A. Collection and Transportation. In California most of the pulpwood used by pulp mills comes in the form of wood chips. Of a total of 8,452,000 tons of pulpwood moved by rail in 1966 on the Pacific Coast, 95 percent was in the form of wood chips and only 5 percent roundwood (Guthrie, 1972). The reason for this is due to the preponderance of sawmills and plywood mills in California. The wood chips produced by the sawmills and plywood mills are used by pulp, paper, and fiberboard manufacturers.

There is some uncertainty as to who normally pays the transportation charges. Often times the mill itself will pay. In every case, however, the cost of transportation is included in the price of the raw material. In order to estimate the delivered cost of rice straw to either a corrugating medium plant or fiberboard plant it was assumed that the rice straw would be cubed and transported 10 to 15 miles by truck and then 130 miles by rail. The costs of collection and transportation are shown in Table 6.25.

The supply of rice straw to either a corrugated medium or a fiberboard manufacturer would cost approximately $41.78 per ton of straw at 14 percent moisture content. Precautions would have to be taken to insure that the rice straw cubes do not get wet. If the rice cubes get wet they swell up to several times their normal size and result in a highly unmanageable feedstock for production purposes.

Table 6.25

COLLECTION AND TRANSPORTATION COSTS
FOR CORRUGATING MEDIUM AND FIBERBOARD PRODUCTION[a]

Collection Costs[b]

	Tons	Overhead $/Ton	Cash $/Ton	Total $/Ton	Total Per Season
Corrugated Medium	140,000	$7.11	$7.27	$14.38	$2,013,200
Fiberboard	136,000	7.11	7.27	14.38	1,955,680

Transportation Costs[c]

	cwt	$/cwt	Surcharge	Total $/cwt	Total Per Season
Corrugated Medium					
Truck (10-15 miles)2x	2,800,000	$0.265	15.25%	$0.61	$1,708,000
Rail (130 miles)[d]	2,800,000	0.75	1.1%	0.76	2,128,000
Total cost					$3,836,000
Fiberboard					
Truck (10-15 miles)2x	2,720,000	$0.265	15.25%	$0.61	$1,659,200
Rail (130 miles)[d]	2,720,000	0.75	1.1%	0.76	2,670,200
Total Cost					$3,726,400
Total All Costs -- Corrugated Medium					$5,849,200
Total Cost Per Ton -- Corrugated Medium					$41.78
Total All Costs -- Fiberboard					$5,682,080
Total Cost Per Ton -- Fiberboard					$41.78

[a]Costs are in January, 1980 dollars.

[b]A 1,200-acre farm size was used to estimate collection costs.

[c]Truck prices are based on common carrier rates. Rail prices based on commodity rates.

[d]Rates quoted for alfalfa cubes on 40,000-pound minimum loads.

Sources: Public Utilities Commission
Southern Pacific Railroad
Copley International Corporation.

At today's prices, rice straw could be supplied as cheaply as wood chips (when competing with market wood chips).* Wood chip prices currently range from $70 to $90 per ton (Crown Zellerback, 1980). There are two primary reasons for the recent high cost of wood chips. First, great quantities of wood chips were sold on the international market (primarily to Japan) which drastically lowered domestic supplies. Secondly, the building and construction industries have slowed down, therefore sawmills and plywood mills are not generating the same quantities of wood chips as in the past. This is considered to be only a temporary condition, however, and prices are expected to drop $10 to $20 per ton. When the market adjusts itself to normal conditions, it is epxected that rice straw cubes could be supplied at prices competitive with wood chips.

Historically, the market price of pulpwood (mostly wood chips) in California has been established by the pulp mills. In 1977, for instance, there were 346 sawmills and planning mills in California (County Business Patterns, 1977). In that same year there were three pulp mills and 19 paperboard mills located in the state. Table 6.26 shows the geographical distribution of the pulp mill and paperboard mills in California.

The majority of California's materials are produced by pulp mills. It becomes readily apparent, therefore, that the prevailing pattern of pulpwood procurement is that of buying

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*A substantial amount of wood chips never entered the marketplace due to the high degree of integration in the paper industry.

from a large number of sellers who supply only a limited number of mills. As a consequence, price determination is dominated by the buyers.

Table 6.26

GEOGRAPHICAL DISTRIBUTION OF CALIFORNIA PULP MILLS AND PAPERBOARD MILLS

County	Paperboard Mills	Pulp Mills
Los Angeles	9	---
Contra Costa	3	---
Alameda	2	---
Ventura	1	---
Santa Clara	1	---
San Joaquin	1	---
Humboldt	2	2
Unknown	---	1
Total	19	3

Source: County Business Patterns, 1977.

A clear advantage that wood chips present over rice straw (cubed or baled) is in storage. Wood chips can be stored uncovered in the open whereas rice straw must be protected from the rain. Inherent problems with rice straw storage include:

- more handling due to its greater volume and storage requirements
- fire hazard from spontaneous combustion

In light of this, as a form of pulpwood, wood chips may be more desirable than rice straw. Historically, though, straw was once a dominant feedstock for pulping processes and it is clear that the technology of collection, transportation, and storage is adequate to supply the paper industry with rice straw or other fibrous raw materials. Therefore, as the price of wood chips increases relative to straw, it is expected that substitution of wood chips for straw will take place.

B. Capital and Operating Costs. The supply of raw materials is only one aspect of the production technology. The process of using straw for the manufacture of a corrugating medium or fiberboard product is decidely more expensive than if wood based raw materials are used. The higher cost for chemicals, labor, and capital facilities required for these two products are the principal cost factors which place rice straw at a disadvantage over wood residues. The associated capital and operating costs are shown in Tables 6.27 through 6.30.

The costs to develop the capital facility for the manufacturer of corrugating medium are $71,160,000 and $56,870,000 for straw and wood feedstocks, respectively. The straw costs were based on using wheat or rye grass straw as the primary fibrous feedstock material. It is unclear whether or not rice straw processes are more expensive than those for wheat or rye grass straw. It is not likely that rice straw would result in lower capital costs than those other systems. This is due principally to the higher chemical recovery costs associated with high silica containing feedstocks.

Table 6.27

CORRUGATING MEDIUM CAPITAL COST COMPARISONS[a]

Production Facilities	Plant Type	
	Straw[b] (10^6 \$)	Wood (10^6 \$)
Material preparation	\$ 2.49	\$ 2.74
Chemical Recovery	15.76	7.78
Pulp Processing	6.67	4.93
Product Fabrication	17.17	17.17
Utility Hook-Ups	8.37	7.51
Miscellaneous	2.64	2.31
Direct Costs	\$53.10	\$42.44
Construction Contingency, Fees, and Taxes, etc. @ 15% of Direct Costs	\$ 7.97	\$ 6.37
Engineering and Design @ 19% of Direct Costs	10.09	8.06
Total Capital Cost	\$71.16	\$56.87

[a]Plant size is 300 tons/day of finished product. Costs include allocation of structural costs for the manufacturing building in each item. Costs are in January, 1980 dollars.

[b]Costs are developed for wet straw process.

Source: Adapted from Battelle, Pacific Northwest Laboratories, 1979

Table 6.28

CORRUGATING MEDIUM PRODUCTION COST COMPARISONS[a]

	Annual Costs	
	Straw	Wood
Supply of Fiber[b]	$ 5,880,000	$ 6,720,000
Boxboard Clipping[c]	1,980,000	1,980,000
Chemicals[d]	829,320	1,553,400
Fuel and Power (1.16)[e]	3,028,644	2,901,392
Other Materials (1.15)[f]	2,131,985	1,854,490
Labor, Administration Overhead (1.10)[g]	7,638,400	6,636,850
Repairs @ 4% of Capital Cost	2,846,400	2,274,800
Taxes and Insurance @ 3% of Capital Cost	2,134,800	1,706,100
Capital Recovery @ 12% for 30 Years	8,783,529	7,019,664
Total Production Costs	$35,253,078	$32,696,696
Total Cost Per Ton @ 130,000 Tons/Year	$271	$251

[a]Output is 300 tons per day finished product, costs are in January, 1980 dollars, wet handling system for rice straw.

[b]Figured at 140,000 tons of rice straw @ $42 per ton and 112,000 tons of hardwood chips @ $60 per ton.

[c]Figured at 36,500 tons @ $54.25 per ton.

[d]Prices escalated 20 percent over January, 1979.

[e]Prices escalated 16 percent over January, 1979.

[f]Prices escalated 15 percent over January, 1979 prices.

[g]Prices escalated 10 percent over January, 1979 prices.

Source: Adapted from Battelle, Pacific Northwest Laboratories, 1979.

Table 6.29

FIBERBOARD PLANT CAPITAL COST COMPARISONS[a]

Production Facilities	Straw	Wood
Material Preparation	$ 1,168,500	$ 666,250
Resin Preparation Plant	840,500	840,500
Product Fabrication	8,189,750	8,189,750
Finishing Plant	2,009,000	2,009,000
Utility Hook-Up	1,096,750	1,096,750
Miscellaneous	1,004,500	1,004,500
Direct Costs	$14,309,000	$13,806,750
Construction Contingency, fee @ 15% of Direct Costs	2,146,350	2,071,013
Engineering @ 19% of Direct Costs	2,718,710	2,623,283
Total Capital Cost	$19,174,060	$18,501,046

[a]Plant size is 73 million square feet per year of medium density fiberboard. Costs are in January, 1980 dollars. Costs include allocation of structural costs for the manufacturing building in each item.

Souce: Adapted from Battelle, Pacific Northwest Laboritories, 1979.

Table 6.30

FIBERBOARD PRODUCTION COST COMPARISONS[a]

	Straw	Wood
Supply of Fiber[b]	$ 5,712,000	$ 4,000,000
Chemicals[c]	13,742,400	3,189,600
Fuel and Power[d]	829,400	1,023,120
Other Material[e]	883,200	883,200
Labor, Administration, and Overhead[f]	4,325,200	3,538,000
Repairs @ 4% of Capital Cost	766,962	740,042
Taxes and Insurance @ 3% of Capital Cost	575,221	555,031
Capital Recovery @ 12% for 30 Years	2,366,722	2,283,649
Total Annual Production Costs	$29,201,105	$16,212,642
Toal Cost/Sq. Ft. @ 73 million	$0.40	$0.22

[a]Output is 73 million square feet of medium density fiberboard annually. Costs are in January, 1980 dollars.

[b]Output is 136,000 tons of straw at $42 per ton and 100,000 tons of wood residues at $40 per ton.

[c]8,180 tons of polysiocyanate resin, 8,180 tons of urea formaldehyde resin, and 1,020 tons of wax. Costs escalated 20 percent over 1979.

[d]Costs escalated 16 percent over 1979.

[e]Costs escalated 15 percent over 1979.

[f]Costs escalated 10 percent over 1979.

Source: Adapted from Battelle, Pacific Northwest Laboratories, 1979.

The annual operating costs when straw is used in place of wood result in a $20 per ton cost disadvantage for the potential straw corrugated medium products. Even though rice straw can theoretically be supplied cheaper than wood chips in this instance, the fuel and other material costs required for production render this system comparitively more expensive.

The capital costs of a fiberboard manufacturing plant is similar for both straw and wood. The capital costs are $19,174,060 and $18,501,046 for straw and wood, respectively. The added costs in the straw fiberboard plant are primarily due to the higher handling and storage costs associated with straw.

Alternatively, the operating costs are significantly higher when straw is used instead of wood in fiberboard manufacturing. Two principal reasons account for this. First, the supply of straw is priced higher than the wood-based feedstock since wood materials can include sawdust and sawmill shavings. Second, a substantially greater amount of chemical resin is required for the straw process. It is likely that the high chemical cost for the straw products also reflect the lowered efficiency of chemical recovery systems when high silica-containing raw materials are used in the production process. In summary, the production of a straw fiberboard represents a 19 cent per square foot disadvantage over wood. On an annual basis this would result in approximately $13,000,000 less in revenues for the straw fiberboard manufacturer.

C. Substitutability for Existing Raw Materials. It is apparent that, from a cost standpoint, rice straw is not presently competitive with wood as a feedstock for corrugated medium and fiberboard manufacturing processes. As the price of wood chips increases, there will be some substitution of wood for straw. Rice straw would have to compete with other straw products (namely, wheat and rye) for available markets. Wheat and rye straw have been applied to paper production processes and the technology of utilizing these two fibrous materials is known. Alternatively, there is little known about the applicability of rice straw in pulping and paper manufacturing processes. Louisiana Pacific Company stated that rice straw was considered as a possible material for paperboard manufacturing; however, rice straw's high silica content and fine texture precluded its use as a suitable raw material (Louisiana Pacific Co., 1980).

In the event that a straw fiberboard could capture its own market as a decorative or superior quality product, the sales revenues associated with this "unique product" might warrant employing the expensive process required for straw fiberboard production. Otherwise, the price of wood chips could increase several orders of magnitude before there would be any possibility of straw supplanting wood as a feedstock for fiberboard manufacturing.

In summary, the ability of rice straw to compete for corrugated medium or fiberboard markets is diminished for the following reasons.

- high bulk of straw, making for difficult and expensive procedures in handling, storage, and processing
- high silica content of straw, which interferes with recovery of waste liquor and cogeneration of steam
- high cost of production relative to existing, wood fiber techniques

Therefore, it must be concluded that rice straw is not suitable in the near future for the grades of fiber products discussed above. Demand for specialty grades of paper may encourage the utilization of rice straw; however, it is not expected that large volumes of rice straw would be required for these specialty grades.

