1999 REPORT TO THE LEGISLATURE

PROGRESS REPORT ON THE PHASE DOWN OF RICE STRAW BURNING IN THE SACRAMENTO VALLEY AIR BASIN

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CALIFORNIA AIR RESOURCES BOARD
CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE
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EXECUTIVE SUMMARY

The Connelly-Areias-Chandler Rice Straw Burning Reduction Act of 1991 (Act) requires the Air Resources Board (ARB or Board) and the California Department of Food and Agriculture (CDFA) to prepare and submit a report to the Legislature every two years on progress in reducing the amount of rice straw burned in the Sacramento Valley.[1] The 1999 report documents that the requirement to phase down rice straw burning continues to be met on schedule.

This report is the third such report and focuses on the activities occurring since the last report submitted to the Legislature in October 1997. The proposed report was released for public comment on November 10, 1999, for consideration at the November 18, 1999, Board meeting. As a result of public comments made at the Board meeting, the Board extended the public comment period and continued the Board meeting until December 10, 1999. After review of the written comments and testimony at the December meeting, the Board directed the staff to make several changes to the report and, upon approval from CDFA, forward the report to the Legislature. The *Report of the Advisory Committee on Alternatives to Rice Straw Burning* is being issued as a separate report.

Background

About 500,000 acres of rice are grown in the Sacramento Valley. Before the Act, most of these acres were burned. Starting in 1992, the Act required progressive reductions in rice straw burning according to a schedule of decreasing percentages of planted acreage. In 1997, the schedule was modified to limit the burning to 200,000 acres annually for three years, starting September 1998[2]. For these three years only, the law set a separate limit for fall burning. Of the 200,000 acres allowed to be burned annually, up to 90,000 acres are allowed to be burned during the fall, subject to the acreage allocations of the Sacramento Valley Agricultural Burning Program. The final step of the phase down starts September 2001, when the law will allow burning only for disease control. The disease control burning will be limited to 25 percent of planted acres or 125,000 acres, whichever is less.

Public Health and Smoke Management

1 Assembly Bill 1378, Statutes of 1991, Chapter 787, section 2; California Health and Safety Code sections 41865-41866.

2 Senate Bill 318, Statutes of 1997, Chapter 745, section 2; California Health and Safety Code section 41865.

The burning of rice straw results in the emissions of smoke and other pollutants, which affect public health and visibility. Smoke of all kinds, including rice straw smoke, contains inhalable particulate matter. Although studies have not been done on rice straw smoke specifically, over 300 individual health studies on the impacts of particulate matter on public health were cited in the United States Environmental Protection Agency's document supporting the change in air quality standards. A bibliography of these studies is available on request.

Exposures during smoke episodes can result in high concentrations of fine particulate matter (less than 2.5 microns) over a several hour period during the afternoon and early evening periods. These levels may be 3 to 4 times higher on an hourly average basis than the rest of the day. People with respiratory illnesses, such as asthma, bronchitis, and allergies, are especially susceptible to the effects of smoke.

While the Act limits the total rice acres allowed to be burned, it is critical to manage when, where, and how all agricultural burning, including rice straw burning, is done to minimize the public's exposure to smoke. These activities are addressed with the smoke management program administered by the ARB and the air pollution control districts (districts) within the Sacramento Valley. The heart of this program is the Sacramento Valley Agricultural Burning Plan (Burn Plan). The Burn Plan is prepared in accordance with regulations adopted pursuant to section 41856 of the Health and Safety Code.

The amount of burning allowed each day depends on prevailing meteorological and air quality conditions. The Burn Plan allows more acres to be burned on days with good ventilation, restricts the acres burned on days with limited ability to disperse smoke, and allows no agricultural burning on days with adverse meteorological and air quality conditions. The Burn Plan encourages spring burning by increasing the allocation by a factor of 1.5.

Relative to the spring, the fall is more critical for managing smoke primarily due to more stagnant meteorological conditions. Therefore, the smoke management program is more restrictive during the fall than in the spring. Burning during the fall is most effective for disease control. Consequently, growers try to burn as much acreage as possible during the fall, subject to the provisions of the Burn Plan and the phase down schedule. Historically, hundreds of thousands of acres of agricultural residue were burned during the fall. Over the last decade, the combination of the phase down and the Burn Plan have reduced the acres burned during the fall months. Since the phase down started in 1992, most of the reduction in burning rice straw has taken place during the spring. While growing practices and other factors call for fall burning, shifting as much burning as possible from the fall to the spring would lessen the air quality impacts of burning in most years.

To minimize smoke impacts, regional smoke management programs are crucial. These programs must include prescribed burning as well as agricultural burning. In March of 2000, the ARB staff is proposing amendments to smoke management program requirements for all the districts in California to ensure that an effective statewide program is maintained. The proposed amendments are an integral component of California's collective efforts to minimize the impacts of the burning agricultural waste and forest materials. The smoke management program used in the Sacramento Valley is being used as a model for the rest of the State.

Alternatives to Burning

Over the last two years, there has been an ongoing effort to pursue alternatives to rice straw burning, including the ARB's rice straw grant program and the CDFA's rice straw utilization tax credit program. In 1998, the Board developed a rice straw diversion plan in consultation with CDFA, the Trade and Commerce Agency, and the Alternatives Advisory Committee.

Despite these programs, alternative uses have not materialized as quickly as hoped. Effective alternatives are critical to the long term success of the phase down. Currently, about 97 percent of the rice straw that is not burned is incorporated into the soil. Incorporation is likely to remain the primary alternative to burning for the next few years. This situation will improve if several promising demonstration programs are successful. However, financial incentives are needed to expand the use of rice straw. In the interim, the smoke management program will continue to be an essential component of the overall program to minimize the public's exposure to smoke.

The following discussion on alternatives addresses the status of five major activities designed to promote alternatives: ethanol and biomass products; the Rice Straw Grant Program; the recommendations of the Advisory Committee on Alternatives to Rice Straw Burning; the Rice Straw Diversion Plan; and the Rice Straw Utilization Tax Credit Program.

Ethanol and Biomass Products

A new opportunity for the use of rice straw may result with the phase out of methyl tertiary butyl ether (MTBE) in California's gasoline. With the phase out, significant quantities of ethanol may be needed for California gasoline both in the short term and the long term. The total market potential of ethanol will depend on refiner decisions related to the production of California Phase 3 reformulated gasoline (CaRFG3) and the U.S. EPA's decision related to California's request for a waiver from the federal oxygenates mandate. However, CaRFG3 will establish a minimum ethanol market of

about 120 million gallons a year to meet oxygenate demands in the South Coast Air Basin.

A California ethanol production industry will develop only if investors feel assured that the ethanol market in California can be sustained over a long period of time to allow a reasonable return on their investment. Otherwise, investment capital may not become available. Due to the amount of rice straw potentially used in these biomass-to-ethanol plants, several commercial plants could substantially contribute to meeting the 50 percent diversion goal for rice straw. Public policy can encourage ethanol production and use by providing incentives such as financial assistance for biomass-to-ethanol plant construction. The ARB and CDFA are very supportive of efforts to develop biomass-to-ethanol facilities in California, specifically rice straw biomass.

In July 1999, the California Legislature adopted Assembly Joint Resolution 4 (AJR-4, Maldonado) to encourage the use of rice straw for erosion control by State and federal agencies. This resolution highlights the benefits of using California-grown rice straw for erosion control and fire rehabilitation. The ARB will work with the appropriate State and federal agencies to direct them to available sources of rice straw. The ARB will also inform these agencies that the resolution specifies that weed-free certification for rice straw is not considered necessary.

The Rice Straw Grant Program

During the last two years, the ARB awarded rice straw grant funds for five demonstration and commercialization projects. If all are successful, the five projects could use 25 to 50 percent of the available rice straw by 2003. For year 2001, when the last step of the phase down limits burning to a maximum of 25 percent, it is estimated that off-field uses will consume only about 5 to 10 percent of the rice straw. Soil incorporation will remain the primary method for complying with the 2001 requirement.

In looking towards the future there are some promising developments. One of the grant recipients, FiberTech, started manufacturing particleboard out of rice straw in October 1999. In this project, FiberTech expects to use 40,000 to 60,000 tons of rice straw annually. This would amount to about 22,000 acres of rice straw or about 4 percent of planted acres.

In spring 2000, the Board will allocate the remaining $1.2 million in rice straw grants. The ARB staff will particularly seek out and encourage proposals for ethanol production projects. The potential for this alternative is substantial because a single commercial plant could use from 80,000 to 200,000 tons of straw annually. As the total potential annual yield of rice straw is about one million tons, a single plant could represent up to about a 20 percent diversion of rice straw to alternatives.

The Advisory Committee on Alternatives to Rice Straw Burning

The Advisory Committee on Alternatives to Rice Straw has made a number of recommendations which could enable alternative uses for rice straw to develop. In summary, the Committee's draft recommendations include: supporting financial incentives to develop rice straw products, such as loans, grants, and tax credits; providing financial assistance, such as a tax credit program, for building barns to store rice straw to make it available year-round; and encouraging the use of ethanol made from rice straw if environmental, technical, and economic studies are supportive.

The ARB and the CDFA support these recommendations as necessary and appropriate to stimulate the alternative uses of rice straw.

Rice Straw Diversion Plan

In December 1998, the ARB issued the *Rice Straw Diversion Plan* which suggested approaches for achieving 50 percent rice straw usage by 2000 and 2003. The plan also recognized that, without additional government assistance, only about 20 percent would likely be used by 2003. The additional measures needed to increase use include financial incentives and assistance with infrastructure related to rice straw harvesting, distribution, and storage.

Rice Straw Utilization Tax Credit Program

The CDFA has issued tax credit certificates for the purchasing of about 6,000 tons of rice straw in both 1997 and 1998. This accounted for about 60 percent of the total amount of rice straw harvested and used in 1998. This harvested rice straw was used primarily for bedding for dairy cows, erosion control, and cattle feed. In its *draft 1999 Report to the Legislature on the Rice Straw Utilization Tax Credit Program*, the CDFA is recommending that the Legislature consider the following:

- Expanding the program by lifting the annual $400,000 cap in order to attract larger and more diverse projects; and

- Allowing a purchase or trading program so that new rice straw projects with little or no California income tax liability could sell their tax credits to a profitable entity that could take advantage of the tax credit.

Progress of the Burning Phase Down

The burning phase down has proceeded as specified in the Act, with growers exceeding the phase down mandates basin wide. Table 1 shows that the total rice acreage burned annually has declined from 303,000 acres in 1992, the first year of the phase down, to about 141,000 acres in 1998. Most of the unburned rice straw continues to be incorporated into the soil. Since the phase down started in 1992, most of the reduction in burning has taken place during the spring. However, fall burning has been reduced due to both the phase down and the Burn Plan.

Table -1
Rice Straw Burning Phase Down
Maximum Allowable and Actual Burned
Sacramento Valley

Burn Year (Sept 1 – Aug 31)	Rice Acres Planted	Rice Acres Burned	Phase Down Act: %Acres Allowed to be Burned:	%Acres Actually Burned
1992	401,807	303,103	90%	75%
1993	450,253	305,636	80%	68%
1994	514,045	293,210	70%	57%
1995	500,705	268,216	60%	54%
1996	514,720	211,322	50%	41%
1997	517,233	133,640	38%	26%
1998	490,625	140,627	200,000 acres	29%

Environmental Assessment

The phase down has resulted in a decrease in smoke and emissions from rice straw burning on an annual basis. While most of the reduction has taken place in the spring, the combination of the phase down and the Burn Plan has also reduced acres burned in the fall. During the last two years, fall air quality has improved and public complaints about agricultural burning during the fall have decreased, which is most likely a result of better smoke management under the Burn Plan.

Overall, fine particulate emissions are greater from burning rice straw than from the alternatives of soil incorporation or offsite removal. In addition, atmospheric simulation modeling shows that the particles in smoke travel farther and remain in the air for a longer time than diesel and dust emissions, thus increasing the potential of affecting populated areas.

From an overall air quality standpoint, the phase down has had a positive public health and environmental impact due to reduced air emissions. However, some growers have indicated that there may be adverse environmental effects resulting from the change in rice straw management practices and the variety of techniques employed. These include: effects on water quality and use, increased methane emissions contributing to global warming, flooding potential, additional fuel use, additional use of pesticides and herbicides, and effects on waterfowl and pheasant habitats during winter. However, the ARB and CDFA staff currently have insufficient data available to adequately assess these effects. Staff will work with stakeholders to identify the available information on potential environmental effects and evaluate the need to conduct additional research.

Economic Assessment

The phase down has had varying economic impacts on individual growers depending primarily on the farmer's capability to incorporate straw. The cost of soil incorporation, the primary alternative to burning, has added to the costs of growing rice. The average cost of soil incorporation is estimated at about $36 per acre, compared with about $2 per acre for burning. A weighted average impact over all planted acres shows that soil incorporation costs have added about $20 per planted acre to production costs during 1997 and 1998.

