Eastern Research Group, Inc.

Non-Burning Management Alternatives on Agricultural Lands in the Western United States

Volume II:

Non-Burning Management Alternatives and Implementation Plan Strategies

FINAL

Prepared for:

The Fire Emissions Joint Forum of the Western Regional Air Partnership

May 15, 2002

Enviro-Tech Communications

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NON-BURNING MANAGEMENT ALTERNATIVES ON AGRICULTURAL LANDS IN THE WESTERN UNITED STATES

VOLUME II:

NON-BURNING MANAGEMENT ALTERNATIVES AND IMPLEMENTATION PLAN STRATEGIES

FINAL

Prepared for:

The Fire Emissions Joint Forum of the
Western Regional Air Partnership

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DISCLAIMER

This document was developed for the Fire Emissions Joint Forum (FEJF) of the Western Regional Air Partnership (WRAP) by Eastern Research Group, Inc., (ERG) and Enviro-Tech Communications. Although the contents of this report have undergone extensive review by the FEJF, the opinions, findings, and conclusions expressed represent those of ERG and Enviro-Tech Communications and not necessarily those of the members of the FEJF.

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ACRONYMS

ADEC	Alaska Department of Environmental Conservation
AK	Alaska
ARMS	Agricultural Resource Management Study
ARS	Agricultural Research Service
AZ	Arizona
CA	California
CARB	California Air Resources Board
CDFA	California Department of Food and Agriculture
CGE	computable general equilibrium
CO	Colorado
CO_2	carbon dioxide
CRP	Conservation Reserve Program
DEQ	Department of Environmental Quality
ERG	Eastern Research Group, Inc.
ETC	Enviro-Tech Communications
FEJF	Fire Emissions Joint Forum
FSA	Farm Service Agency
GIS	geographical information system
HI	Hawaii
ID	Idaho
KBG	Kentucky bluegrass
MT	Montana
NASS	National Agricultural Statistics Service
ND	North Dakota

NM	New Mexico
NO_x	nitrogen oxides
NRCS	National Resources Conservation Commission
NV	Nevada
OR	Oregon
PM_{10}	particulate matter less than 10 microns in aerodynamic diameter
QA/QC	quality assurance/quality control
RIMSII	Regional Input Output Modeling System, version 2
RL	residue loading (tons/acre)
SD	South Dakota
UC	University of California
USDA	United States Department of Agriculture
U.S. EPA	United States Environmental Protection Agency
UT	Utah
WA	Washington
WESTAR	Western States Air Resources Council
WGA	Western Governors' Association
WRAP	Western Regional Air Partnership
WY	Wyoming

EXECUTIVE SUMMARY

The Western Regional Air Partnership and its Fire Emissions Joint Forum (WRAP/FEJF) sponsored this project to investigate the alternatives to agricultural burning. The geographical scope of the project includes the 15 Western states of Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, North Dakota, New Mexico, Nevada, Oregon, South Dakota, Utah, Washington, Wyoming, and the tribal lands within these states.

The objectives of this project were designed to facilitate the development of crop production and agricultural burning activity data to support analysis of alternatives to burning, and they include:

- Development of a crop production database and an agricultural burning activity database;
- Identification of the "universe" of potential non-burning management alternatives;
- Design of a methodology to assess the impacts of alternatives (e.g., agronomic, environmental, economic, etc.);
- Identification of existing and potential accountability mechanisms for tracking if, and which, non-burning alternatives are used by federal, state, local, and tribal entities, and potential barriers to their implementation; and
- Development of a plan for implementing alternatives in the 15 Western states.

This analysis was supported by a three-tiered approach to research. The three tiers of sources included: (1) federal agencies such as the U.S. Department of Agriculture (USDA) and the National Agricultural Statistics Service (NASS); (2) agencies such as the University Agricultural Extension Services and state air agencies; and (3) private consortiums such as growers, producers, distributors, and information clearinghouses.

The results of this project are documented in two reports under the title "Non-Burning Management Alternatives on Agricultural Lands in the Western United States," Volume I and Volume II.

Volume I: Agricultural Crop Production and Residue Burning in the Western United States

The goal of the crop production database was to compile acres harvested by crop at the county level for all major crops harvested and/or crops known to be burned in each of the 15 Western states. The crop production database was developed from three main sources of information:

1. The NASS database;
2. State agricultural statistics data and reports; and
3. The 1997 Census of Agriculture.

Also, the Farm Service Agency (FSA) website was used to obtain information on lands included in the Conservation Reserve Program (CRP). Although the target year for these data was 1996, it was necessary to include 1997 data when 1996 data were missing for crops that were known to be burned. The crop database underwent an extensive quality assurance/quality control (QA/QC) process to ensure that at least 90 percent of the acres harvested of major (i.e., top 10) crops and 100 percent of all crops burned were accounted for in the database. In total, over 50 different crops were grown in the 15 Western states which amounted to nearly 77,000,000 acres harvested in a single year during the 1996/1997 timeframe. The resulting county-level data were mapped using a geographical information system (GIS) (see Appendix B).

The agricultural burning database was developed for purposes of identifying the extent of burning in the Western states, and to assist with the emissions inventory being developed by the WRAP/FEJF. The burning database was compiled from three types of data representing various geographical areas within the 15 Western states region:

- Burn permits issued or other mechanisms for determining actual burn activity;
- Emissions inventory estimates;
- Anecdotal information from surveys sponsored by the WRAP/FEJF, the Western States Air Resources Council (WESTAR); and
- Data resulting from peer review of the draft agricultural burn activity database prepared for this project.

Although a significant amount of data were obtained, burning was known to occur in certain counties and states for which data were unavailable. A gap filling technique was developed to provide estimates of acres and residues (tonnage) burned at the county level for those unaccounted areas (i.e., North Dakota, New Mexico, and South Dakota). Table ES-1 shows the results of the overall database in terms of average percentage of acres burned by crop. The resulting county-level data were mapped using GIS (see Appendix D).

Although the data that were collected and compiled were subject to specific QA/QC procedures, some of the data and results have inherent uncertainty. These uncertainties are due to such factors as use of "as is" data sets provided by the various sources and an inconsistent definition of "agricultural burning" within these data sets. Also, the gap filling averages used to provide missing data in some states cannot accurately depict actual burn activity that occurred in those states. Even for some areas where gap filling was not used, information originally provided for the draft database was revised with significantly different information obtained during the peer review process (e.g., Utah). While it can be concluded that the peer review process worked in this case, this result is illustrative of the need for a coordinated, systematic process to collect agricultural burning data, establish data quality objectives, and resolve conflicting data.

The researchers and peer reviewers contributing to the final agricultural burn activity database made the following recommendations pertaining to future improvements of this database:

1. Develop a mechanism (e.g., program, regulation, etc.) whereby the relevant state, county, tribal, agricultural, and stakeholder entities establish data quality objectives, define data sources, and compile data on a regular basis to estimate the extent of agricultural burning in the Western United States. Also, this mechanism should provide a consistent definition of the residue types to be included in the agricultural burning category.

2. Conduct research to identify and/or calculate specific yield-based RL factors for each geographical zone or area; and

3. Incorporate the impact of irrigated and nonirrigated land agricultural practices.

Table ES-1. Average Percentage of Acres Harvested that are Burned for Selected Crops in the Western United States

Crop	Acres Harvested[1]	Acres Burned	Overall Average Percentage of Acres Burned
Wheat	31,619,000	905,756	2.9%
Rice	500,000	254,706	50.9%
Corn	5,766,000	10,668	0.2%
Barley	5,696,900	137,872	2.4%
Sugarcane	42,900	30,000	69.9%
Orchards (Trees, Bushes, Vines)	2,497,767	530,100	21.2%
Grasses and Seeds	899,976	394,077	43.8%
CRP	286,174[2]	28,917	10.1%

Notes:

[1] Acres harvested and burned are for the 15 Western states, excluding Nevada because burning in that state was not identified for specific crops .

[2] Value represents number of acres in the Conservation Reserve Program (CRP).

Volume II: Non-Burning Management Alternatives and Implementation Plan Strategies

The majority of information collected and reviewed in this study suggests that states, local agencies, tribal communities, and fire control experts agree that the development and use of non-burning alternatives is desirable. However, identification, development, and use of these alternatives throughout the 15 Western states and tribal communities appears to be in the fundamental research stages. This fact, in combination with the lack in most states of formal requirements to implement non-burning alternatives, made identification and characterization of alternatives a difficult task. Over 20 different non-burning alternatives were identified in the following categories:

1. Leave residues in place either with or without infield residue treatment (e.g., cut, mulch, and drop in place; soil incorporation);

2. Improved management practices and scientific advancements in horticulture (e.g., genetic selection for disease/pest resistance or less fuel residual);

3. Alternative land use (i.e., conservation tillage; land conversion to non-agricultural use; and plant crops with residues that do not need to be burned); and

4. Residue collection and hauling for use offsite (e.g., haul to waste or landfill facility; haul to ethanol production facility).

In order to determine the reasonableness, or feasibility, of implementing non-burning management alternatives, it is important to assess the impacts they have on agriculture, the environment, and other aspects of society. In this study, the impacts to non-burning alternatives were defined and criteria were established for assessing their effects and determining the feasibility of implementation. The range of impacts due to implementation of non-burning alternatives included:

- Agronomic impacts—what happens to the agricultural production unit when an alternative is implemented, what the grower must do on the land and how does that change affect the productivity of the land;

- Environmental impacts—what effect does the alternative have on visibility, air quality, water quality, wildlife, and other vegetation;

- Health and safety impacts—what hazards do alternatives present in the workplace when implemented;
- Energy impacts—what are the impacts due to use of agricultural waste to produce energy;
- Economic impacts—what is the cost of implementation considering the difference in cost of agricultural operations between the traditional burning operation and the new alternative approach;
- Social and equity issues—beyond cost considerations, how are the growers, tribal communities, and other groups, affected by non-burning alternatives, and what is the equity of controlling some burning/crops and not others; and
- Political issues—when promotion of non-burning alternatives tends to antagonize farmers and agricultural interest groups.

Criteria were developed to evaluate each potential impact relative to a particular crop/alternative combination. A rating scheme using feasibility factors was developed that can be applied to the potential impacts relevant to each alternative being evaluated (e.g., 0 = No impact; 1 = Some impact/problem; 2 = Definite problem; and 3 = Major problem). High ratings indicate worse impacts relative to low ratings. This methodology is demonstrated in two case studies (for rice straw and grass seed) in order to show how to quantify some impacts (e.g., cost-effectiveness) and apply feasibility factors. As an example, the results showed for rice straw that the average feasibility factors for the non-burning alternatives ranged from 1.1 (least negative impact) for alternatives such as Cut/Collect and Haul to Ethanol Production Facility, to 2.1 (most negative impact) for Land Conversion to Non-Agriculture.

Accountability mechanisms are procedures used for tracking if, and to what extent, non-burning alternatives are used by local, state, tribal, or federal entities. In-place mechanisms are categorized and discussed. How the mechanisms support or promote the use of non-burning management alternatives is described in the implementation section (Section 7.0 of Volume II). The information gathered on accountability mechanisms came from state, county, local, and tribal environmental authorities representing all 15 Western states. The 17 different accountability mechanisms were identified in the following categories:

a. Accountability initiated at the state or regional level (i.e., exemption or inclusion of agricultural burning in regulations);

b. Accountability at the state or local level that supports active regulation of agricultural burning activities (e.g., existing regulations or rules addressing agricultural burning activities);

c. Accountability at a programmatic level that supports a formal approval and/or permitting process (e.g., smoke management programs);

d. Mechanisms that encourage accountability at the local level and provide information for applying non-burning alternatives to current agricultural burning practices (e.g., fuel types burned, emissions tracking); and

e. Mechanisms that facilitate and encourage the use of non-burning alternatives (e.g., pre-burn permits, financial assistance).

The presence, or in some cases absence, of accountability mechanisms appears to be an indicator of whether non-burning alternatives will be used in the Western states. In general, for states with aggressive mandates to reduce agricultural burning such as Washington, Oregon, and California, many accountability mechanisms are in place. These states also have the largest number of non-burning alternatives in use. An important finding, which served to complicate the identification and interpretation of information on accountability mechanisms, was the inconsistent definition of "agricultural burning" in the 15 Western states. For example, in some areas irrigation ditch, fenceline, and weed or land clearing for range land improvement is included in regulations covering agricultural burning; in other areas these are not addressed.

Non-statutory administrative barriers are those situations, circumstances, activities, or factors that serve to minimize, deter, or prevent the active use of non-burning alternatives. Eighteen barriers that fall into the following four categories were identified:

- *Economic challenges* including labor costs; increased liability; disposal, storage, packaging, or transport costs; availability and/or willingness of investors to provide capital for new technologies or non-traditional methods; market return; crop yield, quality, and production rates;

- *Geographical limits* due to climate or topography;

- *Political, cultural, or religious practices* including activities that center around agriculture/harvest activities or tribal ceremonies; historical promises of land as a lure to relocate;

- *Public acceptance* of a practice or program result (which may be closely tied to aesthetics); and

- *Aesthetics* including visual, olfactory, and auditory impacts, but possibly nuisance due to plant debris or dust in or near homes and businesses.

A strategy for increasing the development and use of non-burning alternatives is described as applicable to the 15 Western states. A detailed discussion lays out the critical elements of an effective implementation plan, including items such as developing a strategic plan, allocating resources, and providing consistent program implementation. Based on the results of this study and the suggested guidelines, recommendations were made for developing an successful non-burning alternatives program at the state, local, and tribal level:

1. Air quality or environmental program entities should conduct a focused review to identify the nature and extent to which agricultural burning contributes to air quality problems in the state, or local, or tribal area. A starting point for this review could be the evaluation of agricultural burning activity such as that presented in Section 3.0 of Volume II. A key element of this review that should be included is a careful consideration of the definition of "agricultural burning". This is important so that accurate comparisons can be made between other state, local or tribal programs.

2. If agricultural burning does not contribute significantly to local or statewide air quality problems which fall under the jurisdiction of the state, local or tribal entity, it is still recommended that the focused program assessment also take into account, to the greatest extent possible, the potential impacts agricultural burning may have on interstate regional air quality.

3. If agricultural burning is not found to be a significant source of air pollution for a given state, local region, tribal entity, or interstate region, it may not be necessary to continue with non-burning alternatives program development.

4. If agricultural burning is found to make a significant contribution to air quality problems on either a local, state, tribal community, or regional level, then the air quality or environmental agencies in authority in the affected areas and the areas contributing to the problems should work together to define solutions and develop non-burning alternatives programs. This will help to ensure success on a regional level.

5. If agricultural burning is found to be a significant source of air pollution for a given state, local region, tribal entity or interstate region, or if a given entity desires to more effectively implement non-burning alternatives, then an overall air quality review should be conducted to determine how to integrate agricultural burning. One goal of this review would be to determine which of the accountability mechanisms identified in Section

5.0 of Volume II are in place and how they are being used. Table 5-2 of Volume II can be used to determine specific accountability mechanisms and tailor the agricultural burning program.

6. For those states, local regions, and tribal entities desiring to more effectively address the use of non-burning alternatives in general, it is recommended that a list of effective and economically viable non-burning alternatives be developed (ideally including non-burning alternatives for use by crop, by season, and by region or area). Table 2-1 of Volume II (listing of non-burning alternatives by crop) can be used to identify specific alternatives. The criteria, methodology, and case studies described in Sections 3.0 and 4.0 of Volume II can be used to determine feasibility.

7. It is further recommended that a list, or in some cases multiple lists, of feasible non-burning alternatives should be maintained and updated periodically by the participating lead public or private entity. The list(s) should be made available using a variety of common effective communication strategies, methods, and technologies.

8. If non-burning alternatives have not been previously identified or have not been characterized for practical use an area, it is recommended that air quality and environmental entities work closely with university and agricultural extension scientists, affected agricultural community stakeholders, and interested members of the public to identify and characterize non-burning alternatives for specific use in their state or region.

9. WRAP member states should form a technical working group or task force to systematically identify and review the current use of non-burning alternatives and to make recommendations, if desired, on how and where the use of these non-burning alternatives may be improved or enhanced in other states, local regions, and tribal communities.

10. WRAP member states should work together to begin to address ancillary non-emission related program implementation issues, such as assisting the affected agricultural community and local business developers with post-residue removal product development, manufacturing, distribution, and marketing. Although this often falls outside the traditional charter of most state air quality and environmental programs, it does not fall outside the realm of services offered by other state agencies, boards and environmental departments. Some states have taken steps to assist in the research and development stages but their efforts have not extended to distribution and marketing.

11. It is highly recommended that the results of this and any of the above mentioned program efforts be carried out in close coordination with a well defined stakeholder outreach, education and communication program.

The agency roles and responsibilities associated with the identification, development, and implementation of non-burning alternatives are not clearly identified for any of the 15 Western states. It is recommended that as non-burning alternatives programs are reviewed and developed in the future, that the air quality or environmental agency responsible for developing the non-burning alternatives program (see Recommendation 4 above) be the agency responsible for monitoring and implementation. Regional approaches to defining responsibility for non-burning alternatives programs are also needed. This is in response to instances such as the relocation of grass seed companies within the last five years from Washington and Oregon to Wyoming where there are relatively less stringent air quality regulations.

A well designed, closely coordinated, and consistently implemented stakeholder involvement, outreach, and communication effort is essential to the success of any non-burning alternatives program. Stakeholder involvement is not only an important way to encourage the use of non-burning alternatives, it will be key in developing future alternatives to infield burning of agricultural residues.

A number of directions for further research and information development are recommended for the Western states and tribal communities in order to increase knowledge and encourage use of feasible non-burning management alternatives:

- Better characterization of agricultural burning activities in the 15 Western states and tribal communities, including development of a consistent definition for “agricultural burning”;
- More thorough collection and evaluation of agricultural burning activity data (e.g., daily acres burned by county, permits records, etc.) by regulatory agencies and stakeholders;
- More thorough assessment of the air quality impacts from agricultural burning;
- On-going investigation into effective non-burning alternatives;

- Effective inclusion of stakeholders in the identification and implementation of non-burning alternatives; and

- Development of a well designed, consistently implemented stakeholder outreach, education, and communication programs that address local, state, tribal, and regional issues pertaining non-burning alternative program implementation.

1.0 INTRODUCTION

Air emissions from burning agricultural residue, primarily consisting of fine particulate matter (CARB, 1996), can impact visibility in Class I areas located near burns, as well as those Class I areas located far away through regional transport. The Western Regional Air Partnership (WRAP) and its Fire Emissions Joint Forum (FEJF) sponsored this study to assess the non-burning alternatives to infield burning of agricultural residues, including their impacts on the environment, economy, health and safety, society, politics, and on the business and productivity of the agricultural industry. This study was performed under the Western Governors' Association (WGA) Contract 30203-31 by Eastern Research Group, Inc. (ERG) and Enviro-Tech Communications (ETC).

In the context of this study, "agricultural burning" is defined as the burning of organic crop residue consisting of field crops, wood, and leaves. Also, the burning of ditch banks adjacent to, or associated with, crop production are included in this evaluation of alternatives to agricultural burning. The geographical scope of the project includes the 15 Western states of Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, North Dakota, New Mexico, Nevada, Oregon, South Dakota, Utah, Washington, and Wyoming, as well as tribal lands in these states.

The temporal scope of the data collected for this project was 1996, chosen to coincide with the WRAP base year emissions inventory effort. However, as described herein, it was necessary to use data from 1997 or other years in some cases when 1996 data were not available. This use of various years of data is an important limitation of the results of this project. There is no assurance that 1996 crop production acreage, for example, is indicative of 2001 acreage due to factors such as increasing urbanization and regulatory impacts. Also, crop rotations will impact year-to-year variations.

1.1 Study Objectives

The objectives of this study are diverse. They are designed to facilitate development of crop production and agricultural burning activity data to support analysis of the alternatives to burning—which is the main objective of this study. Also, these data are used for

estimating emissions from agriculture burning under another project. The specific objectives of this study are as follows:

1. Identification of crops grown and the extent to which residue is disposed of through burning for the 15 Western states. The goal is to develop county-level estimates of acres harvested and acres (or residues) burned by crop for each of the 15 Western states.

2. Display of the crop and residue burned data using a geographical information system (GIS). The goal is to illustrate the level of crop production (acres harvested) and agricultural burning (acres or residues burned in tons) within the 15 Western states. The GIS maps provide a useful means to compare burning activity county-to-county, and to ensure that all available data are included and that gap-filling procedures provide accurate results.

3. Identification of potential alternatives to agricultural burning and characterization of their agronomic, environmental, health and safety, social, economic, and political impacts. A three-tiered approach to collecting information on the potential impacts to non-burning alternatives is employed. The three tiers include: (1) federal agencies such as the United State Department of Agriculture (USDA); (2) state agencies such as the University Agricultural Extension Services; and (3) private consortiums such as growers, producers, distributors, and information clearinghouses.

4. Development of criteria for selecting reasonable non-burning alternatives, cost-abatement curves (i.e., cost of alternative by crop), and examples of how to apply the criteria and cost-abatement curves (i.e., case studies) to evaluate alternatives. The goal is to develop a global methodology that can be used to assess the reasonableness of non-burning alternatives; thereby, minimizing the need for region-and crop-specific assessment when possible.

5. Identification of existing and potential accountability mechanisms for tracking if, and which, non-burning alternatives are used by federal, state, local, and tribal entities. The goal is to describe the specific mechanisms, mainly statutory and currently in-place (e.g., required burn permits, available financial incentives, agricultural burning exemptions, etc.), that support, promote, or hinder the implementation of non-burning alternatives.

6. Identification of existing and potential barriers to the use of non-burning alternatives including non-statutory barriers (e.g., public acceptance, cultural practices, etc.) and recommendations on how these can be overcome. This objective presents the “flip-side” of Objective 5

(accountability mechanisms) in order to understand the current limitations (i.e., non-regulatory) to new program development and implementation of non-burning alternatives.

7. Development of a plan for implementing a non-burning program based on the analysis, findings, and recommendations developed in this study. The goal of the implementation plan is to give the WRAP/FEJF a "course of action" for implementing the recommendations developed under this project. The plan recommends agency responsibilities for implementation, and methods for disseminating information to stakeholders such as private landowners and others who will ultimately be responsible for implementing non-burning strategies.

1.2 Data Collection Methodology

Data were collected for this project based on a three-tiered approach. The first-tier sources were expected to have the highest quality data; the second-tier sources were expected to have readily available data; and, the third-tier sources were anticipated to provide additional crop-, state-, or regional-specific information pertaining to the identification and use of non-burning management alternatives. The primary data sources used in this project were as follows:

- Tier 1 sources included the Farms Services Agency (FSA), Economic Research Service, National Agricultural Statistics Service (NASS), USDA within each state, several state Natural Resources Conservation Service (NRCS) offices, Federal Agricultural Research Centers;
- Tier 2 sources included land grant universities, joint agency working groups and task forces (e.g., California Advisory Committee on Alternatives to Rice Straw Burning), State Agricultural Research Centers, University Agricultural Extension Services, divisions or departments of pesticide management; and
- Tier 3 sources included various private consortiums, farmers, distributors, professional agricultural organizations, and information clearinghouses.

Specific data sources are discussed as they pertain to crop production and residue burning, and identification and implementation of non-burning management practices.

1.3 Document Organization

This document is organized into two volumes that address all of the objectives of the project. Earlier in-progress work was reported in three draft reports–the Task 1 Draft Report

which addressed Objectives 1, 2, and 3; the Task 2 and Task 3 Draft Report which addressed Objectives 4, 5, and (partially) 6; and, a Draft Final report which provided a complete initial analysis addressing all objectives. A detailed description of the content of the final Volume I and Volume II reports, and how the study objectives are addressed within each report is as follows:

- Volume I: Agricultural Crop Production and Residue Burning in the Western United States:

  - Section 1.0 describes the project background and objectives. This section also explains the data collection methodology and organization and content of the Volume I and Volume II reports.

  - Section 2.0 describes the development and results of the crop production database (Objectives 1 and 2). This section quantifies the level of crop production in each of the 15 Western states, including the number of acres harvested by crop and county. The results are presented in various tables and maps. A detailed quality assurance/quality control (QA/QC) procedure ensures the accuracy of the results.

  - Section 3.0 describes the development and results of the agricultural burning database (Objectives 1 and 2). This section explains the data collection and compilation procedure used to compile the burn activity data (e.g., acres and residues [tons] burned by crop and county). Also, since only limited data on actual burn activity is available in the 15 Western states, a gap-filling procedure is employed to provide estimates in states/counties where burning is known to occur, but records on specific quantities are not tracked. The results are presented in various tables and maps.

  - Section 4.0 provides relevant conclusions and recommendations pertaining to the crop production and agricultural burning databases.

  - Section 5.0 lists the references used in the development of Volume I, including reports, journal articles, websites, and personal communication.

  - Appendix A contains a listing of the crop production data (i.e., acres harvested by crop, county, state).

  - Appendix B contains the crop production GIS maps for each state.

- Appendix C contains listings of the agricultural burning activity data (i.e., residues burned [tons] by crop, county, state).

- Appendix D contains the agricultural burning activity GIS maps for each state.

- Appendix E contains relevant tables from Volume II.

- Volume II: Non-Burning Management Alternatives and Implementation Plan Strategies:

  - Section 1.0 describes the project background and objectives. This section also explains the data collection methodology and organization and content of the Volume I and Volume II reports.

  - Section 2.0 describes the "universe" of non-burning alternatives which are in-use, or have been used in the past in the 15 Western states (Objective 3). The alternatives are listed in a table based on applicable crop and by category (i.e., leave in place, scientific improvements, alternative land use, cut or collection and haul).

