

Author

Andreae, M. O.

Date of Publication

December 2001

Original Research

Additional Authors

P. Merlet

Date study was performed

Compilation

Other

Title

Emission of trace gases and aerosols from biomass burning

URL Address

Publication Reference

Global Biogeochemical Cycles, Vol. 15, No. 4, pages 955-966.

Annotation

Using a large body of information on emissions from various types of biomass burning, the authors have critically evaluated the presently available data and integrated these into a consistent format. The paper presents a set of emission factors for a large variety of species emitted from biomass fires. Where data were not available, the authors propose estimates based on appropriate extrapolation techniques.

Biomass categories include: savanna and grassland; tropical forest; extratropical forest; biofuel burning; charcoal making; charcoal burning' and agricultural residues.

Emission factors presented for wide range of species including, but not limited to: CO, CO2, CH4, total nonmethane hydrocarbons, benzene, toluene, xylenes, formaldehyde, phenol, NH3, SO2, pm2.5, total particulate matter, total carbon, nitrogen oxides, NH3, and furans.

Agricultural or Wildland

Agricultural and Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

savanna and grassland; tropical forest; extratropical forest; biofuel burning; charcoal making; charcoal burning' and agricultural residues

Baseline/Type of ERT(s)

not specified

Variables

Time of year burn performed

not specified

Location of burn

worldwide

Annotated Author Designation

Andreae

Author

Boubel, R.W.

Date of Publication

January, 1969

Original Research

Additional Authors

Date study was performed

Summer 1967

Compilation

Other

URL Address

unknown

Title

Summary of Atmospheric Emission Data from Grass Field Burning Tests in Agricultural Field Burning in the Willamette Valley

Publication Reference

Agricultural Field Burning in the Willamette Valley, Air Resources Center, Oregon State University, January 1969.

Annotation

See Boubel (1)

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

bluegrass, perennial rye, bentgrass, annual rye, fescue, orchard

Baseline/Type of ERT(s)

Baseline

Variables

moisture (2 to 71%)

Time of year burn performed

unidentified for tower; summary for burns in Willamette Valley

Location of burn

Burning tower at UC at Riverside; Willamette Valley, Oregon

Annotated Author Designation

Boubel (2)

Author

Boubel, Richard

Date of Publication

July 1969

Original Research

Additional Authors

Ellis Darley, Edward Schuck

Date study was performed

1965

Compilation

Other

URL Address

unknown

Title

Emissions from Burning Grass Stubble and Straw

Publication Reference

Journal of Air Pollution Control Association, Vol. 19, No. 7, pgs 497-500.

Annotation

Samples of various grass straws and stubble residue for the important grass species from the Willamette Valley of Oregon were burned in the laboratory burning tower at the University of California at Riverside. Complete analyses were determined for gaseous and particulate emissions. Emission values were compared with those obtained from field studies (see Boubel (2)) and found to be similar.

NOTE: Same results also reported in "Summary of Atmospheric Emission Data from Grass Field Burning Tests," Agricultural Field Burning in the Willamette Valley, Air Resources Center, Oregon State University, January 1969.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

bluegrass, perennial rye, bentgrass, annual rye, fescue, orchard

Baseline/Type of ERT(s)

baseline

Variables

moisture (2 to 71%)

Time of year burn performed

unidentified for tower; summary for burns in Willamette Valley

Location of burn

Burning tower at UC at Riverside; Willamette Valley, Oregon

Annotated Author Designation

Boubel (1)

Author

Canode, C.L.

Date of Publication

1977

Original Research

Additional Authors

A.G. Law

Date study was performed

1968-1975

Compilation

Other

Title

Post-Harvest Residue Management in Kentucky Bluegrass Seed Production

URL Address

Publication Reference

College of Agricultural Research Center, Washington State University, Bulletin 850. June 1977.

Annotation

This document reports on alternatives to burning Kentucky bluegrass and their effect on seed yield. Alternatives included are mechanical straw removal, wide row spacing, open burning with low temperature, and machine burning after straw removal. Open burning with low temperature produced slightly better seed yields than mechanical straw removal, but these yields were usually significantly less than those obtained by open burning at high temperature. To maintain seed production, machine burning of stubble and thatch after straw removal appeared to be the most nearly satisfactory alternative to open burning of residue. Machine burning at high temperatures (800 to 900 deg F) resulted in seed yields that compared favorably with those from open burning at high temperatures. Various types of bluegrass were studied at various locations in Washington and Idaho. Not all sites received the same set of treatments.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Kentucky Bluegrass

Baseline/Type of ERT(s)

raking, swathing, chopping, machine burning

Variables

temperature of burn

Time of year burn performed

Location of burn

Rathdrum, ID, Rockford, WA, Pullman, WA

Annotated Author Designation

Canode

Author

Carrol, John

Date of Publication

November, 1973

Original Research

Additional Authors

Date study was performed

August 1971 thru April 1973

Compilation

Other

Title

Determination of Temperature, Winds, and Particulate Concentrations in Connection with Open Field Burning

URL Address

<ftp://ftp.arb.ca.gov/carbis/research/apr/past/arb-2114.pdf>

Publication Reference

not applicable

Annotation

This report is primarily concerned with the evaluation of the effectiveness of various field practices (i.e., different burn techniques) on particulate emissions. Meteorological conditions are presented for the burn days during the 1971 to 1973 burning seasons. The size distribution of the particulates was also sought. Backfires were found to produce about 10 to 20 percent fewer particles than front fires in terms of total particulate emissions per ton of fuel burned. Into-the-wind strip firing was found to produce particulate emissions at levels between those of backfiring and front firing.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

rice, barley

Baseline/Type of ERT(s)

backfiring, front firing, into-the-wind strip firing, piles

Variables

moisture (4 to 19.2%)

Time of year burn performed

spring, fall

Location of burn

CA

Annotated Author Designation

Carrol

Author

Chi, C. T.