On a regional basis, the phase down has cost growers about $10 million in direct costs from soil incorporation. After applying economic multipliers, the phase down appears to have reduced the output of goods and services produced in the region by about $19 million, with an estimate of 434 jobs lost. This represents about 0.04 percent of the Gross Valley Product and about 0.05 percent of the Valley's total employment. The impacts on Colusa County were most significant since rice growing is a major part of the county's economy, representing less than 2 percent of the Gross County Product.

The estimates of production costs and revenues used here do not represent any individual rice grower. The production cost estimates represent a hypothetical farm using farming procedures considered typical using industry average costs. The revenues also represent industry averages.

Based on the University of California Cooperative Extension data, the average cost of growing rice is estimated to be $823 per acre in 1997 and $842 per acre in 1998. In general, production costs do not vary greatly year to year; however, the revenue received for the rice crop does, because both crop yield and market price vary yearly. Rice growers' total average revenue was estimated to be about $908 per acre in 1997 and $940 per acre in 1998. Considering all costs, on average, growers gained about $85 per acre in

1997 and $98 per acre in 1998. Cash earnings were $254 per acre in 1997 and $274 per acre in 1998.[3]

These estimates include transitional payments, authorized under the federal Agricultural Market Transition Program, of $165 per acre and $172 per acre in 1997 and 1998, respectively. These transitional payments are scheduled to end beginning in 2003. In 1998, growers also received federal emergency assistance payments of about $78 per acre.

Recent studies by the University of California at Davis, Plant Pathology Department, and the University of California Cooperative Extension have shown an increase in the incidence and severity of two major rice diseases, stem rot and aggregate sheath spot, with repeated straw incorporation when compared with burning. Rice experts believe that the new disease levels seemed to have reached a higher plateau and may have resulted in a reduction in yields. Research is needed in order to assess the economic impact of the phase down in terms of potential for reduced yields.

The ARB and the CDFA are concerned about reduced yields. Starting September 2001, the Act allows the burning of rice straw only for the purposes of disease control. To assist the ARB in developing conditional burn regulations authorizing the use of burning to control rice diseases, the Act established the Rice Straw Disease Management Burning Committee. The ARB is tentatively scheduled to consider these regulations in the fall of 2000. As part of its regulatory development effort, the ARB will consult with the Committee, rice growers, and other stakeholders to address this issue.

CONCLUSIONS AND RECOMMENDATIONS

The phase down requirements are being met. However, alternative uses for rice straw have not developed as quickly as hoped. As such, there is a general consensus among all stakeholders that additional efforts must be placed on developing alternatives to rice straw burning and soil incorporation. These alternatives could be encouraged through the use of additional financial incentives such as grants, loans, or tax credits. The ARB and CDFA agree and recommend that the Legislature appropriate funding to support the development of alternatives, particularly ethanol production from rice straw. The ARB and CDFA staff will also continue to work with all stakeholders to promote the development of promising alternatives to rice straw burning.

Given the status of alternatives, rice growers continue to be concerned about the economic impacts of the phase down. Soil incorporation is more costly than burning,

3 Non-cash costs include lost opportunity cost of capital invested in land and equipment and unpaid labor of the rice grower.

and, according to studies by the University of California, Davis, causes an increase in rice diseases and weeds which may cause a reduction in yields. The ARB and CDFA recommend that the Legislature appropriate funding to research the economic impacts of the phase down in terms of reduced yield potential.

There may be environmental effects associated with the phase down of burning that have not been adequately studied. For the next progress report, staff will work with stakeholders to identify the available information on potential environmental effects of the changes in rice straw management and evaluate whether further research is needed.

From a public health perspective, other stakeholders commented that burning during the fall is the least attractive option because of the less favorable meteorological conditions and that an effective smoke management program is important to minimize the impacts of all burning. In general, rice growers agree that an effective smoke management program has and will continue to help reduce public health impacts. In addition, rice growers urge the ARB and CDFA to educate the public that not all smoke impacts are due to the burning of rice straw.

The ARB and CDFA understand and appreciate these public health concerns and are committed to implementing a smoke management program that effectively balances the needs of rice growers and the public health impacts of the burning of rice straw.

Introduction

The Connelly-Areias-Chandler Rice Straw Burning Reduction Act of 1991 (Act) requires the Air Resources Board (ARB or Board) and the California Department of Food and Agriculture (CDFA) to prepare and submit a report to the Legislature every two years on progress in reducing the amount of rice straw burned in the Sacramento Valley.[4] This report, entitled *1999 Biennial Report to the Legislature-- Progress Report on the Phase Down of Rice Straw Burning in the Sacramento Valley*, is the third such report and focuses on the activities occurring since the last report submitted to the Legislature in October 1997.

About 500,000 acres of rice are grown in the Sacramento Valley. Before the Act, most of these acres were burned. Starting in 1992, the Act required progressive reductions in rice straw burning according to a schedule of decreasing percentages of planted acreage (90 percent, 80 percent, 70 percent, etc.). In 1997, the schedule was modified to limit the burning to 200,000 acres annually for three years, starting September 1998. For these three years only, the law set a separate limit for fall burning. Of the 200,000 acres allowed to be burned annually, up to 90,000 acres are allowed to be burned during the fall, subject to the acreage allocations of the Sacramento Valley Agricultural Burning Program. The final step of the phase down starts September 2001, when the law will allow burning only for disease control. The disease control burning will be limited to 25 percent of planted acres or 125,000 acres, whichever is smaller.

The Act also required the establishment of two advisory committees. The Advisory Committee on Alternatives to Rice Straw Burning was established to study alternative uses of rice straw and to set priority goals to develop these alternatives. The Committee's 1999 report will be issued under separate cover. The Rice Straw Disease Management Burning Committee was established to advise the ARB in developing the conditional burn regulations for the use of burning to control rice diseases after September 2001. The Board will consider these regulations in the fall of 2000.

The Act requires that the following topics be covered in the biennial reports:

- alternatives to rice straw burning and recommendations from the Alternatives Advisory Committee;
- progress toward achieving the 50 percent diversion goal;
- progress of the burning phase down;

4 (Assembly Bill No. 1378, Chapter 787, sec. 2, Statutes of 1991, as Health and Safety Code sections 41865-41866).

- environmental and economic assessments; and
- any related issues, including any recommendations.

In preparing this report, the staff of ARB and CDFA reviewed the current information on each of these topics. The key issue continues to be the status of alternatives to rice straw burning. This report provides an update on the existing and promising new projects for use of rice straw. The primary current alternative to burning is soil incorporation as was the case at the time of the 1997 report.

In gathering information for this report, the ARB and CDFA staff held public workshops and individual meetings with interested parties. Two public workshops were held; the first on Tuesday evening, June 29, 1999, at the ARB headquarters, in Sacramento and the second on Wednesday evening, June 30,1999, at the Colusa County Air Pollution Control District.

A proposed report was released for public comment on November 10, 1999, for consideration at the November 18, 1999, Board meeting. As a result of public comments made at the Board meeting, the Board extended the public comment period and continued the Board meeting until December 10, 1999. After review of the written comments and testimony at the December meeting, the Board directed the staff to make several changes to the report and, upon approval from CDFA, forward the report to the Legislature.

Public Health and Smoke Management

Background

Burning rice straw in the field has traditionally been the means for controlling rice diseases and for disposing of rice straw after the crop has been harvested. Rice is the most widely planted crop in the Sacramento Valley. After Sacramento Valley rice growers harvest the grain in the fall, they must clear rice straw from about a half a million acres in preparation for future crops. Typically, about four tons of rice straw are produced per acre. When rice straw is harvested for use, about two and a quarter tons per acre are recovered. Use of burning for straw removal results in about three tons of rice straw burned per acre.

Burning during the fall is most effective for disease control. Therefore, growers try to burn as much as possible during the fall, subject to the provisions of the Burn Plan and the phase down requirements. Unfortunately, relative to the spring, the fall can be a poor time to burn because of poor air quality due to stagnant meteorological conditions. In contrast, the spring typically has better vertical and horizontal mixing of the atmosphere that enables particulate matter emissions to be better dispersed.

Historically, hundreds of thousands of acres of agricultural residue were burned during the fall. Over the last decade, the combination of the phase down and the Burn Plan have reduced the acres burned during the fall months. Since the phase down started in 1992, most of the reduction in burning rice straw has taken place during the spring. Smoke effects during fall burning can be significant, especially on days when meteorological forecasts are not successful and the smoke drifts to the populated areas of the valley. However, such days are infrequent.

Public Health Impacts

The practice of open-field burning of rice straw, forest materials and other plant residues releases large quantities of smoke particles and gases into the air. These airborne pollutants can be harmful to people. Smoke exposure has been associated with adverse health effects particularly among those with respiratory and cardiovascular illness.[5]

5 Liu, D.; Tager, I.B.; Balmes, J.B.; Harrison, R.J. 1992. The effect of smoke inhalation on lung function and airway responsiveness in wildland fire fighters. Am. Rev. Respir. Dis. 146:1469-1473.

The key components of rice smoke that are of health concern include directly emitted particles, particles formed from emitted materials, and gaseous, vapor-phase materials. There is no direct epidemiological or toxicological information that specifically explains how rice smoke impacts health.

However, there is a great deal of information on how the constituents of smoke, in general, can worsen existing illnesses. Smoke of all kinds, including rice straw smoke, contains inhalable particulate matter. Although studies have not been done on rice straw smoke specifically, over 300 individual health studies on the impacts of particulate matter on public health were cited in the United States Environmental Protection Agency's document supporting the change in the particulate matter ambient air quality standard. A bibliography of these studies is available on request.

Over 97 percent of the particles directly emitted from the burning of rice straw are less than 10 microns in size.[6] These particles are small enough to be inhaled and can be especially harmful to people with existing vascular or respiratory illness, the aged, and the very young. Exposure to such particles may worsen existing disease conditions. They can produce symptoms ranging from breathing difficulties to increased respiratory infections and even death.[7] Observations of a clear association between ambient fine particle levels and these effects have been reported in numerous studies performed in cities across the nation and the world. These reports form the basis of State and federal ambient air quality standards for particulate matter.

The findings of the recently published literature have focused on the health consequences of PM_{10} and smaller size fractions. These studies indicate that when particle levels increase health effects increase as well. For example, when 24-hour PM_{10} values increase by 50 micrograms per cubic meter ($\mu g/m^3$) above a base value, total daily mortality rates increase by approximately one extra death per million people.[8] Most of these deaths occur two or three days following the episode. More than half of these deaths occur in people over 65 years of age. Most deaths are due to cardiovascular and respiratory causes. Should high ambient concentrations persist for several days, mortality increases over these several days may be as high as 1.5 deaths per day, per million

people. Hospital admission rates have also been found to increase following increases in PM_{10} and $PM_{2.5}$ levels.

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6 Atmospheric Pollutant Emission Factors From Open Burning of Agricultural and Forest Biomass by Wind Tunnel Simulations, ARB Contract No. A932-126, April 1996, B. M. Jenkins, Principal Investigator

7 Dockery, D.W.; Pope, C.A. III; Xu, X.; Spenger, J.D.; Ware, J.H.; Fay, M.E.; Ferris, B.G. Jr.; Speizer, F.E. 1993. "An association between air pollution and mortality in six U.S. cities". N. Engl. J. Med. 329:1753-1759.

8 Ibid

Particles directly emitted from rice straw combustion include soil material entrained in the smoke plume and products from the combustion of the rice straw itself. Soil particles are fairly large in size, mostly in the fraction above $PM_{2.5}$. The directly emitted combustion particles include partially burned residues which may be quite large, but include substantial amounts of small particles. The smaller particles are largely made up of the organic remains of the straw that did not burn completely.

Particles originating from the gaseous products of combustion are a result of condensation and chemical processes. Complex organic compounds are formed in this process, along with some sulfates and nitrates. Known and suspected human carcinogens have also been found in these particles.[9]

Vapor or gas phase materials are also released in large quantities by open-field rice straw combustion. The list of components is very large, but the dominant ones include carbon monoxide, carbon dioxide, nitrogen dioxide, sulfur dioxide, and numerous organic substances. The extent to which these materials impact ambient air quality is not well studied, but most are harmful to health when present at elevated levels. The organic substances include known human and animal carcinogens.[10] Some of the organic vapors are precursors to the formation of ozone.

Definitive studies regarding the health consequences of rice straw smoke exposure would be helpful but they are difficult to perform successfully. Epidemiological studies of how people are affected by rice straw smoke exposures are complex and are of limited value with respect to open-field burning practices. However, there have been some studies designed to improve our understanding of the public health impacts.

