TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE

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Agricultural Air Quality Conservation Measures

Reference Guide for Cropping Systems And General Land Management

Purpose

The United States Environmental Protection Agency (EPA) and the United States Department of Agriculture - Natural Resources Conservation Service (USDA-NRCS) have collaborated to develop this reference guide to provide a compilation of conservation measures for air pollutant emission reductions and/or reduction of air quality impacts from agricultural land management and cropping operations.

The reference guide can be used to address agriculturally-related air resource concerns in areas where agricultural emissions from cropping systems and general land management are determined to be significant contributors to air quality impairment. The methods presented in this guide are consistent with USDA objectives that promote the use of cost-effective practices and innovative technologies to address air resource concerns from agricultural operations and to meet federal, state and local regulatory requirements. Many of the measures provided in this guide also have additional resource benefits such as soil, water or energy conservation. Some co-benefits are identified, but this document is primarily focused on air quality.

Attachment A :

- Table 1 - Matrix for Approved Conservation Practices and Impacts on Air Quality Resource Concerns (PM-10)
- Table 2 - Air Quality Conservation Practices for Ozone
- Table 3 - Air Quality Conservation Practices for Green House Gases

Agricultural Air Quality Conservation Measures

Reference Guide for Cropping Systems And General Land Management

October 2012

United States Department of Agriculture
Natural Resources Conservation Service

Purpose

The United States Environmental Protection Agency (EPA) and the United States Department of Agriculture - Natural Resources Conservation Service (USDA-NRCS) have collaborated to develop this reference guide to provide a compilation of conservation measures for air pollutant emission reductions and/or reduction of air quality impacts from agricultural land management and cropping operations. Livestock operations will be covered in a separate reference guide in the future. This reference guide can be used to address agriculturally-related air resource concerns in areas where agricultural emissions from cropping systems and general land management are determined to be significant contributors to air quality impairment. The methods presented in this guide are consistent with USDA objectives that promote the use of cost-effective practices and innovative technologies to address air resource concerns from agricultural operations and to meet federal, state and local regulatory requirements. Many of the measures provided in this guide also have additional resource benefits such as soil, water or energy conservation. Some co-benefits are identified, but this document is primarily focused on air quality.

Over the past several years, EPA has received multiple requests to identify USDA-approved measures that may be considered to manage air emissions from cropping systems and general land management sources and potentially satisfy State Implementation Plan (SIP) requirements. These requests have come from a variety of stakeholders, including USDA's Agricultural Air Quality Task Force, agricultural producers, industry representatives and state and local agencies. In the 2006 Particulate Matter (PM) National Ambient Air Quality Standards (NAAQS) and 2008 Ozone NAAQS preambles, EPA recommended that in areas where agricultural activities have been identified as a contributor to a violation of the NAAQS, when properly implemented to control airborne emissions of the desired NAAQS pollutant, USDA-approved conservation systems and activities may be implemented to achieve reasonably available control measure (RACM) and best available control measure (BACM) levels of control.

This reference guide is chiefly designed as a technical tool to provide a compilation of USDA-NRCS approved practices to address air emissions from agricultural sources in areas where agricultural activities have been demonstrated to contribute to air quality issues. To learn more about NRCS practice standards please contact your local NRCS state office. Contact information for NRCS state offices can be found under the "browse by location" link at www.nrcs.usda.gov. USDA-NRCS may be able to offer technical and financial assistance to agricultural producers for implementing these and other conservation practices. Additionally, national funding assistance may be available from the EPA.

Furthermore, the USDA-NRCS was involved in the development of additional conservation measures for air quality purposes in California and Arizona and, where appropriate, references to these USDA-NRCS approved measures are included in this guide. Some of these conservation activities were patterned after NRCS conservation practice standards, but despite similarities in some of the names, application of these conservation activities may differ slightly from application of the NRCS practice standards.

For more information on the California measures, please see the Agricultural Air Quality Conservation Management Practices for San Joaquin Valley Farms handbook and table, which are available at:

Handbook: http://www.valleyair.org/farmpermits/updates/cmp_handbook.pdf
Table: http://www.valleyair.org/farmpermits/applications/cmp/cmp_list.pdf

For more information on the Arizona measures, please see the handbook for Agricultural PM_{10} Best Management Practices, which is available at:

Handbook:http://www.azda.gov/ACT/Best%20Management%20Practices%20Guide%20for%20web%20view%20reducec.pdf

This Reference Guide is Intended to:

- Provide a broad, though not comprehensive, set of USDA-NRCS approved practices that may be relied upon to address air resource concerns.
- Provide regional, state and local regulatory agencies with technical tools and information on how to manage agricultural air emissions with USDA-NRCS approved measures and USDA and EPA expertise.
- Allow stakeholders the flexibility in choosing which measures are best suited for their specific situations/conditions and desired purposes.

This Reference Guide is <u>NOT</u> Intended to:

- Identify agricultural sources as a significant contributor to air quality issues in all areas.
  - There are currently only a handful of areas in the United States where agricultural sources have been identified as a significant contributor to nonattainment of the PM and Ozone NAAQS. However, for those areas where it is demonstrated that agricultural sources are a significant contributor, this document can be useful to the state or local regulatory agency as it reviews options for managing air emissions from agricultural sources.
- Provide a comprehensive listing of all potential emissions reduction measures for mitigating agriculturally-related air quality impacts.
- Provide conservation measures that will be suitable for every specific case.
  - Geographic location, environmental conditions and intended purposes will differ for each particular agricultural situation. Thus, USDA and EPA strongly encourage state and local agencies to work with individual producers and NRCS conservationists to develop plans that include feasible and effective measures for each site.
- Provide any regulatory measures from the EPA.
  - This document is solely for informational purposes. It may be useful for states and local air agencies needing additional information on how to reduce emissions in areas where agricultural sources are demonstrated to contribute to a non-attainment designation.
- Provide details about the numerous co-benefits of these measures with respect to water quality, soil health, energy savings, greenhouse gases and many others.
  - Many of the practices listed in this guide may already be implemented to achieve other resource benefits (e.g. soil conservation, water conservation, etc.). This document was

designed to solely focus on the air quality benefits achieved from implementation of the conservation measures. It should be noted that in some cases, measures taken to achieve air quality benefits may cause other environmental impacts, and each situation needs to be carefully analyzed to achieve mutually beneficial outcomes.

When Implementing Conservation Measures:

- Regional, state, and local regulatory agencies should coordinate (as appropriate) with the producers, landowners, operators, state and local agencies, NRCS, and EPA to determine which measures may be best suited for a particular situation to attain the desired goals.
- Consider the geographic location and environmental conditions (soil type, precipitation, humidity, temperature, water availability, wind conditions, terrain, etc.) in which the practices will be implemented, as they will also play a role in deciding which conservation measures are most suitable.
- Assess implementation costs and benefits to determine the most cost-effective control measures that provide the greatest emissions reductions.
- Refer to the most up-to-date NRCS conservation practice standards or guidance to ensure that implemented measures follow current guidelines.

Using the Reference Guide

This technical tool identifies the current USDA-NRCS approved conservation measures available to the agricultural industry for the emission reductions of PM, PM precursor and ozone precursor emissions from agriculture operations. The measures are listed in eight sections, each categorized by type of activity or result to be achieved. For example, measures intended to maintain soil surface cover, and thus reduce PM emissions from erosive agents (wind, vehicle tires, implements, etc.) are included in Section 1.

It should be noted that all practices will not be well-suited for every region or specific farm/ranch or land management operation. Thus, the conservation measures are designed so that producers will have options and flexibility in selecting the most effective practices for their operation.

This guide is intended to provide information on USDA-NRCS approved measures that reduce air emissions. However, many of these measures also provide co-benefits for other resource concerns that are not identified in the document. To learn more about co-benefits from practices outlined in this guide, please contact your local NRCS State Office. Note that USDA-NRCS may also be able to offer technical and financial assistance to agricultural producers for implementing these and other conservation practices.

USDA-NRCS has developed conservation practice standards using scientifically-proven research and demonstration of technologies. For measures that have related practice standards, the NRCS Practice Codes are listed. The conservation practice standards contain information on why and where the conservation practice is applied and set forth minimum quality criteria that must be met during application to achieve the intended purpose(s).