Date of Publication

July 1977

Original Research

Additional Authors

D. L. Zanders

Date study was performed

Compilation

Other

Title

Source Assessment: Agricultural Burning State of the Art

URL Address

Publication Reference

EPA-600/2-77-107a

Annotation

This report summarizes reported data on air emissions from agricultural open burning in the United States. The report uses emission factors derived from limited literature data to estimate emissions of particulates, HC, CO, and nitrogen oxides from agricultural burning and compares them to national emissions of these pollutants. Emission factors are also shown for trace metals (sugarcane only) and benzo(a)pyrene. The report also discusses control technologies of fire and fuel management to reduce emissions and alternatives to open field burning such as mobile field sanitation and straw utilization, and incorporation of waste into the soil.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Rice straw, grass, woody fuels, leave clippings, leaves, tree branches, sugar cane, pineapple, fruit prunings, barely straw

Baseline/Type of ERT(s)

baseline, head fire, backfires

Variables

Time of year burn performed

not specified

Location of burn

California, Hawaii, not specified

Annotated Author Designation

Chi

Author

Chilcote, D. O.

Date of Publication

March 1975

Original Research

Additional Authors

H.W. Youngberg

Date study was performed

Compilation

Other

Title

Propane Flamer Burning of Grass Seed Field Stubble

URL Address

Publication Reference

Progress Report EXT/ACS 8, Agricultural Experiment Station, Oregon State University. March 1975

Annotation

This document reports on a study to compare propane flamer burning of grass seed fields with open burning. Most of the residue down to a 2-inch stubble height was removed by flail-chopping prior to flamer treatment. Time of season, grass species, and speed of operation were variables. Environmental conditions were found to affect the effectiveness of the propane flamer. Early season propane burning is more beneficial than late burning, probably because of the presence of lesser amount of green regrowth with higher moisture content and the higher moisture content of straw, which is likely to occur later in the season. Early propane flaming resulted in seed yield response that compares favorably with open burning. Except for creeping red fescue, propane flaming resulted in seed yield equal to or better than open burning. Slower operating speeds provide the most effective thermal exposure. Propane flaming at rates above 2 miles per hour in annual ryegrass failed to destroy weed seeds. This casts doubts on the ability of the flamer to destroy disease organisms. If the speed of travel is slow enough, satisfactory sanitation might be obtained. Smoke emissions, although reduced, is still a problem (incomplete combustion of residue and smoldering after passage of the flame front) and it is confined to lower levels of the atmosphere. Total emissions should be reduced because only a portion of the total residue is burned (straw and stubble were chopped and removed prior to flaming and burning remaining residue).

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

chewings fescue, creeping red fescue, orchard grass, merion bluegrass, highland bentgrass

Baseline/Type of ERT(s)

propane flaming

Variables

time of season, grass species, speed of operation

Time of year burn performed

Location of burn

Annotated Author Designation

Chilcote (3)

Author

Chilcote, D.O.

Date of Publication

1975

Original Research

Additional Authors

H.W. Youngberg

Date study was performed

1968-69

Compilation

Other

Title

Techniques and Timing of Post-Harvest Grass Seed Field Burning

URL Address

Publication Reference

Agronomic Crop Science Report, Progress Report EXT/ACS 7, Agricultural Experiment Station, Oregon State University, March 1975.

Annotation

This document reports on research undertaken to evaluate different burning times and procedures in terms of smoke emissions and impact on seed crop yield. Burning field plots early, mid-season, and late (August, September, October) showed that burning early in the early season when green tissue is minimal, before growth is initiated, and when the straw is dry, is preferable from the standpoint of both smoke emissions and dispersion as well as subsequent seed yield. Late season burning, after regrowth had begun, was less advantageous because of greater stand injury and reduced seed yield. Late season burns encounter the problems of plant regrowth and high straw moisture content, which create greater smoke emissions. Backfiring field plots reduced emissions and worked effectively when environmental and straw-stubble conditions were favorable (dry, with low humidity) for burning. Straw load was important - greater amounts of residue improved the uniformity of the burn and carry the fire throughout the field. Difference in total emissions were difficult to ascertain. Burning of the stubble only was also an effective procedure under dry, low-humidity conditions and has the added advantage of substantially reducing the total amount of residue burned, thereby contributing to reduced emissions by virtue of changes in fuel load. No adverse agronomic effects of the various burning methods was noted in these tests.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

chewings fescue, highland bentgrass, orchard grass, bluegrass, creeping fescue

Baseline/Type of ERT(s)

Backfiring, seasonal timing, parallel strip backfiring, pile burning

Variables

Time of year burn performed

August, September, October

Location of burn

OSU Agricultural Research Center (?)

Annotated Author Designation

Chilcote (4)

Author

Chilcote, D.O.

Date of Publication

August, 1976

Original Research

Additional Authors

Date study was performed

Compilation

Other

Title

Grass Seed Field Burning: Air Quality and Agronomic Aspects

URL Address

unknown

Publication Reference

Annual Meeting of Soil Conservation Society of America, pages 124-126.

Annotation

Data reported is from the 1967 field studies in the Willamette Valley as reported in Boubel (1) and Boubel (2).