One study of rice growers has been performed to evaluate how their occupational exposures might relate to possible adverse health effects, assuming that growers might be exposed to elevated levels of smoke. In this study, air samples were taken during several phases of rice growing practices, including pre-planting cultivation, harvest, and burning. The authors of the study found the 464 subjects studied had lower percentages of both smoking and smoking-related symptoms than the population as a whole. Rice growers, as a group, also had normal or above-normal readings in tests of lung function. The researchers speculated that this could be due to more active lifestyles. However, in the study, authors did document chest X-ray observations that are consistent with dust or fiber exposure, and evidence that suggests rice field preparation activities may be related to development of asthma. It is important to note that no conclusions were reached

9 Jenkins, opt cite
10 Jenkins, opt cite

regarding rice straw smoke exposures or its health impacts.[11]

The ARB is sponsoring controlled clinical studies to look at the specific health effects of burning rice straw and other agricultural waste.[12] These studies include exposing human volunteers to controlled, quantified levels of smoke from burning rice straw and other vegetative materials. Subjects have been recruited from the general population as well as from groups that are likely to be sensitive to smoke, such as asthmatics and people with allergies. Lung function changes and other health effects following brief, multi-hour exposure periods to varying levels of smoke are being examined. Studies such as this will provide information critical to establishing how and to what extent smoke from these sources and other vegetative burning directly impacts human health.

In summary, the practice of open-field burning may impact public health. Presently, we cannot quantify the extent to which these effects now occur or may occur in the future. In light of this, it is important to move forward with research efforts focused on:

1) improving our knowledge of the levels of smoke to which people are exposed; and

2) better characterizing and, if possible, quantifying how people of varying health status (healthy or diseased) respond to smoke.

Smoke Management Program

While the Act limits the total rice acres allowed to be burned, it is critical to manage when, where, and how all agricultural burning, including rice straw burning, is done to minimize the public's exposure to smoke. These activities are addressed with the smoke management program administered by the ARB and the air pollution control and air quality management districts (districts) within the Sacramento Valley.

Agricultural burning has been regulated since 1971 pursuant to section 41850 *et seq.*, of the Health and Safety Code. Regulatory guidelines for implementing the program are set forth in Title 17 of the California Code of Regulations (CCR), sections 80100 *et seq.*, as well as in the rules and regulations of the Sacramento Valley's districts. From 1971 until the fall of 1981, agricultural burning in the Sacramento Valley was regulated using a simple *burn* or *no-burn* control program similar to that used in the rest of the State.

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11 *Respiratory Health Among California Rice Farmers*, a report prepared for the California Rice Research Board, November 1993, Stephen A. McCurdy, M.D., M.P.H., Joel Swartz, Ph.D., Thomas Ferguson, M.D., Ph.D., David F. Goldsmith, M.S.P.H., Ph.D., Marc B. Schenker, M.D., M.P.H.

12 *The Effects of Smoke from Burning Vegetative Residues on Airway Inflammation and Pulmonary Function in Healthy, Asthmatic and Allergic Individuals*, ARB Contract No. 97-322

Agricultural burning in the Sacramento Valley is now regulated with a unique, variable acreage burning program. This program was developed in 1981, tested during the falls of 1981 and 1982, and approved by the ARB on September 30, 1983.

Each year, the Sacramento Valley Basinwide Air Pollution Control Council (BCC) and its Technical Advisory Committee (TAC) prepare the Sacramento Valley Agricultural Burning Plan (Burn Plan). The BCC is comprised of representatives of all the districts in the Sacramento Valley. Title 17 requires the ARB and the BCC to cooperate in developing the Burn Plan to be effective from September 1 through August 31 of each year. The ARB contributes to the development and revision of the Burn Plan through participation with the district staff, growers, and the public at meetings and workshops held by the BCC. As specified in Title 17, the BCC submits a revised Burn Plan annually to the ARB for approval.

The Burn Plan specifies the criteria to be used in deciding when, where, and how much agricultural burning will be done. The amount of burning allowed each day depends upon prevailing meteorological and air quality conditions. The plan allows more acres to be burned on days with good ventilation, restricts the acres burned on days with limited ability to disperse smoke, and allows no agricultural burning on days of adverse meteorological and air quality conditions.

The burn program is based on allocation formulas that are designed to match the amount of burning allowed each day with the ability of the atmosphere to disperse smoke on that day. The program's goal is to avoid public exposure to smoke, prevent significant deterioration of existing air quality, and ensure burning does not cause or contribute to violations of the State ambient air quality standards. The burn program has resulted in substantial reductions in smoke impacts in the fall.

Every day during the fall intensive burning period, the number of acres that the ARB determines may be burned is distributed among the districts by the coordinator of the BCC in accordance with the annual Burn Plan. The distribution is based on air quality, prevailing meteorological conditions, and district needs (acres ready to burn). Burn acreage is distributed among the districts through a computerized telecommunications network. The intensive fall burn season begins on September 15 and ends at the beginning of the fall rain season each year since the rains make the agricultural debris too wet to efficiently burn. Changes to the Act in 1997 changed the definition of the fall as being from September 1 through December 31.

Relative to the spring, the fall is more critical for managing smoke primarily due to more stagnant meteorological conditions. Therefore, the smoke management program is more restrictive during the fall than in the spring. Because burning during the fall is most

effective for disease control, growers try to burn as much as possible during the fall, subject to the Burn Plan and the phase down schedule. Historically, hundreds of thousands of acres of agricultural residue were burned during the fall. Over the last decade, the combination of the phase down and the Burn Plan has reduced the acres burned during the fall months. Since the phase down started in 1992, most of the reduction in burning rice straw has taken place during the spring. While growing practices and other factors call for fall burning, shifting as much burning as possible from the fall to the spring would lessen the air quality impacts of burning in most years.

To minimize smoke impacts, regional smoke management programs are crucial. These programs must include prescribed burning as well as agricultural burning. In March of 2000, the ARB staff is proposing amendments to smoke management program requirements for all the districts in California to ensure that an effective statewide program is maintained. The proposed amendments are an integral component of California's collective efforts to minimize the impacts of the burning agricultural waste and forest materials. The smoke management program used in the Sacramento Valley is being used as a model for the rest of the State.

Alternative Uses for Rice Straw

Since the last progress report two years ago, several promising developments have occurred to improve the outlook for alternative uses for rice straw. The ARB and CDFA believe that these developments could greatly contribute to the goal of diverting 50 percent of the rice straw in the long term. However, alternative uses for rice straw generally have not developed as quickly as hoped. The development of alternatives is critical to the long term success of the phase down and financial incentives are necessary to ensure that this goal is met in the shortest time possible.

One promising new opportunity for the use of rice straw may result from the phase out of methyl tertiary butyl ether (MTBE) from California's gasoline as directed by the Governor. With the MTBE phase out, significant quantities of ethanol may be used in California gasoline. To the extent that ethanol is used in California gasoline, both the ARB and CDFA want to encourage its production in California, specifically from rice straw.

Because bio-ethanol plants utilizing rice straw will rely upon cutting-edge technologies that have not yet been applied commercially, the agencies will seek ways to encourage and support rice straw-to-ethanol demonstration projects. This is an example where financial incentives or subsidies may be needed to make alternative uses for rice straw economically feasible.

To support efforts in this direction, ARB will target ethanol production projects when awarding the last increment of rice straw grants in the spring of 2000. The ARB will hold a third round of solicitations for grant applications within the next few months. A total of $1.23 million is available for this third and last year.

The grant program for rice straw demonstration and commercialization projects is progressing well. During the past two years, the ARB has awarded grants totaling $3.1 million for five projects which could use significant amounts of rice straw. One of these projects has just started production of its rice straw particleboard. FiberTech expects to use 40,000 to 60,000 tons of rice straw annually. This would amount to about 22,000 acres of rice straw or about 4 percent of planted acres. This marks a major milestone as the first large-scale industrial use of rice straw anywhere in the world. The four remaining projects are making good progress and, if all are successful, could use 25 to 50 percent of the rice straw five years from now.

Although these developments hold promise for the longer-term, in the near term most of the rice straw that is not burned will be incorporated into the soil. The use of rice straw is

expected to increase to about 20 percent by 2003, but soil incorporation will likely remain the primary alternative to burning for the next few years. All stakeholders agree that financial incentives, such as grants and loan guarantees, are needed to speed the development of commercial uses for rice straw.

Ethanol and Biomass Products

Ethanol

In December 1998, Governor Davis signed Executive Order D-5-99 directing the phase out of methyl tertiary butyl ether (MTBE) in California's gasoline. The Executive Order also directed several State agencies to analyze and evaluate ethanol as a possible replacement for MTBE.

The California Energy Commission is exploring the potential for development of a California biomass ethanol industry. In another study, several Cal/EPA agencies evaluated the environmental effects of ethanol use in gasoline. The ARB evaluated the air quality effects of ethanol use, the State Water Resources Control Board reviewed the surface and ground water effects, and the Office of Environmental Health Hazard Assessment analyzed the potential for health risks related to the use of ethanol in gasoline. These agencies reported their analyses in December 1999, and the full report was approved by the California Environmental Policy Council on January 18, 2000.

A new opportunity for the use of rice straw may result with the phase out of methyl tertiary butyl ether (MTBE) in California's gasoline. With the phase out, significant quantities of ethanol may be needed for California gasoline both in the short term and the long term. California Phase 3 reformulated gasoline (CaRFG3) will establish a minimum ethanol market of about 120 million gallons a year to meet oxygenate demands in the South Coast Air Basin. However, the total market potential of ethanol will depend on refiner decisions related to the production of CaRFG3 and the U.S. EPA's decision related to California's request for a waiver from the federal oxygenates mandate. The California Energy Commission estimates that refiners of CaRFG3 may need from 148 million gallons per year to 1.15 billion gallons per year.[13]

A California ethanol production industry will develop only if investors feel assured that the ethanol market in California can be sustained over a long period of time to allow a reasonable return on their investment. Otherwise, investment capital may not become available. Public policy can encourage ethanol production and use by providing incentives such as financial assistance for biomass-to-ethanol plant construction.

13 Evaluation of Biomass to Ethanol Fuel Potential in California, Draft Report, California Energy Commission, October 1999, P500-99-017A.

A biomass-to-ethanol plant could use 150,000 tons of rice straw and produce 20 million gallons per year of ethanol. This would represent about 15 percent of the total rice straw available. Just a few of these plants could substantially contribute to the 50 percent diversion goal. As such, the ARB and CDFA are very supportive of efforts to develop biomass-to-ethanol facilities in California, specifically rice straw biomass.

Biomass-to-ethanol plants using rice straw rely upon cutting-edge technologies and there are no commercial plants operating at this time. However, two biomass ethanol projects have been planned in the Sacramento Valley, in Gridley, by the City of Gridley and BC International, and the Sacramento Ethanol Project in Rio Linda by Arkenol and Ark Energy. These two projects have proposed to use rice straw as a primary biomass component. In total, the projects would produce about 24 million of gallons of ethanol per year. Currently, both projects are in the active planning stages.

Biomass Products and Bio-energy

In July 1999, the California Legislature adopted Assembly Joint Resolution 4 (AJR-4, Maldonado) to encourage the use of rice straw for erosion control by State and federal agencies. This resolution highlights the benefits of using California-grown rice straw for erosion control and fire rehabilitation. The ARB will work with the appropriate State and federal agencies to direct them to available sources of rice straw. The ARB will also inform these agencies that the resolution specifies that weed-free certification for rice straw is not considered necessary.

Within the last year, two Presidential Executive Orders were issued focusing on promoting biomass products and bio-energy. Presidential Executive Order 13101, titled "Greening the Government Through Waste Prevention, Recycling and Federal Acquisition." was issued September 1998. The Order directs federal agencies to give preference to purchasing biobased (plant-based) products. Because the federal government is a significant purchaser of goods in this country, this directive should help create market demand for products made from agricultural fibers such as rice straw.

A second Presidential Executive Order was issued August 12, 1999, which established the goal of tripling the use of bioenergy and biomass industrial products by 2020. This biomass initiative also called for the creation of the Interagency Council on Biobased Products and Bioenergy which will annually propose a research program for biomass projects. New rice straw technologies could be developed under this new program.

The Council is composed of the Secretaries of Agriculture, Commerce, Energy, and the Interior, the Administrator of the United States Environmental Protection Agency, the Director of the Office of Management and Budget, the Assistant to the President for

Science and Technology, the Director of the National Science Foundation, the Federal Environmental Executive, and the heads of other relevant agencies as may be determined by the Co-Chairs of the Council.

Rice Straw Grant Program

In 1997, Senate Bill 318 created the Rice Straw Demonstration Project Fund (the Rice Fund) to provide grants for developing commercial uses for rice straw. The Rice Fund was appropriated $5 million for the two-year program. The ARB was directed to award the grants during the last two fiscal years, 1997-98 and 1998-99.

The ARB staff developed the criteria for evaluating applications by consulting with the University of California, the Trade and Commerce Agency, and the Department of Food and Agriculture. The Board adopted the criteria at its January 29, 1998, public meeting.

Twelve applications were received the first year and 13 the second year. The applications were reviewed by a panel of 10 experts from the University of California, Davis, the United States Department of Agriculture (USDA), the Trade and Commerce Agency, the rice industry, and staff from the ARB and CDFA. In total, seven projects were approved for grants. Two of those projects had financial difficulties and their grants were cancelled.