OTHER USES FOR RICE STRAW

In this section several possible alternative uses for rice straw are briefly discussed. In general, these uses are believed to represent a small fraction of the overall potential demand for rice straw. Three principal alternatives are discussed which include rice straw for mushroom culture, furfural production, and bedding for livestock. For each of these alternatives contact was made with spokespersons for the respective industries.

There are several miscellaneous uses described for silica which can be extracted from rice straw. It is expected that hundreds of commercially important compounds can be rendered from high quality amorphous (non-crystalline) grades of silica. Presently, private research is being conducted to examine the potential demand for this biological grade of silica.

Mushroom Culture

Certain microorganisms that belong to the generic family of Basidiomycetes (commonly called mushrooms) are very effective at degrading lignocellulose compounds. These mushrooms convert lignocellulosic material directly into edible protein. Mushroom culture is heralded to produce more protein per unit land area than any other form of agriculture (Han, 1973). As a result, mushroom growers have been able to utilize substantial quantities of straw and other agricultural residues to an economical advantage.

The most commonly cultivated species of mushroom include: Agaricus bisporus (common cultivated mushroom), Letimus edodes (shiitake), Volvariella volvacea (paddi straw mushroom), Pleurotus ostreadtus (oyster mushroom), and Tuber melanosperum (perïgord truffle), (Han, 1973). Commercial production is normally restricted to areas that enjoy coastal climatic conditions. Santa Cruz, Watsonville, Santa Clara, and San Mateo Counties comprise the majority of production in California.

Mushroom growers normally use wheat straw with an organic manure for the growing medium (horse manure is favored throughout the industry.) Other types of agricultural residues used include corn cobs, corn stocks, and chicken manure. The straw/manure mix is composed and sterilized before being inoculated with spawn.*

*Propagating material used by growers for planting beds is called spawn.

Contrary to popular belief, mushroom culture requires considerable knowledge and experience before profits may be realized. The industry tends toward secrecy and non-conformity. The actual substrate (growing medium) formulation which is used by growers is a matter of private concern. Formulas for propagating medium preparations are safeguarded and not exchanged on an industry-wide basis. Growers obtain a formulation which is specialized for their particular growing requirements and are reluctant to change. However, the mushroom industry is highly competitive and experimentation with other forms of substrate is being conducted.

During the course of this study, two large mushroom growers who had experimented with rice straw were contacted. Both growers stated that they had poor results when rice straw was used as a propagating medium. One grower concluded that rice straw was "difficult to break down and that production was reduced with it."

The volume of straw utilized may range from less than ten tons per week for a small grower to 275 tons per week for a large grower. Correspondingly, mushroom production ranges from 2,000 pounds per year to seven or eight million pounds per year. Assuming an average ratio of straw to mushrooms produced at 2.5 pounds to one, then the estimated demand for straw amounts to nearly 66,400 tons per year.*

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*Based on 1978 California mushroom crop yield of 531,000 cwt.

In order for rice straw to be absorbed into the mushroom industry its price would have to be competitive with wheat straw. There are positive charges associated with both forms of fiber. The cost of wheat straw to the mushroom grower arises from handling and trucking from race tracks primarily. Neither mushroom growers or wheat straw suppliers would disclose the exact price of the delivered wheat straw. Based on the collection and transportation charges calculated for the delivered price of rice straw to fiberboard manufacturers, CIC estimates that rice straw could be supplied to mushroom growers at approximately $48 per ton.

In summary, rice straw is suggested to be a suitable substrate for mushroom culture. It does not seem likely, however, that mushroom growers would be willing to convert their technologies to the use of rice straw. The yield of mushrooms on rice straw is lower than with other readily-available substrates and the cost of the rice straw does not appear to offer any significant economies to the mushroom industry.

Furfural

Furfural is obtained from products containing pentose sugars and is collected by acid hydrolysis and distrillation procedures from straw, corn cobs, oatmeal, jute, and certain gums. Oat hulls and corn cobs appear to be the best sources of furfural, the former yielding about 12 percent or more. Rice hulls and rice straw yield 10 to 11 percent (Jenkins, 1980).

The Quaker Oats Co. has a furfural plant at Bayport, Texas which utilizes rice hulls in a distillation process. The company has spent a great deal of money in research and development for utilizing different feed products for furfural production. A spokesperson for Quaker Oats stated that corn cobs and rice hulls were the most feasible feed products for their processes. The exact volume of materials utilized in the process could not be disclosed.

The Quaker Oats Co. has researched the feasibility of utilizing rice straw in their operations. It was concluded that rice straw had low potential compared to rice hulls and corn cobs. The chief constraint with the straw was that it was fluffy and light and difficult to transport. The Quaker Oats Co. experimented with cubing the rice straw and concluded that this form of collection was not suitable due to the intensive fuel requirements. In addition, pelletizing equipment was experimented with and problems with preparing the rice straw for pelletizing also precluded using rice straw to an economical advantage.

The production of furfural requires a large, capital intensive plant in order to maximize profits. Large volumes of furfural are produced throughout the year, thereby resulting in lowered marginal production costs. If rice straw was used as a source of pentose sugars for distillation to furfural, a long term supply of straw would be required. Quaker Oats Company suggested that the bulky nature of rice straw presented excessive storage constraints. The relative amount of storage space required for rice straw as compared to corn cobs or rice hulls would be directly proportional to the bulk densities of these various residues. In light of the alternative sources for pentose sugars, the collection, transportation, and storage expenses involved with rice straw renders it a poor competition with rice hulls and corn cobs.

The uses for furfural are many. It can be used as a motor fuel and as a substitute for, or in conjunction with, formaldehyde in the preparation of synthetic resins and moulding compounds. Also, by reason of its germicidal character, it can be utilized as a preservative of adhesive pastes and biological specimins. It may also find some use as a substitute for turpentine in varnish manufactures, and as a substitute for formaldehyde in tanning (Van Nostrand, 1966).

<u>Bedding for Livestock</u>

Rice straw is suitable for use in livestock bedding. Due to its tough and abrasive characteristics it has the advantage of holding together well in horse stables (Stacco, telephone communication, June, 1980). The greatest commercial market for bedding material would be at horse racing tracks and rodeo events.

The seasonal use for straw does not correspond with rice production, however. In Southern California the horse racing season extends from July 21 to September 12. Rodeo events are usually scheduled during these summer months also. Wheat straw serves this market effectively since the harvesting of wheat corresponds to the demand time period.

A bedding straw contractor was interviewed during the course of this study and he reported that rice straw was commonly used at horse racing tracks in the early 60's. He recommended rice straw for bedding material since horse manure can be collected without having to remove the rice straw. The stable owners prefer wheat straw though--the price is approximately 50 percent cheaper than rice straw. The bedding straw collected by the contractor is in turn sold to mushroom growers. Only trucking and handling charges are passed along to mushroom growers. The volume of straw collected by this particular contractor amounts to 1,350 to 1,400 cubic yards per day. Translated into tons per season this would amount to nearly 520 tons of straw (five pounds of straw per cubic foot).

The demand for bedding straw is closely tied to availability and price. Rice straw is a suitable bedding material, although it is not competitive with wheat straw. The seasonal availability of rice straw is also not favorable for its use at horse racing stables and rodeos. Wheat straw has the additional advantage of being demanded by mushroom growers subsequent to its use as a bedding material. If rice straw were used as a bedding material it is likely that stable owners would be faced with similar disposal problems that plague rice growers.

Miscellaneous Uses

There are other possible uses of rice straw to be considered. In general, these miscellaneous uses would create only minimal demand for rice straw, and therefore do not warrant extensive analysis. The alternative uses considered under this heading include:

- carbon black
- silicon tetrachloride
- silicon carbide
- bedding for livestock

Carbon Black. Carbon black is a name that covers a large number of technologically valuable forms of carbon. The use of carbon black in inks and paint is common. Other applications include use as a catalyst support in the manufacture of copolymers (two monomers that can be used together for polymerization), and in reinforcing rocket propellants.

Compounds containing carbon occur in great abundance, and often in great complexity in plants and animals. It is not expected that rice straw's contribution to the carbon black industry would be significant. If rice straw were collected on a routine basis and in large quantities, uses such as for carbon black might be expanded.

Silicon Tetrachloride and Silicon Carbide. Silicon tetrachloride is prepared by heating silicon at very high temperatures in the presence of chlorine. It is a colorless liquid which fumes in air and is decomposed by water into silica and hydrochloric acid. It has been used for producing smoke screens.

Silicon carbide is a very hard dark crystalline compound of silicon and carbon that is used as an abrasive and as a refractory and in electric motors. Many carbides, including aluminum, calcium and silicon carbides, are made by heating the metals or their oxides with carbon.

Due to the abundance of silicon compounds found in nature, rice straw is not expected to be in great demand for this by-product. Should technology develop for hydrolysis application of rice straw then amorphous grades of silicon can be collected and marketed. Presently, the collection of rice straw to produce silicon compounds would not be justified.

SUMMARY

In this chapter eight major alternative uses of rice straw were evaluated for their technical and economic feasibility. In general the use of rice straw in energy conversion applications appear to have the most promising outlook. Other uses for rice straw do not appear feasible or would be insignificant in respect to the total quantity of straw demanded.

The use of rice straw for livestock feed is limited due to the unpalatable nature of the high silicate-containing feedstuff. The most promising treatment to improve the digestibility of the straw is with a pretreatment of sodium-hydroxide (NaOH). Ensilation and microbial fermentation will also improve the digestibility of the rice straw but appears to be uneconomical. The economics of using a pretreatment of NaOH is also uncertain.

Direct combustion of rice straw has its greatest application as fuel for process steam. When the costs of constructing and operating a utility plant for both rice straw and natural gas are compared, the rice straw is shown to have a comparative advantage over natural gas. If an existing natural gas-fired boiler system was retrofitted to accomodate rice straw for direct combustion the economics may be unfavorable.

The technology to pyrolyze rice straw is at the prototype stage of production. Researchers appear confident that rice straw will be a suitable feedstock despite its high silica content. The economics of pyrolysis systems do not appear favorable at this time. If the capital costs of the systems can be substantially reduced then the pyrolysis system may be viable for rice straw applications. Some speculation exists as to the substitutibility of pyrolysis oils with other petrochemical based fuel oils. The indications are that, although pyrolysis oil is suitable for boiler applications, there may be some resistance by fuel consumers to convert over to this low hydrocarbon oil due to the retrofitting and higher maintenance on boiler equipment which may be required.

Gasification of rice straw is similiar to pyrolysis. There remains some technical problems to be worked out in respect to the slagging potential of high silicate containing feedstocks. Researchers state that these problems can be rectified and that rice straw will be suitable for gasification. The economics of converting an existing natural gas-fired dryer facility to gasification does not appear feasible. As with the direct combustion system, if the costs of constructing and operating newly built gas dryer operations then the gasification of rice straw may be feasible. A large factor here will be the cost of natural gas transmission lines.

It was shown that both the technical and economic feasibility of fermenting rice straw in an anaerobic digestor is favorable. The analysis was based on a laboratory scale model which used corn stover as a feedstock. The system has the advantage of accomodating a wide range of agricultural residue which would allow for year-round production of methane. It is recognized that the economic analysis assumed optimum conditions and not all capital costs are accounted for; therefore, the conclusions should be considered tentative.

Based on existing technology, it is believed that cellulose conversion to alcohol is promising from a technical and economic standpoint. Analysis shows that rice straw would be competitive with corn stover from an operating cost standpoint. Although, CIC is not aware of any prototype systems currently operative, it is expected that alcohol could be produced from rice straw at a cost lower than the market price.

Since rice straw would have to compete with low-priced wood chips, the economics of using rice straw as a furnish for a corrugating medium or particleboard is not promising. Technically, rice straw would be suitable for production of these products; however, the operating costs of rice straw processes are higher than if wood chips are used due to the expensive chemical recovery systems.

Other uses for rice straw which were assessed include rice straw as a substitute for mushroom culture, as a source or furfural, as a bedding material for livestock and miscellaneous uses which involve the extraction of amorphous silica. It is believed that rice straw is technically suitable for all of these applications, however, substitute fiber sources render rice straw uneconomical. If amorphous grades of silica can be extracted at low cost then profits may be realized by either the marketing or further chemical treatment of this biological grade of silica.

In conclusion, there appear to be several promising applications for rice straw which would involve a wide range of technologies. It is generally accepted that if profits can be obtained from collection and removal operations then these suggested alternatives may become a reality. The technologies for utilizing rice straw are at the laboratory or prototype stage of production. There will have to be significant capital investment made in these utilization technologies before wide scale collection systems can be initiated. In that the alternatives are at the initial stages of development the relief from open-field burning may not be possible in the next few years. There does appear to be significant interest in the private sector for energy applications and it is expected that relief from open-field burning will come from utilizing rice straw in this manner.

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DRAFT

ECONOMIC VIABILITY OF RICE PRODUCTION AND ALTERNATIVES TO WASTE BURNING

The relative merits of various alternatives to the agricultural waste burning of rice straw have been discussed from a technical and economic standpoint. From an economic standpoint, each waste burning alternative can be looked at in terms of the following three criteria: 1) the operating costs required to dispose of the rice straw either by incorporation or removal; 2) the economic returns to each waste burning, e.g., the savings potential by using rice straw over other forms of energy was evaluated; and 3) the economic impact on the farm as a whole by including the waste burning alternatives into the farm's production technology. Thus far, this report has discussed the economics of waste burning alternatives in terms of the first two criteria. It is the purpose of this chapter to assess the economic feasibility of including these waste burning alternatives with other on-farm operations. A final ranking of the various alternatives, based on the three economic criteria discussed above, will be given.