  - Section 3.0 presents a methodology for assessing the impacts of non-burning alternatives (Objective 4). First, the different types of potential impacts are described (i.e., agronomic, environmental, health and safety, energy, economics, social and equity issues, and political). Criteria are presented to assist in evaluating the relative feasibility of implementing alternatives (e.g., agronomic–soil compression, increased water use; economic–not cost-effective, substantial farm stress, etc.). A table shows available sources of information and expected outcomes of the analysis for each of the impacts. A methodology that can be used to evaluate these impacts for various crops/alternatives is described.

  - Section 4.0 contains two case studies that illustrate the methodology developed to analyze the impacts of non-burning alternatives (Objective 4). Impacts of non-burning alternatives for two significant crops (rice and grass seed) are described. The criteria developed in Section 3.0 are used to evaluate the impacts. Cost curves display the economic impacts of implementing non-burning alternatives.

  - Section 5.0 presents the accountability mechanisms currently in place, or practiced in the past for implementing and tracking progress of alternatives to agricultural burning (Objective 5). A table lists the 17 mechanisms identified through an extensive research effort, along with the state/county where each mechanism is employed.

— Section 6.0 describes the non-statutory administrative barriers currently existing at the state level for each of the 15 Western states (Objective 6). Where they exist, county- and local-level barriers are discussed, along with barriers affecting tribal communities' ability to implement non-burning alternatives.

— Section 7.0 provides a summary of strategies for increasing the development and use of non-burning management alternatives on agricultural lands in the 15 Western states (Objective 7). A summary of the overall results of the entire project is presented along with conclusions and recommendations for future work. The contents for each section of a "state-specific" implementation plan are described, strategies to address stakeholder involvement are given, and suggestions for further research and information development are made.

— Section 8.0 lists the references used in the development of Volume II, including reports, journal articles, websites, and personal communication.

— Appendix A contains a detailed listing of the participants (i.e., name, affiliation, phone, fax, e-mail) contacted as part of the informal survey conducted for this study.

— Appendix B gives a project case study (Alaska Agriculture Project, Delta Junction) that presents realistic information on the success and challenges encountered when developing and implementing a non-burning program in the West.

— Appendix C contains relevant tables from Volume I.

2.0 IDENTIFICATION OF NON-BURNING ALTERNATIVES

This section describes the research approach used to identify and characterize non-burning alternatives to infield burning of agricultural residues. Non-burning alternatives that are currently in use, or have been used in the recent past, by crop residue (i.e., fuel type) within the Western states are discussed.

2.1 Research Strategy and Sources of Information

The identification of existing non-burning alternatives is a complex task. In some states, there are formal requirements to consider alternatives to infield agricultural burning of residues prior to conducting field burning activities; however, there are typically no formal requirements to actually implement non-burning alternatives. Information regarding the availability, applicability, and cost effectiveness of non-burning alternatives is typically not provided by the states. If alternatives are routinely used, the degree to which non-burning alternatives are implemented is often not formally tracked. To collect the desired information and to address the expectedly wide distribution of information sources, a systematic strategy to collect necessary data was developed.

A comprehensive three-tiered approach was employed to identify and research the various potential sources of information. The first level of sources included state environmental agencies, boards and departments; their respective published reports and documents; and articles and summary information posted on official state level websites. It was expected that if any requirements to implement non-burning alternatives were in place at the state level (and if any non-burning alternatives were identified, available, and in use) that this would be known by state environmental agency contacts who had responsibility for implementing the agricultural burning programs (Appendix A).

For states with aggressive mandates to reduce agricultural burning (e.g., Washington, Oregon and California) quality information on non-burning alternatives was readily available. For those states with less aggressive smoke reduction programs or no formal requirements to address agricultural burning, little or no direct information on non-burning

alternatives was available. In these cases, additional contact persons and/or potential sources of related information were obtained by talking with contact persons at the state environmental agency, board and department level.

The additional contact persons and/or information sources identified were typically directly affiliated with state or federal agricultural agencies. These comprised the second level of information sources. The second level sources included state and federal agricultural research centers, state university agricultural extension services offices, individual university agricultural researchers, officially published research documents and reports, and information posted on agricultural research related websites. For some states, the second level sources extended to official state sanctioned or mandated, working groups that were examining agricultural burning. These working groups were usually comprised of representatives from the agricultural community, as well as state agricultural and state environmental agencies.

As the first and second level sources were investigated, a few third level sources were identified. The third level information sources included various private businesses and alternative agricultural information clearinghouses.

The first and second level sources which have provided information pertaining to the identification and use of non-burning alternatives in each of the 15 Western states and tribal lands, include in addition to other sources, the following:

- Informal telephone survey of state agencies (see Appendix A for a complete list of contacts).
- California Air Resources Board:
  - "The Economic Impacts of Alternatives to Open-Field Burning of Agricultural Residues" (CARB, 1993);
  - "Alternative Uses of Rice-Straw in California" (CARB, 1997a);
  - "Progress Report on the Phase Down of Rice Straw Burning in the Sacramento Valley Air Basin 1995-1996: 1997 Report to the Legislature" (CARB, 1997b);
  - "Rice Straw Diversion Plan" (CARB, 1998);

- USDA Agricultural Research and Other Services:
  - "ARS Helps Grass Seed Growers Produce Seed Without Field Burning" (USDA, 1997a);
  - "Less Fire, More Science for Grass Growers" (USDA, 1997b);
- Washington State Department of Ecology:
  - "Cereal Grain Crops Best Management Practices" (WDOE, 2001);
  - Washington Department of Ecology Agricultural Burning Task Force (Pfeifer, 2001);
- Other sources:
  - "Advisory Committee on Alternatives to Rice Straw Burning Report" (SCAC, 1995);
  - "Kentucky Bluegrass (KBG) Seed Crops–Agricultural Methodologies for Reducing Air Emissions," (USEPA, 2001a);
  - "Best Management Practices when Harvesting Surplus Cereal Straw," (GOS, 2000);
  - "Western States Agricultural Burning Survey", (WESTAR, 1999);
  - "Agricultural Burning Smoke Management Program Survey", 2001, Draft Final Report, Contract No. 30202-11, (WRAP, 2001a);
  - "Tribal Emission Inventories and Air Quality Data Gathering and Assessment Project, Draft Report" (WRAP, 2001b); and
  - "Earth Saver: Your Runoff and Sediment Control Solution", (Earth Saver, 2001).

2.2 Non-Burning Management Alternatives Identified

Historically, the types of non-burning agricultural management alternatives available and/or in use have fallen into two categories: soil incorporation of residues in place, and off-site residue use or disposal (CARB, 1993). However, currently non-burning alternatives available and in use today in the Western states typically fall into four different categories and they include:

- Leave residues in place either with or without infield residue treatment;
- Improved management practices and scientific advancements in agronomy and horticulture;
- Alternative land use; and
- Residue collection and hauling for use offsite.

A list of the non-burning alternatives identified by this project is shown in Table 2-1. These alternatives are discussed in detail below.

2.2.1 Leaving Residues in Place

This category of non-burning alternatives includes simple cut and drop in place residue treatments; more complex cut, mulch and drop in place methods; and traditional soil incorporation of residues (wet or dry) including crimp and roll methods. It also includes more complex field management strategies which utilize soil incorporation techniques coupled with deliberate non-burning crop rotation or fallow field practices. Other non-small grain crops in the rotations can utilize the residue quantity produced during the small grain sector soil incorporation of the non-burning rotation (USDA, 1997c). Non-burning alternatives in this category, if applicable to a given crop or fuel type, have the distinct advantage of being convenient and typically less expensive initially; however, increased incidence of insect pest and disease leading to reductions in crop quality and overall decreased profits have been identified.

Hidden costs associated with potential decreases in crop yields and increased use of fertilizers and pesticides have also been cited as drawbacks to widespread use of these non-burning alternatives. More creative and complex field management strategies such as deliberate fallow field or crop rotation practices to increase soil nutrients or break disease and pest cycles offer promising improvements in the implementation of alternatives (NRCS, 2002). Factors such as these are addressed during the assessment of impacts and barriers to the implementation of these and other alternatives in Sections 3.0 through 6.0 of this report.

2.2.2 Improved Management Practices and Scientific Advancements

Non-burning management alternatives in this category include scientific advances in horticulture which have led to the development of genetically distinct types of crops that have

Table 2-1. Non-Burning Alternatives Applicable by Fuel/Residue Type

Fuel/Residue	Leave Residues in Place				Scientific Improvements			Alternative Land Use			Cut or Collect Residues and Haul											
	Cut and Drop Residue in Place	Soil Incorporation: Wet or Dry	Soil Incorporation: Fallow Field, Crop Rotation	Cut, Mulch, Drop In Place; Leave Standing, Crimp or Roll	Genetic Selection: Less Fuel Residual	Genetic Selection: Disease/Pest Resistance	Genetic Selection: Other Tolerance	Plant Crops that do not Need to be Burned	Land Conversion to Non-Agricultural Use	Conservation Tillage Practices	Cut, Mulch, and Haul Residue	Haul to: Waste or Landfill Facility	Haul to: Permitted Burn Facility	Haul to: Power Generation Facility	Haul to: Ethanol Production Facility	Haul to: Redistribution Facility	Haul to: Manufacturing/Use Other[1]	Haul to: Fiberboard Facility	Haul to: Particleboard Facility	Haul to: Use as Compost or Mulch[2]	Haul to: Use as Animal Feed, Bedding	Haul to: Use as Erosion Control[3]
Grains and Hay																						
Barley	•	•	•		•	•	•	•	•	✓		•	•	•	•	•	AK[11]	•		•	AK[11]	•
Corn				•	•	•	•	•	•	✓	•	•	•	•	•	•	•			•		
Hay; Alfalfa[4]	•	•	•		•	•	•	•	•	✓		•	•	•	•	•	•			•	•	•
Hay; All Other	•	•	•		•	•	•	•	•	✓		•	•	•	•	•	•			•	•	•
Oats	•	•	•		•	•	•	•	•	✓		•	•	•	•	•	AK[11]	•		•	AK[11]	•
Rice	•	CA	•		CA	CA	•	CA	CA	✓		CA	CA	CA	CA	CA	CA	CA		CA	CA	CA
Sorghum	•	•	•		•	•	•	•	•	✓		•	•	•	•	•	•			•	•	•
Wheat All	•	CA, WA, ND[14] NM[12]	NM[12], ND[14]		•	CA, WA	•	CA	CA	✓		•	CA	CA, NM[12]	CA	CA	CA, AK[11], NM[12]	ND, NM[12]	WA, ND[14]	CA	CA, AK[11]	CA, NM[12]
Wheat; Winter All	•	ID[13]	ID[13]		•	•	•	•	•	✓		•	•	•	•	•	ID[13]	•		•	•	•
Wheat; Other Spring	•	•	•		•	•	•	•	•	✓		•	•	•	•	•	•	•		•	•	•
Grain Other[5]	•	•	•		•	•	•	•	•	✓		•	•	•	•	•	•	•		•	•	•
Grasses and Seeds																						
Seeds; Alfalfa[4]	WA[6]	•	•		•	•	•	•	•	✓		•	•	•	•	•	•	•		•	•	•
Seeds; Kentucky Bluegrass	•	•	WA, OR, ID	WA, OR, ID	•	WA, OR, ID	WA, OR, ID	•	•	✓		•	•	•	•	•	•			WA, OR, ID	WA, OR, ID	•
Seeds; Other[7]	•	•	WA, OR, ID	WA, OR, ID	•	OR	•	•	•	✓		•	•	•	•	•	AK[11]			WA, OR, ID	WA, OR, ID, AK[10]	•
Orchard																						
Almond				CA		•	•	•	•		•	CA	CA	CA		•	•	•	CA	•		
Apple				•		•	•	•	•		•	•	•	•		•	•	•	•	•		
Apricot				•		•	•	•	•		•	•	•	•		•	•	•	•	•		

Table 2-1. Continued

Fuel/Residue	Leave Residues in Place				Scientific Improvements			Alternative Land Use			Cut or Collect Residues and Haul											
	Cut and Drop Residue in Place	Soil Incorporation: Wet or Dry	Soil Incorporation: Fallow Field, Crop Rotation	Cut, Mulch, Drop In Place; Leave Standing, Crimp or Roll	Genetic Selection: Less Fuel Residual	Genetic Selection: Disease/Pest Resistance	Genetic Selection: Other Tolerance	Plant Crops that do not Need to be Burned	Land Conversion to Non-Agricultural Use	Conservation Tillage Practices	Cut, Mulch, and Haul Residue	Haul to: Waste or Landfill Facility	Haul to: Permitted Burn Facility	Haul to: Power Generation Facility	Haul to: Ethanol Production Facility	Haul to: Redistribution Facility	Haul to: Manufacturing/Use Other[1]	Haul to: Fiberboard Facility	Haul to: Particleboard Facility	Haul to: Use as Compost or Mulch[2]	Haul to: Use as Animal Feed, Bedding	Haul to: Use as Erosion Control[3]
Avocado				•		•	•	•	•		•	•	•	•		•	•	•	•	•		
Cherry				•		•	•	•	•		•	•	•	•		•	•	•	•	•		
Citrus				•		•	•	•	•		•	•	•	•		•	•	•	•	•		
Grapes				•		•	•	•	•		•	•	•	•		•	•	•	•	•		
Nectarines				•		•	•	•	•		•	•	•	•		•	•	•	•	•		
Olive				•		•	•	•	•		•	•	•	•		•	•	•	•	•		
Peach				•		•	•	•	•		•	•	•	•		•	•	•	•	•		
Pear				•		•	•	•	•		•	•	•	•		•	•	•	•	•		
Pecan				•		•	•	•	•		•	•	•	•		•	•	•	•	•		
Plum and Prune				•		•	•	•	•		•	•	•	•		•	•	•	•	•		
Walnut				•		•	•	•	•		•	CA	CA	CA		•	•	•	•	•		
Orchard Other[8]				•		•	•	•	•		•	•	•	•		•	•	•	•	•		
Other																						
Asparagus	•	•	•		•	•	•	•	•	✓												
Beans; Dry Edible		•	•		•	•	•	•	•	✓												
Blueberries										✓												
Canola										✓												
Cotton		•	•		•	•		•	•	✓												
Mint	•	•	•		•	•	•	•	•	✓												
Peas, Dry Edible		•	•		•	•	•	•	•	✓												
Peanuts										✓												
Pineapple		HI		•	•	•	•	•	•	✓	•	•	•	•		•	•					
Potatoes										✓												
Safflower		•	•	•	•	•		•	•	✓	•											
Soybeans		•	•		•	•	•	•	•	✓												
Sugarcane[9]					•	•	•	•	•	✓												
Other Fruits/Veg[10]										✓												

Table 2-1. Continued

Fuel/Residue	Leave Residues in Place				Scientific Improvements			Alternative Land Use			Cut or Collect Residues and Haul											
	Cut and Drop Residue in Place	Soil Incorporation: Wet or Dry	Soil Incorporation: Fallow Field, Crop Rotation	Cut, Mulch, Drop In Place; Leave Standing, Crimp or Roll	Genetic Selection: Less Fuel Residual	Genetic Selection: Disease/Pest Resistance	Genetic Selection: Other Tolerance	Plant Crops that do not Need to be Burned	Land Conversion to Non-Agricultural Use	Conservation Tillage Practices	Cut, Mulch, and Haul Residue	Haul to: Waste or Landfill Facility	Haul to: Permitted Burn Facility	Haul to: Power Generation Facility	Haul to: Ethanol Production Facility	Haul to: Redistribution Facility	Haul to: Manufacturing/Use Other[1]	Haul to: Fiberboard Facility	Haul to: Particleboard Facility	Haul to: Use as Compost or Mulch[2]	Haul to: Use as Animal Feed, Bedding	Haul to: Use as Erosion Control[3]
Other Agricultural Related Fuels[15]																						
Ditches	•			•																		
Land Clearing																						
Rangeland																						
Sagebrush	•	•		•																		
Weeds	•	•		•																		

• = Potentially Applicable

✔ = Currently in practice in most of the 15 Western states

WA, OR, etc. (i.e. State) = Currently in practice to some degree or previously in practice

[1] Includes cement products, building materials, paper packaging, and cardboard manufacturing

[2] Includes food production such as mushroom composting, compost for dairy facilities manure composting, animal bedding, landscaping

[3] Includes wind and soil erosion control, forestry rehabilitation, and landfill covering

[4] Per John Burton, University of Nevada, Agricultural Extension office: "There are no non-burning alternatives (in practice) for alfalfa in Nevada."

[5] Includes undefined grain and hay crops

[6] Per Mark Wagoner, alfalfa seed farmer, Touchet, Washington.

[7] Includes bermuda, fescue, rye, red clover and other grasses for seed production

[8] Includes pistachio, nectarine, persimmon, kiwi, fig and other undefined orchard crops/fuels

[9] Burning of sugarcane occurs prior to harvest so the use of non-burning alternatives that address residues are not applicable (HARC, 2001).

[10] Includes cabbage, carrots, lettuce, tomatoes, green peas, dry onions, melons, and coffee

[11] Per Phil Kaspari, University of Alaska Fairbanks, Agricultural Extension Office.

[12] Per Denise McWilliams, New Mexico Cooperative Extension Services.

[13] Per Roger Veseth, University of Idaho, Agricultural Extension Services: Usage of these practices is highly dependent on rainfall in a given zone. High soil erosion potential is also a limiting factor. Less than 2% is hauled to use in manufacturing or other products due to cost unfeasibility and limited markets for finished products.

[14] Per Duane Bergland, North Dakota University, Agricultural Extension Services.

[15] The use of herbicides, including defoliants and pre-emergent compounds, has been considered in some research applications as an alternative to burning crop residues or to address the problem of weeds. However, this practice was not typically found to be in use for agricultural field crops since the use of these chemicals may interfere with subsequent crops. The use of these chemicals may be explored further as an alternative to irrigation ditch burning.

been selected because they offer a variety of desirable traits. The desirable traits can decrease the need to burn subsequent crop residues. Such traits include increased plant resistance to pests and disease. The development of crop varieties with increased resistance to pests and disease increases the potential feasibility of implementing non-burning alternatives such as soil incorporation.

These desirable traits also include genetic selection for less fuel residue. Scientific advances such as this has made it possible to produce high quality grain, such as rice in California, on crop varieties with shorter stalks. When harvested, these short stalk varieties generate less residue (although this is somewhat offset by their relatively greater shoot density and resulting residue biomass density). Scientific advances in horticulture have also led to the genetic selection for such traits as increased tolerance to shade. For grass seed production in states such as Washington and Oregon, this reduces the need to burn grass seed production crops (i.e., ryegrass). Historically, agricultural burning was conducted to remove previous years' leafy residues and allow sunlight to reach the new growth areas. Removal via burning has also been practiced to help control insects and disease, initiate quick growth, reduce seeding problems, and increase seed production (USDA, 1997c).

This category also includes improved management practices such as crop rotation, crop residue and tillage management alternate management, practices in combination with limited burn activity, farm and equipment sanitation, and pest and nutrient management (NRCS, 2002). This category of alternatives is fairly new in its application to non-burning settings. It will likely change greatly over time, but it offers several of the most promising alternatives available to date. However, scientific improvements take time and a great deal of resources to develop. It can take 10 years or more to develop improved traits and/or varieties.

2.2.3 Alternative Land Use

This category includes the use of alternatives to burning that actively change how the agricultural land will be used. In some cases, growers and producers simply choose to plant crops that do not require burning. In these cases a variety of economic, social and political factors may play a role in the growers' and producers' decision. Such activity may come about in response to a variety of factors, only some of which may be related to environmental concerns

and the need to reduce air pollutants from the burning of agricultural residues. This category also includes non-burning strategies which may take agricultural land completely out of crop production. Again, these practices may or may not come about in response to the need to reduce agricultural burning.

Based upon experience with agricultural burning practices and related issues throughout the West as well as ongoing research on this project, it can be concluded that non-burning alternatives in this category are being implemented. However, it has not yet been determined for what ultimate purpose and to what extent these non-burning alternative strategies are actually being implemented. This category is presently much less defined than the other three categories. Alternative agricultural non-burning land use decisions are expected to be more related to economics and crop production environments, as well as land use pressures such as urban growth and development, than they are to environmental pressures.

2.2.4 Residue Collection and Hauling for Use Offsite

This category of non-burning alternatives is quite broad in its applicability and potential for widespread implementation. All non-burning alternatives in this category are based on the premise that the crop residues, which remain after harvesting, are cut and/or otherwise collected from the field and then mechanically hauled offsite. In some cases residues may be collected and hauled away in alternate years in combination with some burning. Alternatives in this category are largely defined by what happens to the crop residue once it leaves the field. Non-burning management alternatives in this category include the following:

- General cut, mulch, and haul to some unspecified destination;
- Haul to a waste or landfill facility;
- Haul to a permitted burn facility;
- Haul to a power generation facility;
- Haul to fermentation facility for use in the production of ethanol and other chemicals used in automotive fuels production;
- Haul to a redistribution facility;

- Haul to a manufacturing or other use facility such as for cement, building materials, paper packaging or cardboard;
- Haul to a fiberboard production facility;
- Haul to a particleboard facility;
- Haul to use as compost or mulch for food production or horticultural practices;
- Haul to use as animal feed or bedding; and
- Haul to use for erosion control either as bales or as manufactured erosion control products.

A number of these non-burning alternatives have been identified as either being in use currently, or in use in the past, in Washington, California, North Dakota, Oregon and Idaho (NDSU, 1998; OSUES USDA-ARS, 1989; OSU USDA-ARS, 1994; OSU USDA-ARS, 1995). Decisions to implement alternatives from this category are related to economics, reliability of residue production, consistent quality of residues available, and market demands for products produced or the residue uses. These implications are addressed more extensively in Sections 3.0 through 7.0 of this report.

3.0 METHODOLOGY FOR ASSESSING IMPACTS OF NON-BURNING ALTERNATIVES

It is necessary to understand the impacts non-burning alternatives will have on farms, the environment, and the regional society in order to assess the reasonableness of adopting non-burning management alternatives. Often, in environmental policy, what seems like a good idea to address one problem creates numerous unforeseen consequences in other areas.

In this section, impacts are assessed in several different ways in order to develop reasonable criteria for use in determining adoption of non-burning alternatives. Also, the impacts and criteria are summarized in such a manner as to provide an overall methodology for assessing the impacts for different crop/non-burning alternative combinations. Section 4.0 contains two case studies that employ the criteria and methodology described here.

Changing agricultural practices affect not only the agronomy of the farm and its economic well being but also effect the environment as the landscape changes and through society as economic relationships shift and adjust. A shift to non-burning alternatives may have profound effects on sub-regions and cultures. In this study, consideration of these impacts is restricted in two ways.

First, this study does not consider changes in land use either as an alternative to agricultural burning or as a consequence of regulation of agricultural practices. It is unclear whether development of agricultural land for more urban uses reduces or increases overall air emissions in an area. Urban land does not require burning of crop residues but automobiles, home heating, barbecues, and lawn mowers contribute a variety of pollutants to the atmosphere. The loss of farmland also reduces opportunities for ozone absorption in the area. In addition, anecdotal evidence suggests that some growers, who find new burning regulation onerous, have moved to states with fewer regulations. The grower's decision to change crops or take land out of agriculture is complex. The decision depends on local conditions, the economics of substitute crops, the individual firm's investment in machinery and equipment, and the owner's attitude toward rural life. Analysis of the decision requires different analytical tools than the assessment of marginal changes in current practices. The decision analysis would entail modeling of all of the grower's options. These vary from crop to crop and region to region. Thus, likely price and

production possibilities for many substitute operations in many different locations would need to developed. To make a complete assessment, estimates of the likely environmental impacts of the new crop's production process would also be needed. The analysis described in this section, and demonstrated in Section 4.0, is confined to the marginal changes in growing practices that can be addressed with simpler analytical tools.

Second, many alternative practices having applicability to crops grown in the Western states with implications for agricultural burning were identified (See Table 2-1). Section 2.0 showed that a large subset of these nearly 1,000 possible combinations are feasible non-burning alternative options. Since it is not possible to perform a detailed assessment of the impacts of all of the feasible options with the time and resources available, a broad assessment of the implications of adoption for all of the feasible combinations of crops and practices identified in Section 2.0 was performed. This analysis provides a qualitative assessment of the issues that would arise from promoting that crop-practice combination, and gives an indication of what may or may not work and its implications.

3.1 Defining and Establishing Criteria for Evaluating Impacts

This section describes various possible impacts due to implementation of non-burning management alternatives and presents some criteria for evaluating their effects. The list of impacts is not exhaustive, nor will all crops present the same effects. The assessment of any alternative must be based on site specific information for the particular crop of interest. Some of the elements which might be considered are summarized in Table 3-1 and discussed in detail below.

3.1.1 Agronomic Impacts

The first consideration is what happens to the agricultural production unit. How does changing to a non-burning alternative change what the grower must do on the land and how does that change affect the productivity of the land? For example, the results of implementing a non-burning alternative (e.g., cut and drop in place) on alfalfa seed residue resulted in increased costs due to additional cultivation, and pesticide and herbicide applications, and decreased yield (Wagoner, 2002). The field on which the alternative was used produced 1,070 tons/acre as compared to other fields (where the residues were burned which produced 1,200 tons/acre. Also,

Table 3-1. Impacts of Non-Burning Alternatives and Criteria for Assessing Their Effects

Impact	Criteria
Agronomic	Soil compression
	Soil erosion
	Increased water use
	Increased herbicide use
	Increased pesticide use
	Land constraint
	Time or equipment constraint
Environmental	Countervailing air emissions
	Negative wildlife impacts
	Water quality degradation
Health and Safety	Increased equipment use
	Increased chemical use
Energy	No contribution to energy production
	Increased energy use
Economics	Not cost-effective
	Moderate farm stress
	Substantial farm stress
	Negative regional impacts
Social and Equity Issues	Raises tribal/cultural/historical issues
	Raises small business issues
	Impacts low resource farms
Political Issues	Agricultural objections
	Environmental objections

since wheat was a rotation crop, additional land cultivation and water was needed to prepare soil for wheat planting. Conversely, non-burning alternatives may well improve the quality and structure of the soil. Each crop and region must be assessed independently to determine the possible consequences of adopting a new technology. Some of the possible effects are outlined here but the list is neither exhaustive nor all negative.