State-specific versions of the conservation practice standards are available through the NRCS Field Office Technical Guide (FOTG) for each state. If no state conservation practice standard is available in the FOTG, please contact the appropriate NRCS State Office or local USDA Service Center. These offices are available to answer state and local questions and provide many forms of assistance. The locations of these offices can be found at the following websites:

NRCS State (and Local) Offices: www.nrcs.usda.gov
USDA Service Center Locator: http://offices.sc.egov.usda.gov

Additional Resources

NRCS has developed educational tools that are designed to provide information about air quality and are accessible to the public. To view these online courses please visit: www.airquality.nrcs.usda.gov.

EPA has developed a website that provides links to various agriculture and air quality related topics. For more information, please visit: http://www.epa.gov/airquality/agriculture.

Contributors

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U.S. EPA – Office of Air Quality Planning and Standards (OAQPS)

Table of Contents

Page

Section 1: Maintaining Soil Surface Cover **6**

Section 2: In-Field Pass Reductions **10**

Section 3: Soil Conditioning and Timing of Operations Modifications **13**

Section 4: Unpaved Roadways and Other Areas **17**

Section 5: Wind Barriers **21**

Section 6: Equipment Modifications **25**

Section 7: Fire and Smoke **27**

Section 8: Other **31**

Section 1:
Maintaining Soil Surface Cover

Soil surfaces can be sources of PM emissions when winds of sufficient speeds act upon the surface to cause erosion, suspension and entrainment of soil particles or when the action of machinery on soils leads to particulate generation. Both wind erosion and machinery action can lead to significant soil quality issues with the loss of valuable topsoil and deposition of soil on areas where it is not desired, including water bodies and streams (becoming a water quality issue). The degree to which soils erode and particles become airborne by wind or mechanical action is dependent on several factors, including the amount, type and spatial distribution of surface cover (residue, vegetation or other cover), soil type, soil moisture, the amount of compaction versus looseness of the top soil layer and the roughness (micro-topography) of the soil. Conservation practices that maintain soil cover and reduce these wind- and machinery-driven erosion factors will greatly reduce the risk of wind erosion and mechanically-generated PM by separating contact of the erosive agent (i.e., wind, vehicle tires, or implements) from the soil surface. This section is focused on soil cover measures, and Section 3 addresses soil condition measures.

Measures:

- Residue and Tillage Management and Mulching
- Cover Crops and Other Vegetative Surface Covers
- Perennial Crops and Other Vegetation

➢ **Conservation Measure Description: Residue and Tillage Management and Mulching**

Utilizing tillage systems that retain residue on the soil surface and reduce tillage intensity (less soil disturbance), as well as the reduction in vehicular traffic on fields will reduce the potential for PM generation. Where tillage and/or vehicular movement are needed, adopting conservation tillage and residue management, to the extent possible, will help retain topsoil structure and the ability of the soil surface to stay intact and not generate PM. Soil surface cover can also be achieved by mulching, which utilizes materials not present on the field. In cases where soils are bare (especially during times of severe drought when maintaining some type of surface cover becomes impossible) mulching can be very effective. If mulching is not feasible it may become necessary to invoke other conservation actions to prevent significant PM emissions (such as surface roughening, wind barriers, etc.—see Sections 3 and 5).

Several NRCS conservation practices are specifically designed for managing tillage and residue on soil surfaces and for application of mulches. *Residue and Tillage Management No Till/Strip Till/Direct Seed* is used for managing the amount, orientation, and distribution of crop and other plant residue on the soil surface year-round, while limiting soil-disturbing activities to those necessary to place nutrients, condition residue, and plant crops. This is the most stringent NRCS residue and tillage management practice, and its application retains the most residue of any practice. It also can greatly reduce tillage-induced PM generation, since tillage is eliminated or greatly reduced. One of the specified purposes of this practice is to reduce soil particulate emissions.

Other conservation tillage practices, such as *Residue and Tillage Management Mulch Till*, *Residue and Tillage Management Ridge Till*, and *Residue and Tillage Management Seasonal* manage both tillage and surface residue retention, and thus reduce the potential for PM generation compared to conventional tillage systems (though not to the extent of the no-till practice). *Mulching* is the application of plant residues (or other suitable materials produced off-site) to the land surface. Other suitable materials include natural products like wood chips and rice hulls, as well as artificial materials like plastic or fabric. Among other purposes, mulching can be used to reduce airborne particulates, conserve soil moisture, moderate soil temperatures, and improve soil condition.

NRCS Conservation Practice Standards

- Residue and Tillage Management No Till/Strip Till/Direct Seed (329)
- Residue and Tillage Management Mulch Till (345)
- Residue and Tillage Management Ridge Till (346)
- Residue and Tillage Management Seasonal (344)
- Mulching (484)

Additional Conservation Activities

- From the San Joaquin Valley Unified Air Pollution Control District Agricultural Air Quality Conservation Management Practices, (Table, Handbook):
    - Alternate Till
    - Conservation Tillage
    - Mulching
    - Non Tillage / Chemical Tillage
    - Soil Amendments
    - Transplanting
- From the Arizona Guide to Agricultural PM_{10} Best Management Practices, (Handbook):
    - Reduced Tillage System
    - Residue Management
    - Mulching

➢ Conservation Measure Description: Cover Crops and Other Vegetative Surface Covers

Cover crops and other vegetative surface covers are typically annual plantings that are part of a cropping sequence. They often are used during the non-cropping part of a rotation to maintain soil surface cover, as well as to increase soil organic matter content, manage soil moisture, minimize and reduce soil compaction, and capture and recycle or redistribute nutrients in the soil profile. *Cover Crop* is typically used in conjunction with *Conservation Crop Rotation*.

Stripcropping, the practice of growing planned rotations of row crops, forages, small grains, or fallow in a systematic arrangement of equal width strips across a field, can also be used effectively for seasonal soil cover maintenance.

NRCS Conservation Practice Standards

- Conservation Crop Rotation (328)
- Cover Crop (340)
- Stripcropping (585)

Additional Conservation Activities

- From the San Joaquin Valley Unified Air Pollution Control District Agricultural Air Quality Conservation Management Practices, (Table, Handbook):
    - Cover Crops
- From the Arizona Guide to Agricultural PM_{10} Best Management Practices, (Handbook):
    - Cover Crop
    - Sequential Cropping

➢ Conservation Measure Description: Perennial Crops and other Vegetation

Greater soil cover (both spatially and temporally) can be achieved by utilizing perennial crops or perennial vegetation, when appropriate. With these practices, soil cover is almost always maintained, and PM generation from wind erosion or mechanical/vehicular action is greatly reduced or eliminated. These practices can be very effective for long-term soil stabilization and improvement in soil quality. They can be grouped into:

- Perennial cropping and cropping-related practices which allow for the permanent and semi-permanent establishment of forage and/or biomass crops, and buffer areas that maintain soil cover. These include *Field Border and Forage and Biomass Planting.*
- Perennial vegetation practices that establish vegetation for a long period of time. These include *Conservation Cover, Range Planting* and *Tree/Shrub Establishment*. *Critical Area Planting* is intended to establish permanent vegetation on sites that have, or are expected to have, high erosion rates, and on sites that have physical, chemical or biological conditions that prevent the establishment of vegetation with normal practices.
- Agroforestry practices such as *Alley Cropping, Multi-Story Cropping, Silvopasture Establishment and Windbreaks* also can be used to maintain soil cover, and thus reduce potential PM generation, as well as provide additional natural resource benefits. These are also very effective wind barriers and are described more fully in Section 5.