ECONOMICS OF RICE PRODUCTION

In an assessment of the economic feasibility of waste burning alternatives, the existing constraints on rice growers must be considered. It would be folly, for example, to expect rice growers to undertake significant financial burdens if they are presently unable to meet current debt service requirements. By the same token, if rice growers exhibit a secure equity position and generate a substantial amount of income, additional operating expenses may be justified so long as income isn't severely compromised. In this light, the profitability of rice farming will be assessed with respect to before-tax income. This assessment will be made by geographical production areas with respect to farm size and cultural operating conditions.

Farm Revenues

The crop revenue received by rice growers is a function of the yields they receive and market prices for the rice grain. Yields have been increasing over time; however, they vary significantly with different locations. In 1979, an all-time record yield was reported for the State at 64.5 cwt. of rice grain per acre (California Crop and Livestock Reporting Service, 1980). This represented a 12.3 cwt. per acre increase over 1978. These two years reflect both the lowest and highest recorded state average rice yields over a 13-year period.

Market prices for rice grain are equally unstable. Using the same two years as an example, rice prices fluctuated from \$7.06 per cwt. in 1978 to \$9.70 per cwt. in 1978. In terms of revenue, the variability in yields and prices resulted in a per-acre revenue change of \$32.50. Assuming an average farm size of 600 acres, this change in revenue translates into a total gross farm revenue change of \$19,500 in nominal terms. It should be apparent to the reader, therefore, that farmers are subject to a great deal of uncertainty and that farm revenues result from an equilibrium market condition that is difficult to approximate at a point in time.

Rice Yields. A projected 1980 rice yield was calculated for each of the five growing areas. These yield figures are based on a 15-year State trend and calculated percentage variations for each growing area as identified in Copley International Corporation's rice grower survey. Table 7.1 shows the range of yields which could normally be expected to occur in each of the five growing areas.

Table 7.1

RICE YIELDS BY GEOGRAPHICAL LOCATION

Location	Average Yield (cwt./acre)	Range (cwt./acre)[a]
Area 1	59.5	53.0 - 65.9
Area 2	59.4	54.1 - 64.7
Area 3	57.4	50.6 - 64.2
Area 4	58.1	55.8 - 60.4
Area 5	47.3	42.2 - 52.4

[a]Range represents plus or minus one standard deviation from the mean. Standard deviation estimates were derived from survey data.

Source: Copley International Corporation

As shown in Table 7.1, rice yields vary only moderately by growing area., except for Area 5, it appears that within growing rea variation is greater. For example, in Area 1, the average yield is expected to be 59.5 cwt per acre, but actual yields range from 53.0 to 65.9 cwt per acre. If yields are normally distributed then 68 percent of the rice growers fall within this range.

The rice yields of "rice only" growers and growers who raise other crops in addition to rice were compared from survey data. It was found that rice yields did not differ appreciably between the groups. In Area 1, for example, "rice only" grower yields averaged 60.0 cwt. per acre (σ = 6.34 cwt.) and "mixed crop" growers averaged 59.0 cwt. per acre (σ = 6.49 cwt.). This trend was consistent in all growing areas except growing area 3, which included only one "rice only" grower. Hence, the yield data tabulated in Table 7.1 is representative for all rice growers, regardless of their individual farm management (i.e., rotation) programs.

Rice Prices. Rice growers do not receive cash for their crop immediately following harvest. Cooperative marketing of the rice grain is handled through rice-grower cooperatives. There are four major cooperatives in the State, and each of these organizations sell California rice in both national and international grain markets. Beginning in January, rice growers will start receiving payment for their rice according to prevailing market conditions. Initially, rice growers will receive a substantial payment in January ($4.50 to $6.00 per cwt.) and then additional payments throughout the next several months. Occasionally, rice growers will not be reimbursed for a preceding crop until the following season's crop is harvested.

Although there is significant variability in rice prices from one year to the next, cooperative marketing precludes one grower from getting a higher price than his neighbor during a year when both produce the same quality and quantity of rice grain. Rice prices are based on type of grain (short or medium) and quality of the milled product. Therefore, it is entirely possible that due to rice quality (influenced by climate and cultural factors) one area may receive higher rice prices, on the average, than another area. A comparison of six years of rice prices by county showed that signigicant differences in prices received did occur (Agricultural Commissioner Reports, 1973 - 1978).

In general, rice prices in the Sacramento Valley counties coincide with the State average, or a little above. Counties in the San Joaquin Valley receive the lowest prices in most years. Based on these data, area-wide weighted average prices were calculated, including 1976 through 1979 county average prices. Table 7.2 shows the tabulated weighted average price for each area under consideration. Constant dollars (1979) were used for the calculation of each area's average price.

Rice prices are expected to be lowest for Area 4. It is uncertain why Area 4's prices are 10 percent lower on the average than the other locations. The distribution of rice varieties in Areas 4 and 5 are not substantially different; thus the price difference between these two areas is most likely due to cultural conditions. The range in rice prices which is shown for each area arises from the year-to-year variance for each

Table 7.2

RICE PRICES BY GEOGRAPHICAL LOCATION

Location	Average Price ($/cwt.)	Range ($/cwt.)[a]
Area 1	9.13	7.50 - 10.76
Area 2	9.39	8.19 - 10.59
Area 3	9.00	7.49 - 10.51
Area 4	8.06	6.67 - 9.45
Area 5	9.05	7.82 - 10.28

[a]Range represents plus or minus one standard deviation from the mean. Standard deviations were calculated using secondary data.

Source: (Agricultural Commission Reports, 1973-1978)

rice-producing county comprising the particular area. Thus, 1980's "rough rice grain" price in Area 1 will be somewhere between $7.50 and $10.76 per cwt. Price fluctuations from year to year indicate this range will capture 68 percent of the normal variance.

Summary of Farm Revenues. Given the average prices and yields for each area, the revenues have been calculated and are shown in Table 7.3.

The revenues from rice production in Sacramento Valley (Areas 1, 2 and 3) range from $516.60 to $557.77 per acre. The revenues vary approximately $40 per acre within the northern Valley. In the San Joaquin Valley (Areas 4 and 5), the revenues range from $428.07 to $468.29 per acre. A range of $40 per

Table 7.3

RICE REVENUES BY GEOGRAPHICAL LOCATION

Location	Price ($/cwt.)	Yield (cwt./acre)	Revenue ($/acre)
Area 1	9.13	59.5	543.24
Area 2	9.39	59.4	557.77
Area 3	9.00	57.4	516.60
Area 4	8.06	58.1	468.29
Area 5	9.05	47.3	428.07

Source: (Agricultural Commission Reports, 1973 - 1978).

acre exists within the San Joaquin Valley also, Clearly, from a revenue standpoint, Sacramento Valley is the preferred rice-growing area.

These revenues represent average conditions for each of the reported areas. It is expected that both price and yield are reflective of typical conditions. It would be cumbersome to include all the possible outcomes of revenue based on price and yields since there are nine combinations for each growing area, or 45 combinations in all.

Farm Production Costs

The cost of producing rice is an important determinant of waste burning alternatives. Given a geographical area and its associated revenues from rice growing, the cost of rice production will determine farm income and illuminate the farmer's ability to cope with risk and uncertainty. Theoretically, farm production costs should vary as a function of farm size, ownership, cropping plan, cultural growing conditions and farm management. Taken individually, all of these factors are known to have an effect on farm production costs and heretofore influence the farmer's decision-making process.

In this section, typical growing costs are presented for three separate farm sizes. The cost structures correspond to small, medium, and large "rice acreages" which either comprise the entire farm size or represent a portion of its total farm acreage. These farm sizes were derived from survey data which is presented in Chapter 2, Table 2.2. Prior to the presentation of production costs by farm size is a discussion of the components which comprise the farm cost structure

Variable Costs. The costs included as variable costs correspond to out-of-pocket costs, which are normally considered to vary with output (e.g., yield per acre). Further, these variable costs, to include growing and harvesting costs, should be reflective of changes in cultural practices by geographical location. At the outset of this study, it was hypothesized that farm size would have an affect on variable costs of production for rice grain; yet, this was not confirmed in the survey data.

The survey instrument solicited information from rice growers pertaining to the following cost categories:

GROWING COSTS

- Seed Bed Preparation and Planting
- Irrigation
- Weed and Pest Control
- Miscellaneous
- Total Growing Cost

HARVESTING COSTS

- Combine, Bankout
- Haul to Dryer and Dry
- Move Equipment
- Drain Post Harvest, Management (include rice straw disposal costs)
- Total Harvest Cost

These cost data, once collected, were aggregated by growing area (Areas 1 to 5) and by valley. Analyses were conducted on these data to identify trends relating to:

- Variable Cost Versus Total Farm Acreage
- Variable Cost Versus Actual Rice Acreage
- Variable Cost Versus Typical Rice Yield
- Variable Cost Versus Percentage of Land Owned
- Variable Cost Versus Percent Well Water Used
- Variable Cost Versus Percent Stem Rot, and Percent Loss of Yield Due to Stem Rot

Correlation and scattergram analysis showed that no observable trends could be established between variable growing and harvesting costs when compared to the above-mentioned variables. Statistically significant differences were found to exist in different growing areas; yet these differences did not correlate to acreage farmed, rice yield or other variables analyzed.

The variable costs for each growing area are presented in Table 7.4, along with the number of respondents (N) corresponding to each type of farming operation and geographical area (i.e., the growers who solely grow rice or growers who are diversified in other crops).

As shown in Table 7.4, no statistical significance (at the 90-percent confidence level) is observed between reported variable costs for "rice only" growers, as opposed to "mixed crop" growers. As an illustration, consider the tabulated mean growing and harvesting costs for the three categories shown in Table 7.4. Although there are significant differences among the areas (columns), the separate costs tabulated for the three categories of rice growers (rows) are due to randomness and not real differences by type of farming strategy. Hence, all variable costs can be analyzed in the aggregate ("all growers") for each area.

There are significant cost differences among geographical growing areas. In Area 2, for example, the growing cost of $227.23 is unique in respect to Areas 1, 3, and 4. However, the growing costs for Areas 1, 3, 4, and 5 are not statistically different from each other; hence; these four areas exhibit no comparative advantages in terms of costs to grow rice from one area to the next. Area 2, however, appears to be at a slight cost disadvantage with respect to the other areas.

Further analysis was conducted on the relationship between variable costs and percentage of land owned by the farmer. Although no linear trend could be established between these two variables; survey results show that growers in Area 1 who lease all of their land pay significantly higher growing and harvesting costs in the aggregate than do owner-operators. Farmers in Area 1 who lease 100 percent of their rice acreage are paying 20 percent more to grow and harvest rice than are the rice farm

Table 7.4

VARIABLE COSTS TO GROW RICE BY GEOGRAPHICAL AREA*

Location	All Growers		Rice Only Growers		Mixed Crop Growers	
	Growing	Harvesting	Growing	Harvesting	Growing	Harvesting
Area 1	206.73[b]	94.75	192.06[c]	91.28	212.49	95.91
	N = 78		N = 22		N = 56	
Area 2	227.23[bdg]	107.04[e]	246.97[c]	104.06	218.97	108.28[f]
	N = 78		N = 23		N = 55	
Area 3	191.46[d]	76.46[e]	123.80	46.75	195.69	78.31[f]
	N = 17		N = 1*		N = 16	
Area 4	189.18[g]	95.84[a]	193.21	106.39	185.14	85.29
	N = 14		N = 7		N = 7	
Area 5	239.30	62.44[a]	---	---	239.30	62.44
	N = 10				N = 10	
Sacramento Valley	214.62	98.46	218.03	97.08	213.39	98.92[h]
	N = 174		N = 46		N = 128	
San Joaquin Valley	213.26	84.84	193.21	106.39	221.06	75.41[h]
	N = 25		N = 7		N = 18	

*Common letters correspond to statistical significance at the 90-percent level. Student t distribution (2-tailed) was calculated for both rows and columns.

Source: Copley International Corporation

owner-operators. This pattern was evident in the other four geographical areas, but not significantly so.

It is not clear why the disparity in farm production costs between owner-operators and tenant farms exists. One explanation may be that a greater number of owner-operators have taken more elaborate steps in land-leveling and cultural practices which, over the long-run, have resulted in more efficient farming. Also, owner-operators are undoubtedly more familiar with their farms and therefore are able to make more concise management decisions which reduce the likelihood of excess fertilizer and chemical applications.

Fixed Costs. Fixed costs include expenses such as equipment overhead, rent, interest on capital and taxes. Regardless of the level of output, these costs remain constant and are said to be fixed. The most significant components of fixed costs include equipment overhead (depreciation and interest) and land rent (or mortgage payments).

The cost per unit of output is lower when a farm can distribute its overhead over a larger number of acres. In theory, the larger farms are more efficient at utilizing their capital equipment; hence, the smaller firms are under greater economic pressure to increase their size so that they can remain cost-competitive. The cooperative marketing of rice grain reduces the economic pressure on small rice growers to some extent.

Equipment Overhead. The number and type of equipment used by rice growers will vary by size of farm.

Larger, more capital-intensive types of farm machinery are associated with larger acreages. Field interviews with rice growers, along with secondary data, served to identify the type of equipment used in rice production. The ages and make of equipment vary tremendously; however, trends in farm machinery ownership are apparent. A list of equipment and their associated new costs (in some cases used costs) by farm size is shown in Appendix C. Sixty percent of the new equipment cost was used for calculating the on-farm equipment value. In reality, the age of farm equipment will span 20 years or more. Often times, equipment is made by the growers themselves, such as in the case of bankout wagons.