The Status of Projects Awarded Grants

A listing and summary of the status of the seven projects that the Board approved at its May 1998 and April 1999 public meetings are presented below.

- *Bioboard Plant for Colusa, California* submitted by FiberTech USA, Inc. for $750,000.

  A major milestone was reached when FiberTech, one of the grant recipients, started production of its rice straw particleboard named Bioboard® in October 1999. In its application for the grant, FiberTech expected to use about 20,000 tons of rice straw annually. Because FiberTech was able to purchase equipment with much larger production capacity, the company now expects to use from 40,000 to 60,000 tons of rice straw annually. FiberTech becomes the first large-scale user of rice straw.

- *Colusa Rice Straw Project* submitted by Enviro Board Corporation, Inc. for a grant award of $500,000.

Enviro Board expects to have its rice straw fiberboard mill running by early 2000 and is in the process of putting the final touches on its manufacturing facility and showroom in Colusa. The fiberboard panels will be marketed as low-cost building materials such as dry wall, thermal insulation, door cores, office partitions, and sound walls. Enviro Board is currently working with the Colusa County Sheriff's office to construct a sound wall at the county jail.

- *Production of Fermented Animal Feeds from Sacramento Valley Rice Straw: Prototype and Commercial Pilot* submitted by MBI International for $820,000.

  For the past 13 months, MBI International has worked on its demonstration project to convert rice straw to a high value animal feed. An existing facility was modified to utilize MBI's patented Ammonia Fiber Explosion (AFEX) process to produce five tons of the feed, after which it underwent fermentation. An animal feed trial was conducted with dairy cows, replacing seven percent of a typical California feed ration with MBI's rice straw feed. The feed trial was successful showing increased digestibility and acceptable milk production volume and fat and protein content.

- *Preprocessing of Rice Straw for Multiple Products* submitted by Anderson Hay & Grain Co., Inc. for $500,000.

  Anderson Hay & Grain Company is into its second year of baling rice straw. Anderson reported on its baling experiences in 1998, describing problems and possible solutions to baling rice straw and recommending the complement of equipment necessary for a 100,000 ton straw harvest. The report was put on the ARB Rice Fund web site and mailed to stakeholders to enable them to learn from Anderson's experiences. A number of baling companies from various states have viewed the report and in the fall of 1999, have started baling rice straw with baling equipment transported to California. Anderson has also made considerable headway in developing the protocols to export California rice straw to Japan for cattle feed.

- *Production of Citric Acid from Sacramento Valley Rice Straw* submitted by Arkenol Holdings, L.L.C. for a grant award of $519,247.

  Arkenol has a patented acid hydrolysis process to convert rice straw to citric acid. Citric acid, a versatile basic chemical, is used in a broad range of industries, including beverages, food, and pharmaceuticals. Arkenol is optimizing a strain of microorganism to provide acceptable yields, developing preliminary engineering data for detailed engineering design of the full scale plant. The goal is to receive vendor process guarantees for major units of operation and to negotiate customer

contracts for the citric acid production by supplying potential customers with samples of Arkenol's sugar hydrolysates for testing.

- *Phase One Development of the Agriboard Industries L.C. Rice Fiber Based Structural Panel Plant in Sacramento Valley, California* submitted by Agriboard Industries L.C., for a grant award of $665,000.

  A few weeks after the April 1999 grant awards were made, Agriboard Industries informed the ARB staff that it was unsuccessful in obtaining a loan-guarantee from the USDA for a major debt-restructuring loan, which was a condition of the grant award. Agriboard submitted a revised proposal to carry out the rice straw project under the company's restructured circumstances. After evaluating Agriboard's revised proposal, the grant award was withdrawn.

- *Medium Density Fiberboard manufactured from Sacramento Valley Rice Straw Residuals* submitted by Louisiana-Pacific Corporation for a grant award of $565,753.

  Late in July 1999, Louisiana-Pacific informed the ARB staff that it would not be able to accept its grant award after deciding it would not be economical to convert its manufacturing facility to use rice straw.

Executive summaries of the progress reports of the five grant projects are periodically placed on the ARB Rice Fund web site at the following address:

http://www.arb.ca.gov/rice/ricefund/ricefund.htm

New Grant Opportunity for 2000

In anticipation that a project recommended for a grant award might not be successful in completion or even in getting started, the Board approved a procedure for reallocating unspent grant money. At its April 1999 public meeting, the Board amended the funding criteria to allow existing grant recipients, whose projects are in good standing and making acceptable progress, to submit proposals to have their existing grants augmented by expanding their current projects.

When the two projects were cancelled, $1.23 million was left unencumbered. The ARB staff considered this amount to be too much to augment other, existing grants and preferred to open up the grant process to all applicants. In October, the Governor signed

legislation[14] authorizing the ARB to award new grants in fiscal year 1999-2000 using the $1.23 million from the two cancelled grants. As a result, the ARB staff expects to issue a new Invitation for Grant Requests in late 1999 or early 2000.

Alternatives Advisory Committee

The Phase Down Act provided for the establishment of the Advisory Committee on Alternatives to Rice Straw Burning (Alternatives Committee) "…to assist with the identification and implementation of alternatives to rice straw burning… [and to] …develop a list of priority goals for the development of alternative uses of rice straw …" The Committee has been working on these charges since 1993.

In its first two progress reports in 1995 and 1997, the Alternatives Committee identified approximately 50 commercial uses for rice straw and discussed the technical and economic barriers for each. The Committee made recommendations designed to increase the commercial uses of rice straw, such as providing loan guarantees for the most promising technologies, and stated that without financial incentives, alternative uses would be slow to develop.

In its draft report for 1999, the Committee provides a summary of changes and progress during the past two years and a more detailed discussion of the status of rice straw marketing infrastructure (that is, getting the straw from the field to the factory) in California. As with its previous reports, the Committee makes recommendations designed to speed the development of alternative uses of rice straw. The Committee's draft report is summarized below; the entire report will be forwarded to the Legislature after it has been finalized.

The Committee notes that the impending phase out of MTBE should stimulate interest in the use of ethanol, and that California-produced ethanol would have a freight advantage of about 14 cents per gallon over Midwestern sources of ethanol made from corn. The Committee states that a clear message from the State is needed on how ethanol will be used in California as a fuel and fuel additive.

The Committee also supports consideration of measures outlined in the ARB's Rice Straw Diversion Plan, including providing financial incentives, such as loans and grants for rice straw projects; studies on straw infrastructure; support for research; increasing the

rice straw tax credit limit; and encouraging state agencies to use and promote rice straw products where appropriate.

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14 Senate Bill 1186, Statutes of 1999, Chapter 640, section 2; California Health and Safety Code section 41865.5 section 2.

Other recommendations of the Committee include: encouraging the State to undertake building code testing and standardization for straw bale housing and investigating a tax credit program, such as the one used in Oregon, to stimulate construction of storage barns for rice straw in California.

Another important area in which the Committee makes a recommendation is for promoting sustainable agricultural practices in managing straw residue. The Committee cautions that a "…complete reliance on a single system of rice straw management is undesirable and that a blend of straw management alternatives should remain available, including incorporation, baling and removal, and burning, which can be used in a rotational sequence." Each of the three main straw management practices (burning, incorporation, and removal) has positive and negative impacts which recent studies are just starting to identify.

Overall, the ARB and the CDFA support the Committee's recommendations as necessary and appropriate to stimulate the alternative uses of rice straw.

Rice Straw Diversion Plan

Senate Bill 318 directed the ARB to develop an implementation plan and schedule to find uses for 50 percent of the rice straw by the year 2000. In December 1998, the ARB released *The Rice Straw Diversion Plan* (*the Plan*), which outlines measures that could be taken to achieve the 50 percent goal.

Two approaches were identified which could achieve the 50 percent goal on the most expeditious schedule possible. One approach was to target 50 percent usage in the year 2000, as required in the law. However, meeting the diversion goal by this date could be accomplished only with large subsidies and even then would face substantial logistic and technical difficulties. For this 2000 plan, a dairy and cattle feed marketing program could be pursued, which would include a $20 per ton subsidy, to induce dairy and cattle ranchers to buy rice straw for animal feed. This subsidy, totaling almost $10 million annually, would need to continue until other uses of rice straw were developed.

Because of the extreme difficulty and high cost of achieving a 50 percent diversion by the year 2000, the ARB staff also identified an alternative plan that targeted the 50 percent goal for the year 2003. The plan also recognized that without government assistance, only about 20 percent would likely be used by 2003. The suggested measures were categorized into three main areas: straw infrastructure, incentives for end-users, and promoting use of rice straw products.

Because the market for rice straw is just starting to develop, the infrastructure for getting the straw from the rice fields to the factory is also just developing. The infrastructure includes harvesting, transporting, and storing the straw. In the larger scheme, this also includes identifying how much straw is available, and identifying straw quality and straw specifications needed by various end-users.

The Diversion Plan recommended that resources be appropriated to address the issues of developing a rice straw infrastructure since these issues are common to most potential uses of rice straw. The recommendations included providing financial resources, such as low-interest loans, accelerated capital depreciation, or tax credits, toward building storage facilities so that rice straw would be available on a year-round basis.

To encourage developing new rice straw technologies, the Diversion Plan recommended providing financial resources, such as loan guarantees, low-interest loans, or grants, for demonstration and commercialization projects such as the projects currently funded by the Rice Fund Grant Program. Financial incentives could also be provided for research projects to address technological barriers of those technologies which could use significant (at least 50,000 tons) amounts of straw. A Rice Straw Business Assistance Program was also recommended to educate potential rice straw businesses about existing available programs for federal, state, and local financial and educational assistance.

To help create a market demand for rice straw products, the Diversion Plan also recommended that State and local agencies be encouraged to use and promote rice straw products where such use would be appropriate. The existing tax credit program could also be modified by increasing the annual limit, currently set at $400,000.

To date, no legislative appropriations have been made to provide the economic incentives needed to substantially expand the use of rice straw.

Rice Straw Utilization Tax Credit Program

The CDFA administers the Rice Straw Utilization Tax Credit Program[15] and issues State tax credit certificates of $15 per ton of rice straw purchased to the *end-users* of the straw. Taxpayers may carry forward any unused credit for up to ten years. There is a limit of $400,000 for the total tax credits allowed for all rice straw purchases each year. This limit represents the purchase of about 26,000 tons of rice straw. The law requires that the tax credit certificates be issued on a first-come-first-served basis.

For 1997, the first year of the program, $90,509 in tax credits were issued for 6,034 tons

15 Senate Bill 38 (Lockyer, ch 954, 1996) established section 17052.10 of the State Revenue and Taxation Code

of rice straw. Preliminary data for 1998 show $88,360 in tax credits issued for purchasing 5,891 tons of rice straw. In both years, the stated uses of the rice straw purchased were primarily for animal bedding (2,530 tons), animal feed (688 tons), and erosion control (1,673 tons).

The dairy industry represented 15 of the 20 tax credit recipients in 1998. The tax credit served to offset the costs of transporting the rice straw from the Sacramento Valley to the San Joaquin Valley, from 50 to 100 miles. In the future, one large-scale rice straw business could use the entire annual tax credit.

In its draft ***1999 Report to the Legislature Rice Straw Utilization Tax Credit Program,*** the CDFA recommends that the Legislature consider the following:

- Expand the program by lifting the annual $400,000 cap in order to attract larger and more diverse projects;

- Allow a purchase or trading program so that new straw projects with little or no California income tax liability could sell their tax credits to a profitable entity that could take advantage of the tax credit; and

- Dedicate any unused portion of the tax credit to support other activities that promote off-field utilization of rice straw.

Progress of the Phase Down

Phase Down Compliance

The Act limits the acres of rice straw that can be burned each burn year (September 1 through August 31 of the following year). The phase down schedule is presented in Table 2. Table 3 shows the maximum percent of acres allowed to be burned under the Act and the percentages reported as burned for the first seven years of the phase down. In each year so far, rice straw burning has been reduced more than required by the Act. In the 1998 burn year, less than 141,000 acres were burned compared to 303,000 acres in the 1992 burn year.

During the last 18 years, rice acreage has varied from 300,000 to 550,000 per year. Prior to the phase down, most of the straw was burned. Since the phase down started in 1992, the acreage burned has decreased substantially on an annual basis. In 1998, about 508,000 acres of rice were planted. Preliminary data show about 570,000 acres were planted in 1999.

The phase down has been accomplished by decreasing the burning primarily in the spring. Most growers try to burn in the fall for more effective disease control. Also, delayed burning may cause a delay in planting the crop the following spring as some soils take too long to dry out in the spring. Because of these reasons, growers try to burn from September 15 until about the end of November. This time period, called the Intensive Fall Burning Season, is strictly controlled under the Burn Plan.