NRCS Conservation Practice Standards

- Alley Cropping (311)
- Conservation Cover (327)
- Critical Area Planting (342)
- Field Border (386)
- Forage and Biomass Planting (512)
- Multi-Story Cropping (379)
- Range Planting (550)
- Silvopasture Establishment (381)
- Tree/Shrub Establishment (612)
- Windbreak/Shelterbelt Establishment (380)
- Windbreak/Shelterbelt Renovation (650)

Additional Conservation Activities

- From the San Joaquin Valley Unified Air Pollution Control District Agricultural Air Quality Conservation Management Practices, (Table, Handbook):
    - Permanent Crop
- From the Arizona Guide to Agricultural PM_{10} Best Management Practices, (Handbook):
    - Multi-Year Crop
    - Permanent Cover

Geographic and Physiographic Factors:

In general, areas of the United States with lower precipitation and higher winds will be most likely to benefit from implementing measures found in this section. The High Plains from eastern Montana and the Dakotas southward to western Texas and eastern New Mexico can frequently be vulnerable to wind erosion and PM generation and transport, especially during drought periods. Other areas like the winter wheat / summer fallow region of eastern Washington and Oregon also occasionally experience these issues, with the juxtaposition of bare soils, dryland farming and infrequent high wind events. In general, erosive wind events are quite rare in the United States, and years may pass in some areas before atmospheric and soil conditions align for PM generation and transport. Since soil moisture and topsoil conditions are critical for PM generation, it is necessary that these factors, in addition to wind statistics, be strongly considered in determining a location's vulnerability for erosive events and consequently air quality degradation. Thus, during severe drought episodes, there may be very little that can be done to avoid significant wind erosion and PM generation. In fact, this is the very source of the world's loess soils.

Tool: The NRCS/Agricultural Research Service (ARS) Wind Erosion Prediction System (WEPS) is the primary model used by USDA to estimate wind erosion potential. Users can specify soil surface characteristics and management options, such as those described in this section. WEPS also has the capability to model crop growth and include cover crops or perennial vegetation (and barriers). The model delivers estimates of total soil loss as well as PM_{10} emissions from a specified land area. WEPS is not an online tool, but those interested in applying the model should work through their appropriate state and/or local NRCS agronomist.

Section 2:
In-Field Pass Reductions

Agricultural field operations, such as tilling, planting, weeding, fertilizing, harvesting, mowing, cutting, baling, and spreading of manure or compost can produce air pollution emissions. These emissions can be directly emitted from the action of wheels and machinery on soil or from engine combustion. Vehicular and machinery action can break up soil aggregates, making the finer particles more likely to be suspended by additional field actions and/or wind. The amount of dust produced and transported off the field is largely a function of the number of individual operations on a given field and associated atmospheric conditions. Reducing the number of operations reduces the amount of dust produced in the field, as well as engine emissions. Therefore, a reduction in the number of passes over a field can: 1) reduce soil abrasion and the breakup of soil aggregates, 2) reduce direct suspension of PM from vehicle wheels/etc., and 3) reduce engine emissions (ozone precursors [especially oxides of nitrogen (NO_x)], and PM).

Measures:

- Modify Operations
- Precision Delivery

➢ **Conservation Measure Description: Modify Operations**

Reducing in-field passes can be accomplished by modifying operations and improving operational efficiency. This can be achieved by applying conservation tillage, increasing equipment efficiencies, optimizing field space, or combining operations. Overall, these conservation measures can be quite effective at reducing PM emissions. Reduced engine emissions are approximately proportional to the number of reduced passes, taking into account implements used and additional power needs with the combined operation. Conservation tillage limits soil-disturbing activities to only those necessary to place nutrients, condition residue and plant crops. Optimizing field space through adjustments in bed/row spacing (which can increase plant density/canopy through reduction of row width) reduces the number of passes and the resultant soil disturbance. Certain crop cultural practices (including organic practices for reducing pesticide application passes, hand harvesting, and those practices associated with fruit crops, including the use of a continuous tray/dried-on-the-vine system such as that applied in California) can also result in reduced passes. However, in some cases organic production can actually increase field passes, such as increasing cultivation for weed control. In these cases, this measure should not be used as a control measure for reducing PM emissions. Many in-field pass reductions can be applied relatively independently of geographic location. *Residue and Tillage*

Management Mulch Till and *Residue and Tillage Management No Till/Strip Till/ Direct Seed* are conservation practice standards that may be used for managing the residue on soil surfaces, thus reducing required in-field passes.

NRCS Conservation Practice Standards

- Residue and Tillage Management Mulch Till (345)
- Residue and Tillage Management No Till/Strip Till/Direct Seed (329)

Additional Conservation Activities

- From the San Joaquin Valley Unified Air Pollution Control District Agricultural Air Quality Conservation Management Practices, (Table, Handbook):
    - Alternate Till
    - Bed/Row Size or Spacing
    - Combined Operations
    - Continuous Tray/Dried on the Vine, New Drying Techniques for Dried Fruit
    - Conservation Tillage
    - Floor Management
    - Equipment Changes/Technology Improvements
    - Green Chop
    - Hand Harvesting
    - Fallowing Land
    - Mulching
    - Non-Tillage/Chemical Tillage
    - Organic Practices (for biological control of pests)
    - Shed Packing
    - Shuttle System/Large Carrier
    - Transplanting
- From the Arizona Guide to Agricultural PM_{10} Best Management Practices, (Handbook):
    - Combining Tractor Operations
    - Green Chop
    - Reduced Harvest Activity
    - Reduced Tillage System

➢ **Conservation Measure Description: Precision Delivery**

Application of advanced technologies and methodologies, such as *Integrated Pest Management, Nutrient Management, Irrigation System Microirrigation, Irrigation System Surface and Subsurface*, application efficiencies, precision farming and chemigation/fertigation, can precisely deliver herbicides/pesticides and water to crops. These technologies and methodologies can also reduce: operation overlap, number of field passes, soil compaction (which requires additional tillage) and excess water that can enhance weed growth (where weed treatment could require additional tillage and field passes). Integrated pest management and nutrient management are comprehensive practices designed to precisely deliver pesticides and nutrients to the agricultural system. Nutrient and pest management conservation practices strive to apply fertilizer and pesticides from the right source, at the right rate, at the right time, and in the right place (known as the 4R's of nutrient stewardship). Getting the nutrient or pesticide applied in the right place

(precision delivery) can take the form of smart sprayer technology, which places the pesticide precisely on the desired plant location or precision delivery systems, which lead to the elimination of operation overlap. These practices not only reduce direct PM emissions from vehicles and mechanical disturbance of the soil, but also can prevent or mitigate pesticide and nutrient volatilization losses and drift (including volatile organic compounds (VOC) and NO_x).

NRCS Conservation Practice Standards

- Integrated Pest Management (595)
- Nutrient Management (590)
- Irrigation System Microirrigation (441)
- Irrigation System Surface and Subsurface (443)

Additional Conservation Activities

- From the San Joaquin Valley Unified Air Pollution Control District Agricultural Air Quality Conservation Management Practices, (Table, Handbook):
    - Application Efficiencies
    - Conservation Irrigation
    - Chemigation/Fertigation
    - Integrated Pest Management
    - Precision Farming (Global Positioning System)
- From the Arizona Guide to Agricultural PM_{10} Best Management Practices, (Handbook):
    - Chemical Irrigation
    - Integrated Pest Management
    - Precision Farming

Section 3:
Soil Conditioning and Timing of Operations Modifications

Photo: Dusty Eddy, NRCS

Soil conditioning and timing are critical when it comes to cropping systems. Modifying agricultural activities that help condition the soil (such as cultivating, ridging, etc.), as well as modifying the timing of operations, is not always practical but may sometimes be necessitated by local or regional air quality conditions. In regions of the country where agriculture has been identified as a source that contributes to compromised air quality, atmospheric concentrations can be minimized by adopting soil conditioning practices and modifying the timing of operations. Conservation measures and activities that can be adopted to reduce agricultural air emissions include: no-till farming, precision agriculture, monitoring soil moisture, soil amendments, residue and tillage management, closely monitoring weather and atmospheric conditions, and adjusting the timing of operations to minimize air quality impacts.

