February 1991 research report OPPORTUNITIES IN GRASS STRAW UTILIZATION.

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OPPORTUNITIES IN GRASS STRAW UTILIZATION: AN ALTERNATIVE VIEWPOINT

INTRODUCTION

FOCUS

Finding and facilitating market uses for grass straw are major issues facing the Willamette Valley grass seed industry. Loss of traditional methods for on-farm straw disposal, principally open-field burning, have exacerbated the problem. While it is known that straw might be used in a number of markets, there is concern that little has entered the marketplace.

Study uses economic viability criteria to screen grass straw in its ability to compete with other raw materials in a range of markets.

This report is to facilitate commercially viable market uses of grass straw. It does so by providing an initial screening of existing and potential markets for straw as a raw material. In so doing, it identifies the technical, economic, social, and regulatory forces which serve to prioritize the more- from less-likely market potentials. The extent to which these forces may change over time

also is discussed.

Market conditions are changing which may now favor greater straw use than has been the case historically. Supplies of traditional wood fiber raw materials are declining while increasing in price in the Pacific Northwest (PNW). Searches for alternative materials in pulp, paper, particleboard, and power plant operations, in which it is technically possible to use grass straw, are underway in the PNW. Further changes over the next several years in market conditions of the Pacific Northwest timber industry are expected, with resulting further supply restrictions and higher prices for wood based raw materials. Increased demand for wood materials to fire boilers for power generation in California, and projected energy shortfalls from hydroelectric power generation in the PNW by the end of this decade, foretell further searches for alternative materials. Straw however, has a serious problem of boiler deposits (slag) to overcome before being useful as a power plant fuel, or as a home heating fuel.

STUDY APPROACH

This study includes a description and analysis of forces affecting potential straw supply. This includes a discussion of industry and farm practice changes that have occurred over the past decade. It treats also the selected market potentials for straw, an analysis of their current and

future viability, and a preliminary ranking of these potentials. Finally, this report describes the technical, economic and social factors which appear to serve as dominant forces influencing market adoption both now and into the decade of the 1990's.

Study is first of three phases for planned investigation, design, and commercial implementation of most economically promising straw market potentials.

The study was initiated by the Oregon Economic Development Department (OEDD) and the Oregon Department of Agriculture (ODA) as the first of three phases for straw utilization planned for implementation during the decade of the 1990's. Phase II would take the most likely straw market potentials from this current Phase I study and follow up with specific plans for preliminary design of industry plant development and in-depth

technical and economic feasibility analysis. Phase I and II activities are supported both by private and public funds. Phase III, using essentially all private funds, would involve the actual implementation of plant development and modification using straw. Bid documents, construction permits, financing, and contracts would be included.

STRAW SUPPLY AND ON-FARM UTILIZATION

Grass seed is produced under highly diverse conditions in the Willamette Valley.

Considerable variation exists in grass seed production and on-farm straw utilization across farms in the Willamette Valley. To account for these known differences, and their influence upon straw supply, the valley was divided into four geographic areas for the study. The areas are described below. Clackamas, Multnomah, and

Washington counties were excluded from the analysis because of small total grass seed acres. Table 1 compares general relative characteristics of the four areas.

- * South Valley: Broad benchlands of Lane, Linn, Benton, and southern Polk Counties
- * Foothills: Silverton Hills region of Marion, north Linn, and southern Clackamas Counties
- * Marion County Lowlands: River bottom and benchlands of Marion County
- * North Valley: Yamhill and northern Polk Counties

Table 1. Willamette Valley Production Region Characteristics

Characteristics	South Valley	Foothills	Marion County Lowlands	North Valley
Proportion of large farms	High	Medium	Low	Low
Tenure in grass seed production	More than 50 years	More than 40 years	Less than 25 years	Less than 6 years
Crop substitution options	Very limited	Limited	Many	Many
Land rent	Low	Medium	High	Medium
Investment in straw storage	Medium	Low	Medium	Low
Crop diversification	Low	Low	Medium	High
Annual ryegrass production	Considerable	None	Small	Small

PRODUCTION FACTORS AFFECTING STRAW SUPPLY

Post-harvest straw management practices of grass seed growers across the Willamette Valley vary considerably, even for growers of the same grass seed type. These differences are indicative of the set of conditions and factors affecting grass straw availability. These factors, summarized in Table 1, include soil type and production options, physical limitations, farm size, burning regulations, and seed market conditions.

These factors are significant because they, rather than market forces for straw, strongly influence straw supply. In addition, no strong and viable market for straw as a raw material currently exists in which straw commands a positive market value (price).

Cool season turf and forage grass seed has been produced in the Willamette Valley since before World War II, concentrated in the South Valley. Advent of the practice of open-field burning allowed significant expansion in the South Valley and into the Foothills region in the 1940's. Production extended to the Marion County Lowlands by the late 1960's. The expansion of the 1980's pushed acreage further north into Yamhill and Northern Polk Counties, where tenure in grass seed production among growers is generally less than six years.

Grass Seed Acreage

Steady increase in Valley grass seed acreage throughout the 1980's along with straw volume increases from 700,000 tons to 1.1 million tons annually.

the South Valley. Valley grass seed acreage is dominated by production of annual and perennial ryegrass and tall fescue, as shown in Figure 2.

Valley grass seed acreage is dominated by annual and perennial ryegrass and tall fescue.