Until the Act was modified in 1997, the Phase Down Act did not distinguish between fall and spring burning. Only the total yearly burn as a percentage of acres planted was required to be phased down. The 1997 amendments specified an annual burn limit of 200,000 acres including a fall burn limit of 90,000 acres for three years starting 1998.

Figure 1 shows how spring and fall burning have changed as the phase down has progressed. Spring burning has declined substantially as the percentage of allowable acres burned has been decreasing. Table 4 shows the number of acres burned during the fall since the phase down began in 1992.

Table 2

Rice Straw Burning Phase Down Schedule

Burn Year	Maximum Acres Allowed To Be Burned	
	Annual Limit	**Fall Limit**
1992	90% of Planted Acres	No Limit
1993	80% of Planted Acres	No Limit
1994	70% of Planted Acres	No Limit
1995	60% of Planted Acres	No Limit
1996	50% of Planted Acres	No Limit
1997	38% of Planted Acres	No Limit
1998	200,000 Acres	90,000 Acres
1999	200,000 Acres	90,000 Acres
2000	200,000 Acres	90,000 Acres
Starting 2001 Only for Disease Control	The lesser of: 25% of Planted Acres or 125,000 Acres	No Separate Limit

Table 3

Compliance with the Phase Down Schedule

Burn Year:	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Allowable Burned	90%	80%	70%	60%	50%	38%	200,000 acres
Actual Burned	75%	68%	57%	54%	41%	26%	29%
Acres Planted	401,807	450,253	514,045	500,705	514,720	517,233	490,625
Acres Burned	303,103	305,636	293,210	268,216	211,322	133,640	140,627

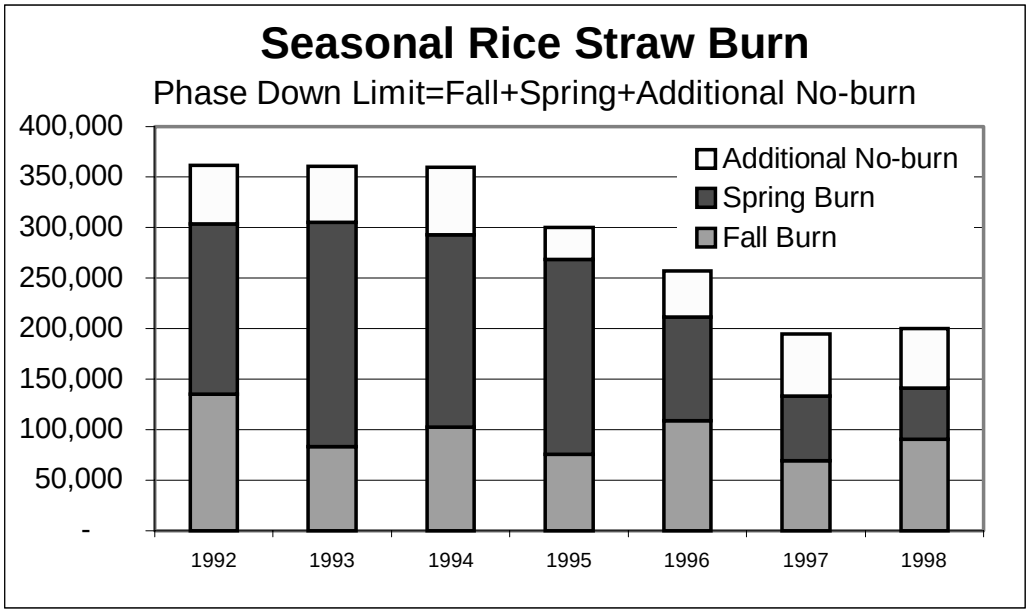

Figure 1

Table 4
Rice Acres Burned Per Year By Season

Season	Rice Acres Burned Per Year						
	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
Fall	135,125	83,520	102,498	75,384	109,077	69,284	89,418
Spring*	167,978	222,116	190,712	192,832	102,245	64,356	51,209
Total*	303,103	305,636	293,210	268,216	211,322	133,640	140,627

* Note: These data represent the best estimate of acres burned. However, there is uncertainty with the data for total acres burned and spring acres burned shown here, because the data were derived from designated no-burn acres reported. The actual burn numbers may be lower in some years.

Tables 5 and 6 show the acres of rice planted and burned for the 1997 and 1998 crop years, respectively. As shown, the rice burn acreage reductions required by the Act have been met in each of the last two years of the phase down. In 1998, less than 141,000 acres were burned compared to 200,000 acres allowed to be burned.

During the last two years, the percentage burned annually (26 percent in 1997 and 29 percent in 1998) has approached the final burn limit of 25 percent. Individual rice

growers have said that the fields they weren't able to burn during the intensive fall burn season were plowed to avoid delay in spring planting.

Table 5
Comparison of Annual and Fall Burns : 1997

County	Acres Planted	Annual Burn		Fall Burn	
		Acres Burned	% Burned	Acres Burned	% Burned
Butte	96,955	29,147	30%	15,645	16%
Colusa	150,690	33,217	22%	17,866	12%
Glenn	85,021	27,164	32%	14,422	17%
Placer	16,800	5,464	33%	2,639	16%
Sacramento	10,157	4,053	40%	2,669	26%
Sutter	93,049	24,154	26%	8,413	9%
Tehama	2,517	0	0%	0	0%
Yolo	23,601	3,789	15%	3,018	12%
Yuba	36,244	6,652	18%	4,612	13%
TOTALS:	**517,233**	**133,640**	**26%**	**69,284**	**13%**
Total allowed to be burned:		38%		No separate fall limit	

Table 6
Comparison of Annual and Fall Burns : 1998

County	Acres Planted	Annual Burn		Fall Burn	
		Acres Burned	% Burned	Acres Burned	% Burned
Butte	90,588	27,086	30%	17,196	19%
Colusa	142,720	38,690	27%	27,129	19%
Glenn	82,977	30,595	37%	18,201	22%
Placer	12,131	4,675	39%	2,658	22%
Sacramento	9,031	3,587	40%	1,719	19%
Sutter	97,752	24,333	25%	13,296	14%
Tehama	800	320	40%	50	6%
Yolo	17,816	3,115	17%	2,344	13%
Yuba	36,810	8,226	22%	6,825	19%
TOTALS:	**490,625**	**140,627**	**29%**	**89,418**	**18%**
Total allowed to be burned:		200,000 acres		90,000 acres	

Soil Incorporation of Rice Straw

Incorporation of rice straw into the soil is the primary non-burning straw management option currently available to growers. The incorporation of rice straw into the soil can be done in many different ways, all necessitating additional labor and other costs. Various combinations of chopping, rolling, discing, and tilling, with or without subsequent flooding of the fields, are used.

The effectiveness of incorporation varies from place to place within the Sacramento Valley because of soil types and availability of water. Areas having poor drainage typically are found where soils are high in clay content. These heavy soils are difficult to work and require additional passes and more powerful tractors to mix the straw with the soil; early rains may make these soils unworkable. In addition, alkalis are prevalent in many of the high-percentage clay soils. With soils that have the lowest clay contents (higher percentages of sand or silt), incorporation has worked very well. Other factors affecting the ability to incorporate straw include cropping patterns and the ability to rotate crops to different areas.

The available scientific evidence suggests that wet incorporation is more effective than dry incorporation because it results in more complete rice straw breakdown. Although the availability and price of water vary greatly around the valley, the east side generally has more water than the west. However, in drought years, water availability may be affected.

The University of California Cooperative Extension studied incorporation of rice straw. About 100 rice fields representing a wide range of geographic locations, practices, soils, and tillage tools and choppers were monitored during 1994 through 1996 for straw cover, straw decomposition, soil physio-chemical characteristics such as rice plant population, leaf nitrogen content, and disease incidence. Cost information was obtained from grower cooperators. Much of the information available about incorporation stems from this work.

An important issue surrounding soil incorporation is the concern that rice diseases may increase with repeated straw incorporation. Two major rice diseases occur in California--stem rot (*Sclerotium oryzae*) and aggregate sheath spot (*Rhizoctonia oryzae-sativae*). Because residue straw is the primary means of re-infestation, open-field burning has been the traditional method of controlling these diseases. Removal of straw residue is considered a more satisfactory alternative than soil incorporation.

Rice blast, the most destructive disease of rice worldwide, was found on California rice for the first time in 1996. The blast fungus (*Pyricularia grisea*) can stay alive over the winter in diseased crop residue, seed, or weed hosts. Straw burning can be an important component of an overall control program although burning plays a different role with rice blast. Because blast is an airborne pathogen, while other common rice diseases are usually waterborne, burning could actually spread the disease via the smoke plumes.

Rice disease experts at the University of California, Davis, and the Cooperative Extension believe that the unusual meteorological conditions occurring in 1996 allowed the disease to reach problematic levels. Rice blast disease is favored by long periods of free moisture, high humidity (90%), little or no wind at night, and night temperatures between 63-73 degrees Fahrenheit. Recently, rice agronomists have concluded that while meteorological conditions in California may be conducive to the blast disease, they are not optimal. A Rice Blast Task Force has been established to identify and implement measures to control the disease.

Environmental Assessment of the Phase Down

Rice Straw Burning Emissions

Annual Emissions

The most significant air pollution impact of rice straw burning is the emission of fine particles of combustion products that make up smoke. Fine particles in the air have traditionally been characterized by the ambient concentration (in micrograms per cubic meter or $\mu g/m^3$) of particles whose diameters are 10 microns (μm) or less; these particles are smaller than one-seventh the diameter of a human hair. Rice straw burning emits about 20.8 pounds of these particles for each acre burned.[16]

Rice straw burning also emits other pollutants including carbon monoxide and precursors to ozone and secondary particulate formation. Table 7 shows the emission factors, calendar year 1998 emissions, and a comparison of rice straw burning emissions to all emissions in the Sacramento Valley on an annual basis. The emission factors used to calculate emissions of these pollutants are the result of work recently completed at the University of California, Davis[17] under a contract with the Board. Although these emission factors are still being reviewed, they were used because they are the best data available.

While the emissions shown in Table 7 may contribute in a relatively small way to regional air pollution levels on an annual basis, the particulate emissions are of special concern on a daily and hourly basis during the fall burn period.

[16] *Atmospheric Pollutant Emission Factors From Open Burning of Agricultural and Forest Biomass by Wind Tunnel Simulations*, ARB Contract No. A932-126, April 1996, B. M. Jenkins, Principal Investigator

[17] *Ibid*

Table 7

Annual Rice Straw Burning Emissions : 1998
(Sacramento Valley Air Basin)

	PM_{10}	ROG	NO_x	SO_x	CO
Emission Factors (pounds/acre)	20.8	5.2	17	3.7	188
Annual Emissions (tons)	1,600	400	1,307	284	14,455
Annual Contribution To Total	2.0%	0.4%	1.5%	7.0%	2.6%

Daily PM_{10} Emissions

Because rice straw burning is concentrated primarily the fall, it is important to look at its relative contribution to fine particle emissions on a daily as well as annual basis. Table 8 shows the relative contribution of PM_{10} emissions from rice straw burning in the Sacramento Valley on an annual basis and on two types of burn days. During 1998, rice straw burning contributed about two percent of PM_{10} emissions on an annual average basis (averaged over 365 days a year). However, on a 3,000 acre burn day, the resulting PM_{10} emissions represent nine percent of all emissions, making this the fourth largest source of direct PM_{10} emissions in the Sacramento Valley during the fall, after the categories of unpaved road dust, farming operations, and paved road dust. When 9,000 acres are burned, considered a large burn day, the resulting PM_{10} emissions represent the largest emission source, representing about 23 percent of all PM_{10} emissions. The annual frequency of major burn days varies depending on the meteorology. During the period from 1992 through 1998, there were 14 fall days on which 9,000 acres or more were burned on one day; in 1997 there was one and in 1998 there was one.

In additional to unpaved road dust, farming operations, and paved road dust as sources of directly emitted $PM_{10,}$ gaseous emissions from motor vehicles and other combustion sources react in the atmosphere to form particulate sulfates and nitrates. These compounds can substantially contribute to ambient concentrations of $PM_{10.}$

Wildfires may also contribute to ambient concentrations of $PM_{10.}$ Many areas of California were adversely impacted from wild fires beginning in late August and lasting into November 1999. The wild fires produced high particulate emissions that created poor air quality under generally adverse meteorological conditions for burning. Peak hourly PM_{10} concentrations from the wild fires exceeded 400 $\mu g/m^3$ in the Sacramento Valley Air Basin. Rice straw burning was not allowed during those days of high PM_{10} impacts from the wild fires.

Table 8

Daily PM_{10} Emissions from Rice Straw Burning
(Sacramento Valley Air Basin : 1998)

Time Period	**Contribution Relative to All Sources**
Annual Average (365 days)	2 %
October Day – 3,000 Acres Burned	9 %
October Day – 9,000 Acres Burned	23 %

Emissions from Alternatives

Currently available disposal alternatives to rice straw burning are incorporation into the soil and removal from the field. Typically, removal is done to harvest the straw for some off-field use. This section compares the emissions produced by rice straw burning with those of incorporation and removal.