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Grass seed

Baseline/Type of ERT(s)

Baseline

Variables

Time of year burn performed

See Boubel (1)

Location of burn

See Boubel (1)

Annotated Author Designation

Chilcote (1)

Author

Chilcote, D.O.

Date of Publication

1975?

Original Research

Additional Authors

H.W. Youngberg

Date study was performed

4 year period

Compilation

Other

URL Address

Title

Non-Burning Techniques of Grass Seed Residue Removal

Publication Reference

Agronomic Crop Science Report

Annotation

This document reports on residue removal (mechanical removal of all or part of the post-harvest residue from grass seed fields), incorporation of straw into the soil where cultivation is possible in annual cropping, and alternate year burning with mechanical straw removal in the year of non-burning. Mechanical residue removal in perennial grasses appears to be practical in younger crop stands and in older stands if burning is alternated with mechanical removal. Results suggest that the more complete the residue removal, the greater the benefit to subsequent seed yield. However, the utilization or disposal of removed residue remains an important problem as does pest control. Alternate year burning of grass fields may allow the maintenance of acceptable pest control and would reduce yield losses compared to strictly mechanical removal methods in perennial grasses. Compared to annual burning, alternative year burning resulted in seed yields from 86 to 98% of those achieved under annual burning. Perennial grasses show a difference in response to mechanical removal techniques, with orchard grass displaying the greatest tolerance to non-burning.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

chewings fescue, creeping red fescue, highland bentgrass, orchard grass, merion bluegrass, perennial ryegrass

Baseline/Type of ERT(s)

Mechanical (flail chop, raking, straw removal), Alternative year burning, Incorporation, herbicide

Variables

Time of year burn performed

not specified

Location of burn

not specified

Annotated Author Designation

Chilcote (2)

Author

Conklin, Frank

Date of Publication

October 1971

Original Research

Additional Authors

R. Carlyle Bradshaw

Date study was performed

unknown

Compilation

Other

Title

Farmer Alternatives to Open Field Burning: An Economic Appraisal

URL Address

unknown

Publication Reference

Special Report 336, October 1971, Agricultural Experiment Station, Oregon State University, Corvallis.

Annotation

The purpose of this study was to evaluate the economic impact of suggested technical choices for open field burning. Technical and economic data were collected from available published sources, focusing on Northwest data where possible. The alternatives included in the report in alternative land use, soil incorporation of residues, mobile field sanitizer, and mechanical residue removal followed by field sanitation (propane flaming or mobile field sanitizer). The report identifies smoke emission reductions of 80 to 90 percent with a mobile field sanitizer compared to open field burning (same as reported in Conklin (1)) and a 99 percent reduction in unburned hydrocarbons. No emission reduction estimates are given for mechanical residue removal followed by field sanitation. The report states that late burning was decidedly inferior for field sanitation control because of plant regrowth had begun to impair burning effectiveness, resulting in lower burn temperatures and increased smoke emissions. The flash treatment from propane flaming raises technical questions regarding long-term disease control, so is viewed as inferior choice to sanitizing.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

ryegrass

Baseline/Type of ERT(s)

mobile field sanitizer

Variables

not reported

Time of year burn performed

unknown

Location of burn

unknown

Annotated Author Designation

Conklin (2)

Author

Conklin, Frank S.

Date of Publication

July 1, 1976

Original Research

Additional Authors

Date study was performed

unknown

Compilation

Other

URL Address

unknown

Title

Adjusting to Air Quality Standards: A Contrast Between Grower and Industry Effects in Grass Seed Production

Publication Reference

Annotation

This paper focuses on the expected initial economic losses and longer-run expected adjustments to the grass seed industry in the Willamette Valley. The paper draws upon other research conducted. The paper addresses five different scenarios for reducing emissions from burning - (1) acreage phase-out, (2) mobile field sanitizer, (3) mobile field sanitizer with alternate year burning, (4) tax on smoke emissions, and (5) leave all straw in field to rot. For the mobile field sanitizer option, the paper reports an expected reduction in smoke emissions of between 80 and 90 percent. For the mobile field sanitizer with alternate year burning, the paper reports an expected smoke emission reduction of between 60 and 70 percent. Estimated reductions in smoke emissions for the other three options are also presented.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

ryegrass

Baseline/Type of ERT(s)

mobile field sanitizer; mobile field sanitizer with alternate year burning

Variables

none reported

Time of year burn performed

unknown

Location of burn

unknown

Annotated Author Designation

Conklin (1)

Author

Core, John

Additional Authors

Title

National Assessment of Smoke Management Practices and Techniques

Date of Publication

Fall, 1999

Date study was performed

Not reported

URL Address

Publication Reference

Original Research

Compilation

Other

Annotation

This document is a synthesis of information generated at a workshop designed to collect and document emission reduction and smoke management practices currently being used by prescribed fire practitioners. It is intended to serve as a guide for those interested in emission reduction and smoke management techniques as currently practiced in the field. Since vegetation type, land topography, climate and dispersion conditions all influence the decision to burn, each region of the country is discussed separately. The applicability of each technique is dependent on the land management objective and site specific environmental conditions.

The document covers a wide range of techniques, but reports reductions for only a few of the techniques. For machine and hand piling, smoke impacts on air quality are reported as being reduced by 75 to 90%. For backing fires, emission reductions of about 30 to 50% are reported. Burning before large fuels cure was reported as having "some reduction in impacts on air quality." Using ungulate (cattle, horse) grazing to reduce fine fuels was reported as having a "negligible" or a "low" effect on smoke. "Burning before green up" was reported as being "moderately effective" in reducing smoke impacts.