The acreage of grass seed produced in the Willamette Valley increased steadily during the 1980's, from 263 thousand acres in 1980 to 368 thousand acres in 1990, as shown in Figure 1. This has increased the total volume of straw produced from about 700 thousand to 1.1 million tons over this period. Essentially all of the increase has come from production of proprietary varieties of tall fescue and perennial ryegrass, predominantly in

choosing type or variety of grass seed. Growers are subject to higher risk with respect to seed markets and, as a consequence, have tested and implemented a wide range of alternative technologies for disposal of straw.

By contrast, North Valley and Marion County Lowlands regions have better soil conditions and more productive options. Long-term economic conditions affecting the grass seed industry are more apt to be reflected in crop substitution.

Physical limitations: The Foothills region stands out as being most impacted by physical limitations affecting productive capability. Steep slopes can render farming and straw handling equipment unworkable.

Farm size: Farms with fewer than 50 and more than 1,000 acres in grass seed can be found in all regions. However, the South Valley, followed by the Foothills, have a higher proportion of larger farms. A primary effect

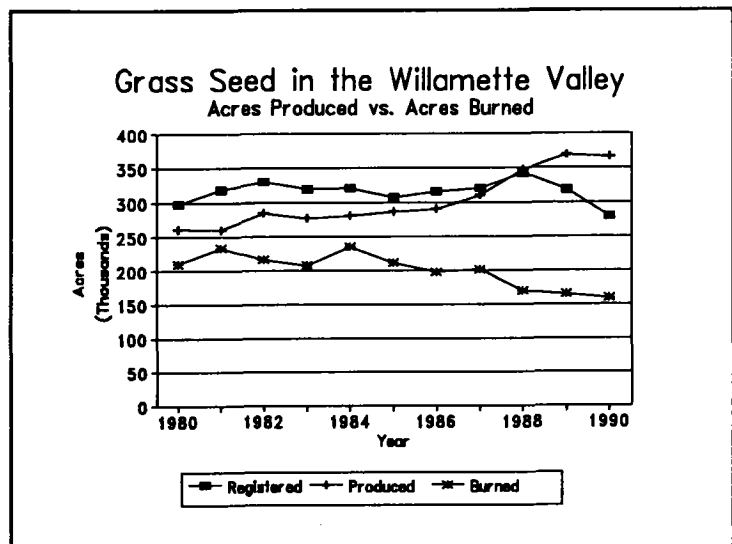


Figure 1

of the larger farms in the South Valley is an ability to afford economies of size in post-harvest management equipment not available further north. However, the higher yields attained further north allow smaller acreage for a commercial farm to be viable.

Significant decline in acres open burned during 1980's as growers shifted to alternative sanitation practices resulting in major increases in volume of straw available.

Burning regulations: While no legislation has been passed since the late 1970's restricting open-field burning beyond the upper limit of 250,000 acres, the number of burn days allowed has been reduced and total acres burned have declined to about 160,000 acres. See Figure 1. The uncertainty in use of burn permits has led many growers to seek and employ alternatives to open-field burning. These approaches were not applied uniformly across grass seed types:

- * Annual ryegrass: 50 percent of acres are open-burned now, down from 75 to 80 percent a decade ago, or a decline of some 30-40,000 acres.
- * Perennial ryegrass: 5 to 25 percent of acres are open-burned now, depending upon location (more in the south), down from 10 to 50 percent a decade ago.
- * Tall fescue: 25 percent of acres are open-burned now, down from 75 to 90 percent a decade ago (although total tall fescue acres in production has increased).

Growers in the Marion County Lowlands have very productive lands and higher land costs than elsewhere (land rents are \$60-70 per acre in the South Valley, more than \$100 in the Marion County Lowlands). The opportunity cost of waiting for a permit may be greatest in this location. As a result, many growers have invested in alternative methods for dealing with straw, including the building of sheds (currently able to store some 20,000 tons in the Marion County Lowlands) and reliance upon export markets to Japan. Newer growers in Yamhill and Polk

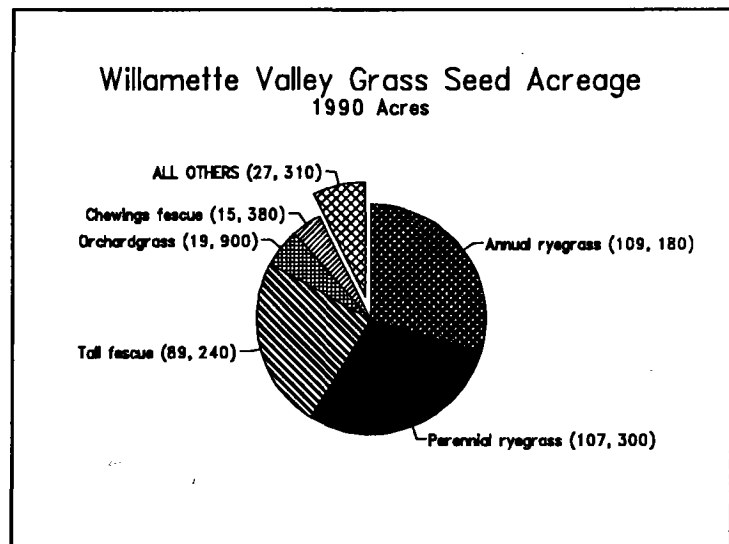


Figure 2

Counties have not made that storage investment and have a higher proportion of acreage open-burned.

The South Valley region has the largest proportion of acreage in annual ryegrass (more than 100,000 acres, with fewer than 5,000 acres elsewhere in the Valley), and much of this is still open-burned. Many growers have shifted their burning allocation to these fields (rather than their perennial grass seeds) because of the higher cost of non-burn alternatives (i.e., plowdown of straw), which cannot be justified with the low profit margin for annual ryegrass. Even so, a decline in burning of annual ryegrass fields has been noted.