Emissions from burning result from the combustion of the rice straw. Emissions from straw incorporation come from farm equipment used to chop the straw and to work it into the soil; these emissions are due to dust and equipment engine exhaust. Emissions from hauling the straw offsite are due to activities in the field which also create dust, such as raking and baling, and exhaust emissions from motorized equipment.

Straw burning produces combustion products such as PM_{10}, CO, ROG, NO_x, and SO_x. The engine exhaust emissions from farming equipment (such as tractors and harvesters) include PM_{10}, CO, ROG, NO_x, and SO_x. The ARB has identified particulate matter from diesel-fueled engines as a toxic air contaminant. Equipment operation also creates airborne dust which include PM_{10} emissions, shown here as *Soil* PM_{10} .

Incorporation of rice straw is not accomplished the same way by every grower. The emission estimates shown here for soil incorporation represent the most common method used by growers: chopping, discing, flooding, then rolling.

As shown in Table 9, emissions are much higher for burning rice straw, compared with incorporation and offsite removal.

Table 9

Rice Straw Removal Emission Factor Estimates
(pounds/acre)

Straw Removal Scenarios	Soil PM_{10}	Burning & Exhaust PM_{10}	ROG	NO_x	SO_x	CO
Burning		20.8	5.2	17	3.7	188
Incorporation	9.2	0.9	1.7	11	0.2	4
Offsite Removal	2	0.3	0.6	4	0.1	1

Note: Some of the factors used here were estimated using engineering judgement from rice growers, agricultural scientists, and emission inventory specialists.

Particle size is another important consideration for evaluating the impact of particulate matter emissions. Atmospheric simulation modeling shows that smaller particles stay in the air longer and are carried farther from the emission source than are larger particles.[18] They also are believed to be of greater health significance.

Agricultural burning and exhaust emissions include higher percentages of extremely fine ($PM_{2.5}$) particles, while dust created by straw tilling and discing operations is comprised mostly larger particles as shown in Table 10.

Table 10

Relative Emissions of $PM_{2.5}$ and PM_{10} for Rice Straw Removal Activities

Operation	< 2.5 μm	< 10 μm	> 10 μm
Straw Burning Smoke	92%	97.6%	2.4%
Diesel Exhaust	94%	96%	4%
Tilling/Discing Dust	10%	45%	55%

Atmospheric simulation modeling shows that the $PM_{2.5}$ particles from burning, which are

18 *Evaluation of Dust Particulate Matter Suspension Time and Travel Distance in Ambient Air*, Draft ARB report, Tony Servin, January 13, 1995.

lofted high into the air, stay airborne for days and travel further than particles from diesel exhaust or soil preparation activities. Dust particles from soil preparation operations, which are predominantly made up of particles larger than 2.5 μm, generally stay airborne for a significantly shorter time than particles from diesel exhaust. The significance of emissions in smoke traveling farther and remaining in the air for a longer time is that they increase the potential of affecting populated areas down wind.

Overall, fine particulate emissions are greater from burning than soil incorporation or offsite removal. Soil incorporation produced fewer total PM_{10} emissions and also proportionally less fine particulate ($PM_{2.5}$) than burning. While diesel exhaust emissions result from offsite removal, from a fine particulate standpoint the emissions are relatively small compared to those from burning. However, from the toxics standpoint diesel particulate is a concern. The Board has listed particulate emissions from diesel-fueled engines as a toxic air contaminant and reducing the health risk from diesel-fueled engines is a high priority.

Air Quality Assessment

The primary objective of the Act was to improve air quality by phasing down the burning of rice straw. An analysis of existing air quality trends is first presented in order to establish the seasonal variability of poor air quality due to particulate matter.

This analysis addresses the impacts of all agricultural burning on air quality. Although rice straw burning represents about 80 percent of all agricultural burning done in the Sacramento Valley, other agricultural burning has similar air quality impacts. For this analysis, fall includes the months of September, October, and November, and spring includes March, April and May.

Particulate Matter Sampling

PM_{10} is monitored at 18 sites in the Sacramento Valley using the official measurement method for determining compliance with the air quality standard, the size selective inlet (SSI), high volume sampler. The PM_{10} samples are collected throughout the year, every sixth day for a 24-hour period. During the fall intensive burning season in the Valley, the sampling interval is increased to every third day at most sites. In addition, eight Tapered Element Oscillating Microbalance (TEOM) monitors record PM_{10} concentrations on an hourly basis. SSI data were used for most of the analyses in this section. Analysis of potassium ion concentrations in particulate samples indicates that biomass burning is responsible for about four to five percent of the PM_{10} in the Valley.

Air Quality Trends

Figure 2 shows the monthly average PM_{10} concentrations in the Valley for the period from 1992 through 1998. Monthly average PM_{10} concentrations begin to increase beginning in May, with the highest levels being reached during September through November. Note, however, that peak concentrations can occur in the fall or the winter months. This is primarily because fall and winter meteorology is not conducive to good dispersion of pollutants. During the spring, there is better vertical and horizontal mixing of the atmosphere that enables the particulate matter and smoke to be dispersed and diluted more completely. Figure 3 shows the monthly distribution of frequencies of basin exceedance days of the State PM_{10} standard, again averaged over the period from 1992 through 1998. A basin exceedance day is a day on which one or more sites in the Valley recorded an exceedance of the standard. As Figure 3 shows, the 24-hour state standard for PM_{10} has been exceeded more often during the fall (on about 30 to 40 percent of days) than during the spring (on less than about 10 percent of the days). The fall burning program reduces or curtails burning on days when high particulate matter concentrations are expected.

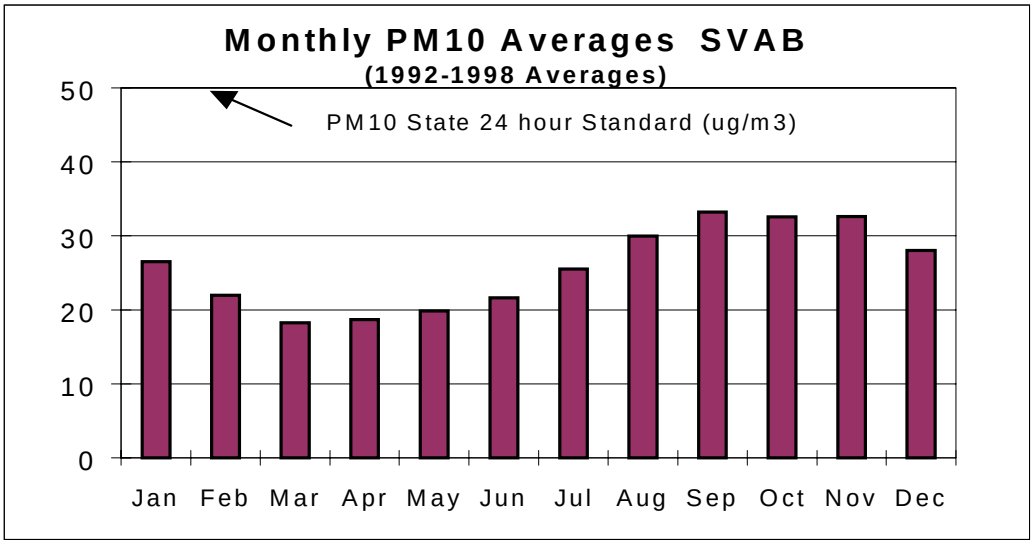

Figure 2

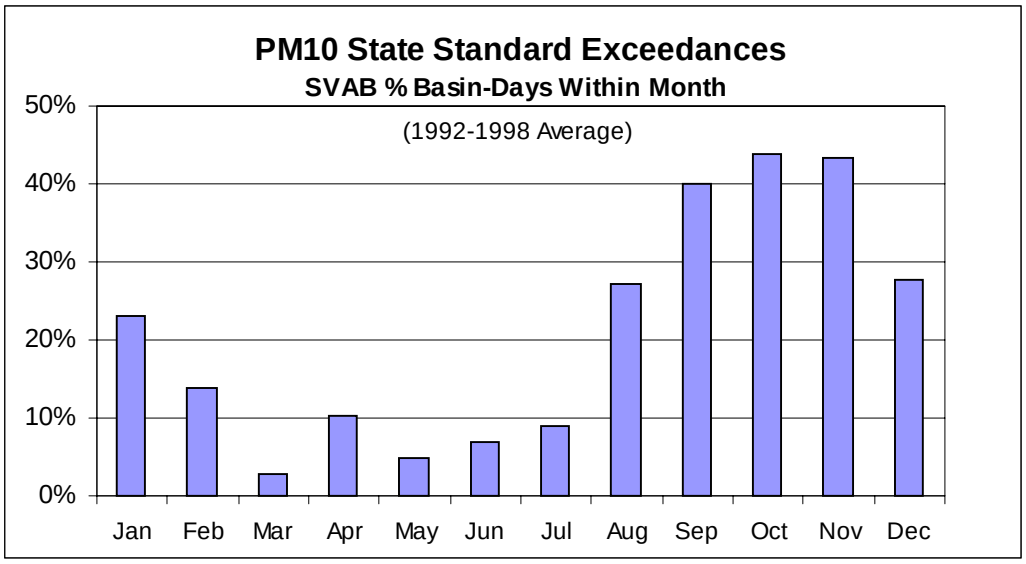

Figure 3

Figures 4 and 5 show for the fall and spring, respectively, the number of basin exceedance days of the State 24-hour PM_{10} standard in the Sacramento Valley for each of the past 12 years. These figures show that there have been more frequent exceedances of this standard during the fall than the spring between 1987 and 1998. These figures suggest that there has been little improvement in spring air quality during the phase down, even though that is the time when most of the rice straw burning was reduced.

Some improvement in fall air quality is indicated. However, there is an indirect correlation between the number of acres burned and the number of exceedance days. This is because the Burn Plan is designed to allow less burning when the air quality is poor and more burning when the air quality is better.

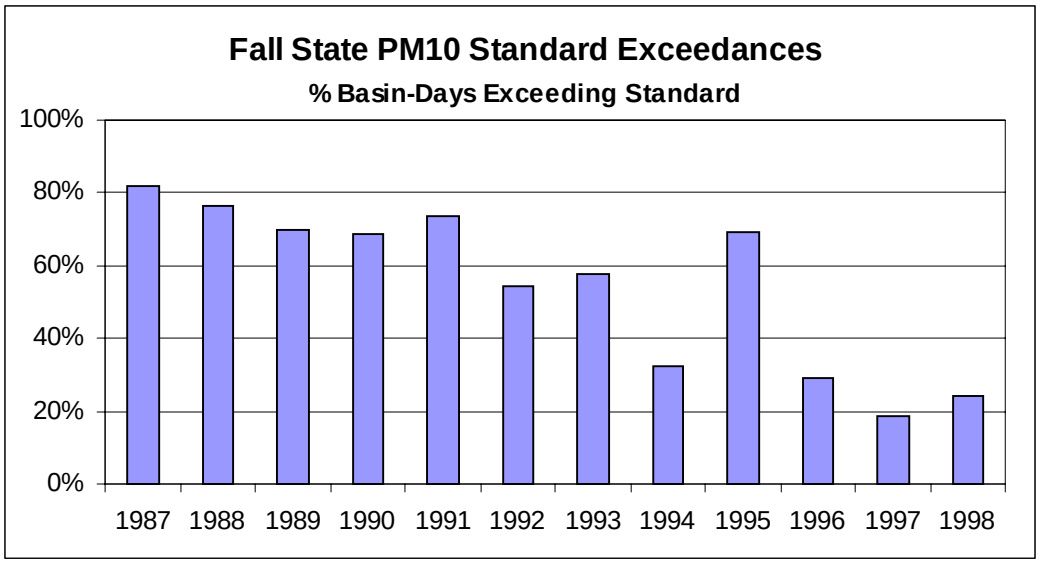

Figure 4

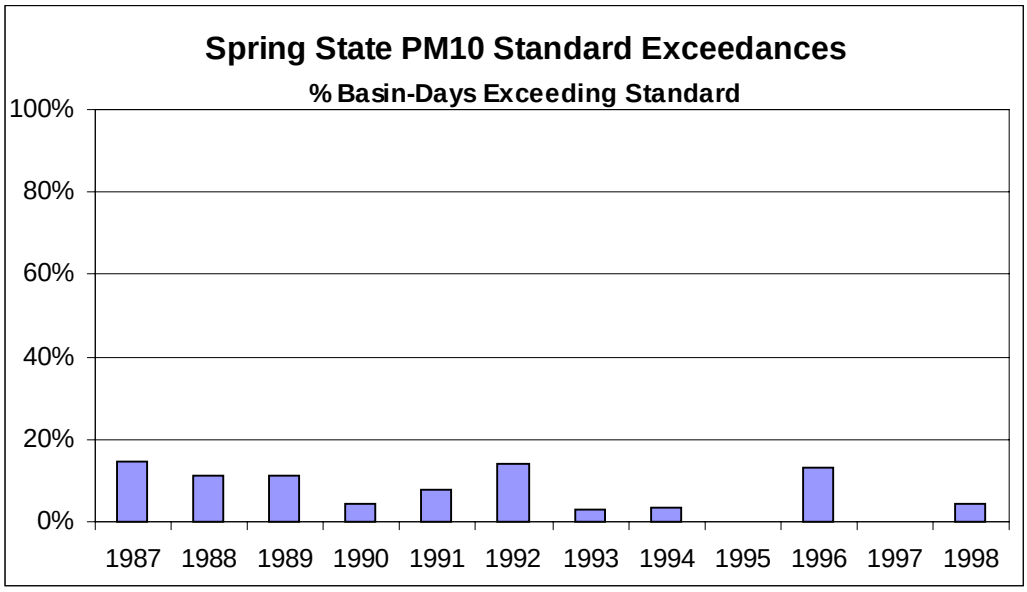

Figure 5

Air Quality on Burn versus No-burn Days

The ARB staff analyzed the average PM_{10} concentrations on burn days and no-burn days during the fall and spring. The analysis showed that air quality was markedly better on burn days than on no-burn days during the fall. While this may seem counterintuitive, it is to be expected because of the way the Burn Plan operates. Under the plan, if existing air quality is poor or if the atmospheric carrying capacity is limited, that day is declared to be a no-burn day. Other sources of particulate matter are not so easily restricted. While

burn days are cleaner than no-burn days during the fall, the reverse is true during the spring, although the air quality during the spring is much better than during the fall.