Farm Tenure. Information relating to farm ownership was obtained from the rice grower survey (Questions A68 and A69). It was found that 36 percent of the survey respondents in Sacramento Valley (244 total respondents) lease all of their rice acreage, while 29 percent own all of their rice acreage. In the San Joaquin Valley, the same general trend was apparent.

There are three common types of lease arrangements. Generally, the cost to lease rice land will range from $85.00 to $150.00 per acre. The cash lease involves a cash payment for the use of the land and necessary improvements. A 20/80 lease requires that the farmer give up 20 percent of the crop in exchange for the use of the lessor's land. The third arrangement is a 25/75 lease, whereby the lessee gives up 25 percent of the crop and the landlord contributes the land, in addition to 25 percent of the chemicals including fertilizers and pesticides. The advantage to leasing is that there is a net savings in the short-run. Under an ownership situation, the mortgage payments and taxes would increase the land cost above leasing. The advantage of ownership, of course, would be realized by the landlord's greater borrowing capacity and resultant net worth.

The cost of rice land differs and necessarily varies by the length of tenure and location. A range of $2,000 to $5,000 per acre would be representative of prices for the majority of California rice land.* The lower price would reflect soils which are unsuitable for rotation, other than for grain crops. The higher price corresponds to land which would be marginal for vegetables; yet it would sustain several types of row crops.

Summary of Farm Production Costs. The costs to produce rice are aggregated and presented for both the Sacramento and San Joaquin Valleys (Table 7.5). The survey cost data are reported for 1979 and inflated to 1980 dollars. The derived per-acre production costs for both valleys are based on a rice acreage of 600 acres, which includes "rice only" and "mixed crop" growers.

*Estimate based on conversations with rice growers in the Sacramento and San Joaquin Valleys.

A 5 percent inflation factor was applied to the variable costs to adjust them to 1980 dollars* (U.S.D.A., 1980). As shown in Table 7.5, the reported 1980 production costs are not appreciably different for the two valleys. It is known that, to a minor extent, cultural practices are different in the San Joaquin Valley. For example, certain pests are not present in the southern alley that exist in the Sacramento Valley, and, therefore, cultural costs are expected to vary as a result. Yet the total of variable and fixed costs in both Valleys do not indicate a comparative cost advantage for either area.

Secondary data pertaining to rice production costs were obtained from Bank of America (1980) and University of California, Davis (1980). Both institutions publish projections of 1980 growing and harvesting costs for various rice-producing districts in California. Bank of America reports that total variable costs for rice production in Marysville and Bakersville are \$324.99 and \$330.60 per acre, respectively.** The University of California, Davis, reports that a typical Northern California rice operation (Butte County, 500 acres of rice on a 600-acre diversified farm) incurs a per-acre variable cost of \$339.95. The 1980 inflated survey results shown in Table 7.5 correspond to the published standards.

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*August, 1979 dollars for production items (249, 1967=100) were adjusted to January, 1980 dollars (262, 1967=100).

**These costs assume that growers irrigate by pumping as opposed to gravity feed. Pumping expenses increase variable costs by \$25 to \$30 per acre.

Table 7.5

VARIABLE AND FIXED COSTS OF PRODUCTION PER ACRE

	Sacramento Valley		San Joaquin Valley	
VARIABLE COSTS	1979	1980	1979	1980
Growing Costs				
Seed Bed Preparation and Planting	$ 54.36	$ 57.08	$ 58.26	$ 61.17
Irrigation	33.75	35.44	56.28	59.09
Fertilizer	52.14	54.75	38.07	39.97
Weed and Pest Control	30.37	31.89	28.47	29.89
Miscellaneous	33.62	35.30	46.89	49.23
Subtotal	$204.25	$214.46	$227.97	$239.35
Harvesting Costs				
Combine, Bankout	52.68	55.31	47.46	49.83
Haul to Dryer, Dry	34.42	36.14	25.92	27.22
Move Equipment	6.07	6.37	6.01	6.31
Drain, Post Harvest[a] Management	10.15	10.66	3.18	3.34
Subtotal	$103.32	$108.48	$ 82.57	$ 86.70
Total Variable Costs	$308.56	$322.94	$310.54	$326.05
FIXED COSTS				
Management		27.00		22.50
Equipment Overhead				
Depreciation		61.53		61.53
Interest[b]		29.76		29.76
Land Rent		120.00		120.00
Real Property Taxes[c]		5.95		5.95
Interest on Operating Capital[d]		19.37		19.56
Subtotal		$263.61		$259.30
Total Production Costs/Acre		$586.55		$586.35

[a]Does not include cost for rice straw disposal.
[b]Interest computed at one-half the average value times 9 percent.
[c]Taxes on equipment computed at .9 percent.
[d]Interest on operating capital figured at 50 percent of variable costs at 12 percent.

Source: Copley International Corporation

It is recognized that significant variability in production costs exist as a function of geographical area. For example, Table 7.4 illustrates the fact that Area 2's variable costs are nearly 25 percent above the mean for Area 3. Taken collectively, these two areas reflect the range of variable costs which might be expected in the Sacramento Valley in a given year. The reported mean for Sacramento Valley reflects typical conditions for the three growing areas (Areas 1, 2, and 3), and, if it is recognized that the range of production costs are likely to vary plus or minus 15 percent from this figure, then this will provide a logical debarkation point for further analysis.

Unlike its northern counterpart, the variation in reported variable costs for San Joaquin Valley rice-growing areas (Areas 4 and 5) do not appear to be statistically significant. Hence, statistically speaking, the reported mean for the entire southern Valley is assumed to be representative for the entire area. As in all parts of the State, significant differences in production costs are likely to occur due to individual farm management decisions. As stated earlier, a host of variables including financial constraints and cultural practices will affect the farm managers' decision-making process. It is therefore likely that the tabulated production costs shown in Table 7.5 will not reflect an individual operator's cost structure; rather, they will be representative of growers' production costs in the aggregate.

With regard to farm size, it was stated that larger farms are able to produce a given level of output at lower per-unit costs compared to small farms. According to each farm-size category determined from survey data, an assessment of the costs and the type of equipment which would be required to facilitate typical cultural practices was made. It was found that larger farm sizes resulted in lowered fixed costs of production. This was due to the ability of large farms to spread their equipment over a larger number of acres and thereby gain a comparative advantage over smaller farms. As shown in Table 7.6, the equipment overhead is inversely related to farm size. As farm size increases, lower per-acre depreciation and interest charges result.

Theoretically, this phenomenon is referred to as "Economies of Scale" (University of California, 1975). Under most circumstances, the economies of large farming are also apparent in the marketplace. Large producers are able to exert a dominant effect on commodity market prices; however, since rice grain is marketed through cooperatives, the economies of scale are most apparent from a production cost standpoint. Discussions with rice growers indicate that there is no pressure on them to increase farm size from a marginal cost standpoint.

ECONOMICS OF ALTERNATIVES

If open-field burning of rice straw is prohibited, rice growers will turn to either collection or incorporation disposal alternatives. These disposal methods have been discussed in

Table 7.6

TOTAL PRODUCTION COSTS PER ACRE BY FARM SIZE[a]

	Small Farm Size (320 acres)	Medium Farm Size (600 acres)	Large Farm Size (1200 acres)
TOTAL VARIABLE COSTS	$322.94	$322.94	$322.94
FIXED COSTS			
Management	27.00	27.00	27.00
Equipment Overhead			
Depreciation	65.51	61.53	51.44
Interest	30.33	29.76	25.09
Land Rent	120.00	120.00	120.00
Real Property Taxes	6.07	5.95	5.02
Interest on Operating Capital	19.37	19.37	19.37
Subtotal	$268.28	$263.61	$247.92
Total Production Costs/Acre	$591.22	$586.55	$570.86

[a]Variable costs are representative of Sacramento Valley mean 1980 growing and harvesting costs.

Source: Copley International Corporation

detail, although a few points remain to be clarified. In addition, it was shown in the previous section that rice growers are operating under financially constrained conditions. This section will bring to focus the trade-offs of the different disposal technologies as a function of farm size.

Faced with the decision to dispose of his rice straw, the grower will try to minimize his losses or maximize his profits. Of course, the latter is preferred; however, for small farms the ability to realize a profit from rice straw disposal appears very low. As an illustration, two situations will be viewed. First, the costs of incorporation will be assessed by three farm-size categories. Second, the cost of a mobile field cubing system will be assessed in the same manner. As a result, it will become apparent that the small rice grower is at a particular disadvantage with respect to straw disposal operations, compared to the large grower. Empirically it can be shown, however, that such economies of scale do exist in relation to farm size. Real or perceived, it remains apparent that large farms are able to absorb more capital-intensive technology into their operations than small farms. For example, assume that straw disposal practices require the addition of a piece of equipment valued at $150,000. This value represents over two-thirds of the small farm's total equipment value, whereas it comprises approximately one-fifth of the large farm's equipment inventory. Moreover, from a financial point of view, large farms offer a great deal more collateral than their small counterparts (ceteris paribus) and would, therefore, be more likely to obtain borrowed capital.

The effects of farm size in relation to net income are shown in Table 7.7. At first glance, the reader will observe that all derived net incomes are negative. This indicates that after all costs, cash and non-cash, are accounted for, the farmer does not realize a profit on his operation. Under the assumed conditions of average prices and yields, none of the farm sizes in five geographical areas are shown to make a profit. One may ask why farming wiould continue under these conditions. Indeed, the rice industry has continued to expand and growers have been able to expand their rice acreages; therefore, derived incomes would seemingly reflect this situation.

From the grower's standpoint, it seems apparent that they do not consider certain costs which are accounted for in this study. For instance, a farm management cost was included in the fixed cost component of total production costs. Since most growers contribute their own labor, they may not feel justified in accounting for their time other than for the direct man hours employed during the growing and harvesting periods. From a theoretical point of view, a management cost is attributed to the farming operation to compensate the grower for his supervisory and bookkeeping skills. In this study, 5 percent of the gross revenue was used as a guide for calculating the cost of farm management.

Table 7.7

NET INCOME PER ACRE BY FARM SIZE AND GEOGRAPHICAL AREA

REVENUES[c]	Area 1	Area 2[b]	Area 3	Area 4	Area 5
High	$640.22	$629.05	$603.27	$549.05	$486.24
Average	543.24	557.77	516.60	468.29	428.07
Low	446.25	486.49	429.93	387.53	369.89
COSTS (320 acres)					
Variable	322.94	342.32	322.94	326.05	326.05
Fixed	268.28	268.28	268.28	268.28	268.28
Total Cost	$591.22	$610.60	$591.22	$594.33	$594.33
COSTS (600 acres)					
Variable	322.94	342.32	322.94	326.05	326.05
Fixed	263.61	263.61	263.61	263.61	263.61
Total Cost	$586.55	$605.93	$586.55	$589.66	$589.66
COSTS (1200 acres)					
Variable	322.94	342.32	322.94	326.05	326.05
Fixed	247.92	247.92	247.92	247.92	247.92
Total Cost	$570.86	$590.24	$570.86	$573.97	$573.95
NET INCOME (300 acres)	($47.98)	($52.83)	($74.62)	($126.04)	($166.26)
NET INCOME (600 acres)	($43.21)	($48.16)	($69.95)	($121.37)	($161.59)
NET INCOME (1200 acres)	($27.62)	($32.47)	($54.26)	($105.68)	($145.88)

[a]All revenues and costs stated in 1980 dollars. Income figures were calculated from average revenues.

[b]Area 2 variable costs were escalated 6 percent over Area 1 and Area 2, which are reflective of Sacramento Valley as a whole.

[c]Revenues were calculated by taking average yields (Table 7.1) and multiplying them by the range in prices (Table 7.2), based on the assumption that farmers have more control over yields than prices.

Source: Copley International Corporation

The depreciation of farm machinery and improvements results in a significant per-acre cost for rice growers. Since this is not a cash cost, rice growers may or may not account for this cost in a bookkeeping sense. In terms of net farm income, if depreciation is not accounted for, actual income will be overstated, and rice growers sooner or later will have to account for the deterioration of their equipment and improvements.

These cost analyses did not consider cooperative use of farm equipment. Rice growers, particularly small operators, exchange cultural or harvesting services with their neighbors. This exchange of services precludes growers from having to invest in expensive farm equipment which may only be used once or twice a season. Furthermore, the resourcefulness of farmers should not go unmentioned. Often times, growers' ability to improvise or apply "old-fashioned ingenuity" to a problem can reduce their costs substantially in comparison with the accepted "state of the arts" technology. It was learned, for instance, during face-to-face interviews with rice growers, that many of them engineered and constructed some of their own farm equipment. It is difficult to assess the cost differential between farmer-built and industry-built equipment, although it is certain that this type of ingenuity enables the farmer to continue operating in light of escalating machinery and other factor input costs.

Given the costs and revenues shown in Table 7.7, it is doubtful that farmers could undergo expensive rice disposal practices which would place an additional burden on their finances. Essentially the farms depicted in Table 7.7 can be considered, in an economic sense, as the marginal farms. That is, these farms are the ones who are the most sensitive to any change in the market environment and, thus, are operating at a higher marginal cost than other intramarginal farms in the industry. Therefore, the marginal farms outlook appears to be questionable, at best. This does not imply, however, that all firms in the industry are faced with a loss expectation. Intra-marginal farms which have lower costs would undoubtedly be placed in a preferred market position. If a profit could be realized from straw collection, this would provide a strong incentive for waste burning alternatives. These analyses show that if rice farms are forced to absorb additional costs without the promise of higher revenues or some form of remittance, then an indeterminable number of rice growers would be forced out of business.