An improved mobile field sanitizer prototype has been in use the past three seasons. It produces virtually no smoke, uses no auxiliary fuel on dry fields, can operate efficiently on poor field conditions and at night with propane assistance. Estimates indicate costs approximating \$60 an acre to own and operate. The machine has sanitized about 1,000 acres to date.

Foothills farmers must consider the consequences of not burning and have chosen a burn priority for the fine fescues. To the extent possible, colonial bentgrass fields have had straw removed for the feed market.

Seed market conditions: There is a projected leveling off, and in some cases decline in prices for most grass seed types, that will affect the market for and availability of grass straw. Although the near term indicates a stable and abundant supply of straw, declining seed prices could eventually induce a contraction in production of grass seeds. Any reduction in total acres will likely be concentrated in the North Valley of Polk and Yamhill Counties, where production options remain available.

Despite low prices for annual ryegrass, widespread shifts to other crops (including other grass seed types) appear unlikely due to the high investment cost of substitution. Perennial ryegrass and tall fescue straw supply will remain stable in the short term because of the terms of seed growing contracts. This could change if seed market conditions or continued high stocks lead to falling seed prices.

CURRENT AND POTENTIAL STRAW SUPPLY

At present, some 1.0 to 1.2 million tons of straw are generated statewide by grass seed growers (980 thousand to 1.1 million tons in the Willamette Valley). Of this amount, about 600 thousand tons of straw currently are removed from farm fields.

In the Willamette Valley, the largest volume of straw (by grass seed type) is tall fescue, which represents about 45 percent of current straw removed. A slightly smaller proportion is perennial ryegrass straw. Orchardgrass represents about 7 percent as the next highest volume.

Virtually no annual ryegrass straw is removed from fields. Kentucky bluegrass is about 4 to 6 percent of the statewide total, but 70 to 80 percent of that available in Eastern Oregon.

There is inherent difficulty in predicting what growers will do under new circumstances. Nevertheless, it is useful to examine the volume of straw that growers would be willing to supply under realistic conditions for straw. Growers face economic, agronomic, and physical limitations on some grass seed types that prevent them from being willing to supply all straw produced.

Predominant volume of grass straw located in South Valley.

The largest volume of straw produced is in the South Valley where farms produce from two-thirds to three-quarters of a million tons annually. Refer to Figure 3. This is also an area that is able to supply, under ideal economic conditions, a very high proportion and volume of straw. In fact,

under some economic conditions the potential available from the South Valley could increase by 250 to 400 thousand tons above that currently available. Most of that increase would come from annual ryegrass fields (as much as 300 thousands tons), although 50 to 100 thousand tons could come from other grass seed types in the South Valley.

Other areas present more limited potential changes. The North Valley could supply an additional 40 to 50 thousand tons of straw than at present but, as has been noted, growers in the North Valley provide the least long-term certainty in supply of straw. Marion County Lowland growers provide more certainty of supply in the future but could increase volume by less than 30 thousand tons. The smallest change in supply would come from the foothills region where, at best, some 2 to 4 thousand additional tons could be supplied.

COST OF STRAW MANAGEMENT

Open-field burning is the least expensive means for disposing of straw. Alternative forms of straw management cost more for all grass seed types and farm sizes and in all regions. There are, however, differences in cost due to farm size, annual versus perennial grass seed, and by region in terms of straw volume.

Unit costs per acre tend to be lower for large farms due to economies of size in machine use. However,

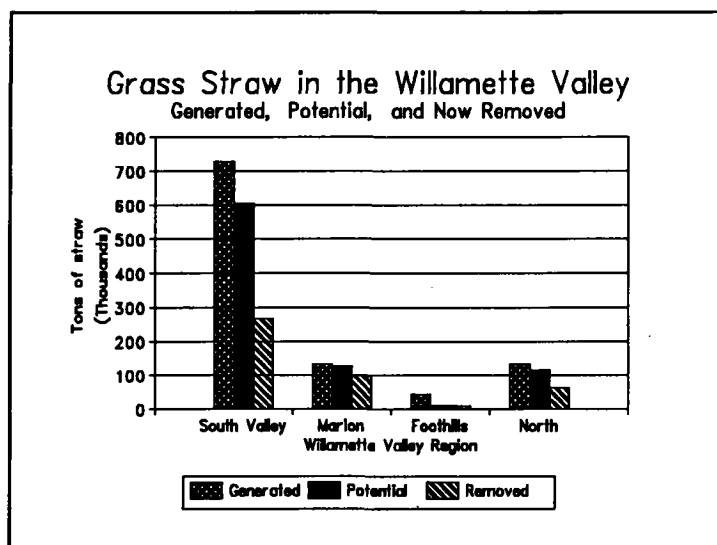


Figure 3

Many growers have turned to straw removal, stubble management and field sanitation practices as effective but costly substitutes for open field burning.

because straw volumes may differ by geographic region (volumes per acre are lower in the South Valley), post-harvest costs per ton of straw for South Valley farms as compared to those farther north may be higher. The combined cost of straw removal, stubble management and field sanitation for perennial grass fields exceed \$60 per acre above the cost of open-field burning for all regions and may exceed \$110 per acre under some

circumstances. Without a positive market for straw most, if not all of these costs are borne by the growers. A strong and expanding grass seed market throughout the decade of the 1980's permitted such cost absorption by growers without their going out of business.