Farms may not have adequate land for storage of crop residue or labor time to transport it. The basic logistics of the alternatives need to be assessed along with growers' resources to accomplish them. For example, when ash is no longer left on the ground, soil nutrient levels may be reduced. Burning also reduces weeds and plant pathogens as well as removing refuges for insect pests. The alternative practice may require more passes over fields with heavy equipment and so may compact the soil. Growers may need to increase application of chemical fertilizers and pesticides to counteract these effects and maintain productivity over the long term. In such cases where elimination of burning is not possible or desirable, a feasible approach would be to combine burning with other non-burning management practices.

The results of field trials and experiences of early adopters of non-burning alternative practices can be used to assess the impact of wider adoption of the practice. Variation from place to place and crop to crop will need to be considered for each suggested alternative. No single approach will be appropriate for all crops or all regions. This report focuses on experiences in the 1990s. Time and budget constraints prevented a much deeper assessment of earlier efforts or traditional approaches. Many possible alternatives discussed in this report are somewhat speculative. Their assessment is based on anticipated changes in agriculture and experience with similar new technologies. While these approaches may not be suitable for adoption immediately, the charter for this project suggested the net be cast to include the broadest array of alternatives foreseeable.

Information collected from experts is used to assess the field-level impacts of each alternative. A more detailed assessment would require specific information from field trials of the alternative practice in the crop of interest. Long term information would be especially useful as long run productivity is the central agronomic impact. Substantiation and quantification of changes in long-run productivity and non-air impacts, such as increased

pesticide and herbicide use, would improve upon the assessment of feasibility using multi-year crop budgets as was done in this study.

3.1.2 Environmental Impacts

The goal of promoting non-burning alternatives for agricultural activities is to reduce the environmental impact of burning on visibility and air quality. However, it is expected that the non-burning alternatives will entail new practices which may have their own environmental consequences. For example, with increased tractor operations and transportation of field and orchard debris, more diesel fuel will be burned. This may increase overall carbon dioxide (CO_2), nitrogen oxides (NO_x), and particulate matter in the air. Also, primary particulate matter from vehicle travel on paved and unpaved roads may increase. Additionally, increasing tilling would increase airborne particulate matter. If power plant emissions are poorly controlled, burning orchard or field crop wastes as fuel for electricity generation could reduce the benefits of decreased open burning. Thus, reductions in emissions released from each non-burning alternative vis-à-vis current practices were determined. Also, the implications of using agricultural waste for animal feed, mulch, and other uses were assessed by discussing the environmental consequences of these alternatives with appropriate experts.

Fire is a powerful agent of ecological change. Wildlife adapts to the agricultural practices in their environment. The timing of hay cutting, for example, has a tremendous effect on the survival of ground-nesting birds. Any changes in burn practices are likely to alter these adaptations. Follow-on effects from increased fertilizer and pesticide applications may have negative water quality effects in surface or groundwater. These effects should be noted in discussions with experts in the field who have experience with alternatives and highlighted where applicable to alternatives.

Environmental impacts present a challenge for more detailed case studies. Standard engineering data are used to estimate emissions increases from residue use that offset emission reductions. However, for other types of impacts, only the relative significance of adverse impacts (i.e., which non-burning alternatives raise the greatest environmental concerns) were assessed in this analysis.

3.1.3 Health and Safety Impacts

Alternatives must not increase the health or safety risks relative to current burning practices. A literature review and interviews with local experts form the basis for assessing qualitative changes in health and safety factors associated with current burning practices and the major alternatives. Safety impacts must be carefully assessed for each alternative considered. Where the alternative does not change the types of activities conducted appreciably, there is little change in safety. Where the alternative entails using unusual equipment or operating equipment in more perilous ways (e.g., driving tractors on steep slopes), then safety may be a serious concern.

3.1.4 Energy Impacts

Crop residues can provide a renewable source of biomass for power generation. Sugarcane bagasse and nutshell fueled furnaces have been added to sugar mills and nut processing plants for many years. Existing stand-alone biomass power plants rely on urban and lumber mill wood waste. They are capable of mixing in orchard prunings, but avoid non-woody crop residues.

Field crop residues present several challenges for electricity generation. First, they have a low heat content. It requires a large volume of straw to generate as much energy as a cubic foot of natural gas. Collection is, therefore, often costly. Large volume also creates handling problems in getting fuel into furnaces efficiently. Second, crop residues are seasonal. Large amounts of straw need to be removed from fields at certain times of the year and may not be available during the remainder of the year. Orchard pruning provides cuttings in late winter but not at other times. As a consequence, large quantities of fuel will typically need to be stored for considerable periods to keep a power plant operating continuously. Third, some residues must be dried, chipped, or otherwise pre-processed to be efficient fuels. If energy must be expended to process the residue, the possibility exists that it may require more energy to process the fuel than the fuel provides when it is burned.

Even with these management issues, persistent high wholesale electricity prices may make an agricultural residue burning power plant a viable option for some locations. CARB (1993) and other sources have evaluated the prospect for new biomass power plants. In this

study, each crop's suitability as a fuel is scored. A detailed assessment would consider the feasibility of power plants for the specific crop given the characteristics of the residue and prior experience using it as a fuel.

3.1.5 Economic Impacts

The economic impact of adopting non-burning alternatives is an important consideration. One criterion for selecting the preferable options will be cost effectiveness, e.g., the lowest cost per ton of particulate emissions reduced, such as particulate matter less than 10 microns in aerodynamic diameter (PM_{10}). This is a useful standard since it can be used to directly compare the agricultural non-burning alternatives with industrial and automotive PM_{10} source reduction programs. Costs of adopting a non-burning agricultural alternative are measured by the difference in the cost of agricultural operations between the traditional burning operation and the new alternative approach. Each alternative is assessed at the enterprise, farm, and regional level. While the cost of implementing an alternative for a given farm field is a component of the selection among alternatives, the viability of any alternative also depends on the farm's ability to remain profitable given the new labor, capital, and land requirements of the new technology. The ability of farms to finance the change and continue in business must also be assessed. Regionally, the non-burning alternatives may shift employment and supply relationships.

In this analysis, information on whether the alternative is cost-effective, affordable, and regionally sustainable was requested during an informal survey of stakeholders affected by and knowledgeable of agricultural burning and alternatives (see Section 5.0). A more detailed assessment would include comparative enterprise budgets, financial ratio analysis, and regional impact analysis.

Cost-Effectiveness – Enterprise Level Assessment

Engineers can estimate the tonnage of PM_{10} released from agricultural burning of different crops each year using residue loading factors (tons of residue per acre) and emission factors (pounds of pollutant per ton of residue burned). (Usage of these factors is illustrated in Section 4.0 of this report.) Each fuel source has a characteristic profile of burn products. While the profile varies with weather conditions, average values will be used to estimate emissions per

ton of fuel burned. This rate of emission can be expanded to an acreage basis using average fuel production per acre harvested. Burn reduction programs in Washington and Oregon have significantly reduced human exposure to particulates without eliminating burning by permitting burns when the wind will carry pollutants away from population centers (WDOE, 1998a). A detailed GIS system combined with regional wind pattern and population information could conceivably develop estimates of expected population exposed to smoke under different permitting scenarios. For alternative development, however, a reasonable goal is overall reduction in particulate emissions, and thus considers cost effectiveness in terms of reduced tonnage of emissions rather than reduced human exposures.

Crop production budgets are used to estimate the incremental costs per acre of the alternatives. Basically, a farmer has four options:

1. Leave the residue in place,
2. Haul it somewhere else,
3. Use varieties selected for characteristics that reduce the need to burn; or
4. Use the land for some other purpose that does not require burning, either a different crop or a non-agricultural use.

The first three options change operations on the farm and may affect operations elsewhere (e.g., wherever you haul the residue). While these may be costly changes, the producer continues to produce the same crop and the basic structure of the farm economy remains intact. The fourth option is much more consequential. Although changing crops may be a significant contributor to reduced particulate emissions, it raises large issues about the character of rural areas and the future of rural development.

For example, in Maricopa County, Arizona, cotton is being replaced with alfalfa resulting in a fewer air quality impacts to "neighbors" due to less frequent tillage and planting (i.e., every year with cotton as compared to every three or four years with alfalfa) (Rogers, 2002). Although this switch from cotton to alfalfa appears to be driven mainly by economics due to improving local markets for alfalfa, and is not related to implementation as a non-burning alternative, the air quality benefits appear to be substantial. Also, the economic benefits from the growing market for alfalfa is somewhat offset by the increased costs to farmers when switching

due to several factors such as increased expenses associated with the need to buy new equipment, cost of alfalfa seed, and employing laser leveling.

Crop production budgets for current agricultural practices show all of the necessary tasks to raise the crop and their costs per acre by expenditure category for a well-run operation. Budgets do not represent the average but generally show an idealized production operation using the best practices suggested by the state cooperative extension service. Budgets have also been produced for some non-burning alternative practices.

Many enterprise budgets show a loss whether or not the crop is actually viable. A more accurate measure of profitability is revenues minus variable costs. Many growers will continue to operate at a paper loss as long as their cash flow is adequate to cover variable costs and the essential fixed costs (e.g. debt service). If the additional costs of the alternative practice make the variable costs greater than revenues, then that alternative is definitely not affordable. If the alternative practice reduces net income considerably, growers will reassess the profitability of that enterprise and may switch to another crop or to a different non-burning alternative.

Table 3-2 shows a budget for producing tall fescue seed. The propane burn alternative assumes straw is baled, stacked, and later burned or composted elsewhere on the farm. It incurs additional variable costs of $28.16/acre and additional fixed costs of $18.47/acre over the current open burn practice. Propane burn continues to have a positive net income and so is a viable alternative. Crew-cutting also involves baling excess straw followed by one pass over the field with a crew-cutter. The additional pass involves more equipment for a longer time period so fixed costs are higher than the other alternatives. Although variable costs are slightly lower than propane burning, the crew-cut alternative has a negative net income. However, crew cut gross income minus variable costs is greater than the propane burn approach so crew cut is also a viable option. This budget assumes yield is unchanged through time no matter which option is selected so a simple analysis of an annual budget is appropriate.

Several alternatives have the possibility of producing revenue from new by-products. A complete feasibility study should be conducted for any new product, including the costs of marketing and delivering it. Such studies are well beyond the scope of work for this project so this study only indicates where such opportunities may be available. In this study,

Table 3-2. Enterprise Budget for Tall Fescue Seed, Willamette Valley, Oregon (Dollars per Acre)

Budget Element	Alternative			Difference from Conventional	
	Open Burn	Propane Burn	Crew-Cut	Propane Burn	Crew-Cut
Total Gross Income	542.75	542.75	542.75	0	0
Total Variable Cost	278.75	306.91	304.24	28.16	25.49
Gross Income – Variable Cost	264.00	235.84	238.51	-28.16	-25.49
Total Fixed Cost	213.52	231.99	242.67	18.47	29.15
Total of All Costs	492.27	538.9	546.91	46.63	54.64
Net Projected Returns	50.48	3.85	-4.16	-46.63	-54.64

Source: Cross, et al.,1992.

current prices of similar products are used to indicate the possible net revenues given current market conditions. Where the alternative practice has long term effects on the productivity of the land, such as by promoting pest survival, costs will be annualized over the cropping cycle to determine the costs in terms of yield as well as the direct costs of the alternative. Annualization converts a flow of unequal payments through a period of time to an equivalent series of equal annual flows.

Cost effectiveness is measured as the change in budgeted expenditures to implement the alternative per ton of PM_{10} avoided by adopting the alternative practice. Most costs of the alternative practices are variable and emissions will be defined per acre, so abatement cost curves will be essentially linear. Key assumptions can be tested by sensitivity analysis.

Affordability – Farm Level

Growers will not adopt a new technology or practice unless it makes economic sense for their farm as a whole, thus the impact of the alternatives on the agricultural production farm's profitability and financial stability should be assessed. This is often evaluated in terms of changes in the farm's income and financial ratios. If income falls significantly, or financial ratios fall into a range where banks will hesitate to loan money, then the alternative may not be affordable and will not be widely adopted. Crop budgets are used to assess whether a typical well-managed operation would confront financial difficulties in implementing the alternative technologies. Balance sheets and other information from the USDA Agricultural Resource Management Study (ARMS), an annual survey, serve as a baseline for analysis (USDA, 2001).

The most intuitively direct measure of affordability is net income. As most farms are privately held and only report financial information for tax purposes, they have a disincentive to report positive net income. Percentage change limits are set such that a change in average revenues minus variable costs of a given percentage is considered to indicate a moderate affordability problem. U.S. EPA typically uses changes of 3 or 5 percent as indicators of moderate stress. Negative net revenue indicates severe stress (USEPA, 2001b).

Debt-to-asset ratios should also be considered. Banks and other lenders have criteria for lending to agricultural firms which include the levels of various asset ratios. If a

farm's debts become too high in proportion to its total assets, the long-term burden of debt can require a large share of cash resources. The higher probability of default discourages banks from lending additional funds to the farm, making equipment replacement costly and difficult. The USDA considers a debt-to-asset ratio higher than 0.40 to be an indicator of financial distress (USDA, 1999).

Indirect Impacts – Regional Level

Changes in farm operations can have impacts in the regional economy. Collecting and transporting crop residue may require extra labor which may generate more income for farm workers. Demand for additional labor may raise wage rates, changing the cost structure for producers, and, ultimately, creating different optimal sizes and capitalization for farming operations. New equipment that might be needed or faster depreciation of old equipment may increase sales at agricultural implement dealers. Such effects generate ripple effects throughout the regional economy. The California Air Resources Board (CARB, 1993) used a computable general equilibrium (CGE) model to trace the impact on prices and quantities of adopting different policy options for burning crop residue. CGE is particularly useful in assessing agricultural income changes from switching crops or exiting agriculture. Only rice straw burning in the Sacramento Valley was assessed with CGE in the CARB report. Preliminary assessment of changes for other crops showed the regional impacts were unlikely to be significant and did not merit a full CGE analysis. However, regional dislocations from adoption of non-burning alternative practices can occur (e.g., relocation of grass seed production from Oregon and Washington to Wyoming, which is discussed in Section 5.0 of this report).

In those case studies where alternatives appear to generate changes that may ripple through the economy, publicly available multipliers from the Regional Input-Output Modeling System, Version 2 (RIMS II) (USDC, 1997) are used to derive a first approximation of the impact. The multiplier analysis will estimate indirect and induced changes in employment and output for all sectors of the economy from output changes in the farm sector. CGE modeling is more sophisticated than multiplier analysis and can answer a variety of questions about possible outcomes and the effects of changing assumptions. CGE analysis may be useful at a later stage in alternatives assessments to assess more detailed regulatory options.

3.1.6 Social and Equity Issues

There may be burning practices or non-burning alternatives that have cultural and/or historical implications unique to certain groups beyond cost considerations, such as small growers, culturally diverse groups, or residents of tribal lands. (Survey respondents were asked if they are aware of any special considerations with regard to non-burning alternatives; however, no particular issues were raised.) A more detailed analysis would indicate likely air quality results with and without a group's adoption of non-burning alternatives and will explore state options to address the issue.

3.1.7 Political Issues

Promotion of non-burning alternatives by government, even on a voluntary basis, has the potential to antagonize agricultural interest groups. Most growers, producers, and distributors are politically well organized. They routinely advocate their concerns in state legislatures through crop specific organizations and more general agricultural lobbies. Environmental and recreation interests are also well organized. Any effort to induce change may face political pressure on several fronts. Survey respondents were asked if they are aware of any specific groups with strong positions on agricultural burning. The strength and willingness to compromise of the various interest groups varies from state to state. While stakeholders can indicate potential pitfalls, governments seeking to implement a program of non-burning alternatives will need to make their own assessments of the political viability of any alternatives on a case-by-case basis.

3.2 Methodology for Assessing Impacts

Table 3-3 summarizes the potential impacts from implementing non-burning alternatives and their associated criteria for evaluation. Also, the table gives a summary of the methods and information sources needed to assess the impacts according to their applicable criteria. The methods include a combination of qualitative (e.g., stakeholder surveys and anecdotal information) and quantitative tools (i.e., crop budgets and RIMS multipliers) as described above. Expected results are provided in order to help the assessor of the impacts to focus the analysis on the most significant impacts, depending on the crop/alternative(s) chosen.

Table 3-3. Summary of Criteria and Methods to Assess Impacts of Non-Burning Management Alternatives

Impact	Criteria	Information Sources	Methods	Expected Results
Agronomic:				
	Soil compression	Prior trials; Agronomic experts	Apply results from prior trials to prospective sites	Problem for some crops; long term decline in productivity and/or additional work
	Soil erosion			Problem for some crops
	Increased water use			Little incremental water use
	Increased herbicide use			Likely problem as weeds proliferate without burning
	Increased pesticide use			Likely problem for some alternatives as pests shelter in unburned fields
	Land constraint			May be problem for smaller farms
	Time or equipment constraint			May be problem for smaller farms
Environmental:				
	Offsetting air emissions	Burning facilities emissions history	Compare emissions from burned fields with emissions from facilities	Burning at a power plant or disposal facility is less polluting than field burning
	Negative wildlife impacts	Prior trials	Anecdotal evidence of changes in habitat	Little change in effect from burning
	Water quality degradation	Prior trials	Qualitative assessment of likely changes	Little change anticipated
Health and Safety:				
	Increased equipment use	Crop budgets; Agricultural Injury database	Budgets will indicate extra equipment passes; apply injury rates per hour and compare with injuries from burning	Small increased risk of injury, largely from increased highway driving
	Increased chemical use			
Energy:				
	No contribution to energy production	Alternative description	Use engineering information to estimate energy produced by using residue as fuel	Some opportunity to increase energy output if prices are high enough
	Increased energy use	Life cycle energy assessment	Use agricultural engineering information to estimate changes in energy use.	Small changes in energy use.
Economics:				
	Not cost-effective	Crop budgets; engineers' emissions estimates	Estimate costs of farming practice changes per unit of emissions reduced	Reducing agricultural burning is comparatively cost effective in many situations
	Moderate farm stress	Crop budgets; ARMS survey data	Estimate impact of changes in farm costs on farm financial ratios	Minor impacts on some farms
	Substantial farm stress	Crop budgets; ARMS survey data	Estimate impact of changes in farm costs on farm financial ratios	Very few farms seriously affected
	Negative regional impacts	RIMS multipliers; aggregated costs	Estimate employment and other changes from multiplier changes	Small regional impacts
Social and Equity Issues:				
	Raises tribal/cultural /historical issues	Survey	Qualitative assessment	Unknown
	Raises small business issues	Survey	Anecdotal evidence	Some problems possible
	Impacts low resource farms	Survey; Crop budgets; ARMS data	Anecdotal evidence and estimated impacts from farm costs	Some small farms may be affected
Political Issues:				
	Raises agricultural objections	Survey	Anecdotal evidence	Some objections are likely
	Raises environmental objections	Survey	Anecdotal evidence	Some objections are possible

After the impacts/criteria have been evaluated, the assessor can then estimate the feasibility of a given alternative according to the ranking scheme shown on Table 3-4. The assessor needs to assign a numerical value from 0 to 3 to indicate the existence and/or significance of the negative outcome of the impact likely to occur (i.e., "0" means no problem exists or is likely to occur if the alternative is implemented; "3" means a major problem exists or is likely to occur if the alternative is implemented). While this is a somewhat subjective assessment, it can be valuable in determining the relative severity of a potential impacts. The same person should assign all feasibility factors for a given crop/alternative process. This simple process can address alternatives where there is only a limited amount of information. By assessing adoption of similar alternatives in similar situations, the rough scale of the alternative's impacts can be evaluated. When more information becomes available, a more sophisticated measurement scheme can be employed. This methodology is used in Section 4.0 to evaluate two case studies for implementation of non-burning alternatives.

Table 3-4. Ranking of Non-Burning Management Alternatives[1]

Potential Impacts and Criteria	Leave Residues in Place			Cut or Collect Residues and Haul											Scientific Improvements			Alternative Land Use		
	Mulch Residue	Soil Incorporation: Wet or Dry	Soil Incorporation: Fallow Field	Waste Facility	Permitted Burn Facility	Power Generation Facility	Ethanol Production Facility	Redistribution Facility	Manufacturing or Use Facility	Fiber Board Facility	Particle Board Facility	Use as Compost or Mulch	Use as Animal Feed	Use For Erosion Control	Less Fuel Residual	Disease / Pest Resistance	Other Tolerances	Plant Crops That Are Not Burned	Land Conversion to Non-Agriculture	Conservation Tillage
Agronomic:																				
Soil compression	1	3	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	0	0	1
Soil erosion	1	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	1
Increased water use	1	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	1
Increased herbicide use	2	2	2	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	2
Increased pesticide use	2	2	2	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	2
Land constraint	1																		0	0
Time or equipment constraint	1																		0	2
Environmental:																				
Countervailing air emissions	0																		3	1
Negative wildlife impacts	1																		3	1
Water quality degradation	1																		2	1
Health and Safety:																				
Increased equipment use	1																			1
Increased chemical use	1																			1
Energy Impacts:																				
No contribution to energy production	2																		3	1
Increased energy use	2																		3	1
Economics:																				
Not cost-effective	2																			
Farm financial stress	2																			
Negative regional impacts	1																		3	
Social and Equity:																				
Raises tribal/cultural/historical issues																			3	0
Raises small business issues	1	2	2	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0
Impacts low resource farms	2	2	2	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
Political:																				
Agricultural objections	2	2	2	3	3	0	0	0	0	0	0	0	0	0	1	1	0	3	3	3
Environmental objections	2	1	1	3	3	1	1	2	1	1	1	0	0	0	2	3	2	1	3	0
Average Score	1.4	1.8	1.6	1.9	1.9	1.1	1.1	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.2	1.1	0.9	1.6	2.1	1.1

Steps for Ranking Non-Burning Management Alternatives[1]:

1. Assign feasibility factors to indicate a negative outcome as follows:

   0 = No problem exists;
   1 = Problem may exist;
   2 = Problem does exist;
   3 = Major problem exists; and
   Blank = Not relevant or viable

2. Calculate the average score for each alternative using the feasibility factors for the relevant impacts.

3. The lowest scores indicate the most feasible alternatives.

[1] See Section 4.0, Tables 4-1 and 4-2 for examples of using feasibility factors.

4.0 SELECTING NON-BURNING ALTERNATIVES: CASE STUDIES

This section presents two case studies that assess impacts of non-burning alternatives. These case studies illustrate the use of criteria to determine the feasibility of adoption of the non-burning alternatives. The three-tier data collection effort first described in Section 2.0, was implemented throughout the study, and provided data for the case study analyses. The data that have been collected are described in detail in Section 5.0 of this report.

Open-field burning has been the traditional method to dispose of rice straw and control disease. Alternatives to burning present different sets of challenges to rice producers and their communities. A case study of rice straw alternatives demonstrates the methods of assessment that lead to criteria for adoption. Burning has also been a traditional treatment for grass seed fields. A second case study considers impacts of reduced burning on grass seed producers.

4.1 Rice Straw Case Study

More than 400,000 acres are devoted to rice cultivation in California. When rice fields are harvested, a standing crop of rice straw remains. The least costly means to dispose of the straw is to burn the open field. Burning can create smoke in nearby communities, and sometimes interfere with driving and air travel. Efforts have been underway since the 1970s to reduce the extent of rice straw burning and ensure that it occurs only when meteorological conditions are favorable. Since 1992, rice burning in the Sacramento Valley has been curtailed from 90 percent of planted acreage to less than 30 percent. Beginning in 2001, the annual goal is to burn the lesser of 25 percent of planted acres or 125,000 acres exclusively for disease control purposes. In fact, the industry estimates that under this program, less than 20 percent of its acreage will be burned (Buttner, 2002).

The legislated goal of reduced acreage burned has driven an effort to develop alternatives to burning. Rice straw is a re-newable biomass resource that can be used in many different processes and products. Among the uses being developed are ethanol production, particleboard, paper, composite materials, erosion control products, cattle feed, animal bedding,

and straw bale construction. Agricultural and construction industries use rice straw as a mulching material and bale barrier to reduce sediment runoff from bare soil and promote new growth. California has sought to promote alternative uses through grants and other mechanisms to initiate markets for rice straw. These efforts continue to show promise even though they have not yet been entirely accepted (CIWB, 1998).

4.1.1 Agronomic Impacts

After rice is harvested, rice straw is burned to prevent overwintering of disease organisms, dispose of the straw, and prepare the field for planting. There are, basically, two alternatives to burning rice straw. The first is to incorporate it into the soil in the field. The other is to remove it and utilize it in some other fashion.

Continuous soil incorporation by chopping and discing or rolling the residue into the soil can promote stem rot infection and changes soil tilth. In the long run, these changes may lead to unsuccessful decomposition, decreased yields, and more difficult working conditions as the fields become slower to dry out (REI, 1997). Yield decline represents the largest financial risk to growers from soil incorporation (CARB, 1993). Chopping and discing takes considerably more labor and machine time than burning, but probably does not require the farm to purchase new equipment. Disease build-up may be offset with greater application rates for pesticides. However, the consequences to soil structure of increased traffic over the field cannot be easily mitigated. A combination of soil incorporation and occasional burns may be a viable alternative to annual burning. Winter flooding can also mitigate many of the disadvantages of soil incorporation and improve nutrient cycling and yields. However, it requires greater use of water and fuel which contribute to higher costs (CARB, 1993).