In this first illustration, under Table 7.8, it is shown that the costs of incorporation vary by farm size. The variance in cost per acre is attributable to the fixed cost of ownership of the farm equipment. The large farmer is able to spread the cost of equipment over a large number of acres and thereby lower his per-unit output cost. With respect to income, the small grower is at a $91.56 per acre disadvantage to the large grower after all costs and revenues have been accounted for. It should be noted that no loss of yield or increased pesticide cost was included in these calculations. If stem rot is present in the

Table 7.8

ECONOMICS OF INCORPORATION BY FARM SIZE

	Small (320 acres) $/acre	Medium (600 acres) $/acre	Large (1200 acres) $/acre
REVENUES			
Grain	$550.00	$550.00	$550.00
COSTS			
Rice Production	591.22	586.55	570.86
Incorporation	50.39	45.95	34.63
Total Costs	$641.61	$632.50	$605.49
NET INCOME	($91.61)	($82.50)	($55.49)

Source: Copley International Corporation

grower's field, it is certain that yield losses will occur. If a 5 percent yield loss due to stem rot is included, this would result in a subsequent revenue decline of approximately $27.50 per acre for all farm size categories.

In the second illustration (Table 7.9), it is assumed that a demand is established for direct combustion of rice straw. Furthermore, it is assumed that the price for rice straw will be strongly associated with the cost of collection and removal by the large rice growers, since these individuals account for the majority of rice acreage in California. For larger farm sizes, collection and removal is more advantageous to the grower from a revenue standpoint. In the case of the small grower, he would be indifferent regarding the two alternatives, since his losses are approximately equal in each case.

A review of Table 5.10 shows that there are other alternatives for the small rice grower. Should custom baling operators be available, the small rice grower would benefit from hiring a firm to bale and transport his straw. Unless there were special demands for this type of rice straw packaging (e.g., rice cubes), there would be little incentive for rice growers to invest in collection equipment that results in total costs over and above market rice straw collection services. In regard to timing of operation, each farm operator would have to assess the likelihood of employing a custom operator to collect the rice straw prior to spring seed-bed preparation activities.

If large rice growers choose to invest in rice straw collection systems, there would be a necessity for financing.

Table 7.9

ECONOMICS OF COLLECTION AND REMOVAL BY FARM SIZE

(Mobile Field Cubing)

	Small (300 acres) $/acre	Medium (600 acres) $/acre	Large (1200 acres) $/acre
REVENUES			
Grain	$550.00	$550.00	$550.00
Straw[a]	57.64	57.64	57.64
Total Revenues	$607.64	$607.64	$607.64
COSTS			
Rice Production	591.22	586.55	570.86
Collection[b]	123.58	78.26	52.38
Total Costs	$714.80	$664.81	$623.24
NET INCOME	($107.16)	($57.17)	($15.60)

[a]Assumed price of rice straw at lowest collection cost, i.e., $14.39 plus 10 percent return to the grower. Rice Straw yield at 3.64 tons/acre.

[b]Based on data obtained from Table 5.10, mobile field cubing.

Source: Copley International Corporation

Initially, a downpayment would be required along with annual payments on both the interest and principal portions of the loan. The capital cost of a mobile field cubing system used in this illustration is $185,822. In the first year, a rice grower would pay $60,594, and every year thereafter, for 12 years, $23,430. The total equipment value of a large rice farm (1,200 acres) is estimated to be $668,970. The addition of a field cubing system would be equivalent to replacing nearly one-third of the farm equipment's present value in one year. This is a high risk consideration and may result in a financial upset for the rice grower. In Table 7.10, it is shown that it would take three years to break even on a cash-flow basis. Subsequent to this period, the rice grower could expect to bring in revenues in excess of his cash expenses. These calculations were made without consideration of return to the farm manager. If a cash cost were included for management at 5 percent then the break-even point would be pushed back to the fourth year.

Economics of Public Policy

Public policy issues surrounding rice waste burning must be viewed from two perspectives. First, any policy directed at the rice industry will have noticeable effects upon the production activities of each farm. These production effects will vary depending upon the unique characteristics associated with a particular farming operation. As previously shown, the principal contributor to a farm's adverse financial position is the capital cost component to its cost position. The adversity of

Table 7.10

PROJECTED CASH FLOW FOR ACQUISITION OF RICE STRAW COLLECTION EQUIPMENT
(1,200 Acres)

Investment	Total Farm	Per Acre
Mobile Field Cubing System[a]	$ 185,822	$ 154.85
Annual Payments[b]		
Mobile Field Cubing System	$ 23,480	$ 19.52
Down Payment		
Mobile Field Cubing System	$ 37,164	$ 30.97

CASH FLOW

Revenues[c]	1980	1981	1982	1983
Rice Straw	$57.62	$57.62	$57.62	$57.62
Costs				
Variable	26.46	26.46	26.46	26.46
Fixed				
Down Payment	30.97			
Annual Debt Service	19.52	19.52	19.52	19.52
Total Cash Costs	$76.95	$45.98	$45.98	$45.98
Net Cash	($20.33)	$11.64	$11.64	$11.64
Accumulated Cash	($20.33)	($ 8.69)	$ 2.95	$14.59

[a] Value of mobile field cubing system taken from Table 5.1. All figures are expressed in January, 1980 dollars.

[b] Annual payments were calculated by financing 80% of the investment @ 12% for 12 years.

[c] Revenues were based on 3.64 tons of straw per acre at 10% above costs shown in Table 5.10.

the position appears to be inversely related to farm size. Second, from the broader view of the public as a whole, detrimental air quality effects caused by the rice straw burning must be seriously considered and their impacts evaluated.

Presently, resources are being allocated in the industry without explicitly accounting for the true costs of the waste burning. To the farmer, the majority of these costs are of an external nature and are therefore not considered in the farm's production decision. There is little question as to whether or not the farm should incorporate such cost considerations when planning any output decision. Where the number of affected parties is relatively small, bargaining between them could resolve this problem. However, where the number is large, this is not a feasible alternative, therefore public intervention may be required to secure efficient resource use

Generally speaking, the tools available for intervening in waste burning activities are tax incentives, regulatory directives, and subsidies. Tax incentives involve the imposition of a tax on the waste burning effort. Essentially the tax would decrease the incentive by the farm to burn. For example, a tax per acre could be imposed for each acre burned. It is clear this type of intervention would further deteriorate the financial position of the farm. Regulatory directives, while not extracting a monetary return from the farm, would also impact the farm's production technologies. In all likelihood, the necessary directives would be substantially more restrictive than those presently existing; thus, the financial structure of the farm would be adversely affected.

The remaining intervention tool available in some sort of subsidy to the farming operation. Two types of subsidies are possible, direct and indirect. A direct subsidy entails a monetary payment to the farm operation itself. For example, if the farm undertook a collection and removal operation or an incorporation process, the farm is paid a certain dollar amount per ton removed or a dollar amount per acre incorporated. By directly rewarding the farmer to engage in these waste burning alternatives, the incentive to burn is decreased. As long as the additional costs incurred by the waste burning alternative is compensated by the subsidy payment. Given existing technology in the industry, this public policy approach deserves further consideration.

Subsidies can also affect the rice industry in an indirect manner. As shown earlier in this chapter, the major expenditure in the cost of the incorporation and removal/collection is in capital equipment. Therefore, investment credits or similar incentives could be developed to encourage the employment of these alternative techniques. In addition, for the case of collection and removal, subsidies could be directed to the industry which would process the straw. Since this industry is presently in its infancy and with the probably existence of multiple technology, careful study must be given in determining the most advantageous subsidy program. A positive factor associated with this type of indirect subsidy is the allowance of market forces to determine the value of the straw between the farm and the straw processing industry.

SUMMARY

In many ways, the rice farming industry in California follows the historic economic patterns of the agricultural industry in the United States. The role of capital and its associated cost plays a deciding part in the profitability of a farm. Within the industry, it appears the financial expectation of a farming operation is, in a pure economic sense, negative. The expectation of having a good year, coupled with the failure to explicitly account for all the true farming costs probably encourages the marginal farms to remain in the industry. There is little doubt that intramarginal farms are able to maintain some sort of financial stability. And, as clearly shown in this chapter, large farms have a distinct advantage in sustaining their financial position, due to their handling of capital costs.

From a risk standpoint, the introduction of waste burning alternatives further complicated the decision-making process of the farmer. Again, larger farms are able to spread the risk factor and thus minimize its possible adverse effects. The role of the public sector in underwriting this risk through some type of intervention is clearly a valuable option. At this time and with existing techniques, the most feasible means of intervention is through the usage of a subsidy program directed at either the farm's operations or the processing sector. Finally, the total harvesting concept represents a worthwhile alternative warranting further analysis.

A final option, which would significantly alter the technology within the industry, is for the public sector to encourage the total harvest concept. As mentioned in Chapter 5, this harvesting concept has a number of advantages. By harvesting the straw and rice simultaneously, the separate steps involved in the incorporation or collection and removal alternatives are eliminated. Essentially, the total harvest process becomes one of dealing with a joint product of the farm. That is, the farm under one production technology produces two outputs, straw and rice. This type of situation is classical in economic theory. The scope of subsidies must be focussed at the farm's new capital demands and the capital demands of the rice and straw processor. The total harvest concept show a great deal of possibility from an economic viewpoint and justifies additional study, especially in the area of costs.

Each of the subsidy structures identified above motivates the farmer to undertake the subsidized alternative by providing the farmer or processor with a monetary rebate. The specific structure of the subsidy must be carefully reviewed, since output and/or price distortion can arise. Also, the heterogeneous nature of the farms within the industry would give rise, in the case of subsidies, to economic rents being made by the intramarginal firms. The magnitude and nature of these rents would undoubtedly impact the workability of any subsidy program.

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DRAFT

CURRENT RESEARCH ON WASTE BURNING ALTERNATIVES

The findings contained in this report are based on the most up-to-date primary and secondary research data. Currently, research is underway on various rice straw utilization technologies in both the public and private sector. The outcome of this research may alter the conclusions rendered in this study. It is the intent of this chapter, therefore, to cite ongoing research that Copley International Corporation became aware of during the course of this study.

The ongoing research will be categorized according to the headings used previously in this report. It is expected that the most important research projects dealing with alternative uses of rice straw are covered in this chapter.

COLLECTION AND REMOVAL SYSTEMS

Papakube Corporation

This corporation is experimenting with stationary and portable cubing systems which could result in a very beneficial contribution to existing collection technologies. Among the advantages of the Papakube densifying systems are the operating speed and the long life of the dies and presswheels which are resistant to the abrasive rice straw.

Frajon Fuels, Inc.

This firm has developed a pelletizing process which combines raw materials to produce a clean fuel with a high energy content. The Frajon fuel pellets are produced by combining raw materials such as forest residues, lumber waste, agricultural residues and industrial by-products. The feasibility of using rice straw in this system should be assessed.

Univeristy of California, Davis

The agricultural engineering department is performing a study for the California Solid Waste Management Board entitled "Collection and Handling of Field Crop Agricultural Residues for Alternate Uses." The study will deal specifically with rice straw in respect to total removal of the crop. In addition, the effects of straw collection on stem rot disease will be assessed.

ENERGY APPLICATIONS

Senate bill 771 (Alquist) has appropriated $10 million over the next five years to the California Energy Commission to: 1) provide funds to encourage the development and demonstration of biomass residue conversion, 2) implement a program to demonstrate residue conversion technologies at appropriate locations throughout the State, and 3) select 20 or more projects for the establishment of facilities for the conversion of residue into energy or synthetic fuels. The following provides a brief description of the projects currently in progress.

Direct Combustion

- Tri-Valley Growers, Inc., Modesto, California, is working on a project to retrofit an oil-fired boiler to operate on 80 percent peach pits and 20 percent fuel oil. The boiler will be used to generate process steam for a cannery.

- The Wicks Corporation, Dinuba, California is constructing a wood-fired co-generation plant capable of generating 5 megawatts of electricity for on-site use mostly. Surplus electricity will be sold to a public utility. The system will demonstrate the combustion of forest residue, orchard stumps, and demolition wastes transported from Tulare and Fresno County disposal sites.

- Norman Pitt, Inc., Los Angeles, California in joint cooperation with J.G. Boswell Cotton Gin has modified an existing cotton gin incineration facility to curtail air emissions and reduce slagging. The heat from combusted cotton gin waste is used to dry incoming cotton. The California Energy Commission is testing other problem residues such as rice straw and tree bark in this incinerator.

- The Department of General Services, Sacramento, California plans to utilize large quantities of wood waste for process steam to heat State buildings in downtown Sacramento. Input feedstock requirements amount to 10,000 tons per year.

Alcohol

- The University of Santa Clara, Santa Clara, California, is scheduled to demonstrate the compatability of alcohol-blend fuels with existing unmodified vehicles. The alcohol-blend fuels will be tested in stratified-charge engines on four Honda test cars.

- Other alcohol fuel (e.g., methanol, ethanol) studies will be made possible through funding provided by Senate Bill 620. This bill provides $10 million to investigate the practicality and cost-effectiveness of alternative motor vehicle fuels. The Department of Transportation has responsibility for overseeing the implementation of the findings.