It is important to note that all alternatives to open field burning (crew cut, mobile thermal sanitizers, etc.) require the loose straw (3 tons/acre) to be removed before proceeding. Significant improvements have been developed recently in crew cutting and complete straw removal systems.

Annual ryegrass is the only grass seed type with the option of straw plowdown every year (perennial grass seed types are grown for three or more years before replanting). The plowdown alternative is \$8 to \$10 higher per acre than open-burning. While the differential is considerably less than for perennial grasses, the low return of annual ryegrass necessitates lower costs.

STRAW SUPPLY TRENDS

Projections for the future of grass seed markets have direct implications for the supply of straw. Widespread expansion of grass seed acres over the next decade is unlikely. Perennial ryegrass, tall fescue, and annual ryegrass acreage likely will remain relatively stable. But despite acreage stability for these three major seed types, straw supply, even in the absence of additional markets, could remain unpredictable for three reasons:

1. Growers have changed their straw management techniques dramatically during the 1980's, and indications are they will continue to do so in the next decade. This trend has been away from open-field burning and toward plowdown (in the case of annuals) and straw removal (for perennials). Refer to Figures 4 and 5.
2. The advent of dwarf and semi-dwarf varieties of grass seed, in market response to consumer preferences, may result in lower straw yields for some varieties of tall fescue and perennial ryegrass.

- On-farm utilization potential through straw composting and return of the compost to the fields is an unknown but potentially important issue treated later in this document.

Although these factors affect straw availability in different directions, it appears likely that shifts from open-field burning will increase straw availability more than expansion of dwarf varieties will decrease it during the next decade.

STRAW AS A BYPRODUCT

Straw is a byproduct of grass seed farming which has not commanded economic or agricultural importance in the past. Predominant factors have been its high cellulose and lignin content which is of low feed value, its low bulk density which makes costly densification a prerequisite for transporting it any substantial distance, and its sensitivity to environmental degradation without storage. Thus the cost of straw is sensitive to the amount of preparation required for it to be marketed.

Straw market use potential is influenced by densification and preparation costs, a major economic barrier historically.

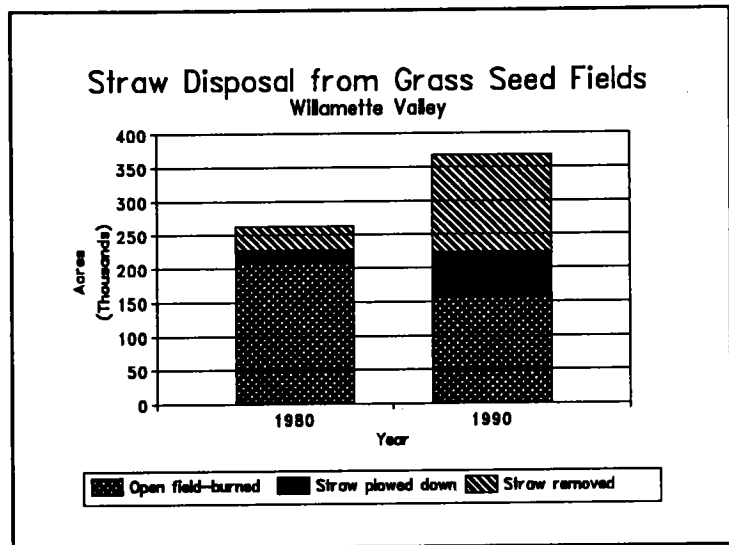


Figure 4

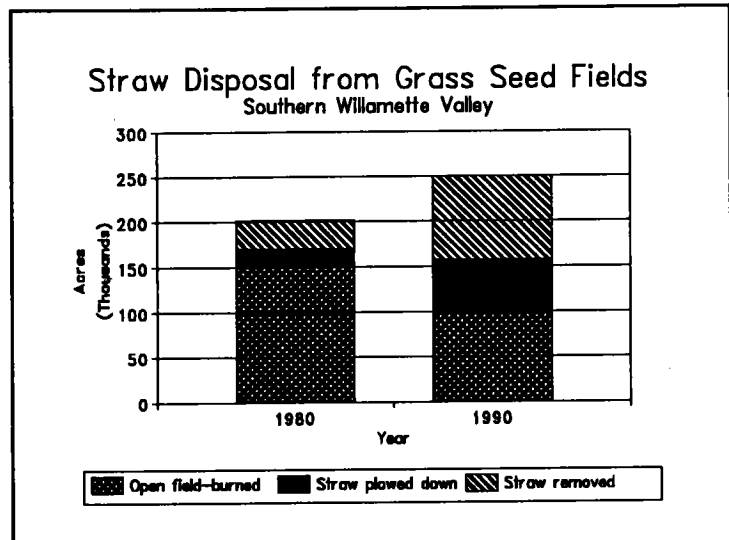


Figure 5

Straw that is baled and roadsided costs \$12 to \$15 per ton. Transportation (up to 150 miles) adds \$15 to \$25 per ton. Storage of straw requires another \$12 to \$15 per ton. This places straw cost in the range of \$39 to \$55 per ton, delivered for market use. Compacting by cubing or pelletizing costs an additional \$30 per ton.

The existence of viable markets for straw could, of course, encourage more straw removal. However, it must be stressed that growers produce grass seed and react to grass seed market conditions with respect to acreage in production and selection of varieties. Since straw is a waste by-product of grass seed production, any positive market forces for straw which might emerge are expected to play little if any role in modifying grass seed acreage and straw supply over time. This is to say that grass seed producers are not apt to be very responsive to market price fluctuations for the grass straw.