Removing rice straw from the field avoids some of the agronomic issues of soil incorporation but creates a large volume of material that must be used or disposed. Other than burning or composting in windrows, removal techniques require baling straw for transport. Purchasing a baler or hiring custom baling services is a significant cost of any removal alternative. Baling standards for many alternative uses are quite stringent which adds to the costs of removal (REI, 1997). Techniques requiring additional passes of machinery over the field raises the risks of soil compaction and possible delays from wet field conditions due to excess

soil compaction. These may be addressed with more expensive technological options, such as tracks or flotation wheels on balers (REI, 1997).

Soil incorporation will continue to require burning or winter flooding of some rice land each year to maintain yields. Removal of rice straw for other uses may be a viable alternative if the producer can offset the added costs of removal with profits from sale of the product.

4.1.2 Environmental Impacts

The goal of promoting non-burning alternatives for agricultural activities is to reduce the environmental impact of burning on visibility and air quality. Alternatives, however, have environmental consequences of their own. Soil incorporation of rice straw reduces smoke and carbon dioxide emissions but increases methane production as organic matter decomposes in the wet soil. Methane is a powerful greenhouse gas with 20 times the heat trapping potential of carbon dioxide. Methane emissions increase 3 to 12 times when rice straw is added to the soil rather than burned (REI, 1997). Clearly, there is a local/global trade-off in environmental impacts from soil incorporation.

Other alternative uses of rice straw offer different trade-offs. Burning rice straw for power generation, for example, can reduce the production of particulate matter and methane because the burning conditions can be tightly controlled. However, the high silica content in rice straw tends to foul boiler tubes and disposal of ash also presents a new challenge. Non-burning alternatives require greater use of tractors and other equipment to chop and disk, or bale and remove, the rice straw. This added activity increases diesel and dust emissions. While the diesel emissions have a considerably smaller volume than the straw burning smoke, particulate emissions from diesel-fueled engines are listed by the California Air Resources Board (CARB) as a toxic air contaminant (CARB, 2001a). Also, increased vehicle traffic on paved and unpaved roads, and in fields, will increase particulate matter emissions. Relative risks from each source need to be considered as alternatives are assessed.

Alternative uses of rice straw that result in aerobic decomposition have fewer balancing emissions issues than soil incorporation. These include uses such as animal bedding, erosion control, and weed suppression. Rice straw is particularly well-suited as a mulch because

it is slow to decay and carries few upland/non-aquatic weed seeds (REI, 1997). Uses that preserve the straw for an extended period or displace the use of other more valuable resources sequester excess carbon and so alleviate global warming without significant negative trade-offs. These include straw bale construction, building materials, and paper-making.

Wildlife adapts to the agricultural practices in their environment. California rice fields have been significant resources for migratory waterfowl (CARB, 2001a). If a non-burning alternative resulted in a change in the flooding regime, historical patterns of waterfowl migration could be affected. Ultimately, waterfowl populations could be reduced. Increased rice production in Arkansas and Texas is considered an important contributor to the over-population of mid-continent white geese and the subsequent destruction of their arctic breeding habitat (FWS, 1999). Such over-population issues have not arisen on the West Coast but indicate the interconnectedness of agriculture and wildlife.

Uses that consume large volumes of straw are also preferable environmentally. Composite materials made from rice straw are another potential use (REI, 1997). Such production, however, will consume only a small portion of the total rice straw harvest even when technological and financial hurdles are overcome. Proven uses which require large volumes of straw may be more successful in developing straw markets in the near term.

4.1.3 Health and Safety Impacts

Farm safety impacts do not appear to be a strong criterion for differentiating among rice straw burning alternatives. None of the alternatives appear to be unusually hazardous compared to other agricultural work.

4.1.4 Energy Impacts

Rice straw can provide a renewable source of biomass for power generation. However, it presents several challenges for electricity generation as described below:

- It has a low heat content. It requires a large volume of straw to generate as much energy as a cubic foot of natural gas. Collection is, therefore, costly. Large volume also creates handling problems in getting fuel into furnaces efficiently.

- Straw supplies are seasonal. Large amounts of straw need to be removed from fields in the fall and may not be available during the remainder of the year. As a consequence, large volumes of fuel will typically need to be stored for considerable periods to keep a power plant operating continuously. This problem can also be mitigated by using multiple biomass fuel sources which would be available in different seasons.

- Rice straw must be dried and chopped to be an efficient fuel. If energy must be expended to process the low energy fuel, more energy may be required to transport and process the fuel than it provides.

- Rice straw has an ash content of 14 to 20 percent, compared to wood that typically has an ash content of from less than 2 percent to 4 to 8 percent (typically used in power generators). Therefore, it leaves more ash to be disposed in landfills or similar facilities.

The California Air Resources Board concluded that the use of rice straw to generate electricity is precluded by technological constraints (CARB, 1993). Clearly, high energy prices or subsidies will be needed to solve the technological problems and overcome the logistical issues. Straw-burning district heating systems are common in Denmark where subsidies have been offered to curtail open-field burning (REI, 1997). Although, it is not possible within the scope of this project to speculate about possible incentive structures to establish a biomass energy industry, it is noted that rice straw has some unusual characteristics that make it particularly unattractive as boiler fuel.

4.1.5 Economic Impacts

The economic impact of adopting non-burning alternatives is an important consideration. One criterion for selecting the preferable options is cost effectiveness (i.e. the cost per acre per pound of particulate emissions reduced). The costs of adopting a non-burning agricultural alternative are measured by the difference in the cost of agricultural operations between a traditional burning operation, about $3 per acre, and alternative non-burning approaches, about $31 to $47 per acre (CARB, 2001a). The viability of any alternative also depends on the farm's ability to remain profitable given the new labor, capital, and land requirements of the new technology. Financial incentives can help overcome or offset the cost of implementing non-burning alternatives. (These are discussed in more detail in Section 7.3 of this report under Accountability Mechanism 16.)

Cost-Effectiveness – Enterprise Level Assessment

Engineers estimate that each ton of rice straw burned emits 6.3 to 9 pounds of PM_{10} (CARB, 2000). The emission factor used in this estimate was 6.9 pounds of PM_{10} per ton (Jenkins, 2002). A typical acre of rice yields approximately 3 tons of rice straw residue after harvest. Thus, each acre burned emits approximately 20.7 pounds of PM_{10} each year. Limiting burning to weather conditions that reduce the probability that smoke will reach cities can reduce the impact of smoke emissions on society. However, since the air quality goal is overall reduction in particulate emissions, cost effectiveness is determined in terms of reduced pounds of emissions rather than reduced human exposures.

Crop production budgets for current agricultural practices show all of the necessary tasks to raise the crop and their costs per acre by expenditure category for a well-run operation. Budgets do not represent the average but generally show an idealized production operation using the best practices suggested by the state cooperative extension service. The University of California (UC) Cooperative Extension Service (Williams, 2001) has produced a rice crop budget that contemplates a farm using a mix of burning and non-burning alternative practices.

An expanded budget that estimates the costs of four alternative straw management strategies was developed by the California Air Resources Board (CARB, 2001a). Rice growers actually use a variety of practices depending on field characteristics, past performance, and the prices of water and fuel. The CARB options range in cost from $31 to $47 per acre with the two most popular practices (Chop/Stubble Disc/Winter Flood and Chop/Chisel/Stubble Disc/Winter Flood) averaging about $43 per acre. The UC rice budget also indicates that the least costly non-burning alternatives are to chop and disc ($37 per acre) or chop, flood, and roll ($32 per acre). However, neither of these methods can maintain yields without resorting to occasional burning.

The UC rice budget suggests that 15 percent of rice land may need to be burned in a given year. Thus, the costs to abate burning rise by $1.40 per pound abated [($32-$3)/(20.7 lbs PM_{10})] until 85 percent of acreage is managed by the chop, flood and roll method. To avoid releasing the last 15 percent of PM_{10} emissions, a more sustainable winter flooding regime must be adopted at an increased cost of $2.13 per pound abated [($47-$3)/(20.7 lbs PM_{10})]. The cost

of complete abatement reaches approximately $31.25 per acre. Figure 4-1 illustrates the relationship between cost of reduced burning and potential reductions in PM_{10} emissions on a per acre basis for rice straw.

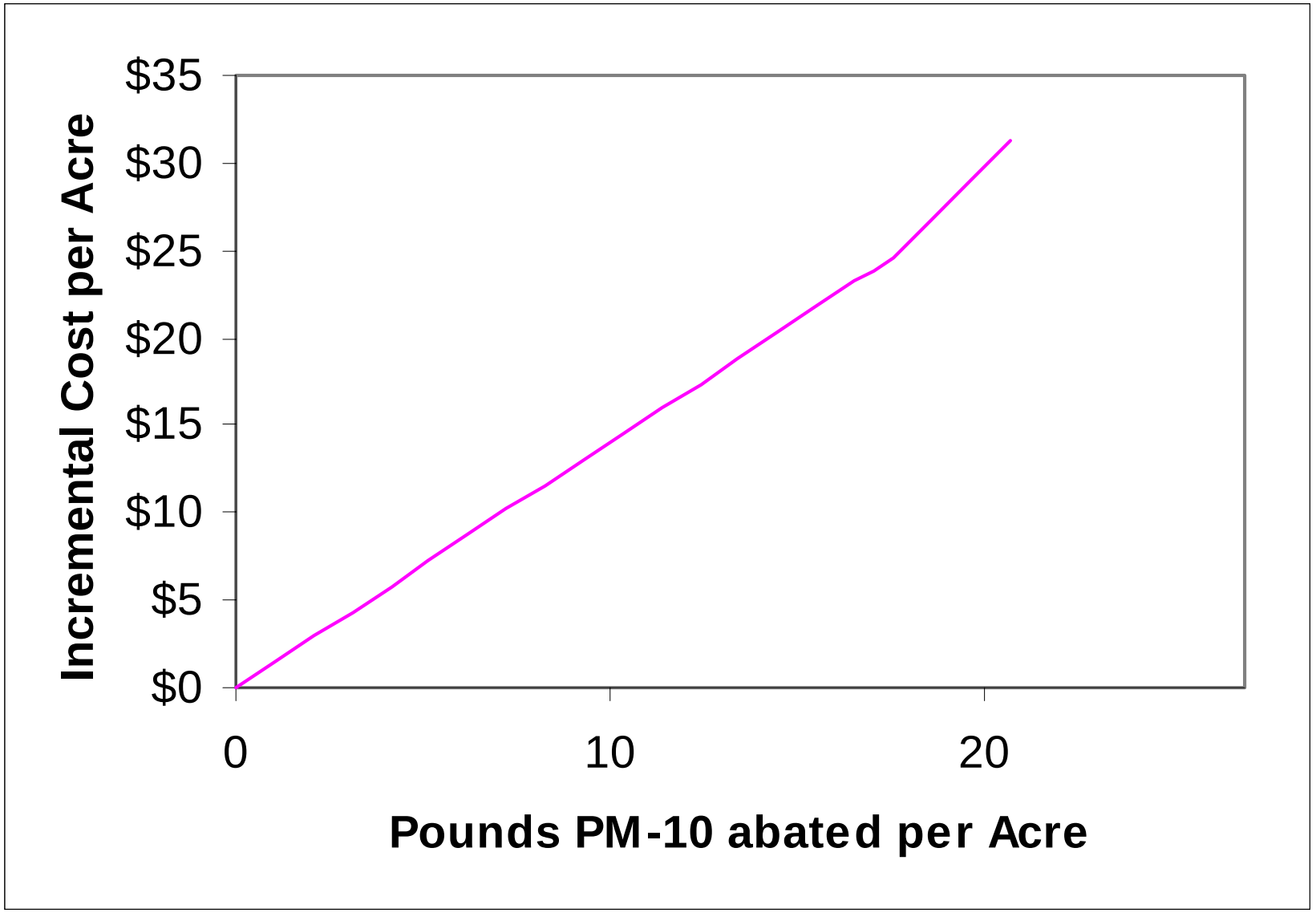
The UC rice budgets do not estimate the costs of baling rice straw, storing, and transporting it to alternative uses. These activities are more costly as they involve investment in a baler or hiring custom baling as well as more fuel and labor time in transit. The California Air Resources Board estimates field removal costs of $75 per acre based on field clearing costs of $60 per acre plus transportation costs of $15 per acre (CARB, 2001a). However, if a market for rice straw evolves, a compensating income could be obtained from baled straw. Furthermore, incentives offered by the state can influence the level of harvesting and use of rice straw. While use as compost or mulch, animal feed, or erosion control are the most likely alternative uses to consume large quantities of straw, there are many possible substitutes which will keep the price of straw for these uses relatively low. Hence, the costs of baling and hauling rice straw may not be recouped at competitive prices.

Affordability – Farm Level

Growers will not adopt a new technology or practice unless it makes economic sense for their farm as a whole. Rice acreage on farms that grow rice tends to be greater than the specific crop acreage of other commodity farms (Chambers and Childs, 2000). Rice farming is also more capital intensive than any field crop, other than cotton. This suggests a greater reliance on a single crop and the possibly a higher degree of borrowing by rice farmers than other producers. (Debt load information specific to California rice farming was not available.)

The UC rice enterprise budget shows producers' operating, overhead, and capital recovery costs are $188 greater than their revenue given current federal rice program payments and a price of $8.00 per hundredweight. Even a well-managed farm is operating at a long run loss. A more closely watched measure of profitability is revenues minus operating costs. Many growers will continue to operate at a paper loss as long as their cash flow is adequate to cover variable costs and the essential fixed costs (e.g., debt service). The UC rice budget indicates a net return above operating costs of $150 per acre. Additional costs to achieve complete abatement of PM_{10} of $35 per acre represents 21 percent of the farm's net return. The U.S. EPA,

Figure 4-1. Rice Straw - Cost of Implementing Non-Burning Alternatives



as an example, typically considers changes in net income of 3 to 5 percent as indicators of moderate stress (USEPA, 2001b). It is unlikely that farms can support such a high level of abatement costs in the long term without earning some return from rice straw sales. Thus, criteria should favor credible alternatives that encourage markets for rice straw.

Indirect Impacts – Regional Level

Changes in farm operations can have impacts in the regional economy. Collecting and transporting crop residue may require extra labor which may generate more income for farm workers. New equipment that might be needed or faster depreciation of old equipment may increase sales at agricultural implement dealers. Such effects generate ripple effects throughout the regional economy. The California Air Resources Board used a computable general equilibrium (CGE) model to trace the impact on prices and quantities of adopting different policy options for rice straw burning (CARB, 1993). Their baseline information indicated that agriculture provides about 10 percent of the Sacramento Valley's value added and employment. Rice production and processing accounts for about 13 percent of the region's agricultural value added and 7 percent of its agricultural employment. So, about one percent of the region's employment and value added come from the rice sector. The conclusion is that small changes in the output of this sector would have very small effects in the regional economy as a whole (CARB, 1993).

4.1.6 Social and Equity Issues

National trends over the last 10 years indicate that the number of large rice farms, measured both in terms of acreage and sales, has been growing faster than other field crop operations (Chambers and Childs, 2000). Very small farms (i.e., less than 100 acres) have also been disappearing rapidly. Large farms have greater yields per acre because they have better access to yield enhancing technologies such as precision leveling and permanent levees (Chambers and Childs, 2000). They may also be more profitable because they distribute fixed costs over a larger output. As a result, large farms may be able to absorb the added costs of non-burning alternatives more easily than small farms. Providing small producers access to straw markets and greater burning flexibility can mitigate the differential impact of adopting non-

burning alternatives. Another equity issue is the stringent control and reduction in rice straw burning in the Sacramento Valley without equal control of other crop residue burning.

4.1.7 Political Issues

Promotion of non-burning alternatives by government, even on a voluntary basis, has the potential to antagonize agricultural interest groups. The California Rice Commission routinely advocates growers' concerns in the state. Environmental and recreation interests are also well organized. Surveyed stakeholders did not cite any specific groups with strong positions on agricultural burning but noted general concerns about implementation of the rice straw burning phase down in the Sacramento Valley.

4.1.8 Summary of Impacts

Table 4-1 summarizes the discussion above by indicating the severity of each potential impact for each alternative to burning rice straw on a scale from zero to three. Blank indicates "not relevant" or "no information." The factors in Table 4-1 are phrased in the negative so that a high number in the table always indicates a stronger degree of negative consequences for that alternative. An alternative with many 3's in its column is probably not a viable option. A total or average of these scores indicates an overall weight of problematic impacts. However, this also implies an equal weighting among the impacts listed, which is unlikely among different interest groups.

The cut and haul residue to a waste facility or permitted burn facility alternatives contain several 3's because they incur the additional costs of baling and hauling without any hope of compensation for the grower. These alternatives are economically and politically untenable. The conversion of land to a non-agricultural use in detail received many 3's because conversion to a developed use is likely to require greater water and energy use as well as generating other forms of air emissions.

4.2 Grass Seed Case Study

Grass for seed is widely grown in Washington, Oregon, and Idaho. Legislation that allows burning only under favorable weather conditions has reduced the number of smoky days experienced in Spokane and other cities (WDOE, 1998a). While burning is a convenient

Table 4-1. Rice Straw - Impacts of Non-Burning Alternatives[1]

	Leave Residues in Place			Cut or Collect Residues and Haul											Scientific Improvements			Alternative Land Use		
Potential Impacts and Criteria	**Mulch Residue**	**Soil Incorporation: Wet or Dry**	**Soil Incorporation: Fallow Field**	**Waste Facility**	**Permitted Burn Facility**	**Power Generation Facility**	**Ethanol Production Facility**	**Redistribution Facility**	**Manufacturing or Use Facility**	**Fiberboard Facility**	**Particleboard Facility**	**Use as Compost or Mulch**	**Use as Animal Feed**	**Use For Erosion Control**	**Less Fuel Residual**	**Disease/Pest Resistance**	**Other Tolerances**	**Plant Crops that are not Burned**	**Land Conversion to Non-Agriculture**	**Conservation Tillage**
Agronomic:																				
Soil compression	1	3	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	0	0	1
Soil erosion	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	1	3	0
Increased water use	1	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	1
Increased herbicide use	2	2	2	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	2
Increased pesticide use	2	2	2	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	2
Land constraint	1	0	0	2	2	2	2	2	2	2	2	2	2	2	1	0	0	0	0	0
Time or equipment constraint	1	2	2	2	2	2	2	2	2	2	2	2	2	2	1	0	0	0	0	2
Environmental:																				
Countervailing air emissions	0	2	1	2	1	1	1	1	1	2	2	0	1	1	0	0	0	2	3	1
Negative wildlife impacts	1	2	2	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	3	1
Water quality degradation	1	2	1	3	3	2	2	2	2	2	2	0	1	0	1	1	0	2	2	1
Health and Safety:																				
Increased equipment use	1	1	1	2	2	2	2	2	2	2	2	2	1	2						1
Increased chemical use	2	2	2	0	0	0	0	0	0	0	0	1	0	1	1	1	0	2	3	3
Energy Impacts:																				
No contribution to energy production	2	2	2	2	2	0	0	2	2	1	1	2	2	2	2	2	2	2	3	1
Increased energy use	1	1	1	2	2	2	2	2	2	2	2	2	2	2	1	0	0	2	3	1
Economics:																				
Not cost-effective	2	2	2	3	3	1	1	1	1	1	1	2	2	2				2		
Farm financial stress	2	2	2	3	3	1	1	1	1	1	1	2	2	2				2		
Negative regional impacts	1	1	1	2	2	1	1	1	1	1	1	1	1	1				1	3	
Social and Equity:																				
Raises tribal/cultural/historical issues																			3	0
Raises small business issues	1	2	2	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0
Impacts low resource farms	2	2	2	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
Political:																				
Agricultural objections	2	2	2	3	3	0	0	0	0	0	0	0	0	0	1	1	0	3	3	3
Environmental objections	2	1	1	3	3	1	1	2	1	1	1	0	0	0	2	3	2	1	3	0
Average Score	1.3	1.8	1.6	1.9	1.9	1.1	1.1	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.2	1.1	0.9	1.6	2.1	1.1

[1] Feasibility factors are phrased to indicate a negative outcome. Higher ratings indicate worse consequences for that impact and alternative.

Blank = not relevant or viable 0 = no problem exists 1 = problem may exist 2 = problem does exist 3 = a major problem exists

disposal method for rice straw, it is an ecological necessity for grasses that evolved in fire-prone environments. Burning stimulates crown and tiller development which enhances seed head production. Cessation of all open field burning results in production losses of 23 to 31 percent even with the best mechanical residue management practices (WDOE, 1998a). Thus, evaluations of burning cessation in grass seed production often entail assumptions about farms converting to alternative crops, most often wheat.

4.2.1 Agronomic Impacts

After the seed is harvested, the remaining stubble is burned to prevent overwintering of disease organisms and condition the field for future growth. Alternatively, the straw must be cut, baled, and stacked and a crewcut vacuum used to remove the secondary residue. Soil incorporation is not an option as the grass is established as a long-lived stand and is not tilled each year. Repeated passes with equipment increase the risks of soil compaction, root damage, and possible delays from poor field conditions. Unlike rice straw, creating markets for grass straw will not mitigate all of the disadvantages of the non-burning alternative. Yields cannot be maintained by mechanical means so the consequences of farms shifting from grass to other crops must be considered. For example, growth of Meadowfoam has been explored as a rotation crop for annual ryegrass in Oregon's Willamette Valley. Meadowfoam seed produces oil that has had fluctuating market demand in the cosmetics industry.

4.2.2 Environmental Impacts

Non-burning alternatives require greater use of tractors and other equipment to cut, bale, and remove the straw. This added activity increases diesel and dust emissions. While the diesel emissions have a considerably smaller volume than the straw burning smoke, particulate emissions from diesel-fueled engines are listed by CARB as a toxic air contaminant (CARB, 2001a). The most likely alternative crop, wheat, exposes soil to wind and water erosion for much longer periods than grass production. Substantial volumes of particulate matter may be raised during wheat operations.

4.2.3 Health and Safety Impacts

Grass is often the crop of choice on relatively sloping sites because of its ability to hold the soil and limited need for cultivation. Non-burning alternatives require more mechanical

operations and so increase the risk of tipping accidents injuring workers operating machinery on steep slopes. Washington state regulations permit burning on steep slopes and so avoid this risk (WDOE, 1998b).

4.2.4 Energy Impacts

Straw can provide a renewable source of biomass for power generation. Like rice straw, it has a low heat content, seasonal supplies, and processing requirements. However, the ash content of grass straw is more comparable to other biomass fuels, so it is preferable to rice straw.

4.2.5 Economic Impacts

The economic impact of employing non-burning alternatives on grass stubble is discussed below.

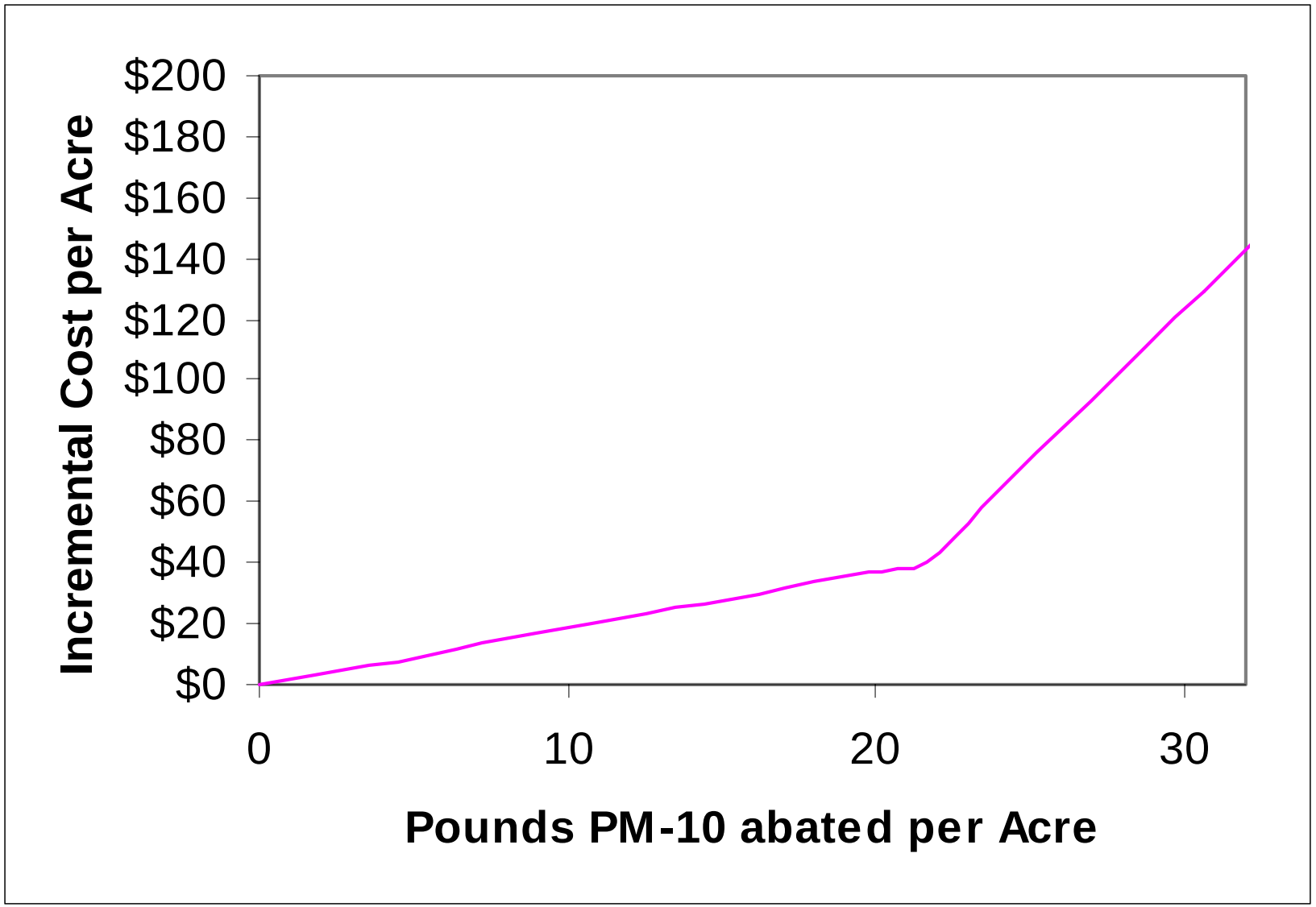
Cost-Effectiveness – Enterprise Level Assessment

Engineers estimate that each ton of grass straw burned emits 16 to 102 pounds of PM_{10} (CARB, 2000). The emission factor used in this estimate was 18.0 pounds of PM_{10} per ton (Jenkins, 2002). A typical acre of grass yields approximately 2 tons of straw acre after harvest. Thus, each acre burned emits 36 pounds of PM_{10} each year.