Figure 6 illustrates this occurrence during the fall of 1999 when smoke from wildfires caused poor air quality as indicated by the high coefficient of haze (COH) readings. The days on which the COH was at high levels were declared no burn days. On those days when the COH readings were relatively low, more burning was allowed.

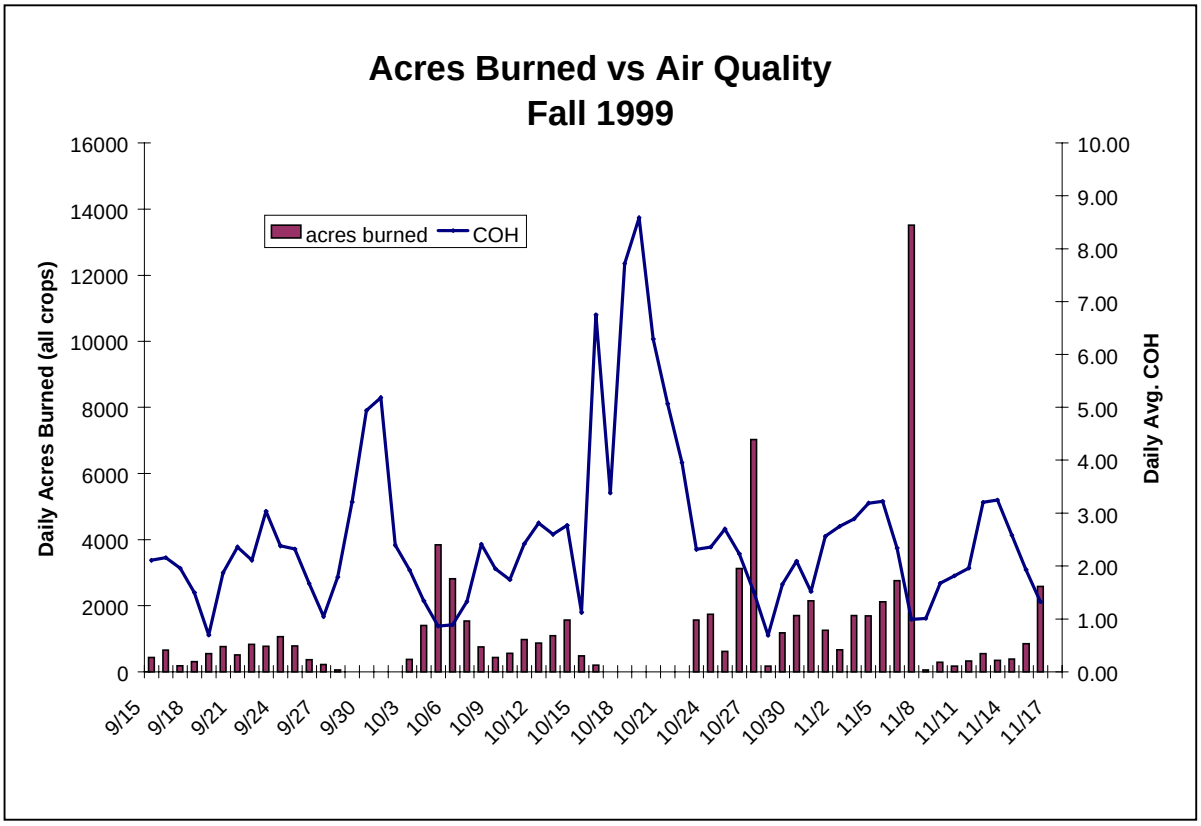

Figure 6

PM_{10} Hourly Concentrations on a Smoke Impact Day

While the smoke management program operates successfully the vast majority of the time, occasional problems do occur. The smoke episode discussed in this section, though extremely uncommon, is used to illustrate the climb of peak concentrations of particulate matter over 24 hours. The Burn Plan is specifically designed to avoid such acute incidences from occurring in urban areas.

While the state PM_{10} standard is based on a 24-hour averaging time, smoke impacts from burning are often of short (typically only a few hours) duration. Because of this,

particulate matter concentrations due to a smoke incident may be extremely high for part of the day, yet the 24-hour concentration may be quite low. A classic example of this was November 1, 1994, when a sudden change in weather conditions caused smoke from rice fires to inundate the Sacramento urban area. For a few hours, smoke impacts in downtown Sacramento were so high that visibility was limited to city blocks, yet the 24-hour PM_{10} concentration measured on that day either achieved or only slightly exceeded the state standard.

Figure 7 shows the hourly variation of PM_{10} concentrations at four sites in Sacramento County during that smoke episode. These data are from TEOM monitors, which record hourly PM_{10} concentrations. The corresponding, 24-hour average concentrations for the four sites are shown in the legend. The maximum hourly concentrations were between 100 and 200 $\mu g/m^3$, while the 24-hour averages ranged from 33 to 59 $\mu g/m^3$. Because the smoke impacts of this episode at the monitoring sites lasted for about four to seven hours, the peak concentration had only small impacts on the 24-hour PM_{10} measurements.

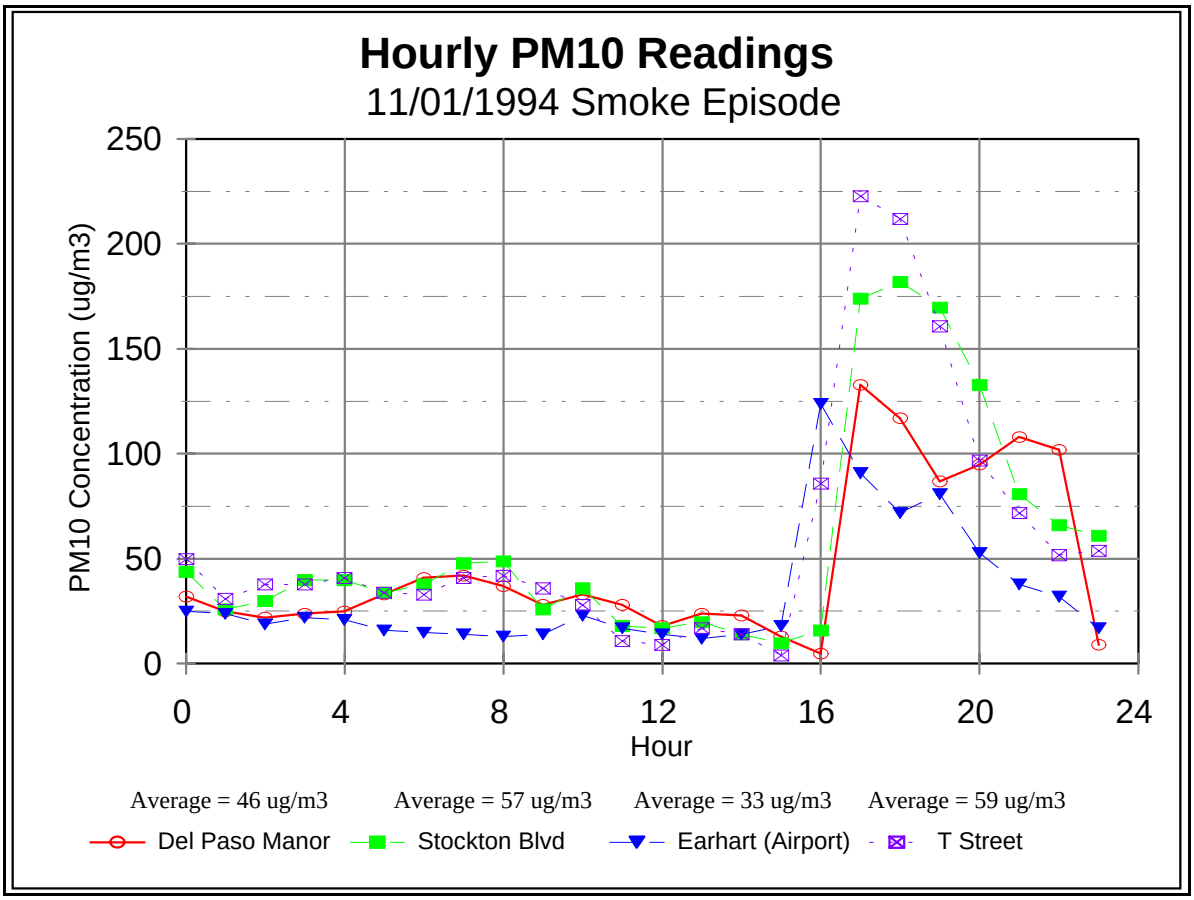

Figure 7

Air Quality - Smoke Complaints

The frequency of complaints from the public about smoke from agricultural burning is sometimes used as an indicator of the extent to which the public is subjected to impacts of smoke. While complaints may not be a true representation of smoke impacts, they can provide useful information about the smoke management program. The ARB and the districts track the number of smoke complaints during the fall intensive burn period. Complaints are received at the ARB's complaint hot-line (1-800-952-5588), the ARB's Meteorology Section, the ARB's Public Information Office, and the districts. Complaints received at the ARB are all referred to the Compliance Division, and they are immediately transmitted to the district of jurisdiction for investigation and response.

During the fall intensive burn season, a copy of each complaint from the Sacramento Valley is sent to the Meteorology Duty Desk. At 8 a.m. each morning, the total number of smoke complaints that the Compliance Division receives during the previous 24 hours is relayed to the ARB Meteorology Section and to the BCC. The complaints are then listed in the daily update of the intensive burn season statistics computer program, which is available to all the Sacramento Valley districts.

Complaints about specific, significant smoke impacts on urban areas are reviewed at meetings of the ARB and district staff that have direct responsibility for agricultural burning. There is usually one of these meetings a day or two following each significant smoke impact. The ARB meteorologists conduct a detailed study of the meteorological conditions that were present at the time of the smoke impact to determine the probable cause(s) of reported smoky conditions, and whether the weather forecast or the burn allocation decision contributed to the smoke problems. Significant complaints are also reviewed by the ARB and districts' staff at the end of the fall intensive burn season.

Table 12 shows the total number of such complaints received during each fall intensive burn season, for the first seven years of the phase down. During the last five years, complaints have decreased significantly.

Table 12

Smoke Complaints During the Phase Down Years
Intensive Fall Burn Season

Year	No. of Smoke Complaints
1992	57
1993	101
1994	336
1995	138
1996	124
1997	78
1998	43

Summary

Avoiding smoke impacts is the primary objective of the smoke management program. In years when fall meteorological conditions are more stagnant than usual, the effectiveness of the burn program is critical to preventing smoke exposures to sensitive populations or deterioration of existing air quality.

From a particulate matter standpoint, air quality in the Sacramento Valley is worse during the fall as compared to the spring. This is primarily due to meteorological conditions. Spring meteorology characteristically has better vertical and horizontal mixing of the atmosphere which enables the particulate matter emissions and smoke to be better dispersed. In the Sacramento Valley Air Basin, the State 24-hour standard for PM_{10} is exceeded on about 30 to 40 percent of the days during the fall compared with exceedances on less than about 10 percent of the days during the spring.

Emissions Reduction Credits

Background

The Act allows emission reduction credits (ERCs) to be issued to rice growers for reduced burning of rice straw (see section 41865(r)) as a means to partially offset the higher costs of straw disposal. In general, ERCs are reductions in emissions, beyond those required by law, from one source that are "banked" and sold for use by another source to "offset" new emissions. Unique to rice straw ERCs, the Act allows ERCs to be generated even by the reductions that are required by law. The issuance of ERCs for reduced burning of rice straw, the phase down of rice straw burning, and the Sacramento Valley Agricultural Burn Program are three separate programs.