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

White Spruce, Boreal Spruce, and Mountain Hemlock, Ponderosa Pine

Baseline/Type of ERT(s)

Burning in Piles, Backing Fires

Variables

not quantified

Time of year burn performed

not reported

Location of burn

Eastern Oregon, Washington

Annotated Author Designation

Core

Author

Darley, E.F.

Date of Publication

August 1974

Original Research

Additional Authors

Date study was performed

Compilation

Other

URL Address

Title

Air Pollution Emissions from Burning Sugar Cane and Pineapple from Hawaii. Amendment to EPA Research Grant R800711.

Publication Reference

Found in "Calculation of Emission Factors for Agricultural Burning Activities," EPA-450/3-75-087, November 1975.

Annotation

This paper discusses aspects of sampling and burning sugar cane and pineapple trash. It reports yield of particulates, carbon monoxide, hydrocarbon, benzo(a)pyrene and selected trace metals. This paper also reports particle size distribution. Larger emissions were found as a result of head fire burning of trash with higher moisture content. Average emissions reported are 9.9 lb/ton particulates, 111 lb/ton carbon monoxide, and 6.5 lb/ton hydrocarbon. This paper is referenced in Wayne ("Calculation of Emission Factors for Agricultural Burning Activities," EPA-450/3-75-087, November 1975). In the EPA document, pineapple emission factors are presented for 6 different moisture levels, ranging from about 8% to 25%.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Sugar cane and pineapple

Baseline/Type of ERT(s)

Backing fire (pineapple)

Variables

Moisture

Time of year burn performed

Unknown

Location of burn

Hawaii

Annotated Author Designation

Darley (7)

Author

Darley, E.F.

Date of Publication

December, 1966

Original Research

Additional Authors

F.R. Burleson, E.H. Mather, J.T. Middleton,  
and V.P. Osterli

Date study was performed

1966

Compilation

Other

Title

Contribution of Burning of Agricultural Waste to  
Photochemical Air Pollution

URL Address

Publication Reference

J. Air Pollution Control Association, 16 (12):685-690.1966.

Annotation

The purpose of this study was to determine the relative contribution of the burning of agricultural wastes from orchards, grain fields, and range lands to photochemical air pollution. An open-to-air burn tower in Riverside, California was used. Total hydrocarbon and 24 individual hydrocarbons as well as carbon monoxide, carbon dioxide and some nitrogen oxides were measured.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Barley, rice, cotton, almond, apple, apricot

Baseline/Type of ERT(s)

Baseline

Variables

Time of year burn performed

Not stated

Location of burn

Burn tower in Riverside, CA

Annotated Author Designation

Darley (3)

Author

Darley, Ellis

Date of Publication

April, 1979

Original Research

Additional Authors

Date study was performed

1979

Compilation

Other

URL Address

Title

Hydrocarbon Characterization of Agricultural Waste Burning

Publication Reference

ARB Project A7-068-30

Annotation

The purpose of this study was to determine hydrocarbon speciation and emission factors from burning residues of 8 field and orchard crops in an out-of-doors, instrumented burning tower at the University of California, Riverside. Field crops were burned with head and back fires and orchard crops were burned in piles. Emissions of particulate, carbon monoxide, and total hydrocarbons as well as oxides of nitrogen, sulfur dioxide and some aldehydes were observed. Emissions for particulate, carbon monoxide and hydrocarbon from fine fuels such as field crops were found to be 2 to 3 times greater than emissions for orchard crops. This finding was similar to findings in Darley (1).

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

barley, corn, rice, sorghum, wheat, almond, grape, peach

Baseline/Type of ERT(s)

headfire, backfire, pile burn

Variables

Time of year burn performed

Between January and April 1979

Location of burn

Burning tower, Riverside, CA

Annotated Author Designation

Darley (2)

Author

Darley, Ellis

Date of Publication

January, 1977

Original Research

Additional Authors

Date study was performed

1974 - 1977

Compilation

Other

URL Address

Title

Emission Factors from Burning Agricultural Wastes Collected in California

Publication Reference

Annotation

The purpose of this study was to determine pollutant emission factors from burning 31 field, vine, and orchard crops and weeds in an out-of-door, instrumented burning tower at the University of California Riverside. This study was conducted from 1974 to 1977. Field crops and weeds were burned as head and back fires at an air dry moisture level. Orchard and vine crops were burned in piles at two moisture levels and two systems of ignition (cold and roll-on). Pollutants observed include particulates, carbon monoxide and hydrocarbons. Size distribution of smoke particles was determined. This study reported that backfiring of field crops resulted in lower emissions of particulates versus head firing, but this was not so for carbon monoxide or hydrocarbons. No significant reduction of particulate or carbon monoxide was obtained by drying most orchard crops below about 35 percent moisture. Back firing produced smaller particles than head firing. Roll-on orchard fires produced larger particles than the first fire of the pair. Overall, orchard crops had less emissions than field crops.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Various fuel types, including field crops, vine crops, orchard crops, weeds

Baseline/Type of ERT(s)

Back burning vs. front burning  
Piles  
Cold start ignition  
Roll-on ignition  
Low moisture

Variables

Moisture  
Ignition type  
Slopes of 15 and 25%

Time of year burn performed

Not clear

Location of burn

Burning tower, University of California Riverside

Annotated Author Designation

Darley (1)