Washington Department of Ecology estimates the cost of mechanical straw management strategies as $70 per acre (WDOE, 1998a). The costs to the farmer to abate burning rise by $1.86 per pound abated [($70-$3)/(36 lb PM_{10})]. This impact is illustrated by the cost curve shown in Figure 4-2.

If farmers burn every third year rather than every year, burning can be reduced by two-thirds while yields are maintained near traditional levels. Thus, a diminution in yield effect becomes significant if more than two-thirds of the emissions are curtailed. The loss of output is part of the cost of abatement so costs rise sharply in Figure 4-2 if more than two-thirds of emissions are curtailed. Yield reductions of one-quarter to one-third have been observed which would reduce revenues per acre by $90 to $120 dollars, more than doubling the $70 direct costs of straw management itself.

Figure 4-2. Grass Seed - Costs of Implementing Non-Burning Alternatives



Affordability – Farm Level

Researchers have developed an enterprise budget for annual ryegrass that shows producers net return per acre with open-field burning is $73 at a price of $0.20 per pound (Taylor, Michael, et al, 1990). Additional costs to achieve complete abatement of PM_{10} of $70 per acre (not including yield effects) represents 96 percent of the farm's net return.

Indirect Impacts – Regional Level

Changes in farm operations can have impacts in the regional economy. Mechanical residue management employs more labor than open-field burning and so smoke abatement increases farm employment slightly (WDOE, 1998a).

4.2.6 Social and Equity Issues

A survey of stakeholders did not reveal any special considerations about social or equity issues among grass seed non-burning alternatives.

4.2.7 Political Issues

Promotion of non-burning alternatives by government, even on a voluntary basis, has the potential to antagonize agricultural interest groups. Survey respondents did not cite any specific groups with strong positions on agricultural burning but noted general concerns about implementation of new burning regulations in Washington. Any new regulation would have the potential to ignite legal controversies. Litigation over regulatory issues can become very costly to state governments.

4.2.8 Summary of Impacts

Table 4-2 summarizes the discussion above by indicating the severity of each impact in relation to each alternative to burning grass straw on a scale from zero to three. None of the "Leave Residues in Place" alternatives are viable for grass seed production because of agronomic issues so they are assigned all blanks. The waste and permitted burn facility alternatives cannot be sustained without subsidies because of the high cost to bale and transport straw without creating a saleable product.

Table 4-2. Grass Seed – Impacts of Non-Burning Alternatives[1]

Potential Impacts and Criteria	Leave Residues in Place			Cut or Collect Residues and Haul											Scientific Improvements			Alternative Land Use		
	Mulch Residue	Soil Incorporation: Wet or Dry	Soil Incorporation: Fallow Field	Waste Facility	Permitted Burn Facility	Power Generation Facility	Ethanol Production Facility	Redistribution Facility	Manufacturing or Use Facility	Fiberboard Facility	Particleboard Facility	Use as Compost or Mulch	Use as Animal Feed	Use For Erosion Control	Less Fuel Residual	Diseasepest Resistance	Other Tolerances	Plant Crops that are not Burned	Land Conversion to Non-Agriculture	Conservation Tillage
Agronomic:																				
Soil compression				2	2	2	2	2	2	2	2	2	2	2	1	1	1	0	0	1
Soil erosion	0			0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0
Increased water use				0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	1
Increased herbicide use				0	0	0	0	0	0	0	0	0	0	0	1	1	1	3	2	2
Increased pesticide use				0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	2
Land constraint				2	2	2	2	2	2	2	2	2	2	2	1	0	0	0	0	0
Time or equipment constraint				2	2	2	2	2	2	2	2	2	2	2	1	0	0	0	0	2
Environmental:																				
Countervailing air emissions				2	1	1	1	1	1	2	2	0	1	1	0	0	0	3	3	1
Negative wildlife impacts				0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	3	1
Water quality degradation				3	3	2	2	2	2	2	2	0	1	0	1	1	0	3	2	1
Health and Safety:																				
Increased equipment use				2	2	2	2	2	2	2	2	2	2	2					0	1
Increased chemical use	2			0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3
Energy Impacts:																				
No contribution to energy production				2	2	0	0	2	2	1	1	2	2	2	2	2	2	2	3	1
Increased energy use	1			2	2	2	2	2	2	2	2	2	2	2	1	0	0	3	3	1
Economics:																				
Not cost-effective				3	3	1	1	1	1	1	1	2	2	2				2		
Farm financial stress				3	3	1	1	1	1	1	1	2	2	2				3		
Negative regional impacts				2	2	1	1	1	1	1	1	1	1	1				1	3	
Social and Equity:																				
Raises tribal/cultural/historical issues																			3	
Raises small business issues				3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
Impacts low resource farms				3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
Political:																				
Agricultural objections				3	3	0	0	0	0	0	0	0	0	0	1	1	0	3	3	3
Environmental objections				3	3	1	1	2	1	1	1	0	0	0	2	3	2	2	3	0
Average Score				1.9	1.9	1.1	1.1	1.2	1.2	1.2	1.2	1.1	1.2	1.1	1.2	1.1	0.9	1.9	2.0	1.2

[1] Feasibility factors are phrased to indicate a negative outcome. Higher ratings indicate worse consequences for that impact and alternative.

Blank = not relevant or viable 0 = no problem exists 1 = problem may exist 2 = problem does exist 3 = a major problem exists

5.0 ACCOUNTABILITY MECHANISMS

This section describes the strategies used to research, identify, and characterize accountability mechanisms of greatest importance in supporting the development and use of non-burning alternatives within the 15 Western states. Accountability mechanisms are procedures used for tracking if, and to what extent, non-burning alternatives are used by local, state, tribal, or federal entities.

Where possible, accountability mechanisms which are currently in place and are actively in use at the state, county, and local levels, as well as in the tribal community setting, are identified in this report. In addition, a discussion of how each accountability mechanism is important in supporting or promoting the development and use of non-burning alternatives is provided. Accountability mechanisms important to the implementation and use of non-burning alternatives by individual burners are also discussed in greater detail in Section 7.0.

5.1 Research Strategy and Sources of Information

The identification and characterization of accountability mechanisms of importance in the development, consideration, and use of non-burning alternatives was a complex process. It required a thorough assessment, understanding, and interpretation of current agricultural burning practices in the West. It also required a thorough assessment of the regulatory and programmatic structures in place for addressing agricultural or open burning activities in each state (and where applicable for each county or local air authority). An understanding of the variety of practical, technical, political, and economic forces affecting stakeholders involved in or currently conducting agricultural burns was also critical for the successful identification and characterization of accountability mechanisms in this effort.

To collect the desired information and to address the expectedly wide distribution of information sources, the same three-tiered approach discussed in Section 2.0 was employed. This approach included contacting and/or researching the availability of information from three different levels of information sources. It was expected that these sources would provide varying information perspectives and levels of programmatic detail. The majority of the information pertaining to this task came from the first level of information sources.

The first level of information sources investigated included state environmental agencies, boards and departments as well as state, county and local air pollution control authorities. Information important to this effort was collected from the respective administrative and statutory rules and regulations, formal published reports and documents, and articles or summary information posted on official state level or county level websites. For all 15 Western states, the presence, or in some cases the absence, of accountability mechanisms important in the identification, development, consideration and use of non-burning alternatives, was clearly documented by these information sources.

To ensure efficiency and effectiveness in the collection of data for this task, a process for reliably identifying, collecting, and documenting information obtained was developed. As part of this process, an informal survey was designed for in-house use only. Contacts at the various state, county, local or tribal environmental authorities were identified for all 15 states. Information was collected by phone or e-mail. Responses to a series of questions designed to identify and characterize accountability mechanisms were used to document information collected for this task. The contact persons have been identified and referenced in Appendix A.

As appropriate, contact was made with secondary sources identified by the first level sources. A focused review of prior agricultural burning survey reports, documents and other information produced by larger and more comprehensive multi-agency environmental and or governmental organizations was also conducted. These organizations included the WGA, WRAP, and its various task forces such as the FEJF. (GCVTC, 1996; WESTAR, 1999; WRAP, 2001a; WRAP 2001b).

5.2 Accountability Mechanisms Identified

Seventeen accountability mechanisms were identified that are important to the use of non-burning alternatives to agricultural burning in the West. The accountability mechanisms identified include the following:

1. Agricultural Burning is Exempt from all Regulations or Rules.
2. Agricultural Burning is Effectively Exempt from Regulations or Rules.

3. Agricultural Burning is Included in Regulations or Rules.
4. Specific Agricultural Burning Regulations or Rules Exist.
5. General Open Burning Regulations or Rules Exist.
6. Other Burning Sources are More Important.
7. Formal Agricultural Burning Approval Process Exists.
8. Agricultural Burning Permit is Required.
9. Agricultural Burning Permit Fees are Charged.
10. Smoke Management is Required.
11. Agricultural Burning Activity Enforcement Process Exists.
12. Requirement to Estimate Fuels, Acreage and Emissions on a Pre-Burn Permit Exists.
13. Requirement to Confirm Fuels, Acreage and Emissions on a Post-Burn Report Exists.
14. Agricultural Burning Activity Data is Reviewed and Included in Inventories.
15. Requirements to Consider the Use of Alternatives Exist.
16. Financial Incentive(s) are Available for Using Alternatives.
17. List of Alternatives is Available.

The results of this effort clearly suggest that the presence, or in some cases the absence, of identified accountability mechanisms may effectively determine whether non-burning alternatives will be used in the 15 Western states. The 17 mechanisms identified above fall into five main categories of accountability. These categories, (a) through (e), are shown in Table 5-1. The 17 accountability mechanisms are discussed in detail below.

5.2.1 Accountability Mechanisms 1 through 3

The most important mechanisms in the initial determination of whether non-burning alternatives will be employed are found in category (a) in Table 5-1. Accountability mechanisms in this category are initiated at the state or regional level. These mechanisms either absolutely (Mechanism 1) or in practice effectively (Mechanism 2) exempt agricultural burning from regulation. Conversely, they actively include agricultural sources for potential regulation

Table 5-1. General Categories of Accountability Mechanisms Identified in the 15 Western States

General Category and Description	Accountability Mechanism
(a) Accountability Initiated at the State or Regional Level	1. Agricultural Burning is Exempt from all Regulations or Rules 2. Agricultural Burning is Effectively Exempt from Regulations or Rules 3. Agricultural Burning is Included in Regulations or Rules
(b) Accountability at a State or Local Level that Supports the Active Regulation of Agricultural Burning Activities	4. Specific Agricultural Burning Regulations or Rules Exist 5. General Open Burning Regulations or Rules Exist 6. Other Burning Sources are More Important
(c) Accountability at a Programmatic Level that Supports a Formal Approval and/or Permitting Process	7. Formal Agricultural Burning Approval Process Exists 8. Agricultural Burning Permit is Required 9. Agricultural Burning Permit Fees are Charged 10. Smoke Management is Required 11. Agricultural Burning Activity Enforcement Process Exists
(d) Mechanisms that Encourage Accountability at the Local Level that Support the Tracking of Emissions and Program Effectiveness	12. Requirement to Estimate Fuels, Acreage and Emissions on a Pre-Burn Permit 13. Requirement to Confirm Fuels, Acreage and Emissions on a Post-Burn Report 14. Agricultural Burning Activity Data is Reviewed and Included in Inventories
(e) Mechanisms that Facilitate and Encourage the Use of Non-Burning Alternatives	15. Requirements to Consider the Use of Alternatives Exist 16. Financial Incentive(s) are Available for Using Alternatives 17. List of Alternatives is Available

(Mechanism 3). Mechanism 3 effectively establishes whether agricultural burning is defined and/or included in any state or local regulation or rule.

State environmental regulatory agencies throughout the 15 Western states either include agricultural burning in statute or they exempt agricultural burning completely from their regulations and rules. They may do this for a variety of reasons. Absolute exemption may occur because agricultural burning may not be a significant source of air pollution in the region, state or air basin. Agricultural burning may not be a source of air pollution because climate, topography, crops planted, or current agricultural practices may not support the need to burn. Also, agriculture activities may not exist or occur in a given state or air basin such that burning of residues or stubble is needed.

In contrast, agricultural burning may be an important and/or significant source of pollution in the state, tribal community, or an air basin in general. It may also be an important, significant source at certain times of the year and not others. However, in spite of this, some states still exempt agricultural burning sources from regulation. In these cases, political, social, economic, regulatory resource, or regulatory climate factors may make it impractical for states to include agricultural burning in their regulations as an air pollution source that can be controlled.

In other cases, state agencies or local air authorities may essentially, in practice, exempt agricultural burning even if it is identified in regulations as a source of air pollution. This occurs for a variety of reasons but for the most part it results from either a programmatic focus on other areas or sources of air pollution of greater concern, or from political, social, economic, regulatory resource, or regulatory climate factors that de-emphasize regulation of agricultural burning sources. Regardless of the reasons why this may occur, if agricultural burning is absolutely exempted or effectively exempted in practice from regulation at the state or regional level, there is little practical incentive, (private or governmental) to develop or implement alternatives to agricultural burning. When agricultural burning is identified in statute as a source of air pollution, the chances of identifying, developing, and employing non-burning alternatives increase substantially.

5.2.2 Accountability Mechanisms 4 through 6

Category (b) mechanisms provide accountability at the state or local level that supports the active regulation of agricultural burning activities. Category (b) mechanisms include mechanisms 4 through 6. If agricultural burning activities are included in state environmental or health statutes, there is a greater likelihood that non-burning alternatives will be identified, developed, and used. If agricultural burning is not otherwise exempted from regulation, the degree to which it will or may be regulated is closely tied to the regulatory strategy embraced by the environmental agency or air quality authority. The extent to which agricultural burning is practically regulated is also dependent on the form and subsequent effectiveness of the regulations used to address agricultural burning as a source of air pollution. The degree to which agricultural burning regulations serve as motivating factors in the identification, development, and use of non-burning alternatives can often be predicted based on the following factors:

- Whether there is a formal rule or regulation in place to address agricultural burning;
- The type or types of regulations or rules in place which address agricultural burning; and
- The relative degree to which agricultural burning is important as a source of air pollution compared to other sources in the state, regional or air basin.

Accountability mechanisms 4 and 5 support the active regulation of agricultural burning at the state and local levels. Mechanism 4 provides for clearly defined regulations or rules specifically designed to address agricultural burning activities. Mechanism 5 provides for the inclusion of agricultural sources in a more general open burn regulation or rule. Both mechanisms increase the likelihood that non-burning alternatives will be identified, developed and used. However, the more specific the regulation, typically the more detailed and ideally effective a regulation or rule may be in addressing a particular source or class of pollutant sources.

Mechanism 6 is also important in the identification, development and use of non-burning alternatives since it has the potential to deter, under some circumstances, the active

addressing of agricultural burning sources. In Mechanism 6 other burning activities such as range management, land clearing or forest management may be more important sources of air pollution from a programmatic implementation standpoint. This may develop because of technical, political, or economic factors, or a combination of the same. In these cases, even though rules or regulations to address agricultural burning are in place at the state level, other vegetative burning sources receive higher implementation priority. In some cases, this may contribute to the effective exemption of agricultural burning activities although it may encourage the development of non-burning alternatives for other vegetative burning sources.

5.2.3 Accountability Mechanisms 7 through 11

Accountability mechanisms that support regulation of agricultural burning fall into category (c): Accountability at a Programmatic Level that Supports a Formal Approval and/or Permitting Process. Mechanisms in this category support more systematic approaches to the review and approval of proposed burn activities, overall program implementation and consistent enforcement of programs which include regulations or rules that address agricultural burning. Accountability mechanism 7 provides for a formal burn activity approval process. Accountability mechanisms 8 and 9 address pre-burn permit requirements and associated permit fees. Mechanism 10 provides for the accountability of smoke released from ongoing burn activities. Mechanism 11 supports compliance with existing regulations or rules as well as provides a forum for education on smoke program benefits through a formal enforcement process. All of these mechanisms provide information and in some cases economic motivation that supports the identification, development, and use of non-burning alternatives.

5.2.4 Accountability Mechanisms 12 through 14

Mechanisms that provide information for applying non-burning alternatives to current agricultural burning practices fall into category (d). These include Mechanisms 12 through 14 which encourage accountability at the local level by supporting the tracking of emissions and program effectiveness. Mechanisms 12 through 14 support the formal identification, tracking, and inventorying of burn activity parameters important in the implementation and review of an agricultural burning program effectiveness and extent of implementation. Some of the most important parameters addressed by these mechanisms include

the identification of fuel types burned, the number of acres burned, and the resulting emissions from all identified agricultural burning sources. Mechanism 12 requires potential burners to estimate parameters such as fuel type, fuel loading, acreage impacted, and in some cases, potential emissions released from any proposed burn activity. This information is usually provided on a pre-burn permit application or even the permit itself. Mechanism 13 increases the assurance of quality data collection by requiring a post-burn report that confirms the parameters initially estimated on the pre-burn permit or permit application.

Mechanism 14 increases the likelihood that non-burning alternatives will be identified and used since it provides a mechanism for formal burn permit data review and the inclusion of important data in statewide inventories and implementation plans. As significant agricultural burning emissions are identified and documented at the state and regional levels, comparison to other more traditionally well-documented sources of air pollution becomes possible. In areas where agricultural activities are economically significant, motivation to continue agricultural production and related activities typically remains high despite the release of potentially significant air emissions. This type of atmosphere can provide motivation and support for, as well as stimulate interest in, the identification, development, and use of effective non-burning alternatives. This is especially true if agricultural source contributions can be documented and the stakeholders can be assured their efforts to use non-burning alternatives will be worthwhile. A more comprehensive discussion of these mechanisms and how they might be used in the effective implementation of non-burning alternatives can be found in Section 7.0.

5.2.5 Accountability Mechanisms 15 through 17

The fifth and final category is category (e). Mechanisms that facilitate and encourage the use of non-burning alternatives are found in this category. While it might seem in some cases that these mechanisms should be the only ones considered, it is unlikely that these mechanisms alone will produce the desired results in any but the most advanced agricultural burning management programs settings. Mechanisms 1 through 14 are essential for the support and validation of Mechanisms 15, 16, and 17. Mechanisms 15, 16, and 17 provide accountability at the state or local level that facilitates the active identification of, and encourages the consistent use of, effective non-burning alternatives in conjunction with, or as a substitute to, more traditional existing agricultural burning practices. Mechanism 15 provides incentive to actively

consider non-burning alternatives by making it a requirement of pre-burn approval. This usually occurs during the pre-burn permitting process. If no pre-burn permitting process exists, in all but the most unique of circumstances, it is impractical and unrealistic to expect non-burning alternatives will be considered to any significant extent.

Mechanism 16 provides financial assistance in one form or another to burners who implement non-burning alternatives. This serves to help overcome one of the most often voiced oppositions to the use of non-burning alternatives which is that of cost "ineffectiveness". Mechanism 17 has the potential to provide useful, practical incentives to the increased use of non-burning alternatives by providing a list of alternatives that are available and/or in use successfully in the area. This mechanism would eliminate another readily voiced opposition to the use of non-burning alternatives, which is that non-burning alternatives do not exist or cannot be used effectively. A more comprehensive discussion of these mechanisms and how they might be used in the effective implementation of non-burning alternatives can be found in Section 7.0 of this report.

5.3 Review and Discussion of the Accountability Mechanisms in Place in the 15 Western States

A review and discussion of the accountability mechanisms identified during this effort and found to be in place in the 15 western states is included here to more fully explain the survey results presented in Table 5-2. (Relevant comments are provided in a comment key in Table 5-2a.) The authors of this report are making the assumption that if accountability mechanisms 3-17 are in place then there is a greater likelihood that non-burning alternatives to agricultural burning will be identified and implemented in areas where agricultural burning significantly contributes to air quality issues. This assumption appears to be supported by the results of the survey effort for those states with more aggressive mandates to address agricultural burning as a significant source of air pollution. However, this does not preclude the possibility that non-burning alternatives may be identified and implemented for other reasons or by other means or methods.

The authors recognize that the development of air pollution emission source reduction programs is a complex process involving countless stakeholders and many years of

Table 5-2. Accountability Mechanisms Important to the Use of Non-Burning Alternatives

State-County(ies) or Area	1 Agricultural Burning is Exempt from all Regulations or Rules	2 Agricultural Burning is Effectively Exempt from Regulations or Rules	3 Agricultural Burning is Included in Regulations or Rules	4 Specific Agricultural Burning Regulation or Rule	5 General Open Burning Regulation or Rule	6 Other Burning Sources More Important	7 Formal Agricultural Burn Approval Process	8 Agricultural Burning Permit is Required	9 Agricultural Burning Permit Fees are Charged	10 Smoke Management is Required	11 Agricultural Burn Activity Enforcement Process Exists	12 Requirement to Estimate Fuels, Acreage, & Emissions: Pre-Burn Permit	13 Requirement to Confirm Fuels, Acreage, & Emissions: Post Burn Report	14 Agricultural Burn Activity Data is Reviewed & Included in an Inventory	15 Requirements to Consider Use of Alternatives	16 Financial Incentive(s) are Available for Using Alternatives	17 List of Alternatives is Available	References	Comments
			Accountability Mechanisms that Support Identification and Use of Non-Burning Alternatives																
AK		✓	✓		✓		✓[2,3]	✓					✓		✓			WRAP, 2001a	1, 27
AZ		✓	✓		✓						✓	✓		✓					2, 28
AZ-Pima			✓[1]		✓[1]		✓[1]	✓[1]	✓[1]		✓[1]								3
AZ-Pinal			✓[1]		✓[1]		✓[1]	✓[1]	✓[1]										4
AZ-Yuma			✓[2]		✓[2]		✓[2]	✓[2]	✓[1]		✓[1]	✓[2]							5
AZ-Maricopa		✓			✓[1]														6
CA			✓		✓[1]			✓[1]	✓[1]	✓[1]	✓[1]			✓	✓	✓		WRAP, 2001a	7, 43
CA-Lake			✓[1]		✓[1]		✓[1]	✓[1]	✓[1]	✓[1]	✓[1]	✓[1]		✓[1]	✓[1]			WRAP, 2001a	44
CA-Sacramento Valley Counties			✓[1]	✓[1]			✓[1]	✓[1]	✓[1]	✓[1]	✓[1]	✓[1]		✓[1]	✓[1]			WRAP, 2001a	45
CA-San Joaquin Valley Counties			✓[1]		✓[1]		✓[1]	✓[1]	✓[1]	✓[1]	✓[1]	✓[1]		✓[1]	✓[1]			WRAP, 2001a	46
CA-South Coast Counties			✓[1]		✓[1]		✓[1]	✓[1]	✓[1]	✓[1]	✓[1]	✓[1]		✓[1]	✓[1]			WRAP, 2001a	8, 47
CO	✓					✓													9
HI			✓		✓			✓	✓		✓	✓			✓				10
ID			✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓			WESTAR, 1999	11, 30
MT		✓	✓		✓	✓		✓	✓		✓								12, 31

Table 5-2. Continued

State-County(ies) or Area	1 Agricultural Burning is Exempt from all Regulations or Rules	2 Agricultural Burning is Effectively Exempt from Regulations or Rules	Accountability Mechanisms that Support Identification and Use of Non-Burning Alternatives 3 Agricultural Burning is Included in Regulations or Rules	4 Specific Agricultural Burning Regulation or Rule	5 General Open Burning Regulation or Rule	6 Other Burning Sources More Important	7 Formal Agricultural Burn Approval Process	8 Agricultural Burning Permit is Required	9 Agricultural Burning Permit Fees are Charged	10 Smoke Management is Required	11 Agricultural Burn Activity Enforcement Process Exists	12 Requirement to Estimate Fuels, Acreage, & Emissions: Pre-Burn Permit	13 Requirement to Confirm Fuels, Acreage, & Emissions: Post Burn Report	14 Agricultural Burn Activity Data is Reviewed & Included in an Inventory	15 Requirements to Consider Use of Alternatives	16 Financial Incentive(s) are Available for Using Alternatives	17 List of Alternatives is Available	References	Comments
ND		✓	✓		✓		✓[1]				✓								13, 32
NM		✓	✓		✓										✓				14, 42
NV	✓													✓				WRAP, 2001a	15, 33
NV-Pershing	✓											✓						WRAP, 2001a	
OR			✓		✓			✓	✓	✓	✓	✓			✓	✓			16, 34, 35
OR-Jefferson			✓[1]		✓[1]			✓[2]	✓[1]	✓[1]	✓[1]	✓[1]				✓[1]		WRAP, 2001a	36
OR-Umatilla			✓[1]		✓[1]			✓[1]	✓[1]	✓[1]	✓[1]	✓[1]				✓[1]		WRAP, 2001a	36
OR-Union			✓[1]		✓[1]			✓[1]	✓[1]	✓[1]	✓[1]	✓[1]				✓[1]		WRAP, 2001a	36
OR-Willamette			✓[1]		✓[1]			✓[1]	✓[1]	✓[1]	✓[1]	✓[1]				✓[1]		WRAP, 2001a	36
SD	✓																		17, 37
UT	✓																	WESTAR, 1999	18, 38
WA			✓		✓			✓	✓		✓		✓	✓	✓		✓	WRAP, 2001a; WESTAR, 1999	19
WA -Benton			✓[1]	✓[1]				✓[1]	✓[1]		✓[1]	✓[1]		✓[1]	✓[1]			WRAP, 2001a	20, 40
WA-Columbia			✓[1]	✓[1]				✓[1]	✓[1]		✓[1]	✓[1]		✓[1]	✓[1]			WRAP, 2001a	21, 40
WA-NW region			✓[1]	✓[1]				✓[1]	✓[1]		✓[1]	✓[1]		✓[1]	✓[1]			WRAP, 2001a	22, 40
WA-SW region			✓[1]	✓[1]				✓[1]	✓[1]		✓[1]	✓[1]		✓[1]	✓[1]			WRAP, 2001a	23, 40
WA-Walla Walla			✓[1]	✓[1]				✓[1]	✓[1]		✓[1]	✓[1]		✓[1]	✓[1]			WRAP, 2001a	24, 40