Farming and ranching operations almost always involve critical timing components that are, at very best, marginally flexible. Producer operations almost always hinge on a suite of dynamic factors, and when the majority of these factors are favorable, the intended farming operations (i.e., tillage, harvest, soil amendments) occur. Implementing one or more proactive conservation measures and timing operations to coincide with favorable atmospheric conditions (wind speed and direction, relative humidity, atmospheric stability, background ambient air quality concentrations, etc.) can prevent adverse agricultural air quality impacts. Producers often need to modify operations due to weather conditions. Air quality can sometimes benefit from modifying the timing of operations, where practicable. In some areas of the country, the calculations behind agricultural decision making have become more complex due to air quality. In these regions, weather conditions and economics are the primary variables; however, ambient air quality must also be considered as a variable in the agricultural decision-making process.

This section focuses on utilizing conservation techniques related to soil conditioning and timing of operations to minimize air emissions while accomplishing the necessary farm/ranch business requirements. Minimizing agricultural emissions can be accomplished through a variety of innovative solutions and good decision-making.

In some regions of the country, the adoption of conservation measures is required of producers. Producers, particularly in these regions, should be cognizant of air emissions from agricultural activities. Careful evaluation of soil conditions and timing of operations to minimize the possibility of agriculturally-produced emissions (which can contribute to compromised ambient

air quality) should be pursued, when feasible. Clearly, producers have many decision-making factors, and there are times when it is critical to proceed with operations (such as completing planting or harvest before a significant weather event). When economic and other considerations allow, modifying timing of operations to ensure adequate air quality should be strongly considered. For example, when meteorological and soil conditions align to indicate a high-wind dust event could occur, limiting in-field activity can be an effective measure for reducing PM emissions.

Emission prevention techniques are generally applicable throughout the country in a variety of agricultural contexts. Conservation measures are most effective when they are prescribed and customized for a particular locality, even a specific agricultural operation under a specified set of parameters. Conservation measures can be most effective in areas where topsoil can easily become airborne due to moisture and physical soil properties and may be most necessary in regions where agriculture occurs in close proximity to population centers. Local regulations and ordinances should be followed and harmonized with conservation measures to meet air quality objectives.

Many of the practices and activities that can be implemented to reduce agricultural emissions also have ancillary benefits and can preserve valuable topsoil, conserve water, and increase productivity.

Measures:

- Soil Conditioning
- Modifying the Timing of Operations

➢ Conservation Measure Description: Soil Conditioning

Increasing the soil moisture content through residue and cover crops can be an effective approach to increasing soil health and minimizing airborne PM. *Cover Crops* can be used through fallow periods in some cropping systems and in areas with sufficient precipitation to reduce soil erosion, increase soil nutrients, and address wind erosion. Several NRCS conservation practices, such as *Nutrient Management*, have been identified as beneficial soil conditioning practices. PM emission reductions from *Residue and Tillage Management, and Stripcropping* are practices that can help address ambient air quality concerns while simultaneously improving soil tilth. *Conservation Cover* and *Mulching* also add organic matter and stabilize the soils to effectively reduce air emissions, even when soils are bare. Pre-harvest soil preparation, such as *Irrigation Water Management and Sprinkler Irrigation Systems* can be used to improve air quality. Water or stabilizing material can be applied to the soil prior to agricultural operations to control dust. However, this should only be an option when ample water supplies exist. *Surface Roughening* is also a proven method of reducing wind-blown PM in cases of extreme dryness, lack of vegetation, and impending strong winds. However, this is an emergency practice only utilized when no other options for controlling dust exist.

NRCS Conservation Practice Standards

- Conservation Cover (327)
- Cover Crop (340)

- Irrigation Water Management (449)
- Irrigation System Sprinkler (442)
- Mulching (484)
- Nutrient Management (590)
- Residue and Tillage Management Mulch Till (345)
- Residue and Tillage Management No-Till / Strip Till / Direct Seed (329)
- Residue and Tillage Management Ridge Till (346)
- Stripcropping (585)
- Surface Roughening (609)

Additional Conservation Activities

- From the San Joaquin Valley Unified Air Pollution Control District Agricultural Air Quality Conservation Management Practices, (Table, Handbook):
    - Alternate Till
    - Conservation Tillage
    - Cover Crops
    - Floor Management
    - Mulching
    - Non Tillage / Chemical Tillage
    - Organic Practices
    - Pre-Harvest Soil Preparation
    - Permanent Crops
    - Soil Amendments
- From the Arizona Guide to Agricultural PM_{10} Best Management Practices, (Handbook):
    - Reduced Tillage Systems
    - Aggregate Cover
    - Synthetic Particulate Suppressant
    - Cover Crop
    - Cross-Wind Ridges
    - Mulching
    - Residue Management
    - Surface Roughening

➢ Conservation Measure Description: Modifying the Timing of Operations

Timing is critical in farming. Adjustments in the timing of operations and/or proper soil conditioning can minimize many agricultural air quality issues. Agricultural operators located in, or in close proximity to, air quality nonattainment areas should integrate air quality considerations into their decision-making criteria.

Minimizing soil-disturbing activities and timing these activities to coincide with favorable atmospheric conditions can reduce agricultural air emissions. Timing tillage, planting, and harvesting to occur when the soil has the appropriate moisture content has multiple benefits. In addition to the air quality benefits that also prevent wind erosion, performing field operations during times of favorable soil moisture can improve yield and soil health. Innovative

conservation measures like *Integrated Pest Management, Nutrient Management, and Residue Management* attempt to maximize the efficiency of field operations while minimizing adverse impacts.

Timing, one of the 4R's of nutrient stewardship, is also critical for integrated pest management. Producers can monitor crops for pests to ensure effective spray timing and incorporate biological practices into the farming operation to reduce the need for spraying.

Other practices, such as limiting agricultural activities during high-wind events, and farming at night when relative humidity and surface soil moisture is higher and temperatures and wind speeds are typically lower, can effectively reduce PM emissions. Maintaining cover crops and managing residue can minimize wind erosion while adding valuable organic matter to the soil (see Section 1 for more details). In regions where residue burning is common, smoke management should be considered as part of planning and executing the burn. See Section 7 of this guide for additional information on *Prescribed Burning* and smoke management.

NRCS Conservation Practice Standards

- Integrated Pest Management (595)
- Nutrient Management (590)
- Residue Management Seasonal (344)
- Prescribed Burning (338)

Additional Conservation Activities

- From the *San* Joaquin Valley Unified Air Pollution Control District Agricultural Air Quality Conservation Management Practices, (Table, Handbook):
    - Combined Operations
    - Equipment Changes / Technology Improvements
    - Fallowing Land
    - Night Farming
    - Night Harvesting
    - Precision Farming (GPS)
    - Time of Planting
    - Transplanting
    - Green Chop
    - No Burning
    - Reduced Pruning
    - Integrated Pest Management
- From the Arizona Guide to Agricultural PM_{10} Best Management Practices, (Handbook):
    - Green Chop
    - Limited Activity during a High-Wind Event
    - Planting Based on Soil Moisture
    - Tillage Based on Soil Moisture
    - Timing of a Tillage Operation
    - Integrated Pest Management
    - Sequential Cropping

Section 4:
Unpaved Roadways and Other Areas

Roadways and farmstead areas that are unpaved or not covered with some type of vegetation or other surface bonding (grass, wood chips, etc.) can generate airborne soil particles. This includes roads, traffic areas, parking lots, staging or assembly areas, equipment storage lots, runways and loading/unloading areas of farms and ranches. Vehicular action on parental material (soil, rock, etc.) causes mechanical fracture (i.e., crushing) into smaller particles that can become airborne. These unpaved areas can also produce dust by natural disaggregation of the parent material when wind acts upon them—though typically wind-eroded particles are larger than those produced by vehicular action.

The principal means of preventing dust generation is via the use of dust suppressants. These are substances applied to unpaved roads and other areas that bind together soil, gravel, dust particles and other materials. Suppressants, sometimes called palliatives, can be very effective in reducing or eliminating the generation and suspension of PM. Another effective method of reducing PM is by controlling the frequency, duration and intensity of mechanical action on unpaved roads and other areas via controls on vehicular actions. Finally, if PM is generated from unpaved roads and surfaces on farms and ranches, vegetation can be used to intercept it and retard its transport into adjoining lands.