STRAW USE MARKET POTENTIALS

Table 2 presents a summary matrix of the range of market use potentials for straw considered in this study accompanied by a synopsis of technical, economic, social/regulatory, and expected trend aspects of each market use potential. Details for each choice are presented in the text. Market uses in the table are presented in declining order of perceived potential use for straw based upon current technical and economic evidence obtained from the study. An underlying economic truism is that marketing straw products is expensive and difficult.

Straw for feed an existing but weak market where even handling costs sometimes are not covered.

Straw as an animal feed source is listed first as it is the only substantial market in which some straw currently is being used. The nature of the market is weak. At best, straw moves as a free good (only densification, storage and transportation costs are covered) and at worst growers bear some of the value added costs. A fairly stable amount

approaching 150,000 tons annually goes overseas to Japan as a roughage source for dairy cattle. While consumer demand has been strong and growing for dairy products in Japan and is expected to continue, the endophyte issue (addressed in the document) places the future role of straw for livestock feed in a somewhat clouded position. The domestic market, tied to the abundance or scarcity of alfalfa hay available, is expected to stay small and variable unless some unforeseen measure emerges which turns straw as a low quality roughage feed into a high quality one at little cost. Such a system has been developed that injects a molasses/protein supplement throughout the bale, enhancing the dry matter digestibility to approach grass hay, increasing the palatability, and insuring complete consumption. At a rate of 30 tons/hour, the additional cost, including labor, is estimated at \$15/ton.

Here too the endophyte situation must be remedied. Current research suggests that endophyte may not be an issue if no more than 50 percent of endophyte infected straw is included in a livestock diet.

Considerable market expansion potential for straw use in commercial hydromulch.

Some 2,000-3,000 tons per year of straw are used in making hydromulch for erosion control and ground cover in reseeded in Oregon. Wood fiber

TABLE 2. SUMMARY OF STRAW UTILIZATION PROSPECTS

STRAW USE	TECHNICAL VIABILITY	ECONOMIC FEASIBILITY	SOCIAL ACCEPTABILITY	A VIEW TO THE 90'S
ANIMAL FEED	Straw suitable as roughage feed. Low bulk density requiring densification and low feed value requiring feed supplements add costs which do not make straw competitive in most feed markets. Endophyte presents new problems for feeding straw to livestock. Current recommendation is not to have straw exceed half of total ration to minimize any disorder.	Only substantial existing market for grass straw but marginal enough that no positive return results to growers for the straw. Some 150,000 tons exported annually to Japan as roughage component in dairy feed. Market expansion uncertain. Oregon market is small. Straw competes as roughage source only when alfalfa hay is scarce/expensive.	No major impacts expected unless several feed processing plants are established involving localized air, noise, land use and transportation effects.	Future role somewhat clouded until endophyte issue clarified. Market analysis needed to assess further demand potential overseas. Breakthrough required to turn a low quality roughage into a high quality one at low cost to permit domestic market expansion.
HYDROMULCH & SPECIALTY MULCH MARKETS	Commercial small scale production demonstrates suitability in residential and roadside applications.	Cost competitive with existing wood and paper products. Limited volume.	Can meet typical process plant requirements.	Secondary fiber and wood fiber price increases will improve economics of straw use.
ON-FARM COMPOSTING	Aerobic composting technically feasible. Further on-farm testing underway to resolve high water use requirements by composting during winter rains. Movement of equipment in fields during winter an issue to be resolved. Processes for incorporating back to fields not yet developed.	A major economic unknown. If technically viable at low cost to growers, it has potential as major "user" of straw. Eliminates market use uncertainty by retaining grower control. Some economic benefit from improved tilth.	No major changes anticipated.	A major "wild card" in use of straw. If economic for growers, it would preclude other potential market uses unless a positive market price were to emerge for straw in those markets, an unlikely outcome in the near term.
PULP AND PAPER (Existing Plant)	Plant modification required as pulping characteristics for straw different than wood fiber. Extent of modification determined by the type of pulp/paper being produced and their market standards. May require separate dedicated digester for straw and modification of handling equipment.	Economics attractive for straw as supplemental fiber source for hardwood chips at one plant in Oregon having separate dedicated digester and producing corrugating medium. Economics of using straw by the industry unknown until technical pulping issues resolved. Potential volume of use on a single plant basis exceeds 20,000 tons annually when used as a fiber supplement.	Rather minimal changes in air, water, noise and land use requirements expected when modification of existing plant is involved. Employment effects minimal.	Straw expected at best to play extender role as its volume available is extremely small relative to overall industry fiber requirements. Recycled paper likely to take on prominence as major fiber source as it is cheap and doesn't require pulping. Shift of pulp operations to Southeast U.S. and current recession likely to deter near term investment in plant modifications for straw use especially if addition of separate dedicated digester required.