- The Solid Waste Management Board is sponsoring a project entitled "The Production of Alcohol and Yeast Protein from Waste Straw." University of California, Berkeley, is conducting this study. The work plan includes: 1) evaluation of acid hydrolysis of ball-milled and chopped rice straw, 2) enzymatic hydrolysis of pretreated straw, 3) examining the suitability of glucose and pentose sugars resulting from rice straw hydrolysis for fuel grade alcohol via yeast fermentation, 4) a preliminary economic analysis of the acidic and enzymatic hydrolysis systems, and 5) a preliminary evaluation of all discharge streams for environmental safety.

Biodyne Laboratories

This company is experimenting with a process to produce ethanol and other by-products from rice straw. Experiments at laboratory scale point to the successful commercialization of an acid and enzymatic cellulose conversion to alcohol process. It is expected that, through the use of special membrane technology, retrieval of pure grades of amorphous silica is possible at low cost. Presently, research is pending subject to further funds. The advances made by Biodyne in the area of chemical recovery systems through membranes may be applicable for other technologies, particularly the pulping process of high silicate containing fibers.

SUMMARY

It is recognized that the utilization technologies discussed in this report are predominantly in the laboratory or prototype stages of development. Further research needs to be conducted to fully demonstrate the technical and economic feasibility of the utilization alternatives. Once demonstrated, venture capital will become available through the public sector to implement these systems. In isolated cases this is already beginning to occur; for example, the public utilities have provided incentives for co-generation and the buyback of electricity. There are entreprenuers considering using rice straw in this capacity. If prototype systems were developed for co-generation of process steam and for turbo-electric power then many of the risk considerations of such a capital intensive venture would be diminished. Hence, commerical and industrial consumer preferences for petroleum based fuels would shift towards biomass feedstocks such as rice straw.

Copley International Corporation recommends that further research and development of energy utilization alternatives be conducted. Of particular importance is the transferability of biomass fuels in boiler applications. In order for rice straw (and other agricultural residues) to be utilized effectively, problems with slagging and fuel delivery systems need to be ironed out. The commercialization of rice straw for direct combustion, gasification, and pyrolysis, will largely be determined by the ease with which boiler fuels can be substituted for petroleum based fuels.

Copley International Corporation expects that significant advances are to be made in the area of cellulose conversion to alcohol. If possible, funding should be made available to both public and private researchers in this field. The advantage of this alternative is that it presents both near-term and long-run solutions as the demand for automotive fuels is well established.

Additionally, it is expected that advances in agricultural engineering will play a prominent role in determining the potential for rice straw utilization. The rigid physical structure of rice straw combined with its complex chemical structure presents a formidable challenge to both equipment designers and scientists alike. As the chemical and biological processes which will increase utilization are conceived, engineering technologies to employ these processes will be developed. It is only through this multi-lateral approach that great advances in rice straw collection and disposal can culminate in providing a solution to this complex by-product utilization

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GLOSSARY OF TERMS, ABBREVIATIONS, AND SYMBOLS

Aerobic -- In the presence of oxygen.

Anaerobic -- In the absence of oxygen.

Anaerobic digestion -- The biochemical decomposition of organic matter into simpler products in an oxygen-free atmosphere. The final product is methane gas.

Anorexia -- Prolonged loss of appetite.

Aquatic invertebrates -- Water-living invertebrate animals e.g., the rice water weevil.

Autolysis -- Self-disgestion occurring in plant and animal tissues.

Bankout wagon -- A vehicle with angled sides which is used for holding and hauling crops.

Bagasse -- Plant residue left after a product has been extracted.

Bivuret -- A concentrated form of nitrogen added to livestock feeds.

British Thermal Unit (Btu) -- The quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit to or near 39.2 degrees Fahrenheit.

Capital intensive -- An operation requiring a large amount of capital input.

Claypan -- A dense, compact layer in the subsoil having a much higher clay content than the overlying material.

Corn stover -- Mature cured stalks of grain from which the ears have been removed.

Correlation analyses -- Statistical analyses used to identify the mutual relation between two or more factors.

Cultural practices -- Field operations used for the production of crops, e.g., plowing, discing, planting, irrigation, and harvesting techniques.

Dentrification -- The biochemical reaction of nitrate or nitrite to gaseous molecular nitrogen or an oxide of nitrogen.

Direct combustion -- The burning of matter to produce steam or electricity.

Disc plow -- A field preparation implement pulled behind a tractor consisting of one or more rows of parallel, 22 inch to 32 inch diameter, circular blades.

Disc treatment -- Use of a disc harrow to break large soil clods and produce a level, furrow-free seedbed.

Distillation -- A process which consists of driving off vapor by heating and then condensing the vapor to recover a liquid.

Ensilation -- The process of preserving succulent fodder in closed pits or silos.

Fermentation -- The process by which sugars are converted to alcohol.

Forage chopper -- A piece of field equipment used to chop rice straw into 2 or 3 inch lengths.

Fungal pathogen -- Fungi which produce diseases.

Gambasia affinis -- A common variety of mosquito fish.

Gasification -- A type of pyrolysis involving the conversion of matter to a gaseous state in a hydrogen, oxygen, or air-fed atmosphere.

Hectare -- A metric unit of land measure equal to 10,000 square meters; equivalent to 2,471 acres.

Hydrolysis -- A chemical process of decomposition involving splitting of a bond and the addition of water.

Inoculate -- To introduce inoculum into a biological system.

Inoculum -- Material such as bacteria placed in organic medium to initiate biological action.

Internode elongation -- A growth cycle of plants during which the internodes of a plant lengthen.

Labile -- Unstable; will readily undergo change.

Lignin -- A material which lends rigidity to cell walls.

Lodging -- Bending or breaking of the stalk which supports a grain hull.

Moldboard plow -- A carved iron plate attached above a plowshare to lift and turn the soil.

MSW -- Municipal Solid Waste.

Mycelium -- The mass of interwoven filaments that forms the vegetative portion of a fungus and is often submerged in another body (such as the tissues of a host).

Population cohort -- A group of individuals having a statistical factor in common in a demographic study.

Profile depth -- Depth of a soil above an impeding layer or above 60 inches.

Pyrolysis -- The chemical decomposition brought about by the action of heat in the absence of oxygen.

r^2 -- Sample coefficient of correlation.

Rice cultivar -- A particular type of rice plant having distinguishing characterisitcs of climate or disease tolerance, or other botanical attributes.

Saccharification -- The process of breaking down complex carbohydrates into simple sugars.

Scattergram -- A diagram showing a collection of data points; used in statistical analyses.

Soil microbes -- Minute plant or animal life important in soil nitrogen metabolism.

Substrate -- The base on which an organism lives.

TDN -- Total Digestible Nutrients; an analysis of metabolized nutrient content of a feedstuff.

Tillage -- Preparation of a field for crop production.

Tiller --An erect or semi-erect branch arising from a bud at the base of the plant.

Urea -- A concentrated form of nitrogen added to livestock feeds.

Venture capital -- Funding available to begin a business or industry.

Viable -- Capable of living or growing.

Wether -- A castrated ram.

Windrow -- The process of depositing crop residue (rice straw) in 2 to 3 foot-wide rows next to the harvester.

APPENDIX A

REVIEW AND ANALYSIS OF NON-RESPONSE SET AND QUESTIONNAIRES

REVIEW AND ANALYSIS OF NON-RESPONSE SET

REVIEW OF NON-RESPONSE SURVEY

A telephone survey of those rice growers who had not responded to the original mail questionnaire was conducted after the mail survey had been processed. The questionnaire used for the non-response survey contained key points from the original one and questions were identically worded. From the list of approximately 800 non-respondents, a random sample of 150 growers was selected. This sample was then telephoned and interviewed. A total of 59 rice growers completed the questionnaires which form the non-response data set.

ANALYSIS OF NON-RESPONSE SURVEY RESULTS

Whenever survey data comprises the information base to a research project, the issue on non-response to the survey arises. Of central importance is whether or not the non-response set differs from the response set in terms of a given set of parameters. Should the non-response set differ in a systematic way from the response set, it implies the response set does not truly represent the population as a whole. Hence, the non-response information would be used to adjust the data base.

For the case of the rice growers survey, a comparison of farming characteristics between the response and non-response sets was made. In total 12 different characteristics were compared between the two sets. These characteristics ranged from information concerning growing and harvesting cost, to farm acreage and the impact of stem rot. The analysis separated the data into the Sacramento and San Joaquin valleys. A total of 53 farmers responded from Sacramento Valley and six farmers from the San Joaquin Valley.

Statistical tests were performed to determine if significant differences existed between the response and non-response set. Basically, two types of tests were employed during the analysis. For those characteristics which could be stated in terms of a mean or proportion standard two-sample tests were computed. For example, the first characteristic involved total farm acreage. This can be expressed as a mean acreage figure, and thus can be statistically tested between the two groups. The remainder of the characteristics entail a distribution of responses for each question asked. For example, the question regarding percent yield loss from stem rot categorized the farmer's response into percent yield loss groups. These resulting groups formed a distribution of responses, i.e., so many farmers in each percent group. A Chi-square test was utilized for these distribution characteristics.

Table A.1 presents the results of the statistical analysis between the response and non-response sets. A review of this table shows that the two sets are essentially compatible. However, a few findings are worth noting. First, the sample size for the San Joaquin non-response set (6) is numerically small but not relative to the size of the response set. However, the smallness of the sample does mandate caution when interpreting the results. As Table A.1 shows, except for the rice proportion characteristic, the two groups are the same. This leads to the conclusion that the non-response set is similar to the response set.

In reviewing the results for the Sacramento Valley two factors appear to dominate the analysis. First, even though differences between the two sets exist, the overall picture suggests that the response and non-response groups generally have comparable farming characteristics. A total of five characteristics differ between the two groups, however three of the five concern stem rot. As previously mentioned in the text, the entire issue of stem rot and the farmer's ability to adequately assess its impact is questionable. If in fact this is the case, then these results are not surprising and therefore do not support the hypothesis that the two groups differ.

From the analysis completed involving the response and non-response groups, the conclusion was reached that no significant difference exists between the two groups. Thus, the response set does reflect the population of rice growers in California.

Table A.1

SELECTED GEOGRAPHICAL PROFILE OF RICE FARMING CHARACTERISTICS FOR RESPONSE AND NON-RESPONSE SET

Farm Characteristic	Sacramento Response Set	Sacramento Non-response Set	San Joaquin Response Set	San Joaquin Non-response Set
1) Total Farm	[a]1149 (1314) {246}	877 (1724) {50}	1460 (2248) {36}	841 (990) {6}
2) Typical Rice Acreage	600 (622) {244}	504 (961) {53}	361 (572) {36}	578 (757) {6}
3) Proportion of Rice Acreage to Total Acreage	.52 (.50) {244}	.57 (.49) {50}	*.25 (.43) {36}	.69 (.46) {6}
4) Proportion of Farms Who Grow Winter Crop	*.32 (.47) {246}	.17 (.38) {53}	.28 (.45) {36}	.33 (.47) {6}
5) Proportion of Acreage by Major Rice Varieties				
M9	*.30 (.46) {504}	.17 (.38) {91}	.17 (.38) {47}	.08 (.27) {10}
S6	.28 (.45) {504}	.30 (.46) {91}	.07 (.26) {47}	.05 (.22) {10}
M7	.15 (.36) {504}	(.19) (.39) {91}	.00 (.06) {47}	.02 (.14) {10}
Calrose	.05 (.22) {504}	.06 (.24) {91}	.24 (.43) {47}	.40 (.49) {10}

[*]=Statistically significant a α= .05

[a]Mean or proportion, (standard deviations), {sample size} .

[b]Each number represents number of respondents in category. (characteristics 9 - 12).

Table A.1 (cont'd)

Farm Characteristics		Sacramento Response Set	Sacramento Non-response Set		San Joaquin Response Set	San Joaquin Non-response Set
6) Growing Costs		215 (76) {174}	213 (82) {15}		213 (73) {23}	273 (64) {3}
7) Harvesting Costs		98 (46) {172}	126 (106) {15}		85 (40) {23}	135 (80) {3}
8) Proportion of Acreage Effected by Stem Rot		[*].42 (.49) {225}	.21 (.41) {33}		.06 (.24) {32}	.00 (.00) {1}
9) Severity of Stem Rot	[*]Heavy	[b]11	13	Heavy	0	0
	Medium	83	8	Medium	1	0
	Light	101	10	Light	7	14
	%			%		
10) Percent Yield Loss from Stem Rot	< 5	65	9	< 5	16	0
	5-10	69	6	5-10	1	2
	10-15	47	2	10-15	3	0
	15-20	18	3	15-20	0	0
	>25	6	7	>25	0	0
11) Main Rice Straw Disposal Method	Headfire	25	5	Headfire	15	1
	Backfire	149	19	Backfire	17	4
	Perimeter Burn	24	3	Perimeter Burn	5	1
	Into-the-Wind	114	19	Into-the-Wind	7	-
	Rake/ Pile	-	-	Rake/ Pile	-	-
	Center Field Ignition	1	-	Center Field Ignition	-	-
	Soil Incorporation	-	-	Soil Incorporation	2	1
	Collect & Remove	-	-	Collect & Remove	-	-

[*]Statistically significant at $\alpha = .05$.
[a]Mean or proportion, (standard deviation), {sample size}.
[b]Each number represents number of respondents in category (characteristics 9-12).