Measures:

- Dust Suppressants
- Vehicular Controls
- Vegetation Controls on Wind and Dust Interception

➢ **Conservation Measure Description: Dust Suppressants**

Dust suppressants, or palliatives, come in many forms, and can vary greatly in PM control effectiveness and longevity. Suppressants such as water are typically effective for only a short period of time (hours to a day or two), while biologically-based products like lignosulfonate have longer lifetimes, and petroleum-based products (like heavy road oil) can have lifetimes of a year or more.

A primary NRCS conservation practice that can be used for this purpose is *Dust Control on Unpaved Roads and Surfaces*. This practice describes various means of controlling unpaved road and surface dust, most typically using some type of suppressant. Results from the utilization of this practice vary according to the suppressant used, but may result in a 50% or greater reduction in PM emissions over the untreated case. Cost and environmental impacts are considerations in suppressant choice. Long-term cost-benefit analyses typically inform landowner decision-making. For instance, water may be the cheapest single-application alternative, but due to the need for repeated applications, it may be cost-prohibitive for long durations and frequent applications. In addition, water may simply be unavailable in arid regions and/or during droughts. There may be environmental impacts of all other suppressants, including salts and petroleum products, and these impacts should be considered when making dust control decisions.

Additional NRCS practices that may also be used for PM emissions control on unpaved areas include *Irrigation System, Sprinkler; Heavy Use Area Protection* and *Mulching*. These practices can be used to provide surface protection and cover to unpaved areas, thus making them less susceptible to erosion.

NRCS Conservation Practice Standards

- Dust Control on Unpaved Roads and Surfaces (373)
- Irrigation System, Sprinkler (442)
- Heavy Use Area Protection (561)
- Mulching (484)

Additional Conservation Activities

- From the San Joaquin Valley Unified Air Pollution Control District Agricultural Air Quality Conservation Management Practices, (Table, Handbook):
    - Chips / Mulches, Organic Materials, Polymers, Road Oil and Sand
    - Gravel
    - Paving
    - Water
- From the Arizona Guide to Agricultural PM_{10} Best Management Practices, (Handbook):
    - Aggregate Cover
    - Synthetic Particulate Suppressant

➢ **Conservation Measure Description: Vehicular Controls**

Control of both the speed and frequency of vehicular movement on roadways and other areas is also an effective strategy for PM control. *Access Control* and *Dust Control on Unpaved Roads and Surfaces* promotes PM control via posted speed limits, speed controls directly applied on engine components of vehicles/farm machinery, reduction of vehicular movement via combining operations, and other methods such as those suggested in Section 2 for farm/ranch fields that could be applicable to unpaved roads and surfaces. In addition, PM can be generated from soil transported from unpaved areas onto hard-paved surfaces that is then disaggregated, and can become airborne by vehicular action on the paved road. Reducing this “track-out” of soil (via mud on tires and other vehicle surfaces) onto hard-surfaces can thus be an effective PM control strategy.

NRCS Conservation Practice Standards

- Access Control (472)
- Dust Control on Unpaved Roads and Surfaces (373)

Additional Conservation Activities

- From the San Joaquin Valley Unified Air Pollution Control District Agricultural Air Quality Conservation Management Practices, (Table, Handbook):
    - Combined Operations
    - Mechanical Pruning
    - Restricted Access
    - Speed Limits
    - Track-out Control
- From the Arizona Guide to Agricultural PM_{10} Best Management Practices, (Handbook):
    - Access Restriction
    - Reduce Vehicle Speed
    - Track-out Control System

➢ **Conservation Measure Description: Vegetation Controls on Wind and Dust Interception**

Dust Control on Unpaved Surfaces may also be achieved by intercepting airborne particulates via vegetative barriers such as *Windbreaks* or *Critical Area Plantings*. However, dust control is best accomplished by preventing its initial generation. Vegetation placed along an unpaved roadway or other area can help contain and capture dust and prevent its transport away from the roadway area. This may be accomplished by following the practice standards: *Field Border, Hedgerow Planting, Herbaceous Wind Barriers,* or *Tree/Shrub Establishment*. Care must be taken to apply the proper vegetation to withhold the expected dust load (especially on younger plantings) and will do an effective job of intercepting the dust. A complete description of wind barriers can be found in Section 5.

NRCS Conservation Practice Standards

- Critical Area Planting (342)
- Dust Control on Unpaved Roads and Surfaces (373)
- Field Border (386)
- Hedgerow Planting (422)
- Herbaceous Wind Barriers (603)
- Tree/Shrub Establishment (612)
- Windbreak/Shelterbelt Establishment (380)

Additional Conservation Activities

- From the San Joaquin Valley Unified Air Pollution Control District Agricultural Air Quality Conservation Management Practices, (Table, Handbook):
  - Wind Barrier
- From the Arizona Guide to Agricultural PM_{10} Best Management Practices, (Handbook):
  - Artificial Wind Barrier
  - Critical Area Planting
  - Tree, Shrub or Windbreak Planting

Geographic and Physiographic Factors:

Regions of the U.S. where extended dry conditions occur and where there is an abundance of unpaved farm roads and surfaces are the most likely places where this issue will be most prevalent. This includes most of the western U.S., the high plains, and the eastern third of the country (where more erosive soil types are found).

Section 5:
Wind Barriers

Vegetative and artificial barriers can: 1) disrupt the erosive flow of wind over unprotected surfaces by changing (slowing) the airflow pattern over the land surface and 2) provide filtration and/or interception of airborne particles and gases. Wind barriers can also reduce the area of exposed soils, and in the case of vegetative barriers, the root structure will further hold the soil in place. Artificial windbreaks can include structures such as fences and stacked hay bales and can be designed with various physical dimensions and porosities to alter wind flow. For all cases, whether reducing the suspension of particles or intercepting airborne particles and gases, wind barriers are most effective when oriented perpendicular to the erosive wind direction. A dry and disturbed soil in flat terrain without vegetation is the situation most likely to lead to the suspension of surface material, and many of the conservation practices in this section are designed to keep soil at the surface and reduce its migration offsite.

Measures:

- Disrupt Erosive Wind Flow
- Intercept Airborne PM and Gases

➢ **Conservation Measure Description: Disrupt Erosive Wind Flow**

When wind blows over a surface, a vertical wind speed profile exists where wind speed is nearly zero at the surface and then increases with height away from the surface. On a bare surface, wind speed quickly increases with height because the surface elements have little drag effect and thus wind speeds can be high quite close to the surface. Roughness elements such as soil aggregates and vegetation create additional drag on the wind, modifying the vertical wind speed profile such that wind speed does not increase with height as rapidly. Thus, the wind in contact with the surface is decreased, reducing wind erosion. Air trapped by clods and other cover elements also reduces the wind energy intensity at the surface. Barriers such as vegetative or artificial windbreaks, vegetative strips, or shallow barriers like surface residue and other types of soil cover (see Section 1) or surface roughening (typically mechanical plowing or cultivation on bare soil) all to some degree alter the vertical wind speed profile, reducing wind speeds near the surface.

NRCS has a selection of conservation practice standards that can be applied to disrupt and reduce the erosive flow of wind over the landscape. *Windbreak/Shelterbelt Establishment* is one of the most effective measures where single or multiple rows of trees or shrubs are planted in a linear fashion, typically perpendicular to the predominant wind direction. Barrier length and

height have the greatest effect on the downwind shelter area. Shelter areas are described in terms of the windbreak height (H) and can range from 14.5H to 25H in length. Taller windbreaks reduce wind speed over a greater distance, with longer and wider windbreaks typically more effective than short and narrow ones. Local NRCS offices have information about recommended tree species for their specific areas.

Other herbaceous and woody vegetation practices, such as *Field Border, Hedgerow Planting, Cross Wind Trap Strips, Herbaceous Wind Barriers*, and *Tree/Shrub Establishment*, have the corollary benefit of reducing wind speeds, but are often implemented for other reasons (i.e., protecting crops from abrasion by windblown particles). Cropping practices such as *Stripcropping* and *Alley Cropping* can also have corollary benefits of reducing wind speeds near the surface and providing shelter to crops downwind.