Table 5-2. Continued

State-County(ies) or Area	1 Agricultural Burning is Exempt from all Regulations or Rules	2 Agricultural Burning is Effectively Exempt from Regulations or Rules	3 Agricultural Burning is Included in Regulations or Rules	4 Specific Agricultural Burning Regulation or Rule	5 General Open Burning Regulation or Rule	6 Other Burning Sources More Important	7 Formal Agricultural Burn Approval Process	8 Agricultural Burning Permit is Required	9 Agricultural Burning Permit Fees are Charged	10 Smoke Management is Required	11 Agricultural Burn Activity Enforcement Process Exists	12 Requirement to Estimate Fuels, Acreage, & Emissions: Pre-Burn Permit	13 Requirement to Confirm Fuels, Acreage, & Emissions: Post Burn Report	14 Agricultural Burn Activity Data is Reviewed & Included in an Inventory	15 Requirements to Consider Use of Alternatives	16 Financial Incentive(s) are Available for Using Alternatives	17 List of Alternatives is Available	References	Comments
			Accountability Mechanisms that Support Identification and Use of Non-Burning Alternatives																
WY		✓			✓	✓													25, 41
Tribal	✓	✓[3]; ✓[4]; ✓[5]				✓[1]; ✓[2]; ✓[3]; ✓[4]; ✓[5]	✓[1]; ✓[2]; ✓[3]; ✓[4]; ✓[5]											WRAP, 2001b	26

Notes:

✓ = State Level
✓[1] = County or Local Authority
✓[2] = Rural Fire District
✓[3] = Natural Resources Authority
✓[4] = Tribal Authority
✓[5] = Federal Land Management Authority

AK = Alaska
AZ = Arizona
CA = California
CO = Colorado
HI = Hawaii
ID = Idaho
MT = Montana
ND = North Dakota

NM = New Mexico
NV = Nevada
OR = Oregon
SD = South Dakota
UT = Utah
WA = Washington
WY = Wyoming

Table 5-2a. Comments Key for Table 5-2

No.	Comments
1	Ann Lawton, AK State Dept. Env. Quality, ERG/ETC Informal Survey 2001 (see Appendix A): No agricultural crops burned. Limited burning conducted to date is for land clearing; may be more in future. Limited to fall and spring because of climate, tourism, and fire danger. Burning occurs in Delta Junction area only. Rest of AK no agricultural burning at all. Permits are required for burns greater than 40 acres in size only. Most of the smoke issues occur with non-permitted burns.
2	Varma Sunil, AZ State Dept. Env. Quality, ERG/ETC Informal Survey 2001: Typically agricultural burning is not addressed in statewide open burning smoke management program. Most burning occurs in Yuma county. 8,000 acre/yr limit via State Implementation Plan. Non-agricultural open burning is allowed in Yuma and Maricopa Counties.
3	Bill Maxwell, Pima County Dept Env. Quality, ERG/ETC Informal Survey 2001: Most burning is tumbleweeds, year round via open burn permit. Based on burn/no-burn days program. No smoke management plan is required and emissions are not tracked.
4	Donald Gabrielson, Pinal County Dept. Env. Quality, ERG/ETC Informal Survey 2001: Principal agricultural burning is for irrigation ditch bank clearing. Occurs in Spring. Most other permitted burning is for residential use burn barrels. Some rural agricultural burning. If okayed for agricultural, annual permit to burn anything up to 320 contiguous acres.
5	Varma Sunil, AZ State Dept. of Env. Quality and Kurt Foster, Yuma County Fire Dept, ERG/ETC Informal Survey 2001: Most burning is limited by the State Implementation Plan up to 8,000 acre/yr. It typically includes citrus and other orchard fuels burning for orchard retirement and removal. Often use a curtain air destructor.
6	Rick Hado, Maricopa County, ERG/ETC Informal Survey 2001: No burning for agricultural residues occurs in county. Majority of burning is for ditch banks, tumbleweeds, fenceline clearing and land clearing. Do often use high temperature propane burners for ditch banks and best management practices.
7	WRAP, 2001a: Agricultural burning is allowed under state law. It is typically permitted at the county air authority level. Many crops are burned, especially rice, wheat and other grains. Orchard prunings are also burned by permit. The newly adopted statewide Title 17 Smoke Management Guidelines for Agricultural and Prescribed burning in CA provides authority, direction and guidance to the local air authorities (air quality management and/or control districts) for the regulation and management of burning. Smoke management plans are required of each local air authority. There is considerable variability in the implementation of local rules and regs and little systematic statewide review of programs or emissions estimates.
8	WRAP, 2001a: Almost any crop can be burned any time of the year.
9	Coleen Campbell, CO State Dept. of Public Health and Phyllis Woodford, CO State Dept. of Public Health, ERG/ETC Informal Survey 2001: Burning occurs only of range land and irrigation ditches. Regulations exempt agricultural residues but do encourage good burning practices. Some spring wheat, corn and sunflower burning may occur in Western counties/Grand Junction area. Approval to burn via courtesy burn/no-burn calls.
10	Lisa Young, HI State Dept. of Health and Janet Ashman, HI Agricultural Research Center; ERG/ETC Informal Survey 2001: Two year crops, roughly half of the acres planted in any year would be burned the following year for both sugar cane and pineapples. Estimate 40,000 to 50,000 acres of sugarcane are in production. Roughly 30,000 acres sugarcane is burned in any given year. Acreage burned for pineapples is unknown. Sugarcane industry is having economic difficulties due to competition with sugarbeet production in other states. Sugarcane burning will likely decrease the future.
11	Diane Riley, ID State Dept. Env. Quality, ERG/ETC Survey 2001; Dan Redline, Coeur d'Alene Regional Office, ERG/ETC Informal Survey 2001; Curt Thornberg, ID Dept. of Agriculture, ERG/ETC Informal Survey 2001, Robert Wilkosz, ID Dept. Env. Quality, WESTAR (1999): Data not available for most of the state. Some data on grass and cereal grains is available for the Kootenai and Benewah counties. Voluntary smoke management plans are used in Kootenai and Benewah counties. Grass seed and cereal crops are burned in the fall (Aug-Sept). Alfalfa, mint and other perennial forage crops are burned in both the spring and fall. Ditch banks are burned in the spring. Individual burners make the burn/no-burn decisions. Open burning rule specifically allows burning of orchard clippings and burning for weed control.

Table 5-2a. Continued

No.	Comments
12	Bob Habeck, MT State Dept Environmental Quality, ERG/ETC Informal Survey 2001: Data on acreage burned are not tracked. State has permit authority Sept-Feb otherwise burner gets to decide when to burn and not burn. Program is geared toward wildlands and forest management, not agricultural. Rarely allowed to burn in summer months because of fire danger. Burning that does occur addresses ditches and sagebrush land conversion.
13	Chuck McDonald, ND State Health Dept., ERG/ETC Informal Survey 2001: Wheat is burned in fall and only in northeastern areas of Red River Valley. Yields are high, similar to rice in CA. Do not track emissions at all. Agriculture is exempt. Open burning is prohibited but variances are issued for prescribed burning of forest lands. One particle/fiberboard plant is highly successful in the state.
14	Brad Musick, NM State Dept of Environment, ERG/ETC Informal Survey 2001: Orchard prunings are the main issue. No emissions data is kept. Wheat is burned in eastern portion of the State. Pecans are the main crop. Prunings, hulls etc. are burned in the Dona Ana (Rio Grande) areas of state. Tumbleweeds and irrigation ditches are burned routinely as a way of life in some areas to supply pecan orchards with water.
15	Colleen Cripps, NV State Dept. Env. Quality, ERG/ETC Informal Survey 2001 and WRAP, 2001a: Agricultural burning is essentially not regulated. Some self regulation occurs in parts of the state with greater community concerns. This includes the Lovelock Valley.
16	Brian Finneran, OR State Dept. Env. Quality, ERG/ETC Informal Survey 2001: Grains burned July-Sept. Basically track emissions through three separate geographically distinct field burning programs. All three programs publish annual emissions reports. Largest source of burning is the Willamette Valley. Complex state run program. Orchard burning is typically allowed statewide.
17	Chris Hansen, SD Dept of Environment and Natural Resources, ERG/ETC Informal Survey 2001; Tim Rogers, SD State Dept of Environment and Natural Resources, ERG/ETC Informal Survey 2001: agricultural burning is not regulated in the state. No Tracking, no records kept, and no permits required for agricultural burning in the state. Grasses burned in spring (March - May) and fall (Sept - Oct). Grain is burned in March and April. Open burning of rubbish, treated woods, wastes, etc. is prohibited.
18	Francis Bernards, UT State Dept. Env. Quality, ERG/ETC Informal Survey 2001; Steven Parkin, UT State Division of Air Quality, WESTAR (1999): State does not track acres burned. Large agri-farming occurs in nearly every county. No burning occurs during Ozone season, (June - Aug). Burn season is Sept-May.
19	Grant Pfeifer, WA State Dept of Ecology, Agricultural Burn Task Force, ERG/ETC Informal Survey 2001; Chad Akins, WA State Dept of Ecology, WESTAR, 1999: Burning occurs in Benton, Columbia, Island, Skagit and Whatcom counties. Wheat is burned in March, April and July-Nov. Fall burning occurs Aug-Nov. Spring burning occurs March-May. Crops burned include wheat, barley, grass seed, pasture and alfalfa seed. A post-burn "Report Card" is required. Emissions from these sources are tracked. Burning incidental to agricultural residue is allowed without a permit. This type of burning includes orchard prunings, fencelines, irrigation and drainage ditches. Emissions are not tracked from these sources. State of WA does support research to explore alternatives to burning.
20	WRAP 2001a: Most of the burning in the county is orchard removal.
21	WRAP 2001a: Spring burning in March through April; Fall burning in Mid-Sept through October
22	WRAP 2001a: Very small amount of acreage burned. 475 total acres in year 2000.
23	WRAP, 2001a: Little agricultural burning occurs in this county. Less than 50 acres in 2000, none were grain or grass seed crops. Burning is allowed year round because so little occurs in the county.
24	WRAP, 2001a: Most burning is done in spring. Fall burning is being phased out.
25	Darla Potter, WY Dept. Env. Quality, ERG/ETC Informal Survey 2001: Emissions are not tracked at all. Burn permits are required for forestry and rangeland. Recently grass seed companies from OR and WA have been relocating to WY which may increase burn emissions from these sources.

Table 5-2a. Continued

No.	Comments
26	WRAP, 2001b: There are 240 Indian reservations in the Western Regional Air Partnership (WRAP) region representing more than 54 million acres of land. Historically each tribal entity manages their own lands independently. No centralized agricultural burning activity data presently exisits. Historically burning occurs on approximately 50% of the reservations within the WRAP region of the 15 Western states. Types of burning include wildland, rangeland and agricultural. Often burns are part of an overall annual burn or land management plan but some are completely independent. Most tribal entities do not have a formal smoke management program although some do. Coordination with other off-site land management entities and air quality authorities is highly variable among the tribes.
27	State of Alaska, Department of Environmental Conservation, Open Burning Policy and Guidelines document. http://www.state.ak.us/dec/dawq.
28	State of Arizona, Department of Environmental Quality, Arizona Guidelines for Open Burning and Permit Application Form, Title 49. http://www.adeq.state.az.us/environ/air.
29	State of Hawaii, Administrative Rules, 11-60.1-51: Open Burning, and Application for Agricultural Burning Permit, http://www.state.hi.us/doh/rules/emd/11-60.PDF.
30	State of Idaho, Statute Title 22, Agriculture and Horticulture, Chapter 48, Smoke Management and Crop Residue Disposal, http://www.state.id.us/idstat
31	State of Montana, Department of Environmental Quality, Rules Title 17, Chapter 8, Air Quality, Open Burning. http://www.deq.state.mt.us/dir/legal
32	State of North Dakota Air Pollution Control Rules, Chapter 33-15-04, Open Burning Restrictions, http://www.health.stat.nd.us/ndhd/environ
33	State of Nevada, Division of Environmental Protection, Smoke Management Program, NAC 445B.381 Open Burning, http://www.state.nv.us/ndep/bao/smoke1.htm.
34	State of Oregon, Department of Agriculture, "Field Burning Rules", http://arcweb.sos.state.or.us/rules
35	State of Oregon, Department of Agriculture Natural Resources Division, http://www.oda.state.or.us/Natural_Resources/smoke.htm.
36	State of Oregon, Administrative Rules, Department of Environmental Quality, "Pollution Control Tax Credits", http://arcweb.sos.state.or.us/rules/OARS_300/OAR_340/340_tofc.html
37	State of South Dakota, Department of Environment and Natural Resources, "Air Quality Guidelines for Open Burning", http://www.state.sd.us/denr/DES/airquality/regulations
38	State of Utah, Administrative Code, Title R307, "Environmental Quality, Air Quality", Section 307-202-1, http://www.rules.state.ut.us/publicat/code
39	State of Utah, Statute, Title 19, "Environmental Quality code" Chapter 2, "Air Conservation Act", http://www.le.state.ut.us
40	State of Washington, Department of Air Quality, Best Management Practices and Administrative Code, "Agricultural Burning", RCW 70.94.656 Open Burning, http://www.ecy.wa.gov
41	State of Wyoming, Air Quality Standards and Regulations, Chapter 10, Section 2, "Open Burning Restrictions", http://deq.state.yw.us.
42	State of New Mexico, Environmental Protection Air Quality, "Open Burning", Title 20, Chapter 2, Part 60.
43	State of California, Title 17 "Smoke Management Guidelines for Agricultural Burning and Prescribed Burning", California Code of Regulations, Section 80100, et. Seq. California Air Resources Board, http://www.arb.ca.gov
44	State of California, Lake County Air Quality Management District, Rules and Regulations: Chapter VIII, Agricultural Burning, http://www.arb.ca.gov/DRDB/lak/CURHTML/LKRulebook7-13-01-PDF
45	State of California, Sacramento Metropolitan Air Quality Management District, Rule 407: Open Burning, http://www.arb.ca.gov/DRDB/SAC/CURHTML/R407.htm and Rule 501: Agricultural Burning, http://www.arb.ca.gov/DRDB/SAC/CURHTML/R501.htm
46	State of California, San Joaquin Valley Unified Air Pollution Control District, Rule 4103: Open Burning, http://www.arb.ca.gov/DRDB/SJU/CURHTML/R4103.PDF
47	State of California, South Coast Air Quality Management District, Rule 444: Open Fires, http://www.arb.ca.gov/DRDB/SC/CURHTML/R444.htm

time and effort. The authors also recognize that the identification and development of non-burning alternatives is something that will likely evolve over time. The results of the survey effort here clearly represent only "a snap shot in time" for all the programs reviewed. The results of this effort are not intended and should not be interpreted as to be predictive of what states or tribal entities may or may not intend to do in the future. Nor should the results of the survey effort reported here be interpreted as necessarily a reflection on state or tribal entities or their staffs commitment or desire to address agricultural burning as a source of air pollution through the identification and implementation of non-burning alternatives. An assessment of state and tribal entity future plans and/or desire or intent to address agricultural burning and the identification and implementation of non-burning alternatives was not included in this effort.

The results of this survey effort simply reflect which of the previously identified accountability mechanism appear to be in place for each state, local area or tribal entities in general. It is important for the reader to keep in mind that this section is intended to be positive and constructive. This section is intended to serve as a useful tool for those state or tribal entities desiring to address the use of non-burning alternatives more effectively. One way to approach this challenge is to compare how different states or tribal entities are addressing accountability mechanism in their programs. Where specific states are used as examples the intent is to provide useful comparisons of different program content. With this in mind the following review and discussion is presented below.

The presence or, in some cases, the absence of Mechanisms 1-17 appears to reflect whether non-burning alternatives will be used in the 15 Western states. In general, for states with aggressive mandates to reduce agricultural burning, such as Washington, Oregon and California, a large number of the accountability mechanisms identified in Table 5-2 were found to be in place. These states have mechanisms in place that fall into all five categories of accountability. These states also currently have the largest number and greatest variety of non-burning alternatives in use.

In those states with less aggressive smoke reduction programs or no formal requirements to address agricultural burning, essentially no accountability mechanisms were found to be in place. This was the case for Colorado, Nevada, South Dakota, and Utah. As a

consequence, little or no direct information on non-burning alternatives was available for these states. However, this finding in and of itself may not be significant. For states where agricultural burning may not be a significant source of air pollution, it makes sense that their programs would focus on other more relevant sources.

For those states that in practice effectively exempt agricultural burning from regulation, few if any accountability mechanisms were found to be in place. Those that were found to be in place were often in place to address other sources of open burning such as forest and range land management activities. This was the case for Alaska, Arizona, New Mexico, Montana, North Dakota, and Wyoming. No agricultural burning is indicated as occurring in Alaska (see Volume I, Section 3.0).

For those states that have little or no agricultural crop production, such as Alaska, Montana, and Wyoming, air quality programs may of practical necessity be focused on other sources such as forest or rangeland management practices. (Crop production in these states is documented in Volume I, Section 2.0.) Burn programs in general may also be in place to address fire safety issues. However, in other states where a number of accountability mechanisms appear to be in place, political, social, economic and practical programmatic resource factors may play a significant role in the overall de-emphasis on addressing agricultural burning as a source of air pollution in the state or region. This may be the case in North Dakota, Arizona, and New Mexico.

In other states such as Idaho and Hawaii, a number of accountability mechanisms are in place. In fact there are mechanisms in place for these states in all five categories of accountability. However, the number of non-burning alternatives identified and in use for these states remain insignificant. Patterns such as this suggest that additional research may be needed to better identify and characterize the nature of the apparent inconsistency. It may be that significant political, social, economic or practical programmatic resource factors are playing a role here.

In tribal communities there appear to be agricultural burning review and approval mechanisms in place. However, these appear to be less formal in nature with little emphasis on agricultural burning per se and essentially no coordination with neighboring non-tribal land

managers. The implementation of these mechanisms also appear to be more widely distributed across local, county, tribal, state, and federal authorities than any of the 15 states in general. This is likely a reflection of the wide variety of types of burning that occurs on the more than 54 million acres of tribal lands (WRAP, 2001b). It is also likely a reflection of the historically independent and self-reliant nature of more than 240 tribal communities found in the 15 Western states. However, this could simply be a reflection of the fact that very little air pollution from agricultural burning sources may result from tribal activities and that air quality programs may of practical necessity be focused on other sources such as forest or range land management practices. Burn programs in general may also be in place to address fire safety issues on tribal properties. As states and other entities gather more information on the extent of agricultural burning activities on tribal lands, the identification and use of non-burning alternatives and the presence of absence of accountability mechanisms in place at tribal government levels should be possible.

Overall, the incentive and motivation to identify and use non-burning alternatives are lacking in many of the 15 Western states. This may be due to a lack of effective accountability mechanisms in place at the state and local program levels. In some states there are formal requirements to consider alternatives to infield agricultural burning of residues prior to carrying out field burning activities (Alaska, California, Hawaii, Idaho, New Mexico, Oregon, and Washington). Although in some cases economic incentives do exist, such as in Oregon and California, there are typically no formal requirements to actually implement non-burning alternative management practices in any states. Furthermore, routine information regarding the availability, applicability, and cost effectiveness of non-burning alternatives is typically not provided by the states in any comprehensive or coordinated fashion. If alternatives are routinely used, the degree to which non-burning alternatives are implemented is often not formally tracked, making it difficult to appropriately credit the proactive participants in the non-burning alternatives community. A more comprehensive discussion of the role these mechanisms might play in furthering the identification, development, consideration and use of non-burning alternatives in those of the 15 Western WRAP member states and tribal communities where agricultural burning appears to be a significant source of air pollution in the region, state or air basin can be found in Section 7.0 of this report.

In some cases statutory changes may be required in order to provide for adequate availability and implementation of the desired accountability mechanisms. In other cases lead agencies may consider the development and implementation of voluntary accountability and/or non-burning alternatives implementation programs. However, it is very important to note that while voluntary programs may facilitate program development and implementation, in cases where this would result in increased economic costs and changes in practical business operations or management, voluntary programs alone are not typically effective in meeting overall air quality program objectives. Voluntary programs under these circumstances often do not provide adequate incentives to bring about significant changes in current practices.

Lastly, a critically important aspect of the burn program and accountability mechanism review is the inconsistent definition of agricultural burning. How agricultural burning is defined varies extensively throughout the regulations and rules reviewed for the Western states. In some cases, agricultural burning defines only row or field crops. In some cases, orchard and vineyard prunings are included as agricultural residues while in others they are not. There is no consistency within the state regulations and rules with respect to how irrigation ditch, fence line, or weed or land clearing for range land improvement or other agricultural purposes are addressed. This complicates the interpretation of the findings of the accountability mechanisms provided here. This issue is discussed further in Section 7.0 of this report.

6.0 NON-STATUTORY ADMINISTRATIVE BARRIERS

This section describes the strategies used to research, identify, and characterize non-statutory administrative barriers. In practice, non-statutory administrative barriers have the potential to limit new program development and implementation to a greater extent than do statutory barriers. Non-statutory administrative barriers are those situations, circumstances, activities, or factors that serve to minimize, deter, or prevent the active use of non-burning alternatives. These barriers are not defined in statute, rules, or regulations. These typically result from, or are defined by, administrative practices associated with the implementation of agricultural or open burning programs in the West. They can also develop as a result of political, social, economic, cultural, and religious pressures that hinder or impede the development and use of non-burning alternatives.

The non-statutory administrative barriers currently in place at the state level for each of the 15 Western states (and where possible, at the county local, or tribal level) are identified and discussed in this section. A discussion of how each non-statutory administrative barrier may be addressed to increase the support, development, and use of non-burning alternatives in each case identified is included in Section 7.0 of this report.

6.1 Research Strategy and Sources of Information

For this task, the same comprehensive three-tiered approach to identifying and researching the various potential sources of information discussed in detail in prior chapters of this report was used. The three-tiered approach included contacting and/or researching the availability of information from three different levels of information sources.

The first level of information sources investigated included state environmental agencies, boards and departments, county and local air pollution control authorities; their respective administrative and statutory rules and regulations; formal published reports and documents; and articles or summary information posted on official state level or county level websites. As expected, the presence, or in some cases absence, of non-statutory administrative barriers relevant to non-burning alternatives were known to staff at the state and county or local

level environmental agencies and air authorities having responsibility for implementing agricultural or open burning programs.

The second level of information sources researched were the agricultural extension services agencies for all 15 Western states. The third level of sources included private sector stakeholders identified during the first and second level research efforts. The most relevant and comprehensive information regarding the identification and characterization of non-statutory administrative barriers has come from informal survey information collected from state and local air quality program staff, agricultural extension research staff and individual stakeholders who currently use or desire to use to some degree, non-burning alternatives. Additional information has also been collected from published reports and literature.

6.2 Non-Statutory Administrative Barriers Identified

There are many non-statutory administrative barriers (i.e. situations, circumstances, activities and elements) which may minimize, deter and/or prevent the active use of non-burning alternatives in the West. Non-statutory administrative barriers include the following categories:

a. *Economic challenges* including labor costs; increased liability; disposal, storage, packaging or transport costs; availability and/or willingness of investors to provide capital for new technologies or non-traditional methods; market return; crop yield, quality, and production rates;

b. *Geographic limits* due to climate or topography;

c. *Political, cultural or religious practices*;

d. *Practical issues* such as supply and demand of essential materials (e.g., seed or seedlings, storage facilities, machinery), reporting mechanisms, timing and effectiveness of the non-burning alternative, and short- or long-term effects on the farm unit or agricultural operation;

e. *Public acceptance* of a practice or program result, which may be closely tied to aesthetics; and

f. *Aesthetics* (e.g., visual, olfactory, and auditory, but also possibly nuisance factors such as plant debris or dust infiltration or deposition in or near homes and businesses).

Eighteen non-statutory administrative barriers, which fall into four of the categories as defined above, were identified. These currently exist in specific situations in the 15 Western states and are summarized in Table 6-1. No non-statutory administrative barriers were identified for aesthetic or for public acceptance reasons, numbers (5) and (6) above.

6.3 Project Case Study

Case studies can be very useful tools in identifying what is working in a program and what may need enhancing or improving. Case studies can provide this information in a succinct format designed specifically for an audience comprised of environmental program coordinators and/or state level executive decision-makers. One case study, entitled "Alaska Agricultural Project, Delta Junction" in located in Appendix B. This case study illustrates how the Alaska Department of Environmental Conservation (ADEC) successfully worked with the agricultural community to address the issue of timing as a smoke management tool pertaining to burning of wastes from land clearing in preparation for agricultural use.