Author

Darley, Ellis

Date of Publication

1972

Original Research

Additional Authors

Date study was performed

Not applicable

Compilation

Other

URL Address

Title

Burning Agricultural Wastes and Effects on Agriculture

Publication Reference

Proc. Symposium on Agriculture and the Environment in the Southern San Joaquin Valley . University of California Division of Agri Sci. P 17-24 (1971)

Annotation

This report was prepared for a symposium on agriculture and the environment in the Southern San Joaquin Valley concerning the effects of air quality on agricultural production. This report presents an estimate of the contribution of fire to general air pollution in the San Joaquin Valley. The report presents emissions factors for hydrocarbons, carbon monoxide, nitrogen dioxide, and particulates for fruit tree prunings and vines, rice straw and stubble, other field crops and range. These factors were compiled from other, unspecified studies. The emissions factors are applied to the amount of wasted burned in the San Joaquin Valley to determine its relative contribution to air pollution.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Fruit Tree Prunings and Vines, Rice Straw and Stubble, Other Field Crops, Range

Baseline/Type of ERT(s)

Baseline

Variables

Time of year burn performed

Not specified

Location of burn

Not specified

Annotated Author Designation

Darley (5)

Author

Darley, Ellis F.

Date of Publication

1974

Original Research

Additional Authors

George E. Miller, Jr., John R. Goss, and Harold H. Biswell

Date study was performed

1972-1974

Compilation

Other

Title

Air Pollution from Forest and Agricultural Burning

URL Address

<ftp://ftp.arb.ca.gov/carbis/research/apr/past/2-017-1.pdf>

Publication Reference

Annotation

The purpose of this study was to obtain information on the effect of atmospheric conditions, residue management, and fire management techniques on particulate, hydrocarbon, and carbon monoxide emissions from open field burning. Burns were conducted with cereal grains including wheat, rice and barley as well as asparagus in both a field and a burning tower in California. The study was conducted from 1972 to 1974 and includes some data from 1970. It was found that moisture content in fine fuels caused the most significant emissions. At high moisture, particulates can be reduced by about 50% by backfiring or into-the-wind strip lighting technique, but this had no effect on hydrocarbon or carbon monoxide emissions. Pile burns were found to produce lower levels of emissions than "un-piled" burns. Particulate size distribution was also observed. Back fires were found to produce less-dense plumes than head fires. A fire management and emission reduction cost analysis was conducted.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

wheat, rice, barley, asparagus fern, orchard prunings, fruits, nuts

Baseline/Type of ERT(s)

backfiring vs. head firing  
Spreading vs. windrows  
into the wind strip lighting  
low moisture  
low residue moisture

Variables

wind speed  
rate of burn  
ambient temperature  
relative humidity  
moisture

Time of year burn performed

Full Year

Location of burn

Burning tower and field studies in Sacramento Valley / Sierra Nevada Mountains

Annotated Author Designation

Darley (4)

Author

Darley, Ellis F.

Date of Publication

April 1973

Original Research

Additional Authors

Harold H. Biswell, George Miller, and John Goss

Date study was performed

Compilation

Other

Title

Air Pollution from Forest and Agricultural Burning

URL Address

Publication Reference

J. Fire and Flammability , Vol. 4. April 1973.

Annotation

Discusses studies in progress as of April 1973 of burning agricultural waste and forest fuels in a burn tower. HC emissions from fairly dry materials vary from 4 to 18 lbs/ton of fuel, averaging about 14 pounds. CO yields vary from 40 to 140 pounds, averaging about 92 pounds. CO2 may range from 1600 to 2500 lbs/ton. Burning green fuels or dead fuels that are wet generally increases the hydrocarbon and carbon monoxide and decreases the carbon dioxide. Nox emission factors have not yet been developed. Preliminary results with pine needles show that particulate from head fires is about 3 times that from back fires. Relatively fresh orchard prunings piled and ignited from the bottom produce more HC than the same fuel spread out and ignited from the center. Emissions data from 60 fires for field crops are in the process being analyzed; no results reported for forest fuels. Objectives of study are to determine the particulate and HC emissions from broadcast and pile burns of various fuel types, loading and moisture and to measure the amount of fuel weight reduction from broadcast burning and the rate of fuel accumulation and decomposition. While all data have not yet been analyzed and the system has not yet been fully evaluated, some trends are evident. Particulate weights from the flaming period were always less than from the smoldering period. Yields ranged from 9 to 20 mg/cu.meter to 28 to 203 mg/cu.meter, respectively. HC values were quite low. Except for methane, which was reported to be 14 parts per million, olefins were then most abundant hydrocarbon. Ethylene was reported at 1-3 ppm and propylene at 0.7 ppm.

Agricultural or Wildland

Agricultural and Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Field studies: rice, wheat, sugar pine, white fir, giant sequoia, ponderosa pine

Baseline/Type of ERT(s)

headfire, backfire

Variables

field crops - normal rows, recked rows, spread over plot

Time of year burn performed

Location of burn

Burn tower at UC Davis

Annotated Author Designation

Darley (6)

Author

Dennis, Ann

Date of Publication

2002

Original Research

Additional Authors

Matthew Fraser, Stephen Anderson, David Allen

Date study was performed

Compilation

Other

Title

Air pollutant emissions associated with forest, grassland, and agricultural burning in Texas

URL Address

Publication Reference

Atmospheric Environment

Annotation

The paper presents an emissions inventory of forest, grassland, and agricultural burning activities in 1996 and 1997. Emissions were estimated based on survey and field data on acres burned and land cover and literature data on fuel consumption and emission factors. Emission factors used were based on the First Order Fire Effects Model (FOFEM 4.0). Emission factors for CO, CH4, NMHC, PM, PM2.5, and PM10 for litter (wood 0 to 1 inch); wood 1 to 3 inches; wood greater than 3 inches; herb, shrub, regen; duff; and canopy fuels are shown for dry conditions. For the same fuel types, emission factors are also reported for CO2, CO, MCE, Nox, and NH3. Emission factors for crop residue (corn, hay/grasses, and wheat and sugarcane) burning are shown for CO, Nox, NH3, CH4, NMHC, PM, PM2.5, and PM10. The hay/grasses emission factors are based on barley straw and the wheat and sugarcane emission factors are based on wheat straw.