As a non-primary means of controlling wind erosion, *Surface Roughening* can be implemented to create random roughness at the soil surface. This is only applicable for bare soils with a surface layer suitable for clod formation and is generally an emergency procedure used in dryland drought situations. *Cross Wind Ridges* can also be formed, which are ridges formed by tillage, planting or other operations. In both cases, wind energy at the surface is somewhat reduced.

NRCS Conservation Practice Standards

- Alley Cropping (311)
- Cross Wind Ridges (588)
- Cross Wind Trap Strips (589C)
- Field Border (386)
- Hedgerow Planting (422)
- Herbaceous Wind Barriers (603)
- Stripcropping (585)
- Surface Roughening (609)
- Tree/Shrub Establishment (612)
- Windbreak/Shelterbelt Establishment (380)

Additional Conservation Activities

- From the San Joaquin Valley Unified Air Pollution Control District Agricultural Air Quality Conservation Management Practices, (Table, Handbook):
    - Cover Crop
    - Permanent Crops
    - Surface Roughening
    - Wind Barrier
- From the Arizona Guide to Agricultural PM_{10} Best Management Practices, (Handbook):
    - Artificial Wind Barrier
    - Cross-Wind Ridges
    - Cross-Wind Strip-Cropping
    - Cross-Wind Vegetative Strips
    - Surface Roughening
    - Tree, Shrub or Wind Break Planting

➢ Conservation Measure Description: Intercept Airborne PM and Gases

Wind barriers such as vegetative or artificial windbreaks and other vegetative strips can also intercept airborne PM and gases. Their design effectiveness is dependent upon the barrier height and porosity, the particle size being intercepted, vegetative or structural elements, and location of the particle or gas source in relation to the wind barrier. Higher barriers can intercept particles and gases that were released at greater upwind distances. Porosity of the barrier plays a role in particle/gas interception. Porosity in vegetative barriers can increase with vegetation height (depending on the vegetation), and increasing wind speeds can increase porosity by streamlining the vegetation. Vegetative elements also help determine particle/gas capture where tighter vegetation elements (e.g. conifers) can capture more PM than broadleaf species. The type of pollutant being intercepted can also impact the health of the vegetative barrier. For example, if intercepting a nitrogen containing compound such as ammonia or oxides of nitrogen, a wide range of impacts have been observed from necrosis to enhanced growth (depending on the plant species). Other factors such as length of exposure, degree of exposure, and other environmental considerations (ex. atmospheric temperature, moisture, etc.) are important as well.

NRCS has a selection of conservation practice standards that can be applied to intercept airborne PM and gases. *Windbreak/Shelterbelt Establishment* is one of the most effective measures where single or multiple rows of trees or shrubs are planted in a linear fashion. Barrier length, height, porosity, and vegetation type have the greatest effect on the interception of airborne PM and gases. Local NRCS offices have information about recommended tree species for their specific areas.

As another means of intercepting particles and gases, practices planting herbaceous and woody vegetation such as *Field Border, Hedgerow Planting, Cross Wind Trap Strips, Herbaceous Wind Barriers, Tree/Shrub Establishment, Alley Cropping,* and *Stripcropping* can be implemented. Some of these practices are specifically intended to protect crops from abrasion by particles (e.g. *Cross Wind Trap Strips*) or can be designed to intercept particles and gases from pesticide applications (e.g. *Hedgerow Planting*).

NRCS Conservation Practice Standards

- Alley Cropping (311)
- Cross Wind Trap Strips (589C)
- Field Border (386)
- Hedgerow Planting (422)
- Herbaceous Wind Barriers (603)
- Stripcropping (585)
- Tree/Shrub Establishment (612)
- Windbreak/Shelterbelt Establishment (380)

Additional Conservation Activities

- From the San Joaquin Valley Unified Air Pollution Control District Agricultural Air Quality Conservation Management Practices, (Table, Handbook):
  - Cover Crop
  - Permanent Crops
  - Wind Barrier
- From the Arizona Guide to Agricultural PM_{10} Best Management Practices, (Handbook):
  - Artificial Wind Barrier
  - Cross-Wind Strip-Cropping
  - Cross-Wind Vegetative Strips
  - Tree, Shrub or Wind Break Planting

Tool: The NRCS/ARS Wind Erosion Prediction System (WEPS) is the primary model used by USDA to estimate wind erosion potential. The model allows users to specify soil surface characteristics and management options. WEPS also has the capability to model crop growth and include cover crops or perennial vegetation. The model has a wind barrier submodel that takes into account important vegetative windbreak characteristics. The user defines the wind barrier's length, width, height, porosity, number of rows, and tree type. Users can choose from the following vegetation types for a wind barrier: shrub, conifer, deciduous, pruned trees, nut trees, dwarf/semi-dwarf orchard, standard orchard, and vineyard. WEPS delivers estimates of total soil loss as well as PM_{10} emissions from a specified land area. WEPS is not an online tool, but those interested in applying the model should work through their appropriate state and/or local NRCS agronomist.

Section 6:
Equipment Modifications

Various types of modifications to agricultural equipment can help to prevent or mitigate emissions of PM, VOC, and/or NO_x. Since the emissions addressed by equipment modifications are typically episodic (related to equipment operation more so than geography or meteorological conditions), the use of equipment modifications may be appropriate in any area where agricultural emissions are contributing to an air quality issue. Equipment modifications can be a broad array of simple or sophisticated changes and can include new equipment, manufacturer options, and independently-customized alterations.

Measures:

- Combustion Equipment Replacement/Retrofit and Operation
- Non-combustion Equipment Changes/Technology Improvements

➢ **Conservation Measure Description: Combustion Equipment Replacement/Retrofit and Operation**

Uncontrolled, older and/or less efficient combustion equipment typically have higher air emissions (especially for PM and NO_x) than controlled, newer and/or more efficient combustion equipment. Combustion equipment includes stationary and mobile sources, such as irrigation engines, tractor engines, heaters, boilers, etc.

Replacing higher-emitting combustion units with lower emitting or non-combustion alternatives can result in significant air quality improvement, as well as possible energy savings. Also, retrofitting existing combustion units with air emission controls or new technologies to improve combustion efficiency can reduce the amount of air emissions from the units.

Proper maintenance and operation is extremely beneficial to minimizing emissions from existing combustion equipment, as well as ensuring the equipment performs as it was originally intended. The load on the engine is reduced when equipment is operating at maximum efficiency, which can result in decreased engine operation time and thus less PM emissions. In some cases, making energy efficiency improvements can also result in decreased fuel use in combustion equipment and/or decreased combustion emissions.

Combustion System Improvement and Pumping Plant may be used if agricultural combustion systems and/or related components or devices are replaced or retrofitted for air quality and energy efficiency improvement.

NRCS Conservation Practice Standards

- Combustion System Improvement (372)
- Pumping Plant (533)

Additional Conservation Activities

- From the San Joaquin Valley Unified Air Pollution Control District Agricultural Air Quality Conservation Management Practices, (Table, Handbook):
    - Irrigation Power Units
    - Conservation Irrigation

➢ **Conservation Measure Description: Non-combustion Equipment Changes/Technology Improvements**

Agricultural equipment changes and technology improvements for reducing air emissions can take many shapes and forms. These can include relatively simple fixes, like using a shield or deflector to knock particulates out of an airstream before they are released, or using lower-pressure pesticide application nozzles to limit volatilization and chemical drift. These can also include more advanced techniques, like making internal design changes to harvesting equipment to separate and deposit residue and dust prior to entrainment. Other examples include utilizing water spray bars and variable rate or targeted pesticide applicators.