Table 6-1. Non-Statutory Administrative Barriers Identified in the 15 Western States

General Category and Description	Non-Statutory Administrative Barriers
a. Economic Challenges	• Transport costs to remove agricultural residues from the field, orchard or vineyard must be incurred. • Labor and machine costs to bail and stack or otherwise collect field residues for offsite use. • Capital for investing in new technologies is limited. • Availability of investors and willingness to invest in new methodologies is limited. • Decreased market return, crop yield, crop quality, and production rates can occur with increased damage from pests or disease. • Availability of economic incentives for burners to try new non-burning alternatives is limited. • Program implementation of existing economic incentive programs is fractured and untimely. • Water costs in the arid West and Southwest increase costs substantially for field residue soil incorporation non-burning alternatives. • Costs to remove straw can be up to 10 to 15 times greater than the costs to burn. • High cost of plowing for soil incorporation. • No or limited markets for marketing products made with residues. • Low market price of products made with residues do not offset costs. • Increased costs are associated with the need for more skilled labor to carry out specialized crop rotations and soil incorporation activities.
b. Geographic Limits	• The steep terrain in some mountainous states make it impractical to implement some non-burning alternatives. • Climate barriers that affect crop yields.
c. Political, Cultural and/or Religious Practices	• Cultural practices in at least one state center around agricultural burning activities. Changes in burning practices may significantly impact local community cultural events. • In at least one circumstance, historical promises play a role in the social and cultural acceptance of the use of non-burning alternative. During the great Dust Bowl, state officials lured farmers away from other states by promises of land and an agricultural way of life. Any changes to that way of life are difficult to address programmatically.
d. Practical Issues	• Soil compaction and decreased drainage resulting from collection and bailing of straw. • Methane poisoning of soils with soil incorporation and increased release of a greenhouse gas. • Increased water usage for soil incorporation. • Increased use of diesel harvesting and transport equipment which could increase air pollution levels. • Decreased crop yields unless burning is allowed on at least a rotating basis. • Increased soil erosion associated with increased fallow periods. • Disturbance of soil micro-organisms and soil fauna with soil incorporation practices. • Genetically improved plant varieties for various tolerances do not provide as high of yields for some uses. • Increased incidence of pest and weed infestations with many types of non-burning alternatives.
e. Public Acceptance	None identified.
f. Aesthetics	None identified.

7.0 IMPLEMENTATION PLAN

This section provides a summary of general strategies for increasing the development and use of non-burning alternatives in the 15 Western states. This section also provides a summary of the overall results of this project to date and identifies some conclusions that may be drawn based on the information, results and conclusions found in prior sections of this report. The main conclusions provided here pertain to the identification and use of non-burning alternatives, the identification and implementation of program accountability mechanisms, and the identification of non-statutory administrative barriers.

7.1 Review of Project Background and Study Objectives

The Western Regional Air Partnership and its Fire Emissions Joint Forum sponsored this project to provide more complete information about the identification and use of non-burning alternatives to the common practice of infield burning of agricultural residues in the West. The geographical scope of the project includes the 15 Western states of Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, North Dakota, New Mexico, Nevada, Oregon, South Dakota, Utah, Washington, and Wyoming. State, as well as tribal, jurisdictional issues were addressed.

The project objectives include the following:

1. Identification of current crops and the extent to which residue is disposed of through burning for the 15 Western states (Sections 2.0 and 3.0 of Volume I);

2. Display of the crop and agricultural burning data in a geographic database using a geographical information system (Appendices B and D of Volume I);

3. Identification of potential alternatives to agricultural burning and characterization of their agronomic, environmental, health and safety, social, economic, and political impacts (Section 2.0 of Volume II) ;

4. Development of criteria for selecting "reasonable" non-burning alternatives, cost-abatement curves (i.e., cost of alternative by crop) and examples of how to apply the criteria and cost-abatement curves to evaluate alternatives (Sections 3.0 and 4.0 of Volume II);

5. Identification of existing and potential accountability mechanisms for tracking if, and which, non-burning alternatives are used by local, state, tribal, or federal entities (Section 5.0 of Volume II);

6. Identification of existing and potential barriers to the use of alternatives, including non-statutory barriers (e.g., public acceptance, cultural practices, etc.), and recommendations on how these can be overcome (Section 6.0 of Volume II); and

7. Development of a plan for implementing a non-burning program based on the analysis, findings, and recommendations developed under this project (Section 7.0 of Volume II).

The methodologies used to carry out this effort and to address the main objectives noted above have been described in each of the previous sections. The overall results of this effort and general conclusions that may be drawn as they pertain to the potential identification and use of non-burning alternatives in the 15 Western states and tribal communities are presented here.

7.2 Summary of Study Results

In addition to review of formal reports and articles, air quality agency, environmental agency, agricultural extension services, and/or state university research representatives from all 15 states as well as representatives from a variety of local regions within several states were contacted (See Appendix A: List of Informal Survey Participants and Contact Information). The information gained by contacting these representatives is presented here as well as throughout this report.

Straw or residue management treatments can impact many aspects of agricultural production and land management. Straw management practices, including the use of prescribed fire, can impact levels of soil nutrients such as nitrogen (RCAAFC, 1998). Agronomists often recommend returning unburned crop residues to the soil to help maintain soil organic matter levels and to maintain or improve soil aggregation which inhibits erosion (NDSUCE, 1974). Often it is highly desirable to keep crop stubble standing and residues in place on the soil surface to protect from soil erosion, especially after seeding when the soil is most vulnerable (SAF, 1999). In some cases the need to burn, as a field residue, orchard, or vineyard management technique, has been established to address disease incidence, pest infestation, or crop production

(UCCE, 2001). For example, burning grass pastures can result in short-term increases in nitrogen mineralization which results in short bursts of nutrient availability. It can also be used to control weeds and sagebrush can be nearly eradicated from rangelands when burned in the late fall when it is dry (MSUES, 1998).

However, in the majority of cases throughout the West, agricultural burning has not been based on scientific reasoning but rather on many practical aspects of farm management such as economics, crop production, expediency, tradition and ease of use (USDA, 1997c). Today these practical aspects also include, in some cases, the absence of effective and economically viable non-burning alternatives. In other cases, effective and economically viable non-burning alternatives may exist, but the affected agricultural community may not have knowledge of their existence or, for a variety of practical reasons may not be willing or able to put them into practice in their daily operations.

Burning of crop residues was found to occur for all of the major crop groups (i.e., grains and hay, grasses and seeds, orchard, and fruits and vegetables). Also, other crops are burned as well including sugarcane. In total, residues from more than 35 different crops are burned in the states of Arizona, California, Colorado, Hawaii, Idaho, Montana, North Dakota, Nevada, New Mexico, Oregon, South Dakota, Utah, Washington and Wyoming. Other agricultural related fuels such as ditches and ditch banks, and CRP lands are reported as burned in Idaho and Washington, respectively. (Appendix C of this report includes a copy of Table 3-5 from Volume I. This table shows the quantity of residues burned by state for various years. Care should be taken not to compare quantities between states where the data represent different years.)

More than 20 different non-burning alternatives organized into at least 4 different major category types were identified in this effort (see Table 2-1 of this report). Qualitatively one or more of these non-burning alternatives were found to be in use today or in the past in at least 7 of the 15 states addressed by this effort. The quantitative extent to which non-burning alternatives are in use in these states is highly variable and largely undocumented. It is possible that these or other non-burning alternatives may in be use by the agricultural community in other states or regions of the Western states; however, the documentation of this does not appear to

exist at this time. Records which document the extent to which non-burning alternatives are being used in lieu of open field burning were not found to be kept by any state or local agency contacted during this research effort. This finding is further explained by the results of the accountability mechanism assessment provided in Section 5.0 of this report. This is a considerable obstacle in the identification and use of non-burning alternatives that has the potential to significantly impact program implementation efforts.

Some states are now taking action to correct this gap in essential data collection. These states include California (with its recent changes to Title 17 of the California Code of Regulations) Washington (with its post-burn report card efforts), Alaska, and Nevada. However, data collected to date remains in handwritten form. It has not been routinely input into electronic form, quality checked, or included in emissions inventories (Pfeifer, 2001: informal survey response from Grant Pfeifer, Washington Department of Ecology, Agricultural Burn Task Force). Any data slated for collection in the future by California and other states was by definition unavailable for this research effort. It is reasonable to expect that these data will remain unavailable until states have fully implemented changes to their existing agricultural burning programs; the data has been collected, and then made available for review. Responses from a variety of other air quality and environmental agency representatives indicate that other states are looking forward to collecting better data on agricultural burning practices in general, as well as documenting the use and effectiveness of non-burning alternatives. For many states significant changes in statutory authority (or in seemingly all cases, increases in essential programmatic resources) are required before agencies and organizations or their representatives can move forward in these program areas.

7.3 Discussion of Results Pertaining to the Identification and Use of Non-Burning Alternatives

The majority of information collected and reviewed suggests that states, local agencies, tribal communities and fire control experts agree that the development and use of non-burning alternatives is desirable for a number of reasons throughout the 15 Western states and tribal communities. However, the identification, development and use of non-burning alternatives throughout the Western states appear to be in the fundamental research stages. A number of non-burning alternatives have been considered for a variety of crops in several states

(CARB, 1993; CARB, 1997a; CARB, 1997b; CARB, 1998; CARB, 2001b; CIWB, 1998; CIWB, 1999a; CIWB, 1999b; CIWB, 2000a; CIWB, 2000b; CIWB, 2001a; CIWB, 2001b; CIWB, 2001c; CIWB, 2001d; MSUES, 1998; NDSUCE, 1974; NDSU, 1998; OSU USDA-ARS, 1994; OSU USDA-ARS, 1995; OSUES USDA-ARS, 1989; SAF, 1999; SCAC, 1995; UCCE, 2001; USDA, 1997c).

However, there is considerable debate within the scientific community regarding the potential impacts, benefits and/or dis-benefits of burning versus not burning. There is considerable debate in the scientific community regarding the effectiveness and potential agronomic impacts of the various non-burning residue treatments. There is also extensive debate among researchers, air quality entities and affected agricultural parties regarding what is "reasonable" or "feasible" when it comes to the use of non-burning alternatives. In many cases, the need to conduct some form of burning, even if only under special circumstances, has been supported by a number of agriculture experts.

As a consequence, the identification and large scale practical use of non-burning alternatives was not found to exist in any state addressed in this effort. Although a few potentially effective non-burning alternatives have been identified and are in use for some crops grown in the West, the practical use has been limited to a very few crops, such as grass seed, wheat, or rice. The practical use has also been limited to a few states or regions of the West. These include Washington, Oregon and California. It is expected that this can be explained largely by the programmatic limitations and overall practical development and implementation issues identified in the assessment of accountability mechanisms outlined in Section 5.0 of this report.

During the survey effort it was found that none of the 15 states surveyed currently have or can provide a list of non-burning alternatives for any crops grown and otherwise known to be burned in their states or agricultural burning regions. This is an important finding of this effort. Representatives contacted during this effort routinely pointed to published research reports and agency summary documents which discussed the issues surrounding the identification and potential use of alternatives that were considered. However, none were able to provide succinct summaries or lists identifying and supporting the practical use of known

alternatives in settings appropriate for their state or region. This is not likely a reflection of the lack of agency staff commitment to the non-burning program efforts; it is more likely a reflection of incomplete statewide or regional program development and inadequate, or in some cases nonexistent, interagency coordination. It is also more likely a reflection of incomplete or inadequate stakeholder outreach, education, and overall involvement in the process to identify and develop successful alternatives to burning in the state or local areas under their jurisdiction.

Accountability mechanisms play an important role in the identification, development, consideration and use of non-burning alternatives to agricultural burning in the West. The results of this effort suggest that the presence, or in some cases the absence, of identified accountability mechanisms appear to effectively determine whether non-burning alternatives will be used in the 15 Western states. The 17 mechanisms identified in this report fall into five main categories of accountability (see Table 5-1). It was expected, and therefore not surprising, that different states had varying numbers and types of accountability mechanisms in place to address agricultural burning as a source of air pollution and visibility impairment. For states where agricultural burning has not been identified as a significant source of air pollution it seems reasonable that a limited number of mechanisms, if any, would be put in place and that accountability mechanisms to address other more significant sources might be emphasized instead. However, in those states and regions where agricultural burning does significantly impact air quality, including visibility, it would be ideal to see the development and implementation of a number of accountability mechanisms to address the issue of agricultural burning.

Mechanisms 1 through 14 are essential for the support and validation of Mechanisms 15, 16 and 17 (see Table 5-2 of this report). The degree to which these accountability mechanisms are in place and in use by the various states is highly variable. There are a number of important mechanisms in place for several of the states or regions which have identified agricultural burning as a significant source of air pollution. These mechanisms actively support the management of agricultural burning activities. However, several of the most important mechanisms necessary for the identification and actual use of non-burning alternatives, such as mechanisms 15, 16 and 17, do not appear to be in place in the majority of the 15 Western states and tribal communities studied, even in those states or regions where agricultural

burning appears to have the potential to significantly impact air quality. These mechanisms actively address the identification of effective non-burning alternatives, establish requirements to consider the use of alternatives to burning prior to burn approval, and offer practical assistance in offsetting costs to implement the typically more expensive non-burning alternatives.

Mechanisms 15, 16 and 17 provide accountability at the state or local level that facilitates the active identification of, and encourages the consistent use of, effective non-burning alternatives in conjunction with or as a substitute to traditional existing agricultural burning practices. Mechanism 15 provides incentive to actively consider non-burning alternatives by making it a requirement of pre-burn approval. This usually occurs during the pre-burn permitting process. If no pre-burn permitting process exists, in all but the most unique of circumstances, it is impractical and unrealistic to expect non-burning alternatives will be considered to any significant extent. The relationship between the requirement to secure approval prior to burning and the requirement to consider or practically implement some form of non-burning alternative to at least a portion of the slated burn acreage is key to encouraging the consideration and use on non-burning alternatives in the West.

Mechanism 16 provides financial assistance in one form or another to burners who implement non-burning alternatives. This serves to help overcome one of the most often voiced oppositions to the use of non-burning alternatives which is that of cost "ineffectiveness". Cost "ineffectiveness" is the most often cited reason for not using or implementing non-burning alternatives. Practical use or effectiveness is another reason (see Table 6-1 of this report). The latter may be overcome in time by more scientific research and close coordination with the agricultural community. The former remains a significant barrier for most state, regional, or local level entities who are trying to implement non-burning alternatives programs. In some cases subsidies, tax credits, permit fee reductions, or rebates may be an effective way to address this barrier. However, it is not always feasible for public entities to accommodate these financial incentives. Although it may not always be feasible to provide financial assistance to offset direct costs, it might be feasible for state air quality or environmental agencies to identify, if not actually recruit, other state or local experts in the areas of manufacturing, product development, marketing, and distribution to assist in the economic development of some types of non-burning alternatives. In at least one case during this research effort, it was found that members of the

agricultural community were willing and able to develop and manufacture highly desirable products from rice straw stubble; however, they have been unable (to date) to overcome state level administrative obstacles in storing, distributing and selling their product (informal survey response, Jerry Maltby, Broken Box Ranch; see Appendix A).

Mechanism 17 has the potential to provide useful, practical incentives for the increased use of non-burning alternatives by providing a list of viable, practical, economically feasible alternatives that are available, currently in use, or have been used in the past. This mechanism alone, if put into practice in each of the 15 Western states and tribal communities, has the potential to eliminate another readily voiced opposition to the use of non-burning alternatives which is that non-burning alternatives do not exist or cannot be used effectively.

If effective non-burning alternatives do exist, but the agricultural community is unaware of their existence or is otherwise unconvinced of their effectiveness, it is impractical and somewhat unrealistic to expect that non-burning alternatives will be considered to any significant extent in any state or region of the West. If viable non-burning alternatives do exist and can be used effectively in a particular state or region of the state, then it seems reasonable that air quality and environmental agencies (with the support and input of the affected agricultural community, other stakeholders, university and extension services researchers) should be able to provide a consolidated well documented list, as needed, to anyone interested in identifying and using non-burning alternatives for a particular crop type in areas or regions of interest in the state. Historically, a number of the 15 states included in this effort have provided significant amounts of funding to support the research and development of non-burning alternatives. This is commendable and an excellent start to addressing this issue; however, these efforts to date do not appear to have contributed significantly to the practical use of non-burning alternatives in the majority of the Western states. Fortunately, this and other related non-statutory administrative barriers may be largely addressed by increased research efforts and improved stakeholder involvement, outreach, and communication efforts.

7.4 Developing Implementation Plans: Content

The results of this effort suggest a very clear starting point and overall path for increasing the identification and use of non-burning alternatives in the West. One important step

is the development of effective non-burning alternatives program implementation plans. Programs that have the potential to be effectively implemented have several critical elements in common (Black, 2000). These include the following eight essential elements:

- Element #1: Program-Specific Strategic Plan;
- Element #2: Correctly Identified Target Audience and Stakeholders;
- Element #3: Clear Concise Messages and Program Purpose;
- Element #4: Effective Communication Tools and Strategies;
- Element #5: Effective Resource Allocation;
- Element #6: Reasonable Program Expectations;
- Element #7: Solid Sustained Executive Commitment; and
- Element #8: Consistent Program Implementation.

7.4.1 Strategic Plan

The most essential element of any successful environmental program implementation plan is the development of a program-specific strategic plan. A well developed strategic plan serves as a road map for the entire program effort. It is essential for identifying target audiences and for the development and delivery of, easily understood program messages. In addition to clearly identifying goals and outlining reasonable objectives, a well developed strategic plan will assist decision makers in defining the reasons for implementing a non-burning alternatives program.

A strategic plan may be very simple in nature with only one or two clearly defined goals and a few reasonable objectives; or it may be highly complex with numerous goals and extensive accompanying objectives. It may encompass the entire organizational state level program or it may address only those aspects related to agricultural burning in a given area. Whatever form and complexity the strategic plan ultimately takes, for a non-burning alternatives program to be successful the first step should be to deliberately develop a strategic program plan.

7.4.2 Correctly Identified Target Audience and Stakeholders

To be successful, non-burning alternatives implementation programs must correctly identify the target audience or stakeholders intended to be reached or ultimately impacted by the implementation effort. The stakeholders identified will be tightly tied to the purpose the air quality entities have for developing the programs. In some cases, it may be important for the non-burning alternatives implementation program to incorporate stakeholder expertise and comments in the identification and development of non-burning alternatives. In other cases the implementation program may be limited to enhancing and encouraging the use of previously identified alternatives.

In most cases, it is expected that plans will be developed to address both these needs in most states or tribal communities where agricultural burning has been identified as a significant source of air pollution. The target audiences or stakeholders identified will also determine what communication tools are necessary for the overall implementation program success. Whether these audiences include members of the regulated community or highly vocal opposition members of environmental groups, if the stakeholders are not clearly identified, the non-burning alternatives implementation program has essentially no chance of success. Fortunately, target audiences and stakeholders can be clearly identified if strategic planning activities are properly conducted.

7.4.3 Clear Concise Messages and Program Purpose

For any environmental program to succeed, it is essential that the program purpose be clearly identified at the beginning. Only after the reason(s) for addressing agricultural burning and for developing non-burning alternatives have been defined does it become possible to develop clear messages which can be communicated to the affected stakeholders and interested members of the public. The most successful non-burning programs developed will have implementation plan elements that effectively deliver clear messages to the target audiences and stakeholders that air quality and environmental entities would like to reach.

The collection and presentation of easily understood facts, data comparisons, emissions estimates, case studies, success stories, photographs, images and diagrams is essential to the success of this portion of the program development and implementation effort. Without

documentation of current burning practices, emissions and air quality impacts, as well as proof of the practical effective infield use of non-burning alternatives, it is difficult to establish program purpose and credibility even with the most well designed and professionally implemented communications program. This appears to be an area where incomplete or uncollected data pertaining to agricultural burning activities and the identification and use of effective non-burning alternatives in the 15 Western states and tribal communities may play a significant role in the development of non-burning alternatives implementation plans. This finding also helps to prioritize which program development elements should be addressed initially for most states as they go on to develop non-burning alternatives implementation programs.

7.4.4 Effective Communication Tools and Strategies

The most successful non-burning alternatives implementation programs will be specifically designed to take advantage of the latest and most effective communication tools available today. These tools will of necessity be tailored to address the communication skills and needs of interested stakeholders as well as the communication skills and resources available to the state, regional, local or tribal agencies. In this age of electronic media, stakeholders have greater access to more information in shorter timeframes than ever before in the history of civilization. Technology has made it possible for motivated members of the public and the regulated community to follow, almost on a real time basis, environmental issues that may impact their lives. Motivated stakeholders have become more informed about environmental issues. As a consequence, they have become in many ways more demanding of service in their search for knowledge. Their expectation of timeliness in the delivery of information has risen exponentially. This changes the way public sector entities must reach out to and communicate with the targeted stakeholders in their non-burning alternatives program implementation efforts.

However, this does not mean that to be successful, public sector entities need to procure state-of-the-art communication technologies. It does mean that they should use what they have effectively and secure the resources in the future to grow as they can. Public sector entities do need to employ effectively those tools that they have at their disposal as well as assess whether the tools they are using will be effective in reaching interested stakeholders. Whatever communication tools and strategies are employed, it is essential that it be easy for stakeholders to obtain information and to participate in the implementation program efforts. If agencies do not

have in-house expertise to at least identify the available non-burning alternatives program communication resources, and define effective strategies for addressing stakeholder communication needs, they may want to consider procuring outside professional assistance. Environmental programs that do not have effective communication tools and strategies in place typically have little chance of successful implementation (USEPA, 2000a).

7.4.5 Effective Resource Allocation

Low, even "no budget", non-burning alternatives program efforts can be tremendously successful if they are carefully planned, consistently implemented, and conscientiously include affected and interested stakeholders (see Section 6.0 and Appendix B of this report). It is worth noting that a "rule of thumb" often applied to environmental program implementation efforts is "the less money and resources spent on a program, the more time it will take to successfully implement any given program". Programmatic resources that are available should be spent in those areas most likely to provide programmatic value. These areas can be effectively identified in a well conducted strategic program planning effort.

7.4.6 Reasonable Program Expectations

The most successful non-burning alternatives implementation program efforts will clearly identify and subsequently set reasonable program expectations. These expectations, if identified correctly, should address a variety of program elements including implementation timelines as well as program outcomes, deliverables, and progress measurement methodologies. If air quality and environmental entities do not set reasonable program expectations and communicate those expectations to interested stakeholders, the chances are very great that the stakeholders will develop their own expectations. These expectations may not match those of the air quality experts. These mismatches in expectations often create unnecessary miscommunications and misunderstandings which often result in conflict. This can ultimately create barriers to the successful implementation of otherwise important programmatic efforts. Program challenges such as these can largely be avoided if reasonable program expectations are established at the beginning of the implementation plan effort. The development of reasonable program expectation often comes out of a well conducted strategic program planning effort.

7.4.7 Solid Sustained Executive Commitment

A solid sustained executive commitment to support an implementation program is essential to the success of any public program. A positive attitude triggers enthusiasm for any effort (Chapman, 1995). This enthusiasm can often be felt even if it is not always seen on a daily basis. However, as competing political, social and economic forces draw agency executive resources and focus toward other often more imminent and seemingly urgent issues, executive commitment to existing programs often wanes. This waning, although not always immediately evident, usually always results in decreased program resources, staffing, and commitment to the original program goals. This decreased commitment more often than not becomes readily apparent to affected stakeholders. From the affected stakeholders' perspective, if air quality and environmental entities expect them commit to modify current agricultural practices and in some cases cultural activities, the commitment on the part of the public agency to support and sustain the implementation of the program will likely be expected.

7.4.8 Consistent Program Implementation

It takes time to effectively implement any public environmental program, especially environmental programs to address air quality concerns which are inherently intangible and can be difficult to grasp. Because of this, it is essential that non-burning alternatives program implementation efforts be designed around reasonable program expectations. To be successful in implementing non-burning alternatives programs, the way people think and feel about agricultural practices, about burning and air quality in general, may need to change. Changing the way people approach business activities, or think about complex environmental issues takes time and consistent program implementation.

The timeframes needed to effectively implement any program will vary based on the target stakeholder audiences identified and the overall non-burning alternatives program purpose. In many cases, implementation programs will be designed to address several purposes and to reach different target audiences or affected stakeholder groups. In these cases, multiple time lines may need to be developed. Program expectations should also be adjusted accordingly. Fortunately, reasonable program expectations and realistic time frames can be readily developed once the program purpose has been defined and the target stakeholder audiences have been identified through a well thought-out strategic planning effort.

7.5 Developing Implementation Plans: Recommended Strategy

The results of this effort suggest a very clear starting point and methodology for developing implementation plans to increase the identification and use of non-burning alternatives in the West. Based on the results and conclusions found in the prior sections of this report, the following strategy for developing successful non-burning alternatives program implementation plans is recommended for any state, region or tribal entity desiring to increase the identification and use of non-burning alternatives:

1. Air quality or environmental program entities should conduct a focused review to identify the nature and extent to which agricultural burning contributes to air quality problems in the state, or local, or tribal area. A starting point for this review could be the evaluation of agricultural burning activity presented in the companion Volume I document to this report. A key element of this review that should be included is a careful consideration of the definition of "agricultural burning". This is important so that accurate comparisons can be made between other states, local or tribal programs. The review should also take into account the potential impacts that agricultural burning may have on interstate regional air quality.

2. If agricultural burning does not contribute significantly to local or statewide air quality problems which fall under the jurisdiction of the state, local or tribal entity, it is still recommended that the focused program assessment also take into account, to the greatest extent possible, the potential impacts agricultural burning may have on interstate regional air quality.

3. If agricultural burning is not found to be a significant source of air pollution for a given state, local region, tribal entity, or interstate region, it may not be necessary to continue with non-burning alternatives program development. This may be the case for some states that appear to lack accountability mechanisms as noted in Section 5.0 of Volume II.

4. If agricultural burning is found to make a significant contribution to air quality problems on either a local, state, tribal community or regional level, then the air quality or environmental agencies in authority in the affected areas and the areas contributing to the problems should work together to define solutions and develop non-burning alternatives programs. This will help to ensure success on a regional level.