The agricultural residue emission factors were taken from Jenkins (1) and from California Air Resource Board, Area Source Methodologies, Section 9.3 Wildfires, 1997.

Agricultural or Wildland

Agricultural and Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

litter (wood 0 to 1 inch); wood 1 to 3 inches; wood greater than 3 inches; herb, shrub, regen; duff; and canopy fuels corn, hay/grasses, and wheat and sugarcane

Baseline/Type of ERT(s)

baseline

Variables

Time of year burn performed

not specified

Location of burn

not specified

Annotated Author Designation

Dennis

Author

Einfield, Wayne

Date of Publication

1991

Original Research

Additional Authors

Darold Ward and Colin Hardy

Date study was performed

Not stated

Compilation

Other

Title

Effects of Fire Behavior on Prescribed Fire Smoke Characteristics: A Case Study

URL Address

Publication Reference

Levine, Joel S., ed. Global biomass burning: atmospheric, climatic, and biospheric implications. Cambridge, MA: MIT Press: 412-419. Chapter 50.

Annotation

The purpose of this study was to examine the importance of combustion phase (flaming or smoldering) on the release of incomplete products of combustion. Logging slash from fir and western larch were burned in open fields in North West Montana. The study used ground and aircraft measurements for a more complete picture of fire behavior and smoke production. Results were comparable to other methods of estimating pollutant yield. Emission factors for carbon monoxide, carbon dioxide, methane, total nonmethane hydrocarbons are reported. Particle size distribution was also noted. Emission factors are reported by flaming and smoldering phase and by overall average for fine particulate, elemental carbon, organic carbon, carbon dioxide, and carbon monoxide.

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

True Fir, Western Larch

Baseline/Type of ERT(s)

Baseline

Variables

Time of year burn performed

Not stated

Location of burn

Open fields in NW Montana

Annotated Author Designation

Einfield

Author

Ensign, R.D.

Date of Publication

December, 1974

Original Research

Additional Authors

Bruce Augustin, Mark Buettner, Peter Gray, Robert Hall, and Robert Nelson

Date study was performed

Fall, 1972 - Summer, 1973

Compilation

Other

URL Address

Title

Burning and Alternative Treatments for Kentucky Bluegrass Seed Production

Publication Reference

Idaho Agricultural Research Progress Report, Progress Report No. 188, December 1974.

Annotation

This document is the third of a series of progress reports related to grass seed production in Northern Idaho. Five locations are reported. Treatments included, but were not limited to, early burn with no hay removal, late burn with no hay removal, early burn with hay removal, medium burn with hay removal, and late burn with hay removal. The document summarizes effects on seed yield compared to a baseline of no hay removal, early burn. The seed yields compared to the baseline of no hay removal, early burn varied depending of the type of bluegrass and the year of the seed crop. The document details the results for each location. In addition, the document discusses the effects of burning on plant growth and development and diseases.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Kentucky Bluegrass

Baseline/Type of ERT(s)

Seasonal burning, mechanical removal,

Variables

Time of year burn performed

August - September

Location of burn

5 locations in Idaho

Annotated Author Designation

Ensign

Author

Erickson, S.L.

Date of Publication

February 9, 1978

Original Research

Additional Authors

W.D. Hartford

Date study was performed

Summer 1978

Compilation

Other

Title

Open Field Burning: An Emissions Factors Study of Alternative Firing Techniques

URL Address

Publication Reference

Annotation

In this study, data was collected from 22 backfires and 24 head fires of both annual and perennial ryegrass. This data was statistically analyzed and used to create equations for predicting particulate emission rates given information on fuel loadings and moistures. Backfire emissions range from 21 to 163 pounds per ton of fuel burned while headfire emissions range from 70 to 290 pounds per ton of fuel burned. Particle size distribution was also noted. Little difference in size of particulates was reported between head and back fires. It was found that straw moisture has a more pronounced effect on emission rate of head fires than backfires. Fuel loading had a more pronounced effect on backfire emissions than headfire emissions. Emissions were also recorded for after burn (smoldering phase). It was reported that about 1% of the total emissions from field burning occurred during after burn. Rain occurred during this experiment and it was discovered that wet fuel created higher emissions for both types of fire. The author cautioned that combined effects of a sharp increase in moisture and a decrease in fuel loading (as a result of the rain) made data difficult to analyze. Also, the ability of the variables to explain the higher emission rates seemed to suffer, indicating another variable such as biodegradation or compaction began affecting the emission rate.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

rye grass (annual & perennial)

Baseline/Type of ERT(s)

Headfire, backfire

Variables

moisture

Time of year burn performed

July

Location of burn

Willamette Valley, Oregon

Annotated Author Designation

Erickson

Author

Freeburn, Scott

Date of Publication

June, 1983

Original Research

Additional Authors

Date study was performed

May, 1983

Compilation

Other

URL Address

Title

Costs and Air Quality Effects of Selected Alternatives to Open Field Burning in Northern Idaho

Publication Reference

Annotation

This report discussed the effects and types of air pollution from burning Kentucky blue grass in open fields in Northern Idaho. The main focus of this report is methods to reduce emissions through alternative post-harvest treatments involving reduced burning. The report assembles results of diverse research activities regarding the need to burn field residue and alternative treatments upon which to evaluate the regulation of field burning and to aid in the selection of methods to reduce emissions from open burning. The report covers effects of fire on grass seed production, the economic advantages/disadvantages of burning, and cost factors related to post-harvest treatment alternatives.