TABLE 2. (CONTINUED)

STRAW USE	TECHNICAL VIABILITY	ECONOMIC FEASIBILITY	SOCIAL ACCEPTABILITY	A VIEW TO THE 90'S
<p>PANELBOARD (Existing Plant)</p>	<p>Potential use as extender for existing wood fibers. Requires chopping for blending. Could require densification for storage and transportation. Small scale straw panelboard plant dependent upon market acceptance of products.</p>	<p>Competitive with wood fiber in baled form. Densification and storage costs can impact acceptance as a supplemental fiber source.</p>	<p>No major changes anticipated if used as extender in existing plants. If strawboard produced, public scrutiny of resins and chemicals used may occur. Market acceptance of strawboard an issue if panelboard characteristics change because of straw.</p>	<p>Straw expected at best to play extender role as its volume available is extremely small relative to overall industry fiber requirements. Other scrap wood fiber sources being sought and preferred to straw at this point. Contraction of industry at this time due to national recession making modification of plants unlikely for some time.</p>
<p>BOILER FUEL SUPPLEMENT (Existing Plant)</p>	<p>Boiler deposits (slag) from straw caused by low ash fusion temperature is a major problem; not yet resolved. Requires periodic and costly plant shutdowns is straw used. Modification of existing equipment to handle the problem not yet successful.</p>	<p>Stable demand and short supplies of hog fuel traditionally used to fire boilers in PNW are driving its price to level where other fuel sources are now competitive. Natural gas now the fuel of choice for plants where conversion to gas is possible. Straw may serve as a supplemental fuel but only if technical slagging problem resolved, and done so economically.</p>	<p>No major changes anticipated.</p>	<p>Boiler slagging limits the extent to which straw can substitute for hog fuel on a large scale in the Valley. Other scrap wood fiber sources may be preferred if price is competitive.</p>
<p>POWER PLANT (Existing Plant)</p>	<p>Straw not a viable fuel source due to serious slagging and deposit accumulation in combustion equipment. Straw has special chopping and feeding requirements for use if and when the slag problem is resolved thus limiting its potential to being a supplemental fuel source.</p>	<p>Natural gas now the fuel of choice to replace hog fuel where such conversion is possible. Straw competitive with hog fuel hence can play a fuel supplement role where conversion to gas not feasible. A single plant would be a potential large user of straw.</p>	<p>No major changes anticipated.</p>	<p>Straw at best to play extender role where hog fuel will continue to be used because of the technical issue and small volume of straw available relative to overall fuel requirements.</p>
<p>POWER PLANT (New plant)</p>	<p>(same as above)</p>	<p>Natural gas now the fuel of choice to replace hog fuel where such conversion is possible. Straw competitive with hog fuel hence can play a fuel supplement role where conversion to gas not feasible. A single plant would be a potential large user of straw. Major capital investment requirements.</p>	<p>Major social/regulatory issues associated with citing, construction and operation of a new power plant. Public scrutiny expected. Limited local benefits for employment from construction and operation.</p>	<p>Additional PNW power demands in excess of existing supply not expected until late in 1990's. Resolution of slagging problem and near doubling of power generating contracts to exceed \$0.07 to \$0.12/kwh required for straw to be competitive as fuel source.</p>

TABLE 2. (CONTINUED)

STRAW USE	TECHNICAL VIABILITY	ECONOMIC FEASIBILITY	SOCIAL ACCEPTABILITY	A VIEW TO THE 90'S
HOME STOVE FUELS	Burning characteristics restrict straw to serve as a minor blend component in densified biomass fuels (DBF), such as pellets, to minimize slagging and ash accumulation.	Not yet competitive with wood fibers due to densification costs.	Air quality restrictions regarding smoke & airborne chemicals likely to increase. Store owners don't like dust and slag from ash.	Air quality impacts to receive greater scrutiny and result in improved efficiency of fuel combustion in wood stoves and/or greater restriction in their use. Present feedstock quality standards are being rewritten to accommodate a wider range of DBF fuels.
COMMERCIAL COMPOST AND POTTING MEDIUM	Testing underway for commercial composting; currently only grain straw used in potting medium.	Economic feasibility unknown. Potting medium market very small. Compost market unknown. Straw volume use unknown.	Limited impacts to environment.	Future for straw unknown in these relatively small specialty markets.
CHEMICAL (DIGESTION, PYROLYSIS/GASIFICATION, AND HYDROLYSIS)	Little chemical compound production appears to be past pilot plant test stage. Most testing done with non-straw biomass materials. Ethanol technically feasible.	Preliminary economic screening not conducted so feasibility of straw use in these markets not established. cursory evidence suggests market is small, PNW not a major source of cheap feedstock and so is a net importer of chemical products.	Air, water, noise, & land use changes likely to be involved. Public scrutiny of chemicals involved likely a major factor.	Recycling of waste products will continue to increase to the extent they become economically viable to do so. National energy policy likely an important determining factor for the future in use of chemical processes in producing fuels.

currently dominates this PNW industry which is currently estimated to produce about 100,000 tons annually. With straw hydromulch selling for \$180/ton and wood fiber at \$200-220/ton, considerable expansion potential for straw appears to exist with appropriate market penetration.

On-farm straw composting a distinct possibility if proved technically practical.

On-farm composting of straw, while still in the developmental stage, must be viewed seriously as a potential major user of straw. At this point it is viewed as a "wild card" because it is unknown if it is technically practical to handle large volumes of straw in this manner. If this proves feasible after further testing this winter, it is quite possible that

Valley grass seed farmers would consider its use. There are several favorable factors for composting. The cost of composting and field incorporation, while unknown, are not perceived to be excessive. Some economic value to growers appears to exist through improved soil tilth when compost is returned to the field. That and limited dependency upon market conditions for growers to get rid of their straw may serve as attractive incentives, especially under current conditions in which the farmer receives little, if any, value for the limited amount of straw now marketed.

If on-farm composting were to achieve widespread adoption, it could have a significant effect upon the volume and likely market price for straw in the potential markets discussed in this section.