The granting of ERCs to any source is generally based upon satisfaction of five basic criteria: the emission reductions must be actual; quantifiable; permanent; enforceable; and surplus. Normally the term “surplus” refers to emission reductions in excess of those required by any law, rule, or regulation. As stated above, however, the rice straw burning phase down law included a provision that guaranteed that the rice acres that are not burned will still be considered "surplus" for purposes of generating ERCs. Rice straw ERCs must comply with the other four criteria.

Moreover, pursuant to district new source review rules, ERCs are "discounted" prior to use. For example, if a one ton per day particulate matter ERC is generated, only 0.5 to 0.8 tons per day may be used by a new source, depending upon its location. This discounting is designed to help ensure that there is an air quality benefit from the ERC program.

In response to the Act, the ARB and the districts in the Sacramento Valley developed a uniform regulation that was adopted by all of the districts. Since adoption of the uniform regulation, however, some districts have amended initial application dates and made other changes that could allow larger quantities of ERCs to be generated for the same size parcel than other districts. The ARB is concerned about the air quality impacts of the credit program as well as the equity among districts and growers. The ARB is working with district staff to resolve the inequities, and the districts have formed a subcommittee to address these issues.

Current Status of Agricultural ERCs

Table 13 shows the amount of emissions in tons per year (TPY) for which agricultural burning ERCs have been issued to date. The majority of these are for rice straw burning reductions.

Table 13

Agricultural Emission Reduction Credit Certificates Issued

District	# ERCs Issued	ROG (TPY)	NOx (TPY)	PM_{10} (TPY)	SOx (TPY)	CO (TPY)
Colusa	8	18	10	19	4.5	163
Feather River	14	69	57	71		

When ERCs are requested by a grower, the district takes the following steps:

1. requests documentation that burning occurred on the field in the past;

2. calculates emission reductions based upon the acreage applied for and the fuel loading and emission factors for rice straw burning. Dr. Jenkins of U.C. Davis recently completed a study on rice burning emission factors for the ARB;

3. obtains specific field location using maps, crossroads, and section/township/range data for inspection and enforcement purposes;

4. issues an ERC certificate in the name of the applicant for the specific field and acreage;

5. places the ERC information in the electronic bank that maintains ERC data; and

6. removes that specific field from the agricultural burning database to ensure that the reduction is actual, permanent, and enforceable.

Air Quality Impacts

When considered as a single event, an ERC transaction is designed to result in a net air quality benefit when a particular field is removed from the burn list and the recipient of the ERC is allowed to emit only a fraction of the emissions had the field been burned. However, this may not be the case during the fall when there is a greater demand for agricultural burning. When a particular field is removed from the burn list by issuing ERCs, other growers who have fields ready to burn move up on the list to burn. Thus, burning emissions during the fall may not decrease while there are additional emissions from industrial sources using the ERCs.

Important to the rice program is that the Burn Plan may lessen some of the increase in emissions on critical days. The Burn Plan allows less burning (or no burning) on days when the ambient air quality is poor and meteorological conditions are less conducive to smoke dispersion. The Burn Plan has no control over industrial sources.

Economic Assessment of the Phase Down

This economic assessment provides estimates of revenues and production costs of a hypothetical rice grower using typical rice farming practices. This assessment focuses on the cost of soil incorporation as a result of the phase down.

Rice is the most widely planted crop in the Sacramento Valley, and California ranks second among states in rice production. The Phase Down Act has caused changes in rice straw disposal management. In the past few years, numerous efforts have been made to develop economically viable uses for rice straw. These efforts have been slow to develop. Most of the straw not burned is still incorporated into the soil. Soil incorporation accounted for 97 percent of the straw that was not burned in 1998. As alternative uses for rice straw develop, the cost of the phase down will decrease. Some growers may even be able to realize positive revenues from the sale of straw.

Soil incorporation is more costly than burning. The added costs have increased production costs of growing rice. The effect on individual growers, however, will vary. The production cost estimates used here are for the hypothetical farm using farming procedures considered typical.[19] In some cases, production costs and revenue estimates are averages valley-wide and do not represent any one farm.

Depending on the actual methods used, the cost of incorporation can range from a low of $8 to a high of $77 per acre. The weighted average is $36.31 per acre. When the cost of incorporation is averaged across all planted rice acres, it comes to about $20 per acre for the entire farm or about two to three percent of production costs. This estimated cost has not changed in the past two years. This average cost was calculated based on acres allowed to be burned (at $2 per acre) and acres required to be not burned (at $36 per acre.)[20]

Growers' incomes fluctuate primarily due to changes in yields and market prices. In 1997, the average rice yield increased substantially to near record levels. In 1998, however, the average yield declined sharply, but its impact on revenue was substantially offset by a corresponding rise in market price. Yields typically fluctuate yearly as a result of weather conditions and other factors such as disease, weed, and insect pressures.

19 For example, to estimate production costs, the UC Cooperative Extension Service assumes the hypothetical farm to be 700 acres, half of which is owned by the grower and the other half rented.

20 While growers burned less that allowed by the Act, acres allowed to be burned and acres required to be not burned was used to calculate the direct financial impact of the law.

Financial Impact

The per acre rice revenue varies widely from grower to grower depending on market prices of the crop, yields, and subsidies. Valley-wide averages are reported here. The average rice yield declined from 83 hundred pounds per acre in 1997 to 68 hundred pounds per acre in 1998. Before adding federal subsidies, revenues were $743 per acre in 1997 and $690 per acre in 1998. The transitional payments from the Agricultural Market Transitional Program subsidy added about $165 per acre in 1997 and $172 per acre in 1998 to growers' income. These payments are scheduled to end beginning in 2003. In addition, growers received about $78 per acre in federal emergency assistance payments in 1998. On a per acre basis, total average revenues were about $908 in 1997 and $940 in 1998. These estimates were calculated based on data provided by the Farmers Rice Cooperative and the Crop Exchange.

Based on estimates provided by the University of California Cooperative Extension, total production costs, including the costs to implement the phase down, were around $823 in 1997 and $842 per acre in 1998. Cash (out-of-pocket) costs were estimated to be about $654 in 1997 and $666 per acre in 1998. Non-cash (implicit) costs include the imputed cost of capital invested in land, equipment and the farmer's own labor. The non-cash costs were estimated to be around $169 in 1997 and $176 per acre in 1998.

Based upon these numbers, the hypothetical rice grower operating under typical farm practices and conditions is estimated to have gained, on average, about $85 in 1997 and $98 per acre in 1998. Most growers continue to operate, at least in the short run, as long as they can generate positive cash profits. Cash profits represent short-term profitability. The cash profit was around $254 in 1997 and $274 per acre in 1998.

On a regional basis, the phase down has cost growers about $10 million in direct costs from soil incorporation. After applying economic multipliers, the phase down appears to have reduced the output of goods and services produced in the region by about $19 million, with an estimate of 434 jobs lost. This represents about 0.04 percent of the Gross Valley Product and about 0.05 percent of the Valley's total employment. The impacts on Colusa County were most significant since rice growing is a major part of the county's economy, representing less than 2 percent of the Gross County Product.

Potential Yield Loss

Figure 8 shows the historic yield data, from the United States Department of Agriculture, for California rice starting 1960. As rice growers have pointed out, since the phase down started in 1992, rice yields have decreased, compared to the historic trend of increasing yields. Growers contend that this is because the phase down has necessitated straw

incorporation which increases diseases and may decrease yields. Currently, it is not known to what extent repeated incorporation decreases yields.

Staff estimated the economic effects for a potential yield loss of ten percent. The potential revenue reduction was estimated at about $24 million valley-wide, with Colusa County suffering the greatest loss at almost $7 million.

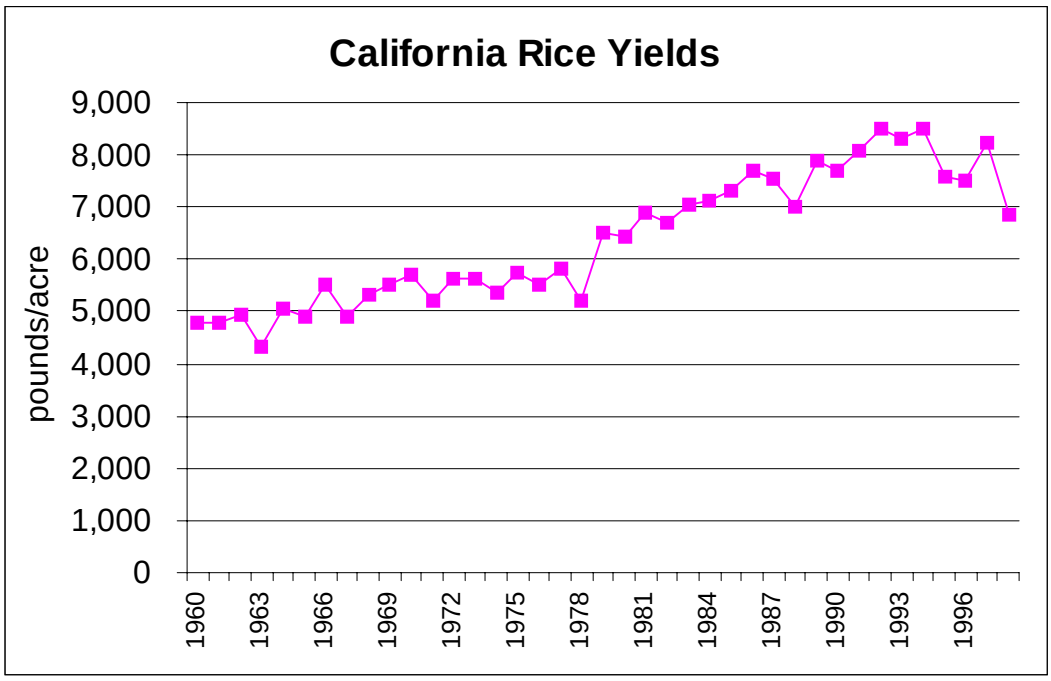

Figure 8

Public Comments on the Phase Down

To gather public input for this draft report, the ARB and the CDFA held two public workshops. The first workshop was held on June 29, 1999, at the ARB's main office in Sacramento. The second workshop was held on June 30, 1999, at the Colusa County Air Pollution Control District in Colusa. The Sacramento workshop was attended by 15 people, while the Colusa workshop had about 40 people in attendance. In addition to these workshops, staff received comments from stakeholders during telephone discussions and meetings before and after the workshops. During the extended comment period after the Board's November Public Meeting, the staff met with interested growers and district staff to discuss their concerns.

There is a general consensus among all stakeholders that additional efforts must be placed on developing alternatives to rice straw burning and soil incorporation. These alternatives could be encouraged through the use of additional financial incentives such as grants, loans, or tax credits. The ARB and CDFA staff agree and intend to continue their leadership role in promoting alternatives, particularly ethanol production.

Given the status of alternatives, rice growers continue to be concerned about the economic impacts of the phase down. Soil incorporation is more costly than burning, and has been shown to cause an increase in rice diseases and weeds, and may reduce yields. Some growers have stated that they would not object to reducing burning to 25 percent if 50 percent of the straw found alternative uses. In addition growers are concerned that the last increment of reduction in burning will be much harder to achieve than the first.

Some growers have also expressed concerns about the unknown environmental effects of the change in rice straw management. These concerns include:

- additional winter water consumption for flooding fields to decompose straw, with concerns about water availability during drought years;
- water quality, including foul smells, from stagnation in winter-flooded fields;
- impacts on waterfowl and pheasant habitats during winter;
- global warming concerns about additional methane production from incorporation of straw;
- possibility of increased winter flood risk from fields already containing water before rains begin;
- additional fuel being consumed in farm machinery to chop and incorporate straw into soil;
- more weeds in rice fields when straw is not burned, resulting in chemical use to

control weeds, and possible reduced rice yields;
- more use of chemicals to control rice diseases when straw is not burned; and
- concerns about impacts on rice handling infrastructure, including harvesters, trucks, and dryers, resulting from a shorter harvest period to allow more time for processing straw in the fields.

For the next progress report, staff will work with stakeholders to identify the available information on potential environmental effects of the changes in rice straw management and evaluate whether further research is needed.

From a public health perspective, other stakeholders commented that burning in the fall is the least attractive option because of the less favorable meteorological conditions and that an effective smoke management program is important to minimize the impacts of all burning. In general, rice growers agree that an effective smoke management program will help reduce public health impacts. In addition, rice growers urge the ARB and CDFA to educate the public that not all smoke impacts are due to the burning of rice straw.

The ARB and CDFA understand and appreciate these concerns. In addition to aggressively pursuing a workable alternatives program, the ARB and CDFA support the use of an effective smoke management program.