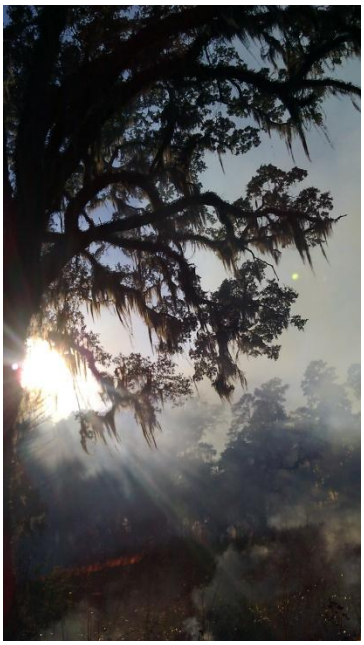
NRCS Conservation Practice Standards

- Integrated Pest Management (595)

Additional Conservation Activities

- From the San Joaquin Valley Unified Air Pollution Control District Agricultural Air Quality Conservation Management Practices, (Table, Handbook):
    - Equipment Changes/Technological Improvements
    - Application Efficiencies
- From the Arizona Guide to Agricultural PM_{10} Best Management Practices, (Handbook):
    - Equipment Modification

Section 7:
Fire and Smoke



Federal, state, and private landowners utilize fire for a range of reasons, such as to:

- Control undesirable vegetation
- Prepare sites for harvesting, planting or seeding
- Control plant disease
- Reduce fuel hazards that lead to wildfire
- Improve wildlife habitat
- Improve plant productivity, health and vigor
- Remove slash and debris
- Enhance seed and seedling production
- Facilitate distribution of grazing and browsing animals
- Restore and maintain ecological processes and ecological site integrity
- Protect air quality from wildfire smoke impacts

Fires impact air quality by releasing PM and ozone precursor trace gases into the atmosphere. The quantity of these trace gases and particulates released to the atmosphere is a function of combustion efficiency, where complete combustion produces carbon dioxide (CO_2) and water, and incomplete combustion produces a complex mixture of trace gases and particulates. Combustion efficiency is a function of the physical and chemical properties of the fuel (i.e., fuel type, arrangement, moisture, and size) and environmental parameters (i.e., wind speed, temperature, and relative humidity). Meteorological information, fuels information, and how such knowledge impacts fuel combustion are key facts used to manage a fire, help reduce emissions from a fire, and manage the smoke from a fire. A suite of conservation practices are available to: mitigate the occurrence of wildfires, inhibit wildfire spread, reduce the quantity of emissions from a fire, provide alternatives to burning, and manage smoke before, during and after prescribed burning operations. In all cases, practices should: be applied as part of a conservation management system, take into account landowner objectives, and balance other ecological needs of soil, water, plants and animals.

Measures:

- Smoke Management
- Alternatives to Burning
- Reduce Trace Gas and PM Emissions from Prescribed Burns
- Reduce Wildfire Risk

➢ Conservation Measure Description: Smoke Management

Where *Prescribed Burning* is implemented, the fire manager should observe the rules and regulations governing burning activities in their area, and follow the appropriate smoke management program (SMP), if one is in place. If a SMP is not in place, there are basic smoke management practices (BSMPs) that can be implemented to manage the downwind smoke impacts. Sensitive receptors, such as roads and highways, schools, housing developments, etc., should be identified and meteorological conditions can then be used to try to schedule the burn to avoid impacting those locations. Wind direction and speed, atmospheric stability, and mixing height are some of the key atmospheric parameters influencing where and how the smoke disperses. Wind direction is a major determinant of where the smoke will go while wind speed controls how quickly the smoke will move and disperse. Both surface and upper level transport winds should be noted, as they can sometimes have very different wind directions. The mixing height is the height through the atmosphere where pollutants can mix and the more unstable the atmosphere the greater is the mixing height, and the more vertical mixing is achieved. Unstable atmospheres can also lead to erratic fire behavior. The National Weather Service (NWS) provides fire weather information that can often be used for managing smoke (http://radar.srh.noaa.gov/fire/).

Other basic smoke management practices that can be employed include monitoring the effects smoke has on air quality, record keeping (smoke journal), communication/public notification, consideration of emission reduction techniques, and coordination of area burning. These various smoke management practices have applicability depending on the type of burn, fuels to be burned and level of effort needed to address air quality concerns. Not all are applicable to all situations, therefore fire managers are urged to investigate the information available and applicable to their area and needs. Furthermore, the BSMPs mentioned here constitute only a subset of possible BSMPs and others can be adopted as needed.

NRCS Conservation Practice Standards

- Prescribed Burning (338)

➢ Conservation Measure Description: Alternatives to Burning

Alternatives to burning include options that may be viable to reduce PM and trace gas emissions to the atmosphere. They do, however, need to be evaluated in terms of the other ecological benefits that may only be achieved with fire. In many forest and rangeland systems, fire is a natural and necessary component to the ecological health of the system: but in many areas, the exclusion of fire has resulted in conditions that could be dangerous if re-introduced directly. Furthermore, it is often not desirable to employ fire close to homes or other structures. In such cases mechanical treatments such as mowing, thinning, selective timber harvest and removal of non-commercial trees and brush can be employed. Thinning stands of trees (covered under the NRCS *Forest Stand Improvement* conservation practice standard) to reduce competition for light, moisture, and nutrients can enhance forest health and provide desired forest structure. Other mechanical treatments that do not remove material from the forest are shredding, lopping, or scattering, which are all covered under the *Woody Residue Treatment* conservation practice standard. Other means of manipulating the landscape can potentially serve as an alternative to

burning such as managing woody plants via *Brush Management* or herbaceous weeds via *Herbaceous Weed Control*. These practices involve managing the plant community with mechanical, chemical or biological methods. Biological controls can be grazing animals and in that case the *Prescribed Grazing* practice applies.

Alternatives to burning are also available for cropping systems. A cost-effective means of disposing of orchard tear-outs, vineyard removals, and encroaching juniper trees is pile burning. However, as an alternative, chipping/grinding/shredding (covered under the NRCS *Woody Residue Treatment* conservation practice standard) may be an option, and depending upon the region, the residue can be used for animal bedding, ground cover, or biomass energy production. Soil incorporation of crop residue, chemical breakdown of the residue, or removal by baling are also options for cases such as grass seed and winter wheat systems. The best system is very locally-dependent on climate and other factors.

NRCS Conservation Practice Standards

- Brush Management (314)
- Forest Stand Improvement (666)
- Herbaceous Weed Control (315)
- Prescribed Grazing (528)
- Woody Residue Treatment (384)

Additional Conservation Activities

- From the San Joaquin Valley Unified Air Pollution Control District Agricultural Air Quality Conservation Management Practices, (Table, Handbook):
    - Baling
    - Soil Incorporation
    - Grinding/Chipping/Shredding
    - No Burning

➢ **Conservation Measure Description: Reduce Trace Gas and PM Emissions from Prescribed Burns**

Emissions from prescribed burning can be reduced by controlling how the burn is implemented and applying other conservation measures to reduce fuel load to be consumed. *Prescribed Burning* can be conducted to improve combustion efficiency and thus reduce the quantity of trace gases and PM emitted to the atmosphere. Backing fires (fire spreading, or ignited to spread, into (against) the wind or downslope) ensures that more fuel is consumed in the flaming phase where combustion is cleaner (i.e. fewer trace gases and PM are released) than during the smoldering phase. Burning in clean and dry piles or windrows also results in a fire that generates greater heat and burns more efficiently.

As part of the conservation planning process, many practices can have a corollary benefit of reducing fuel loads and thus the emissions from prescribed burning operations. These practices can include: *Prescribed Grazing, Forest Stand Improvement, Brush Management, Herbaceous Weed Control,* and *Woody Residue Treatment.*

NRCS Conservation Practice Standards

- Brush Management (314)
- Forest Stand Improvement (666)
- Herbaceous Weed Control (315)
- Prescribed Burning (338)
- Prescribed Grazing (528)
- Woody Residue Treatment (384)

➢ **Conservation Measure Description: Reduce Wildfire Risk**

The risk of wildfires can be increased by a build-up of understory fuels, dense tree canopies, the presence of ladder fuels (which allow the fire to climb from the ground into the canopy), and dry/dead vegetation. Certain invasive species can also be highly flammable. Many conservation practices can address these issues on the landscape to help reduce the risk of a wildfire and the associated release of high concentrations of PM and ozone precursors to the atmosphere. Conservation practices such as *Prescribed Grazing, Prescribed Burning, Forest Stand Improvement, Brush Management, Herbaceous Weed Control,* and *Woody Residue Treatment* reduce the risk of wildfire by reducing the build-up of understory fuels and ladder fuels, disrupting fuel continuity over the landscape (giving a "patchiness" to the fuels), and by controlling weeds and invasive species, which can alter the natural fire regime. Conservation practices such as *Firebreak* and *Fuel Break* can inhibit wildfire spread thereby protecting air quality from the elevated PM and ozone concentrations associated with wildfires.