The report presents a range of emission factors for field burning (page 2-60) for particulate matter, carbon monoxide, nitrogen oxides, sulfur dioxide, and organics. These factors were compiled from Boubel (1) and three other references (one by Boubel, one by Darley, and one by Erickson).

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

field burning, non-specific

Baseline/Type of ERT(s)

not specified

Variables

not specified

Time of year burn performed

not specified

Location of burn

not specified

Annotated Author Designation

Freeburn (1)

Author

Freeburn, Scott

Date of Publication

March 3, 1987

Original Research

Additional Authors

William Greene

Date study was performed

1986

Compilation

Other

URL Address

Title

Determination of Emissions and Impacts from Propane Flaming and Stack Burning of Grass Seed Crop Residues, 1986

Publication Reference

N/A

Annotation

The objective of this study, conducted in 1986 in the Willamette Valley, was to evaluate and quantify the particulate emissions and impacts from propane flaming. Particulate emissions were compared for propane flaming, stack burning and field burning. It was found that if residue was removed (sold and not burned) then 1/3 less emissions from propane were observed than in an open field burn. However, if all materials were propane flamed (not just the residue), only slight overall emission reductions versus open field burning would be observed. The author warned that during periods of intense farming activity, significant dust emissions interfered with smoke sampling as some particulates of dust and smoke are of similar magnitude.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Perennial ryegrass  
Kentucky bluegrass

Baseline/Type of ERT(s)

Propane flaming after removing the straw  
Straw stack burning

Variables

fuel moisture  
fuel loading

Time of year burn performed

August to November 1986

Location of burn

Open fields of Willamette Valley, OR

Annotated Author Designation

Freeburn (2)

Author

Gerstle, R.W.

Date of Publication

May 1967

Original Research

Additional Authors

D.A. Kemnitz

Date study was performed

Compilation

Other

Title

Atmospheric Emissions from Open Burning

URL Address

Publication Reference

J. Air Pollution Control Association, 17:324-327

Annotation

This is a reference from Chi. A copy of this report is not available.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

lawn clippings, leaves, branches

Baseline/Type of ERT(s)

unknown

Variables

Time of year burn performed

unknown

Location of burn

not specified

Annotated Author Designation

Gerstle

Author

Goss, John R.

Date of Publication

June 30, 1973

Original Research

Additional Authors

George E. Miller

Date study was performed

Fall 1972 and Spring 1973

Compilation

Other

URL Address

[Check CARB downloads](#)

Title

Study of Abatement Methods and Meteorological Conditions for Optimum Dispersion of Particulates from Field Burning of Rice Straw

Publication Reference

Annotation

The purpose of this study was to obtain information on the effect of meteorological conditions and management techniques on particulate emissions from Spring open field burning of rice field residue. This study was conducted in the Fall of 1972 and Spring of 1973 in both field and laboratory tests in California. Carbon dioxide emission and particulate production as well as particulate size distribution were measured. It was found that particulate emissions could be minimized by burning at low moisture and by back fire techniques. Backfire was found to have a 50% particle emission decrease over front fire. Increasing fuel loading showed decreased particulate emissions. The practicality (including cost) of fire and residue management techniques was studied in several large open field burns. In 1973, headfire was found to cost 19 cent / acre while back burning cost 65 cent/ acre and strip lighting cost 25 cent/ acre.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Rice Straw

Baseline/Type of ERT(s)

single line backfire v/s single line headfire  
spread straw  
windrowed straw  
raked spread straw

Variables

air temperature  
wind speed  
humidity

Time of year burn performed

Fall & Spring

Location of burn

Open fields and laboratory in California

Annotated Author Designation

Goss

Author

Hangebrauck, R. P.

Date of Publication

July 1964

Original Research

Additional Authors

D.J. Von Lehmden, J.E Meeker

Date study was performed

Compilation

Other

Title

Emissions of Polynuclear Hydrocarbons and Other Pollutants from Heat-Generation and Incineration Processes

URL Address

Publication Reference

J. Air Pollution Control Association, 14:267

Annotation

This is a reference from Chi. A copy of this report is not available.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

grass clippings, leaves and branches

Baseline/Type of ERT(s)

not specified

Variables

Time of year burn performed

not specified

Location of burn

not specified

Annotated Author Designation

Hangebrauck (1)

Author

Hangebrauck, R. P.

Date of Publication

1967

Original Research

Additional Authors

D.J. Von Lehmden, J.E. Meeker

Date study was performed

Compilation

Other

Title

Sources of Polynuclear Hydrocarbons in the Atmosphere.

URL Address

Publication Reference

U.S. Dept. of Health, Education, and Welfare, Public Health Service Publication No. 999-AP-33.

Annotation

This a reference from Chi. A copy of this report is not available.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

grass clippings, leaves, and branches

Baseline/Type of ERT(s)

not specified

Variables

Time of year burn performed

not specified

Location of burn

not specified

Annotated Author Designation

Hangebrauck (2)

Author

Hardy, C. C.