5. If agricultural burning is found to be a significant source of air pollution for a given state, local region, tribal entity or interstate region, or if a given entity desires to more effectively implement non-burning alternatives, then

an overall air quality review should be conducted to determine how to integrate agricultural burning as a source. One goal of this review would be to determine which of the accountability mechanisms identified in Section 5.0 of this report are in place and how they are being used. Table 5-2 can be used to determine the specific accountability mechanisms and tailor the agricultural burning program. In some cases statutory changes may be required in order to provide for adequate availability and implementation of the desired accountability mechanisms. In other cases lead agencies may consider the development and implementation of voluntary accountability and/or non-burning alternatives implementation programs. However, it is very important to note that while voluntary programs may facilitate the development and implementation of portions of programs in some settings, in other cases they may not be effective. For example, in where program development and implementation are associated with increased economic costs and changes in practical business operations or management, voluntary programs alone are not typically effective in meeting overall air quality program objectives. Voluntary programs under these circumstances often do not provide adequate incentives to bring about significant changes in current practices.

6. For those states, local regions, and tribal entities desiring to more effectively address the use of non-burning alternatives in general, it is recommended that a list of effective and economically viable non-burning alternatives be developed (ideally including non-burning alternatives for use by crop, by season, and by region or area). Table 2-1 (listing of non-burning alternatives by crop) can be used to identify specific alternatives. The criteria, methodology, and case studies described in Sections 3.0 and 4.0 of this report can be used to determine feasibility.

7. It is further recommended that a list, or in some cases multiple lists, of feasible non-burning alternatives be maintained and updated periodically by the participating lead public or private entity. The list(s) should be made available using a variety of common effective communication strategies, methods, and technologies.

8. If non-burning alternatives have not been previously identified or have not been characterized for practical use an area, it is recommended that air quality and environmental entities work closely with university and agricultural extension scientists, affected agricultural community stakeholders, and interested members of the public to identify and characterize non-burning alternatives for specific use in their state or region.

9. WRAP member states should form a technical working group or task force to systematically review the identification and current use of non-burning alternatives and to make recommendations, if desired, on how and where

the use of these non-burning alternatives may be improved or enhanced in other states, local regions, and tribal communities.

10. WRAP member states should work together to begin to address ancillary non-emission related program implementation issues, such as assisting the affected agricultural community and local business developers with post-residue removal product development, manufacturing, distribution, and marketing. Although this often falls outside the traditional charter of most state air quality and environmental programs, it does not fall outside the realm of services offered by other state agencies, boards and environmental departments. Some states have taken steps to assist in the research and development stages but their efforts have not extended to distribution and marketing.

11. It is highly recommended that the results of this and any of the above mentioned program efforts be carried out in close coordination with a well defined stakeholder outreach, education and communication program.

7.6 Agency Roles and Responsibilities

The agency roles and responsibilities associated with agricultural burn program implementation were found to vary greatly throughout the 15 Western states and tribal communities addressed in this effort. It was found that the accountability for agricultural burning program development, coordination and implementation, although typically originating at the state level, was in many cases delegated directly to local or regional entities (see Tables 5-2 and 5-2a of this report). In some states, where the primary concerns regarding agricultural burning impacts were fire hazard and public safety, the authority to approve burning was delegated to local fire agencies or even private contract fire control businesses. In no cases was it found that local implementing agencies were required to quantitatively report back to the state or region level on the status of the agricultural burning program implementation.

There was found to be essentially little or no coordination between tribal and non-tribal burn entities (WRAP, 2001b). The authority to approve burns on tribal lands was found to be exceptionally variable and spanned the entire range of agency authority from rural fire district authority to federal land management agency.

The agency roles and responsibilities associated with the identification, development and implementation of non-burning alternatives are not clearly identified for any of the 15 Western states. In one case, the primary contact for the identification and use of non-

burning alternatives was the state Waste Management Program (informal survey response, Tim Rogers, South Dakota Department of Environment and Natural Resources; see Appendix A). In another case, it was found that while a state level air quality agency and legislative authority had generously developed and made available a monetary subsidy to support and encourage the alternative use of rice straw, the program implementation was delegated to another agency (the Department of Food and Agriculture). It appears that since the rice straw subsidy program was not one of their own programs, the staffing and implementation priority were not given. The end result of this agency role and responsibility inconsistency was the existence of a potentially helpful economic subsidy provided by the state, the availability of several qualified applicants currently using rice straw for other purposes, and more than a 2 year (and counting) wait for application acceptance and subsidy funding (Public testimony provided by Jerry Maltby, Broken Box Ranch Feedlot and Compost, California Air Resources Board public meeting to discuss the impacts of legislative mandate to phase-down rice straw burning in the Sacramento area, June 28, 2001; see Appendix A).

As non-burning alternatives programs are reviewed or developed in many states, it is recommended that the air quality or environmental agency responsible for initiating the identification and development of non-burning alternatives also be responsible for monitoring and implementing the non-burning alternatives program at the local level. While it makes sense to work closely with the affected agricultural community through existing pathways, such as the agricultural extension offices, natural resources conservation offices, local fire agencies or the local and state departments of agriculture, unless these agencies and departments are fully invested in statewide or even local or regional air quality program efforts, it may be difficult to get the program implementation results desired. Nonetheless, these existing pathways can be hugely valuable in the successful implementation of non-burning alternatives programs if they are effectively incorporated, and relationships are clearly defined, in the air quality or environmental entity's strategic planning process.

Regional approaches to defining agency roles and responsibilities, where possible are highly desirable as well. In another case, because Washington and Oregon have more stringent air quality regulations, in the last 3-5 years grass seed companies have been relocating to Wyoming where air quality regulations are less stringent (informal survey, Darla Potter,

Wyoming Dept of Environmental Quality, 2001; see Appendix A). Clearly, the air quality and environmental agency roles and responsibilities, whether defined by statute or delegated by the same statutory authority, play an important role in the development and implementation of non-burning alternatives in the West.

7.7 Strategies to Address Stakeholder Involvement

Stakeholder acceptance of any effort to address environmental challenges will always be tightly bound to the success of the lead environmental entity's public outreach and communication efforts to address the subject. It will also be tightly bound to their efforts to include stakeholders in developing and implementing solutions to the identified challenges. This is true for any state, region, local area or tribal community. To be successful in these efforts, lead environmental agencies should provide the following critical program information to interested parties and stakeholders:

- Clearly identified problem(s) or challenge(s);
- Carefully quantified significance or effect of the problem(s) or challenge(s);
- Clearly identified solution(s) to the problems or challenges or, at a minimum, a clearly defined method for identifying or obtaining critical information necessary to develop solutions; and
- Clearly identified plan for addressing the problems or challenges identified.

Not surprisingly, a well designed, closely coordinated and consistently implemented stakeholder involvement, outreach and communication effort incorporating this critical program information is also essential to the success of any non-burning alternatives program. Not only will stakeholder involvement be essential for promoting the use of non-burning alternatives, it will likely be key in developing future alternatives to the current practice of infield or onsite burning of residues. In this age of electronic media and the Internet, people have become much more knowledgeable and increasingly more demanding of timely service in their search for that knowledge. Unless the commitment to identify and implement the use of non-burning alternatives is understood and its value embraced and shared by the public as well

as the regulated agricultural communities, the implementation of non-burning alternatives will likely remain marginal in many of the 15 states and tribal communities addressed in this effort.

Stakeholder involvement, education and communication efforts can be handled on a one-on-one basis as an organization's staff come in contact with stakeholders and other members of the public or they can be addressed with a formalized, organization supported and endorsed outreach effort. Although it is still based in part on one-on-one contacts, the latter is much more effective and is preferred.

To be more successful in these efforts, air quality agencies and environmental managers must develop non-burning alternatives implementation programs that contain solid well supported public outreach and communication efforts that also increase stakeholder involvement. The strategies and tools needed to address stakeholder outreach in the 15 western states and Tribal communities included in this effort were not assessed directly. This was not within the scope of this current effort. However, based on the results of the accountability mechanisms assessment provided in Section 5.0 of this report, stakeholder involvement is expected to vary greatly.

Those states with more aggressive mandates to address agricultural burning, in general, may already have in place fairly adequate stakeholder outreach programs. States that are just developing programs to address agricultural burning are less likely to have well developed programs to address stakeholder involvement. Taking into consideration the results of the accountability mechanisms assessment found in Section 5.0 of this report, if they do desire to address the use of non-burning alternatives more effectively, it is likely that all 15 Western states and tribal entities identified in this effort could benefit greatly from well designed, focused, and consistently implemented non-burning alternatives stakeholder involvement, outreach and education programs. A careful assessment of current stakeholder involvement efforts is recommended for each state, local, regional or tribal entity interested in addressing agricultural burning through the use of non-burning alternatives.

No matter what the ultimate goal of a non-burning alternatives implementation program is, historical burning practices will always remain more familiar, more immediately tangible and likely more cost effective. This is because existing agricultural operations are

already set up to conduct business in the traditional fashion. In some cases, whole cultures and communities have grown up around specialized agricultural operations.

This is the case in New Mexico where centuries-old farming practices rely on the communal management of water delivered by an elaborate system of irrigation ditches. These irrigation ditch systems, or "acequia," are maintained by the entire community. Acequias formed the basis for settlement of New Mexico's Indo-Hispanic communities between two and four hundred years ago (NMAA, 2002). Today, a statewide organization of communities representing the 1000 or so autonomous organizations that maintain their own acequia and share water by custom and tradition has been formed and it is called the New Mexico Acequia Association. There are often community celebrations and cultural activities centered around the maintenance of the acequias. The maintenance of acequias in many parts of New Mexico also involves the annual burning of weeds that grow in these irrigation ditches (informal survey response, Brad Musick, New Mexico Environmental Department Air Quality Bureau; see Appendix A). Changing agricultural practices in these communities and possibly many others throughout the West is very challenging since it may require in some cases the modification or ultimate abandonment of some cultural practices. In some cases, this practically equates to changing the way people have lived their lives and conducted business in their communities for generations.

As urban communities encroach on these more rural agriculturally based communities, public pressure to decrease or eliminate burning may play a role. Although the fuel source and agricultural practices may differ in New Mexico, this is much the same situation as seen in most all of the growing Western states. It is expected that political and social pressures supporting the need to find and make use of viable non-burning alternatives will come into play to a greater extent in the future. It is also expected that these will have an impact on how stakeholder involvement is carried out in each of the 15 Western states and tribal communities identified in this effort. Program implementation success will be greatly tied to an agency's ability to communicate to the public and affected industries it serves, why the program is valuable and provide valid information as to why it is expected that the program will be successful. The public is intelligent and informed and more than capable of understanding the need to address air quality concerns. However, neither the public nor the regulated agricultural

communities will accept what they can not understand or what they do not value (USEPA, 2000b). It is up to the air quality and environmental management entities to effectively communicate the need to identify and utilize alternatives to burning in the West.

Lastly, it is important to note that program implementation planning and timing is very important in the development and implementation of programs to encourage the use of non-burning alternatives. When in place, statutorily mandated 30 and 60 public noticing requirements often dictate the assignment of communication program and implementation timelines for regulatory activities. However, these statutory requirements often have little or nothing to do with the actual timeframes needed to develop and implement effective public communication programs. Instead, although expectedly unintended, they are often instrumental in defining unreasonable communication and program implementation expectations.

While statutory deadlines must be met, reasonable program expectations should also be set if a public communication program and stakeholder involvement effort is to be successful in addressing the identification and use of non-burning alternatives. The key to addressing the issue of program implementation and timing is to involve stakeholders in the beginning of any process. The key is also to allow adequate time for the communication and stakeholder involvement effort to work. It is reasonable to expect that effective stakeholder involvement and communication efforts may take on the order of 1 to 3 years or more to implement.

For most states surveyed as part of this research effort, few if any of the four essential information areas necessary for developing and implementing effective stakeholder outreach and involvement efforts as noted above, have been adequately addressed. This is an area where additional work is recommended for those states and tribal communities that desire to address the use of non-burning alternatives. Fortunately most states desiring to address agricultural burning appear to be aware of these issues and are taking steps to begin addressing these program development and implementation challenges. However, in light of the time frames discussed here and the program information data gaps discussed here and elsewhere, it seems clear that good strategic planning and program development will be essential for any state,

local, regional or tribal entity desiring to address the use of non-burning alternatives more effectively.

7.8 Suggestions for Further Research and Information Development

A number of directions for further research and information development necessary for Western states and tribal communities to begin addressing the identification and use of non-burning alternatives more effectively have been identified through this study. These fall into the following main categories:

1. Better characterization of agricultural burning activities in the 15 Western states and tribal communities addressed in this effort, including the development of a consistent definition for "agricultural burning";

2. More consistent and thorough collection and evaluation of agricultural burning activity data by regulatory agencies and stakeholders;

3. More thorough assessment of the impacts agricultural burning has on air quality and visibility in the participating states, local areas, tribal communities and WRAP member state regions;

4. On-going identification, characterization and accounting of effective non-burning alternatives and their use;

5. Effective inclusion of stakeholders in the identification and implementation of non-burning alternatives; and

6. Development of well designed, consistently implemented stakeholder outreach, education and communication programs that not only address state or local issues but bridge gaps in interstate and regional communication and provide consistent, readily understood messages.

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APPENDIX A

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End

APPENDIX B

PROJECT CASE STUDY:
ALASKA AGRICULTURE PROJECT, DELTA JUNCTION

Alaska Agriculture Project, Delta Junction

Objective:

To present realistic information on the successes and challenges currently seen or encountered in developing and implementing non-burning alternatives in the West.

Geographic Location (i.e. State, County, Region, Tribe, etc.):

Delta Junction, Alaska (64° latitude, 146° longitude)

This community is rather remote, but still on a road system. It is a three-hour drive to Fairbanks (in good weather with good road conditions), which is its nearest large community.

Description:

The Alaska Agriculture Project was initially started in Palmer, Alaska, in approx.1940. The objective was to populate the Alaska territory so that it could become a state. Because the Palmer Project was a success, the Delta Project (approx. 1970s) was implemented and designed to improve the state's resource base. As land was cleared to provide open spaces for agriculture, large piles of woody debris were deposited along the edges of cropland (Figures 8-1 through 8-3).

Agriculture in Alaska is difficult at best, but it can provide produce (potatoes, kole crops), meat (cattle, swine, some elk, reindeer, buffalo), feed (dryland hay and grain primarily) and milk at a price that is cheaper than shipping it from Lower 48 markets. However, a sustained, reliable supply is not always achievable. Proceeds from crops only during the past ten years were variable, from $1.9 million to $5 million, largely depending on weather.

The Delta Projects are in danger of "going away" primarily because weather conditions are severe, which limits a sustained supply, which limits the market. Politics are also a limiting factor here, partially because a state-funded program must exist in order to sustain agriculture through low-market prices, small infrastructure, and other limitations to farming. Hope springs eternal, however, particularly among Alaskan farmers. They are a tough breed. They call themselves "The Frozen Chosen."

This case study has more to do with proper timing and coordination of agricultural burning than it does with non-burning alternatives. Timing is an important smoke management tool.

Figure B-1: Close up View of piles woody debris from land clearing (Delta Junction, Alaska).

Figure B-2: Close up view of piled woody debris and vehicle for scale, land clearing (Delta Junction, Alaska).

Figure B-3: Aerial “Birds Eye” view of long rows of piled woody debris from land clearing (Delta Junction, Alaska).

Figure B-4: Post burn view of prior woody debris pile from land clearing (Delta Junction, Alaska).

Case Study Successes or Positive Benefits

The success of this case study comes in the manner that the challenge was overcome. They still burn, but in a more coordinated and environmentally-safe fashion (Figure B-4).

Practical considerations outweighed political and social considerations in the end.

Environmental and statutory considerations were satisfied.

The Delta Projects were allowed to continue burning to remove debris (which is the cheapest and most practical alternative for this situation), and the community keeps its farming resource which is desperately needed due to the closure of nearby Fort Greely, one of its major sources of income.

Challenges or Limits

When the land was cleared in the 1970s, the idea was to either use the piles as windrows or burn them in place. The clearing method that was used intentionally incorporated dirt into the piles because the "proper" burning technique at the time involved a "kiln-effect" where the debris smoldered within the pile and the dirt and snow prevented smoke from escaping. This technique didn't work.

Because the piles were not clean, burning did not occur, or when it did it was a dismal failure. Not only did the piles smolder for many days, the debris often didn't completely burn, which left large debris without fine material to get it lit and keep it burning.

Alaska legislature recently passed a "Right to Farm" bill limiting civil suits against farmers for odors or smoke. This was done in direct response to the open burning practices done by the farmers prior to Alaska Dept. of Environmental Conservation (DEC) coordination. The bill does not limit DEC enforcement.

Prior to the Right to Farm bill and DEC coordination with farmers, smoke from open burning of land clearing debris was so bad, you literally could not see the road. It caused a school bus to run off the road. No one was injured, but it led to a series of events that caused friction between Alaska Division of Forestry, Division of Agriculture, DEC, the farmers, the local residents, and the Governor's office.

Recommendations to Overcome Challenges or Limits

Communication and flexibility among all stakeholders, including regulatory agency. Due to the controversial nature of the smoke problem, we established a "Task Force" which brought all interested parties to the table to work out a resolution. If nothing else, this method defused the situation and brought about a more thorough understanding of all parties' grievances. Angry words were said, but ultimately solutions were achieved.

Anecdotal incident: Prior to the formation of the Task Force, DEC had tried several techniques of enforcement. All of these techniques failed, primarily because DEC did not fully understand the cultural, logistical and societal elements of the problem.

At the Governor's request, DEC held a public meeting in Delta which was attended primarily by the farmers who thought DEC would inflict more unreasonable regulations on them. Needless to say, the tone of the meeting was tense at best.

I presented the DEC's case to the farmers at this meeting, and was well aware of the negative reaction I was receiving. Alaskans are notorious for their dislike of government intrusion, and this is particularly the case in remote Alaska. Arms folded, frowns, and grunts were the primary

responses to my statements. When I asked how I could fix the problem, how we all could fix the problem, they asked me if I could stay another day to take "The Tour." I readily agreed.

The next day, seven of us piled into a Suburban and began driving. It should be noted that it was late October and bitter cold with a lot of snow on the ground. We drove for nearly an hour, asphalt road became gravel, gravel became dirt, yet we kept driving. I had no idea where I was. I was also new to Alaska and understood that remote areas can be deadly without proper respect for the environment. It appeared we were deep in the "Cold As I've Ever Been Middle of Nowhere."

At last we stopped, and the driver got out. I nervously asked (with humor), "Is this where I get out?" The driver said, "Oh no! You could still get back from here!"

********** Case Study Participant Additional Comments*********

The Tour ended up being an excellent experience. For me, it was a tremendous opportunity to understand the full extent of the problem, to get to know the people, and some of the things they believe are more important than unreasonable state regulations. In return, they began to understand that there are better ways to burn. We achieved a workable compromise, which makes it a 100% success.

I also attended some Farm Symposiums (statewide conference) and gave a presentation at the Farm Forum (a yearly gathering in Delta). Now, I'm fairly well-known by the community, the local Cooperative, the Agricultural Extension staff, and the Division of Agriculture. They know that if there's a problem, we'll all figure out a way to fix it.

Magnitude of Potential Impact

The debris does not easily decompose primarily due to extreme weather. It's been there for 10 to 30 years and has only gotten spongy and regrown trees and weeds. It's now much more difficult to burn than it was 30 years ago. In addition, they usually need to be burned twice (burning piles, replying into round piles, burning again).

Alternatively, it is also an extreme wildfire hazard at times, partially due to high winds and dry conditions in the summer. The debris is also a target for arsonists, which makes it a double-

hazard. Most residents in the area cannot afford fire insurance. In addition, when the piles ARE burned, wildfire escapement is a very real danger.

Alaska Division of Forestry recommended moving residents out of areas for short period of time while they conducted controlled burns to remove hazard. Proposal estimate at $2 million in 1995. Project denied due to high cost. Approximate cost to state for wildfire suppression and smoke past ten years = approx. $7 million.

One wildfire destroyed thousands of acres of farmland and nearly destroyed the entire town of Delta in mid-80s in which arson was a prime cause (arson was denied by the community and it was blamed on rouge lightening). Those farmers with completely cleared land are thriving and consist of the largest acreage and largest financial income at this time.

Most often heard: "It's a serious liability for the farmer to do it, might burn down the area, including houses. It was the state's idea to do it this way, let the state come up with the money to clean it up."

Average percentage of farmers with debris piles on their land = 75%; average size = 40 ft. wide x 10 ft. high with majority being longer than 1,000 ft in length without breaks; average total length on land = 6 miles; 0-100 ft. from standing trees.

Statistics indicate that the debris piles comprise about 20% of the fields. The piles harbor pests and weeds, interfere with drainage and water access (snow accumulates on one side which limits water on the far side and water does not flow evenly), and interfere with efficient cultivation (requiring extra passes with equipment, blockages in turning equipment, etc.).

Protecting Alaska produce from diseases is important because currently Alaska is able to sell "organic" produce and seed stock due to the lack of common disease organisms. Very little pesticide, if any, is needed here.

In 1997, the Delta Project had approximately 18,300 acres in cropland (of potential 90,000 acres total for livestock and crop land), which was almost 60% of the state total for that year. Harvest of crops in the Delta Project was $2,830,000 which was 29% of the state total. Crops and

livestock production for the Delta area was $4.7 million which accounted for 32% of the state totals.

Removing all piles, assuming they presently comprise 20% of crop land, might increase proceeds to greater than 20% due to: greater efficiency, higher acreage in production (important in small business/small infrastructure), larger amount of feed for livestock in area, greater water capacity/drainage, etc.

When viewed from the bigger perspective, it is in the best interest of all concerned to make sure the hazards and obstacles are removed as much as possible. This includes obstacles in the form of government regulations. This can be accomplished without compromising public health if done properly.

The ultimate solution required flexibility from DEC, a streamlined permitting process, and more oversight and guidance from the local Alaska Division of Forestry. Forestry conducts an inspection for each site. They are on heightened alert during burning, which generally occurs during the spring and fall. Fall is best because they wait for a low front to come in carrying snow three days after the piles have been ignited. The snow covers the embers which after three days are beginning to smolder. The wood under the snow continues to burn down for a month or more. Only one or two land owner is allowed to burn at a time, and they still incur all liability for burning. But the process is safer, smoke complaints have been reduced 99%, and the community appears quite happy with the compromise.

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APPENDIX C

RELEVANT VOLUME I TABLES

Table 3-5. Summary of Agricultural Residues Burned within the Western States for Various Years (1996-1999) (Tons)[1]

Fuel/Residue	AZ 2000/01	CA 1996/97/99	CO Avg	HI 1996	ID 1996	MT 1996	ND Avg	NM 1996/Avg	NV[2] 1998	OR 1996	SD Avg	UT 1996	WA 1999	WY 1996/97
Grains and Hay														
Barley		889			167,943					21,429	14,158	4,671	22,223	3,060
Corn, for Grain	1,680	36,380											3,310	
Corn, Unspecified										5,112				
Hay, Alfalfa		7,213											2,882	
Hay, All Other		361											327	
Oats		3,944								7,902			1,021	
Rice		764,293												
Rye		124												
Wheat, All	15,352	224,709			376,010	5,055	410,145	6,560		244,755		17,379	48,121	
Wheat, Spring			2,000										63,125	
Wheat, Winter All											84,140		223,869	
Grasses and Seeds														
Bermuda	9,400	49,224												
Grasses, Propaning										3,204				
Grasses, Stack Burning										38,205				
Seeds, Other		1,604											394	
Seeds, Alfalfa					6,701								1,959	9,600
Seeds, Grasses (Field Burning), Unspecified	3,014									569,616			542	2,000
Seeds, KBG					100,000								750	
Sudan		5,770												
Orchard														
Almond		310,836												
Apple	74	8,071											879	
Apricot		6,603												
Avocado		1,371												
Cherry		7,511											88	
Citrus	548	15,458												
Fig		12,097												
Grape		78,860											513	
Nectarine		6,951												
Olive		8,042												
Pruning, Unspecified	2	5,570											458	
Pruning, Other		2,454												

Table 3-5. Continued

Fuel/Residue	AZ 2000/01	CA 1996/97/99	CO Avg	HI 1996	ID 1996	MT 1996	ND Avg	NM 1996/Avg	NV[2] 1998	OR 1996	SD Avg	UT 1996	WA 1999	WY 1996/97
Removal, Unspecified		84,359										11,265	32,024	
Peach		22,940											52	
Pear		17,748											395	
Pecan	7	3,186												
Pistachio	17	24,136												
Plum, Prune, Pluot		25,152											7	
Walnut		113,223												
Other														
Asparagus		8,819											21	
Beans	300	4,430											245	
Other		3,561			352								555	
Peas		1											495	
Safflower		6,686												
Sugarcane		4		420,000										
Agricultural Related Fuels														
CRP													76,096	
Ditches, Ditch Banks	1,225	25,552			160,013							3,030		
Total[3]	**31,619**	**1,898,134**	**2,000**	**420,000**	**811,018**	**5,055**	**410,145**	**6,560**	**20,952**	**890,223**	**98,298**	**36,345**	**480,349**	**14,660**

[1] AK does not conduct agricultural burning as defined under this project; thus only 14 states are shown. Values on this table represent tons of agricultural residue burned as reported by each state or developed with gap-filling/averaging techniques. As such, values for states should not be compared to each other.

[2] NV reports 20,952 acres burned; since specific crops are not indicated, residue (tons) cannot be estimated (Sergent, 2002).

[3] Sum of individual crops may not be equal total due to rounding.

Seeds, Other = All seeds not including alfalfa and Kentucky bluegrass (KBG).
Pruning, Other = Bushberry, kiwi, date, persimmon, pomegranate, quince
Other, Other = Other fruits and vegetables, unspecified, sorghum, peanuts, mint, jojoba beans, canola, hops
Wheat, All = All wheat not including spring and winter, all