Table A.1 (cont'd)

Farm Characteristic		Sacramento		San Joaquin		
		Response Set	Non-response Set		Response Set	Non-response Set
12) Alternative Rice Straw Disposal Method	Headfire	21	3	Headfire	2	1
	Backfire	23	7	Bankfire	3	-
	Perimeter Burn	17	1	Perimeter Burn	1	-
	Into-the-Wind	32	2	Into-the-Wind	2	-
	Rake/ Pile	4	-	Rake/ Pile	-	-
	Center Field Igni-tion	2	-	Center Field Igni-tion	-	-
	Soil In-corpora-tion	11	1	Soil In-corpora-tion	2	-
	Collect & Remove	-	-	Collect & Remove	-	-

[a]Mean or proportion, (standard deviation), {sample size}.
[b]Each number represents number of respondents in category (characteristics 9-12).

CIC - PROJECT #680 QUESTIONNAIRE # ___________

STATEWIDE AGRICULTURAL STUDY
RICE GROWERS QUESTIONNAIRE

Mailing Wave 1 2 3

ALL INFORMATION COLLECTED WILL BE KEPT CONFIDENTIAL AND USED FOR ANALYSIS ONLY WHEN GROUPED WITH OTHER QUESTIONNAIRES.

OFFICE USE ONLY

1. In a typical year, how many acres do you plant in rice?

   ___________ acres. A1______

2. How many acres did you plant in rice this year?

   ___________ acres A2______

3. What is your total farmable acreage?

   ___________ acres A3______

4. What is your total farm crop mix in a typical year? (If applicable, specify winter crops)

CROP	ACRES	CROP	ACRES
___________	______	___________	______
___________	______	___________	______
___________	______	___________	______
___________	______	___________	______

A4______
A5______
A6______
A7______
A8______
A9______
A10______
A11______
A12______
A13______
A14______
A15______

5. Do you rotate any other crops with rice?

   Yes No A16______

5A. If YES, considering the prevailing market conditions, what is your typical rotation schedule for your rice acreage? (Example: 2 yrs. rice, 1 yr. safflower; or 2 yrs. rice, 1 yr. fallow, etc.)

   ______________________________________ A17______

   ______________________________________ A18______

   ____

6. If you grow winter crops on your rice acreage, how many acres are typically involved and what type of crops are grown?

CROPS	ACRES
___________	___________
___________	___________
___________	___________

A19______
A20______
A21______
A22______
A23______
A24______

OFFICE USE ONLY

7. In general, what yields would you expect from these alternate crops if grown on your rice soils? (Circle one for each crop)

Safflower	Above Average	Average	Below Average	A25___ ___
Corn	Above Average	Average	Below Average	A26______
Sorghum	Above Average	Average	Below Average	A27___ ___
Vetch	Above Average	Average	Below Average	A28______
Alfalfa	Above Average	Average	Below Average	A29___ ___
Wheat	Above Average	Average	Below Average	A30______
Barley	Above Average	Average	Below Average	A31___ ___
Oats	Above Average	Average	Below Average	A32______
Cotton	Above Average	Average	Below Average	A33___ ___
Sugar Beets	Above Average	Average	Below Average	A34___ ___
Tomatoes	Above Average	Average	Below Average	A35______
Other________	Above Average	Average	Below Average	A36___ ___
____________	Above Average	Average	Below Average	A37______

7A. Over the last few years, what is your typical rice yield per acre?

________________ cwt/acre — A38___ ___

8. How would you rate the quality of your irrigation water? (Circle one)

Good — Fair — Poor — A39______

8A. If you answered POOR, please explain why. (Example: high salt, boron, pH, low water temp., etc.)

____ A40___ ___

____ A41______

____ A42______

OFFICE USE ONLY

9. To what extent do you rely on the below-named sources of water for irrigation purposes?

	Percent	
a. Irrigation District	________	A43______
b. Private Wells	________	A44______
	100%	

10. Approximately how many acre feet of water do you use annually for the production of your rice crop?

_______________ acre-feet per acre — A45______

11. What percent of your total acreage used for rice production would you say is infected with stem rot disease?

_______________% NONE ______ — A46______

11A. If stem rot disease is present, how would you rate the severity of it in your rice fields? (Circle one)

Heavy   Medium   Light — A47______

11b. Overall, what percentage loss in rice yields do you attribute to stem rot disease on an annual basis? (Circle one)

0-5%   5-10%   10-15%   15-20%   25% or more — A48______

12. What rice varieties are you growing this year?

VARIETY	ACRE	VARIETY	ACRE
____________	________	____________	________
____________	________	____________	________
____________	________	____________	________

A49______
A50______
A51______
A52______
A53______
A54______
A55______
A56______
A57______
A58______
A59______
A60______

OFFICE USE ONLY

13. Do you grow breeder seed, foundation seed, or registered seed for the production/sale of certified rice seed stock? (Circle one)

Yes No — A61__ __

13A. If YES, how many acres? __________ acres — A62_____

14. What portion of your rice acreage is contract harvested?

__________ acres — A63__ __

15. During your harvesting operation, is the rice straw piled in windrows or spread from the combine?

Spread ________ acres Windrowed ________ acres — A64__ __ A65_____

16. What method(s) do you use for the disposal of rice straw? (Check where applicable). Please estimate the costs of rice straw disposal for the appropriate method(s).

	Main Method	Alternate Method	$/Acre	
				A66_____
Headfire (burn with the wind)	___	___	___	A67__ __ A68_____
Backfire (burn against the wind)	___	___	___	A69_____ A70__ __
Perimeter Burn	___	___	___	A71__ __ A72_____
Into-the-Wind Striplighting	___	___	___	A73__ __
Rake/Pile Burn	___	___	___	A74__ __ A75_____
Center Field Ignition	___	___	___	A76__ __
Soil Incorporation (No Burn)	___	___	___	A77__ __ A78_____
Collection and Removal from Field (e.g. baling, field cubing)	___	___	___	A79__ __ A80__ __ A81_____
Other ________	___	___	___	A82_____ A83__ __
________	___	___	___	A84__ __ A85_____

17. If you incorporate your rice straw into the soil, do you reduce the straw size by a cutting, shredding or mowing operation? (Circle one)

Yes No — A86_____ A87_____

OFFICE USE ONLY

18. During what time of year does your rice straw disposal operation take place?

	Percent	
Fall	______	A88 ______
Spring	______	A89 ______
	100%	

19. Do you lease or own the rice acreage currently farmed by you?

Lease ______ acres Own ______ acres

A90 ______
A91 ______

20. Please estimate your total cash costs per acre for growing and harvesting rice this year (include labor, fuel and repairs.)*

GROWING COSTS	$/acre	HARVESTING COSTS	$/acre
Seedbed preparation & planting	______	Combine, Bankout	______
Irrigation	______	Haul to dryer and Dry	______
Fertilizer	______	Move Equipment	______
Weed & Pest Control	______	Drain Post Harvest Management (include rice straw disposal costs)	______
Miscellaneous	______		
TOTAL GROWING COST	______	TOTAL HARVEST COST	______

A92 ______
A93 ______
A94 ______
A95 ______
A96 ______
A97 ______
A98 ______
A99 ______
A100 ______
A101 ______
A102 ______

*The listed categories are provided for your convenience; only TOTAL GROWING and HARVESTING COSTS are necessary.

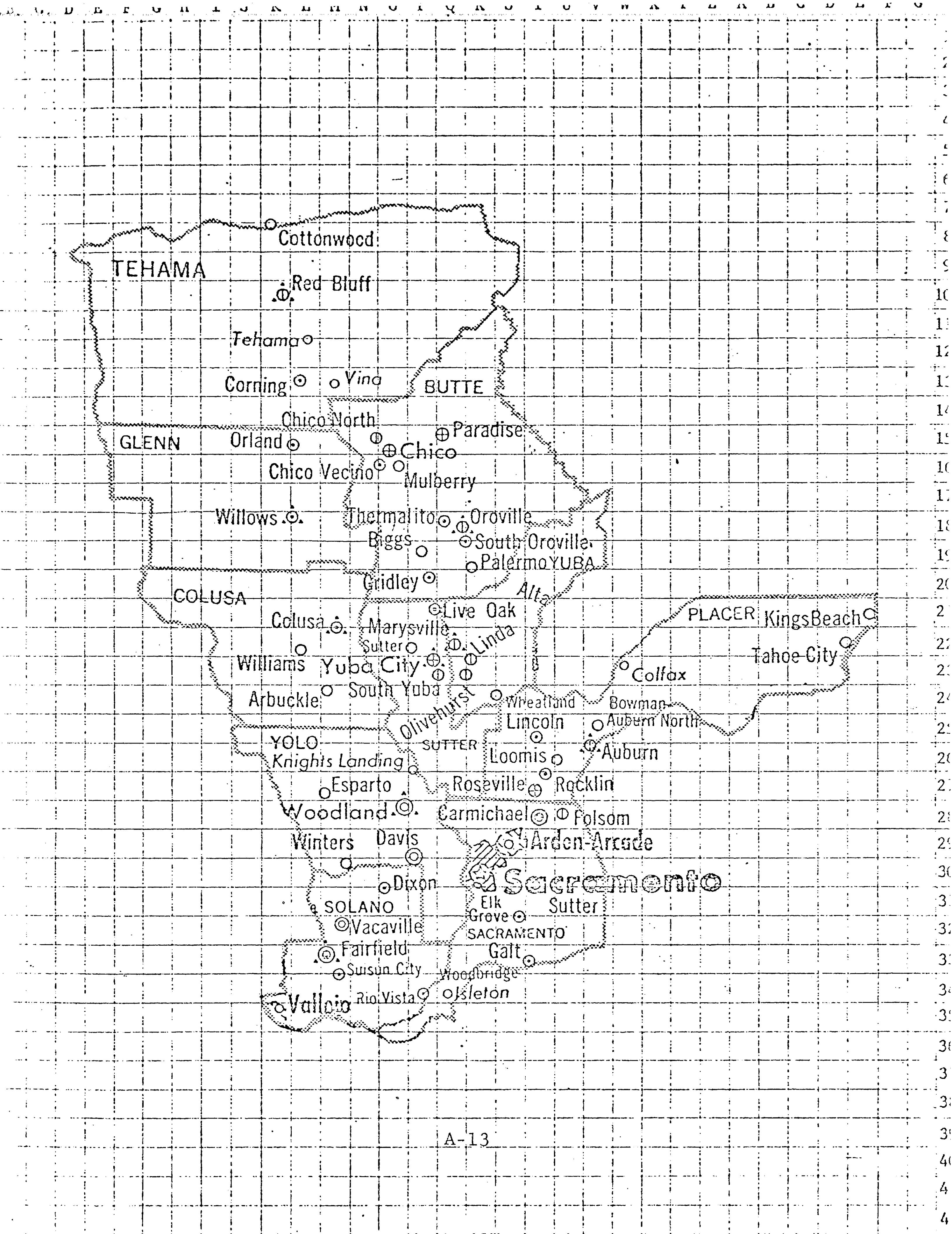
21. Using the map on the following page, please list below the quadrant(s) in which your rice acreage is located.

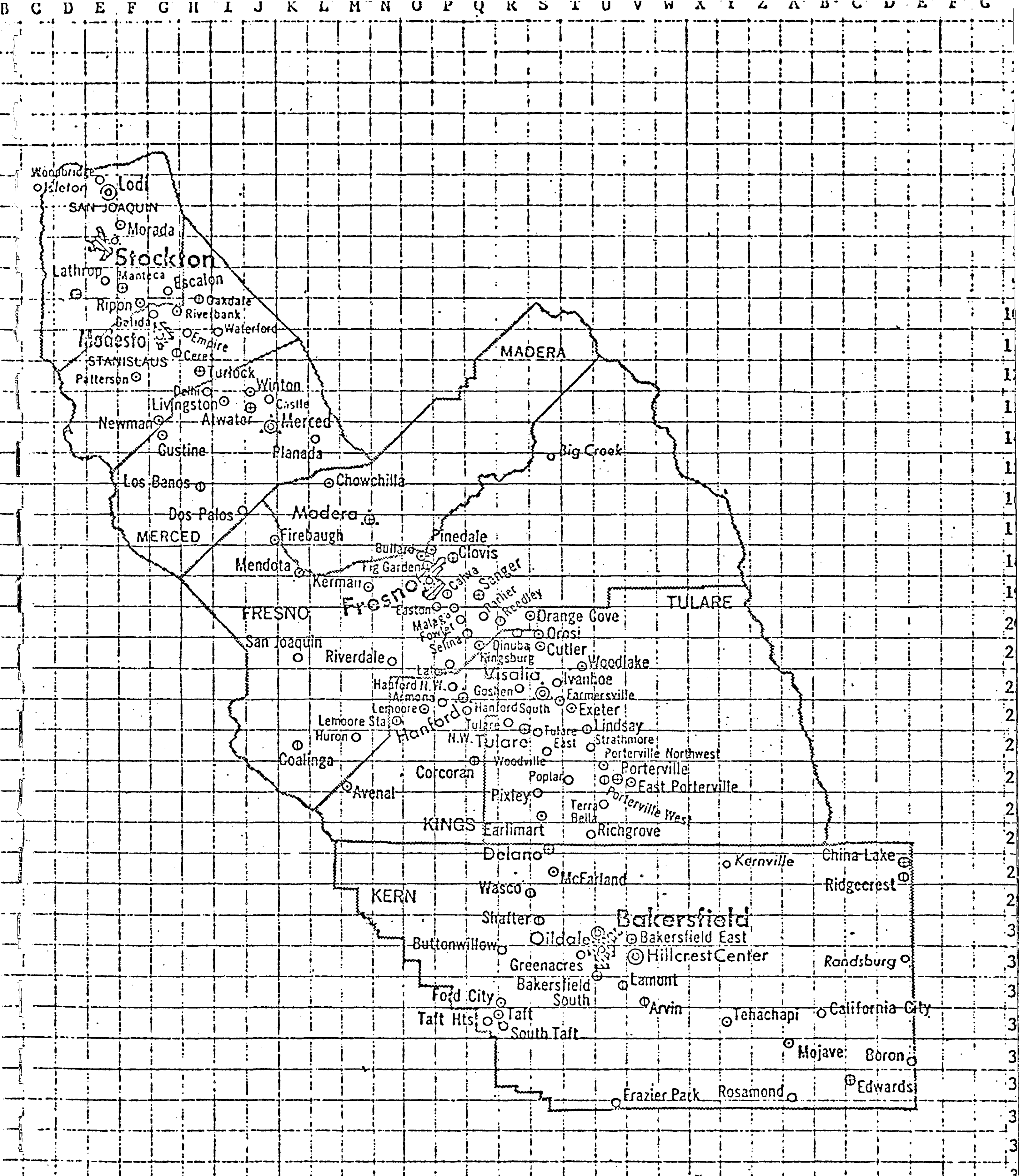
Quadrant(s) ______ ______ ______ ______ ______

A103 ______

(Example: M24 or B'22)

THANK YOU FOR YOUR COOPERATION. PLEASE USE THE ENCLOSED SELF-ADDRESSED, STAMPED ENVELOPE FOR YOUR RETURN.