Straw as a fiber source in pulp/paper manufacture appears attractive for one plant producing corrugating medium in Oregon, having a separate digester which could be devoted to straw. This potential is based solely on the delivered cost of grass straw which is now competitive with hardwood chips, the dominant wood fiber input. Straw as a source of fiber for pulp/paper is likely to remain stable or improve as the relative volume of hardwood chips available in the PNW continues to shrink over time. Paper is the highest value product obtained from wood fiber raw materials. The cost of raw material for paper is an important but not overriding factor in generating returns. The technology for using straw for pulp, with adaptations to U.S. conditions, exists. Production of paper products is somewhat less

Pulp and paper manufacturers are examining technical issues of straw as a raw material source, but large capital costs associated with digestors could inhibit widespread adoption.

vulnerable to changes in the U.S. economy than are other wood based products, such as lumber and particleboard, which are tied directly to housing starts and highly susceptible to economic upswings and downturns. However, technical factors which may require a separate dedicated digester solely for straw could serve as a formidable economic barrier for other straw pulp/paper plants in the PNW.

The overriding, but probably not insurmountable limitation to using straw will be the magnitude of

capital cost necessary for modification of plant and equipment. Existing plant modification is more feasible than construction of completely new plants. The limited volume of straw produced supports using it as a supplemental rather than sole fiber source for the PNW pulp/paper industry. Economic uncertainties of the industry do not favor building a new plant solely dependent upon straw.

The overall volume of straw use will be dictated by the percentage of straw blended with wood fibers and the number of plants converting to use of some straw. Straw cannot be expected to play a major role in papermaking as its maximum potential volume available is small relative to overall fiber requirements.

Straw as a fiber source in panelboard manufacture is competitive at \$39-\$55/ton with some wood fibers now being used by the industry. It is economically more attractive when straw can be chopped directly from bales in manufacturing panelboard. If further densification is necessary, then technical issues in using straw may require the price of wood fiber materials to rise somewhat higher before straw becomes economically feasible. Panelboard has a

narrower margin of return than paper so the price of raw material is a more critical issue. Panelboard manufacturing is also more sensitive to economic conditions such as housing starts. At best, straw can be used only as an extender or supplement to wood fiber in existing plants because of plant modification issues and low overall volume relative to industry requirements.

Straw is economically competitive under certain conditions as a raw material in panelboard, particularly as an extender in existing plants.

If more than 10-20 percent straw is used in the mix, market acceptance of the "new" product becomes an issue. A small-volume production plant producing a 100 percent straw fiber panelboard could be possible, with market research determining its true viability. A small straw fiber panelboard plant, already in operation in the Valley, perhaps could be used to manufacture and market test panels.

In the PNW, many industrial and institutional plants use wood fired boilers for steam power generation, heating, and other industrial uses. Hog fuel has been the traditional fuel source, but reduced supplies and increased local demands as well as expanded cogeneration plants in

California have led to marked increases in hog fuel prices with further price increases expected in the future. Straw is a potential fuel source in industrial plant conversions (boiler fuel). Current prices favor natural gas as the preferred fuel choice followed by hog fuel and then straw. This suggests that major conversion to natural gas will take place, where feasible. Conversion is already occurring in some cases. Straw might serve as a supplemental or extender fuel source to hog fuel where

Technical problem of deposits (slag) must be overcome for straw to serve as a boiler fuel extender in industrial plants. Current economics favor natural gas and hog fuel as feedstock sources.

conversion to natural gas is not feasible or practical. However, a serious technical problem of deposit accumulation (slagging) must first be resolved. Grass straw, along with nearly all agricultural residues, have sufficient potassium (some 10 times greater than found in wood residues) to lower the ash fusion point from 2,300° F for wood ash to 1,500° F for straw ash. The result is liquid slagging on grates and in fluid beds, and flying ash deposits that foul the upper furnace and heat exchange surfaces. At present no solution to the problem exists. Cubing, while concentrating straw mass for use in boilers, only exacerbates deposit accumulation. Deposits cause periodic plant shutdowns and costly manual removal of slag. Until the issue is resolved, straw is not a viable feedstock as a boiler fuel. Even European pulp mills using straw as a pulp feedstock use oil as a boiler fuel. If there is technical resolution of the problem, the overall straw volume is too low relative to needs of industry.

Straw as a fuel supplement in existing or new power plants unlikely to be competitive with natural gas and other fuels during the 1990's.

About half of the electric power used in the PNW comes from hydroelectric sources. Another 45 percent comes from power generation and cogeneration plants that produce power as a byproduct of their primary function. Those plants use coal, oil, gas, and nuclear energy for boiler firing. Only 5 percent use wood. Straw is a potential fuel source for existing dedicated and cogeneration power plant operations. At the

present time, and for the foreseeable future, natural gas is likely to be the most economical choice of fuel for firing such operations. Straw is not competitive with natural gas nor is it likely to be because of straw's lower burning efficiency and low volume available relative to overall demand. To sell power to the PNW power grid would require a contract price in excess of \$0.08 to \$0.12/kWh for a straw fired power plant to be profitable, a rate considerably in excess of the current contract price range of \$0.025 to \$0.05/kWh, according to a computer simulation used in this study, and shown in Figure 6. Technical problems with combustion resulting in deposits and slagging require resolution before straw can be considered a technically viable fuel source.

Use of straw as a supplemental fuel is not expected in this decade in new power plants. Resolution of the deposits problem, major capital investment requirements, financing and social/regulatory issues associated with siting, construction, and operation of a new power plant, are all substantial hurdles.