NRCS Conservation Practice Standards

- Brush Management (314)
- Firebreak (394)
- Forest Stand Improvement (666)
- Fuel Break (383)
- Herbaceous Weed Control (315)
- Prescribed Burning (338)
- Prescribed Grazing (528)
- Woody Residue Treatment (384)

Section 8:
Other

Additional measures that do not necessarily fit into the other sections in this document may also be implemented to reduce air emissions. The need for these measures and their usefulness can be dependent on geographic and/or climatic factors, or they may be independent of these influences. In particular, the handling of bulk solid materials, such as compost, soil, gravel, etc., in a manner that reduces disturbance of the material, will also reduce emissions from material storage piles.

Measures:

- Bulk Materials Handling

➢ **Conservation Measure Description: Bulk Materials Handling**

Handling and disturbance of bulk material piles can result in the entrainment of particles or the release of gases due to the exposure of a greater surface area of the material to the air and airflow/wind. Minimizing the disturbance of a pile, such as covering the pile, limiting the surface area from which material is removed, and limiting the number of times the material is handled and the duration of disturbance, will reduce the potential for air emissions from the pile.

Additional Conservation Activities

- From the San Joaquin Valley Unified Air Pollution Control District Agricultural Air Quality Conservation Management Practices, (Table, Handbook):
    - Bulk Materials Control

Table 1

Particulate matter (PM) pollution is a public health issue because smaller particles can penetrate deep into the lungs and cause health problems. Particulate matter comes from soot, dust, unburned fuel suspended in the air, and can also be formed in the air from chemical reactions involving gaseous precursors.

Matrix for Approved Conservation Practices and Impacts on Air Quality Resource Concerns				
		Particulate Matter and PM Precursors	**Ozone Precursors**	**Greenhouse Gases**
Air Quality Conservation Practices by PM 10	**Code**	Comprehensive Air Quality Management Plan (CAP 126) has no certified NRCS technical service providers (TSP) available. N/A		
Combustion System Improvement*	372	High	High	Medium
Residue and Tillage Management, No Till/Strip Till/Direct Seed*	329	High	Medium	High
Residue and Tillage Management, Mulch Till*	345	High	Low	Medium
Dust Control from Animal Activity on Open Lot Surfaces	375	High	None	None
Dust Control on Unpaved Roads and Surfaces*	373	High	None	None
Feed Management*	592	High	Low	High
Windbreak/Shelterbelt Establishment*	380	High	None	High
Air Filtration and Scrubbing*	371	High	Medium	Medium
Roofs and Covers*	367	Medium	Low	High
Conservation Cover*	327	Medium	Low	High
Conservation Crop Rotation*	328	Medium	None	Low
Hedgerow Planting*	422	Medium	None	Low
Mulching*	484	Medium	None	None
Prescribed Grazing*	528	Medium	None	Low
Pumping Plant*	533	Medium	Medium	Medium
Windbreak/Shelterbelt Renovation*	650	Medium	None	Low
Alley Cropping	311	Medium	None	Medium
Amendments for Treatment of Agricultural Waste	591	Medium	Low	Low
Anionic Polyacrylamide (PAM) Erosion Control	450	Medium	None	None
Cover Crop	340	Medium	None	Medium
Critical Area Planting	342	Medium	None	Low
Cross Wind Ridges	588	Medium	None	None
Cross Wind Trap Strips	589c	Medium	None	Low
Drainage Water Management	554	Medium	None	Low

Matrix for Approved Conservation Practices and Impacts on Air Quality Resource Concerns (continued)				
		Particulate Matter and PM Precursors	**Ozone Precursors**	**Greenhouse Gases**
Air Quality Conservation Practices by PM 10	**Code**	Comprehensive Air Quality Management Plan (CAP 126) has no certified NRCS technical service providers (TSP) available. N/A		
Heavy Use Area Protection	561	Medium	None	None
Herbaceous Wind Barriers	603	Medium	None	Medium
Integrated Pest Management	595	Medium	Medium	None
Irrigation System, Sprinkler	442	Medium	None	Low
Irrigation Water Management	449	Medium	None	Low
Nutrient Management	590	Medium	Medium	High
Stripcropping	585	Medium	None	None
Surface Roughening	609	Medium	None	None
Access Control	472	Low	Low	Low
Agrichemical Handling Facility	309	Low	Low	None
Composting Facility	317	Low	Low	Low
Field Border	386	Low	None	Low
Forage and Biomass Planting	512	Low	None	High
Forest Stand Improvement	666	Low	Low	High
Multi-Story Cropping	379	Low	None	Medium
Range Planting	550	Low	None	Medium
Riparian Forest Buffer	391	Low	None	Medium
Riparian Herbaceous Cover	390	Low	None	Medium
Silvopasture Establishment	381	Low	None	High
Solid/Liquid Waste Separation Facility	632	Low	Medium	Low
Tree/Shrub Establishment	612	Low	None	High
Waste Treatment	629	Low	Low	Low
Anaerobic Digester, Controlled Temperature	366	None	Low	High
Waste Treatment Lagoon	359	None	Low	None
Woody Residue Treatment	384	None	Low	Medium

Table 2

Ground level or "bad" ozone is not emitted directly into the air, but is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of sunlight. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of NOx and VOC.

Air Quality Conservation Practices for Ozone	Code	Ozone Precursors
Combustion System Improvement	372	High
Air Filtration and Scrubbing	371	Medium
Integrated Pest Management	595	Medium
Nutrient Management	590	Medium
Pumping Plant	533	Medium
Residue and Tillage Management, No Till	329	Medium
Solid/Liquid Waste Separation Facility	632	Medium
Access Control	472	Low
Agrichemical Handling Facility	309	Low
Amendments for Treatment of Agricultural Waste	591	Low
Anaerobic Digester, Controlled Temperature	366	Low
Composting Facility	317	Low
Conservation Cover	327	Low
Feed Management	592	Low
Forest Stand Improvement	666	Low
Residue and Tillage Management, Reduced Till	345	Low
Roofs and Covers	367	Low
Waste Treatment	629	Low
Waste Treatment Lagoon	359	Low
Woody Residue Treatment	629	Low

Table 3

Greenhouse gas emissions from agriculture come from livestock such as cows, agricultural soils, and agricultural production. Emissions or sequestration of CO2 can occur as land uses change. For example, CO2 is exchanged between the atmosphere and the plants and soils on land as former cropland is converted into grassland, as new areas are cultivated and become cropland, or encouraging the transformation of cropland to forest. In addition, using biological feedstocks (such as energy crops or wood) for purposes such as electricity generation, input to processes that create liquid fuels, or building materials can lead to emissions or sequestration.

Air Quality Conservation Practices for GHG	Code	Greenhouse Gases
Anaerobic Digester, Controlled Temperature	366	High
Conservation Cover	327	High
Feed Management	592	High
Forage and Biomass Planting	512	High
Forest Stand Improvement	666	High
Nutrient Management	590	High
Residue and Tillage Management, No Till	329	High
Roofs and Covers	367	High
Silvopasture Establishment	381	High
Tree/Shrub Establishment	612	High
Windbreak/Shelterbelt Establishment	380	High
Air Filtration and Scrubbing	371	Medium
Alley Cropping	311	Medium
Combustion System Improvement	372	Medium
Cover Crop	340	Medium
Herbaceous Wind Barriers	603	Medium
Multi-Story Cropping	379	Medium
Pumping Plant	533	Medium
Range Planting	550	Medium
Residue and Tillage Management, Reduced Till	345	Medium
Riparian Forest Buffer	391	Medium
Riparian Herbaceous Cover	390	Medium
Woody Residue Treatment	384	Medium
Solid/Liquid Waste Separation Facility	632	Low
Waste Treatment	629	Low
Windbreak/Shelterbelt Renovation	650	Low