TEHAMA
Cottonwood
Red Bluff
Tehama
Corning
Vina
BUTTE
Chico North
GLENN
Orland
Paradise
Chico
Chico Vecino
Mulberry
Willows
Thermalito
Oroville
Biggs
South Oroville
Palermo
YUBA
Gridley
COLUSA
Alta
Live Oak
PLACER
Kings Beach
Colusa
Marysville
Sutter
Linda
Tahoe City
Williams
Yuba City
Colfax
Arbuckle
South Yuba
Wheatland
Bowman
Olivehurst
Lincoln
Auburn North
YOLO
SUTTER
Loomis
Auburn
Knights Landing
Esparto
Roseville
Rocklin
Woodland
Carmichael
Folsom
Winters
Davis
Arden-Arcade
Sacramento
Dixon
SOLANO
Elk Grove
Sutter
Vacaville
SACRAMENTO
Fairfield
Galt
Suisun City
Woodbridge
Vallejo
Rio Vista
Isleton



SAN JOAQUIN
Lodi
Woodbridge
Stockton
Morada
Lathrop
Manteca
Escalon
Ripon
Oakdale
Riverbank
Salida
Waterford
Modesto
Empire
Ceres
STANISLAUS
Turlock
Patterson
Delhi
Winton
Livingston
Castle
Atwater
Merced
Newman
Gustine
Planada
Los Banos
Chowchilla
Dos Palos
Madera
MERCED
Firebaugh
MADERA
Big Creek
Pinedale
Clovis
Bullard
Fig Garden
Mendota
Kerman
Fresno
Calwa
Sanger
FRESNO
Easton
Reedley
Orange Cove
TULARE
Malaga
Fowler
Orosi
Selma
Dinuba
Cutler
Kingsburg
San Joaquin
Riverdale
Woodlake
Visalia
Ivanhoe
Hanford N.W.
Goshen
Armona
Farmersville
Lemoore
Hanford South
Exeter
Lemoore Sta
Hanford
Lindsay
Huron
N.W.
Tulare
Tulare East
Strathmore
Coalinga
Woodville
Porterville Northwest
Porterville
Corcoran
Poplar
East Porterville
Avenal
Pixley
Terra Bella
Porterville West
KINGS
Earlimart
Richgrove
Delano
Kernville
China Lake
McFarland
Ridgecrest
Wasco
KERN
Shafter
Bakersfield
Oildale
Bakersfield East
Buttonwillow
Hillcrest Center
Greenacres
Randsburg
Lamont
Bakersfield South
Ford City
Arvin
Tehachapi
California City
Taft
Taft Hts
South Taft
Mojave
Boron
Edwards
Frazier Park
Rosamond

ARB NON RESPONSE
QUESTIONNAIRE

Q NO ____________

PHONE # ____________

1. IN A TYPICAL YEAR, HOW MANY ACRES DO YOU PLANT IN RICE? ____________ 1. ____________

2. WHAT IS YOUR TOTAL FARMABLE ACREAGE? ____________ 2. ____________

3. DO YOU GROW WINTER CROPS ON YOUR RICE ACREAGE? 3. ____________

_____ Yes (ask 3a & 3b)

_____ No (ask Question 4)

3a. WHAT WINTER CROPS DO YOU GROW? (record crop)

Crop	Acres
____________	________
____________	________
____________	________

4. ____________

5. ____________

6. ____________

3b. HOW MANY ACRES OF (insert crop) DO YOU GROW?

7. ____________

8. ____________

9. ____________

4. WHAT PERCENT OF YOUR TOTAL ACREAGE USED FOR RICE PRODUCTION WOULD YOU SAY IS INFECTED WITH STEM ROT DISEASE?

_____ (if none, ask Q5) 10. ____________

(If stem rot is present, ask:)

4a. WOULD YOU SAY THAT THE SEVERITY OF STEM ROT IN YOUR RICE FIELDS IS (read responses)

Heavy Medium Light

(circle response) 11. ____________

4b. OVERALL, WHAT PERCENTAGE LOSS IN RICE YIELDS DO YOU ATTRIBUTE TO STEM ROT DISEASE ON AN ANNUAL BASIS?

(read choices)

0- 5% 5-10% 10-15% 15-20% 25% or more

(circle response) 12. ____________

5. WHAT RICE VARIETIES ARE YOU GROWING THIS YEAR? (record variety)

Variety	Acres	
		13. ________
________	________	14. ________
________	________	15. ________
________	________	16. ________
		17. ________
		18. ________

5a. HOW MANY ACRES OF EACH VARIETY DID YOU PLANT? (record above)

6. THINK ABOUT THE METHODS YOU USE FOR THE DISPOSAL OF RICE STRAW? DO YOU USE (read choices)? (If method is used, ask:) IS THIS YOUR MAIN DISPOSAL METHOD OR AN ALTERNATE? (record answer) WHAT IS YOUR COST PER ACRE FOR THIS METHOD? (record answer)

	Main Method	Alternate Method	$/Acre	
Headfire (burn with the wind)	____	____	____	19. ________
Backfire (burn against the wind)	____	____	____	20. ________
Perimeter Burn	____	____	____	21. ________
Into-the-Wind Striplighting	____	____	____	22. ________
Rake/Pile Burn	____	____	____	23. ________
Center Field Ignition	____	____	____	24. ________
Soil Incorporation (No Burn)	____	____	____	25. ________
Collection and Removal from Field (e.g. baling, field cubing)	____	____	____	26. ________
Other ____________	____	____	____	27. ________

THINKING ABOUT YOUR TOTAL GROWING COSTS SEPARATE FROM YOUR HARVEST COSTS,

7. WHAT IS YOUR BEST ESTIMATE OF YOUR TOTAL GROWING COSTS PER ACRE INCLUDING SEED BED PREPRARATION & PLANTING, IRRIGATION, FERTILIZER, WEED & PEST CONTROL, LABOR, FUEL & REPAIR COSTS? ____________ 28. ________

8. WHAT IS YOUR BEST ESTIMATE OF YOUR TOTAL HARVESTING COSTS INCLUDING COMBINING & BANKOUT, HAULING TO A DRYER, MOVING EQUIPMENT, DRAIN POST HARVEST MANAGEMENT, LABOR, FUEL & REPAIR COSTS?

____________ 29. ________

9. IN WHAT COUNTY IS YOUR RICE ACREAGE LOCATED? ____________ 30. ________

10. WHAT IS THE CLOSEST CITY TO YOUR FARM? ____________ 31. ________

THANK YOU VERY MUCH FOR YOUR COOPERATION.

APPENDIX B

DESCRIPTION OF DISEASE SEVERITY IDENTIFICATION

DESCRIPTION OF DISEASE SEVERITY IDENTIFICATION

Healthy and infected tillers are divided into five categories based on the amount of disease as follows: (i) healthy, no symptoms. Water stains on old and dried leaf sheaths could be distinguished from infected tissue by the presenece of selerotia in the latter; (ii) lightly infected with symptoms and selerotia on the outer leaf sheaths only; (iii) mildly infected with discoloration of and selerotia in the inner leaf sheaths, culm green and healthy; (iv) moderately infected, slight to mild discoloration of the culm, interior of the culm healthy; (v) severly infected, culms infected internally either collapsed or not.

Each category weighted and the disease index (DI) calculated as follows:

$$DI = \frac{1(H^n) + 2(L^n) + 3(M^n) + 4(M^{*n}) + 5(S^n)}{\text{Total number of tillers examined}}$$

where: H^n = number of healthy tillers, L^n = number of lightly infected tillers, M^n = number of mildly infected tillers, M^{*n} = number of moderately infected tillers, and S^n = number of severly infected tillers. Therefore, a DI of 1.00 represents all healthy tillers, and a DI of 5.00 all severely infected tillers.

Source: (Krause and Webster, 1972)

DRAFT

APPENDIX C

EQUIPMENT LIST BY FARM-SIZE

Small Farm-Size
(Less than 320 acres)

No.	Tractors	New Cost	Life	Depreciation
2	85 HP (Crawler)	$ 90,000	12	$ 7,500
1	135 HP (4WD)	42,000	9	4,666
1	30 HP (2WD)	17,500	12	1,458
	Sub-total	149,500		13,624
	Implements			
1	Offset Disk, 21'	13,000	15	866
1	Stubble Disk, 14'	20,370	10	2,037
1	Spike tooth Harrow, 20'	3,310	15	220
1	Triplane, 15' X 35'	9,400	15	627
1	Mower, 7'	2,200	10	220
1	Sprayer	2,800	10	280
1	Rice Checker	13,000	15	867
1	Combine (used)	60,000	8	7,500
1	Bankout Wagon, S.P.	20,000	8	2,500
1	Surface Irrigation	30,000	10	3,000
	Sub-total	174,080		18,117
	Transportation and Shop			
1	Pickup (4WD)	10,000	5	2,000
	Farm Shop 30' X 60'	19,900	25	796
	Tools	6,000	15	400
	Sub-total	35,900		2,196
	TOTAL ALL EQUIPMENT	$359,480		$ 34,937
	@ 60% VALUE	$215,688		$ 20,962

Medium Farm-Size
(320 to 820 acres)

No.	Tractors	New Cost	Life	Depreciation
1	85 HP (Crawler)	$ 90,000	17	$ 5,294
1	85 HP (Crawler)	60,000	12	5,000
1	135 HP (4WD)	64,000	10	6,400
1	90 HP (2WD)	28,000	10	2,800
1	30 HP (2WD)	17,500	10	1,750
	Sub-total	259,500		21,244
	Implements			
1	Chisel Plow, 12'	4,300	10	430
2	Offset Disk, 21'	26,000	15	1,733
2	Stubbe Disk, 14'	40,740	10	4,074
1	Spiketooth Harrow, 20'	3,310	15	221
1	Finish Level, 12' X 45'	8,600	12	717
1	Triplane, 15' X 35'	9,400	12	783
1	Implement Carrier, 25'	3,500	15	233
1	Mower, 7'	2,200	10	220
1	Sprayer	2,800	10	280
1	Rice Checker	13,000	15	867
1	Check Breaker	600	10	60
1	Combine (New)	97,500	10	9,750
1	Combine (Used)	60,000	8	7,500
1	Bankout Wagon, (New)	20,000	10	2,000
1	Bankout Wagon, (Used)	10,000	8	1,250
	Surface Irrigation System	46,000	10	4,600
	Sub-total	347,950		34,718
	Transportation and Shop			
2	Pickup (4WD)	20,000	5	4,000
	Farm Shop (40' X 60')	25,872	25	1,035
	Tools	8,000	15	533
	Sub-total	53,872		5,568
	TOTAL ALL EQUIPMENT	$661,322		$ 61,530
	@ 60% VALUE	$396,793		$ 36,918

Large Farm-Size
(Greater than 820 acres)

No.	Tractors	New Cost	Life	Depreciation
2	85 HP (Crawler)	$ 180,000	17	$ 10,588
1	85 HP (Crawler)	60,000	12	5,000
2	135 HP (4WD)	128,000	10	12,800
2	90 HP (2WD)	56,000	10	5,600
2	30 HP (2WD)	35,000	10	3,500
	Sub-total	459,000		37,488
	Implements			
2	Chisel Plow, 12'	8,600	10	860
3	Offset Disk, 21'	39,000	15	2,600
3	Stubble Disk, 14'	61,110	10	6,111
2	Spiketooth Harrow, 20'	6,620	15	441
2	Finish Level	17,200	12	1,433
1	Triplane	9,400	12	783
1	Implement & Carrier, 25'	3,500	15	233
1	Mower, 7'	2,200	10	220
1	Sprayer	2,800	10	280
2	Rice Checker	26,000	15	1,733
1	Check Breaker	600	10	60
2	Combine (New)	195,000	10	19,500
2	Combine (Used)	70,000	8	8,750
2	Bankout (New)	40,000	10	4,000
1	Bankout (Used)	10,000	8	1,250
	Surface Irrigation System	92,000	10	9,200
	Sub-total	584,030		57,454
	Transportation and Shop			
3	Pickup (4WD)	30,000	5	6,000
	Farm Shop 50' X 60'	31,920	25	1,277
	Tools	10,000	15	667
	Sub-total	71,920		7,944
	TOTAL ALL EQUIPMENT	$1,114,950		$ 102,886
	@ 60% VALUE	$ 668,970		$ 61,732

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