Technical (slagging) and economic (high cost) problems currently preclude use of straw as a home stove fuel feedstock.

The overall volume potential for densified biomass fuels (DBF) as feedstock for home stoves (as logs or pellets) is growing rapidly, especially for use in pellet stoves. Total wood fiber use at this time is estimated in excess of 200,000 tons in the PNW. Straw is a potential biomass fuel. However, the combustion problems of deposit accumulation, referred to earlier in using straw as a boiler fuel

and in power plants, are no less severe in home stove fuels. To minimize such difficulties, straw must be a minor component in a DBF blend. Additionally, the current price of wood fiber feedstock, ranging from \$3 to \$41/bone dry ton, does not yet make straw fiber competitive. However, the home stove fuel supply industry is beginning to experience a shortage of traditional supplies. In response they are considering relaxing feedstock quality standards to accommodate a wider range of potential fuels, including straw.

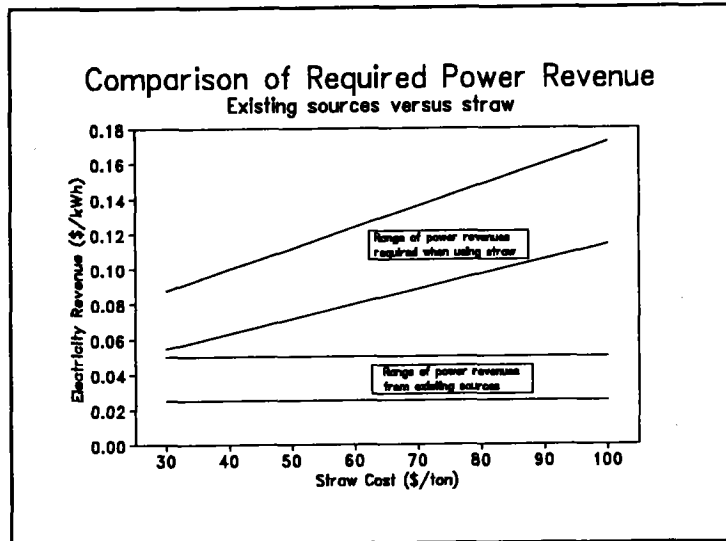


Figure 6

Expansion of straw use as a potting medium and as commercial compost unlikely.

Straw is also a potential fiber source in commercial soil amendments including potting medium and compost. However, the potting medium market is extremely small, with less than 2,000 tons sold annually, and to this point has been confined to using grain straws. No economic analysis was conducted on the commercial compost market.

Volume potential also is unknown. Tests are at a preliminary stage in the development and marketing of commercial compost containing straw. Competition from municipal compost plants is expected.

No known potential for straw in chemical markets.

Straw is a potential raw material source in the manufacture of chemical products. Chemical extraction methods by digestion, pyrolysis/gasification, and hydrolysis are capable of producing a wide range of products including alcohol, ethanol, methane, oils, complex sugars,

acetic acid, and others. However, the PNW is not a major source of cheap feed stock, such as oil, used in chemical conversion so is not a center for the production of chemical products. The PNW is a net importer of chemical products.

Limited resources precluded a complete preliminary economic screening of straw use, as was done with the other straw market potentials, to analyze straw potential in the chemicals market. As a consequence, it is unknown what the nature and scope of that market is, the raw materials currently used, the supply of those materials, their price, the ability for straw to be price competitive with those materials, and the technical efficiency in use of straw compared with existing materials.

Cursory evidence suggests that the chemical market in the PNW is small, limited largely to pilot plant rather than full scale commercial operations and that straw will have to compete with a variety of other waste products as raw material sources. A market assessment of the PNW chemical industry is necessary to answer these questions.

AN ALTERNATIVE RANKING OF MARKET USE POTENTIALS FOR STRAW

Overall, straw is becoming more feasible as a substitute for wood fiber. Current and expected future economic conditions are more favorable than existed in the past. However, higher market prices for hog fuel, wood chips, sawdust and other fiber resources will be necessary before technical conversion to grass straw for pulp/paper and panelboard production can be justified. If and when this occurs, the overall volume of straw is low relative to industry needs, so it cannot be expected to serve in more than an extender or supplemental role. Stable long-term contracts with growers (say five years) likely will be necessary to assure a continuous and stable supply of straw to commercial plants. Where straw is contemplated as a fuel source for power plants, boiler fuel supplement, and home stove fuels, a major technical problem of boiler slag deposits must first be resolved. Even with such resolution, current and projected power rates dictate that straw as a fuel source will happen only over the long term.

SUMMARY AND CONCLUSIONS

A summary ranking of straw use potentials and the conditions necessary for their adoption are stated as follows:

Most likely near term expansion in straw use:

- Animal feed
- Hydromulch and specialty mulch products
- On-farm composting

Straw use expansion if wood fiber prices (hog fuel, sawdust and wood chips) increase another 25-50 percent:

- Pulp/Paper
- Panelboard

Likely long-term expansion requiring an 80-100 percent increase in natural gas prices, or a near-doubling of power sale rates, but only if significant combustion problems (slag) solved:

- Boiler fuel supplement
- Power plant (existing)
- Power plant (new)

Unknown or unlikely straw use expansion:

- Commercial compost and potting medium
- Chemical markets
- Home stove fuel

These results indicate that a select few of the many technically possible uses for straw meet the preliminary economic screening criteria used in this study. For those, an additional in-depth technical and economic analysis is urged to assess each proposed project selected for Phase II follow-on.