Date of Publication

1998

Original Research

Additional Authors

S.G. Conrad, J.C. Regelbrugge, D.T. Teesdale

Date study was performed

Compilation

Other

Title

Smoke emissions from prescribed burning of southern California Chaparral

URL Address

Publication Reference

Res. Pap. ONW-RP-488, Portland, OR. USDA, Forest Service, PNW Research Station.

Annotation

Provides emission factors for sagebrush and chaparral but combustion stage and as average for PM, PM2.5, PM10, CO, CO2, CH4, and NMHC.

Do not have reference. This study is referenced in Ottmar (1).

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

sagebrush, chaparral

Baseline/Type of ERT(s)

Baseline

Variables

Time of year burn performed

Location of burn

Annotated Author Designation

Hardy (2)

Author

Hardy, Colin

Date of Publication

N/A

Original Research

Additional Authors

Date study was performed

unknown

Compilation

Other

Title

Guidelines for Estimating Volumes, Biomass, and Smoke Production for Piled Slash (REVIEW DRAFT)

URL Address

not known

Publication Reference

N/A

Annotation

This report provides methods to determine the quantity of emissions produced from burning piled logging debris (slash piles) by first finding volume of slash pile, net mass of fuel of pile and appropriate emission factors. Emission factors are reported for particulate (including PM10) carbon monoxide, carbon dioxide, methane, and non methane hydrocarbons for both grapple piles and tractor piles. These factors are from Ward, Hardy, et. Al. "Mitigation of prescribed fire atmospheric pollution through increase utilization of hardwoods, piled residues, and long-needed conifers: Part III -- Emissions Characterization. Final Report. U.S. Dept. of Energy IAG DA-A1179-85BP18509: on file PNW Fire and Air Resource Management Research Project, Seattle, WA.

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Slash

Baseline/Type of ERT(s)

piles

Variables

grapple piles  
tractor piles

Time of year burn performed

unknown

Location of burn

unknown

Annotated Author Designation

Hardy (1)

Author

Holland, David

Date of Publication

June 1997

Original Research

Additional Authors

Kathleen Painter, R. Douglas Scott, Philip Wandscheider, David Willis

Date study was performed

Compilation

Other

URL Address

Title

Estimates of the Benefits and Costs from Reduction in Grass Seed Field Burning

Publication Reference

Annotation

This report presents information on the probable economic benefits and costs that would result from the limitation on grass seed field burning and a consequent reduction in grass smoke. Three scenarios covered in the report were (1) continued production of blue grass in all areas but at reduced yields, (2) half-out scenario, in which bluegrass is replaced with an alternative use on one-half of the affected acres and (2) rotational burning, in which the bluegrass fields are burned every other year.

The report states that experimental results show that yields following a burn after the second year were virtually identical to yields in fields that are burned every year (see Canode and Law).

The largest potential benefit identified was improved air quality from reduced smoke emissions.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Bluegrass

Baseline/Type of ERT(s)

Alternate year burning

Variables

Time of year burn performed

Location of burn

Annotated Author Designation

Holland

Author

Jenkins, B. M.

Date of Publication

April, 1996

Original Research

Additional Authors

Turn, S.Q., Williams, M. Goronea, Abd-el-Fattah, H., Mehlschau, J., Raubach, N., and

Date study was performed

April 1992 - April 1993

Compilation

Other

URL Address

Title

Atmospheric Pollutant Emission Factors from Open Burning of Agricultural and Forest Biomass by Wind tunnel Simulations (THREE VOLUMES)

Publication Reference

Annotation

Air pollutant emissions factors were determined for carbon monoxide, nitrogen oxides, sulfides, total hydrocarbons, methane, nonmethane hydrocarbons, total sulfur, carbon dioxide, particulate matter and polycyclic aromatic hydrocarbons by wind tunnel simulations of open-air burning of six types of agricultural waste and two types of forest waste including barley straw, corn stover, rice straw, wheat straw, almond prunings, walnut prunings, Ponderosa pine and Douglas fir branches and needles. All field crop residues were spread before burning. Only backing fires were used. Each fuel was characterized as to chemical composition, moisture content, heating value, size of fuel pieces and fuel bed structure. Correlations were determined between emissions rates and burning conditions and fuel composition. Particle size distributions were obtained. All wood wastes were burned in stationary pile fires of 30 - 50 kg. These sizes were smaller than would normally be encountered in the field. The extent to which data from the burning of these piles can be applied to larger scales was examined by comparison against existing field data. The repeatability of the data obtained from the tests was good, and the values obtained for the emissions factors were consistent with data obtained by other researchers. The only major discrepancies identified between wind tunnel and field data were in the particulate matter emission factors for smoldering in slash burns. Wind tunnel values were substantially lower.

Agricultural or Wildland

Agricultural and Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Almond Tree Prunings, Barley Straw, corn stover, Douglas Fir slash, rice straw, Ponderosa Pine Slash, Walnut Tree Prunings, Wheat Straw

Baseline/Type of ERT(s)

Backing fire piles

Variables

Time of year burn performed

Full year

Location of burn

Wind tunnel in Riverside, CA

Annotated Author Designation

Jenkins (1)

Author

Jenkins, B. M.

Date of Publication

1994

Original Research

Additional Authors

S. Q. Turn

Date study was performed

Compilation

Other

Title

Primary atmospheric pollutants from agricultural burning: Emission rate determination from wind tunnel simulation.

URL Address

Publication Reference

in Proceeding from ASAE meeting, Kansas City, Kansas, June 19-24, 1994.

Annotation

Provides emission rates fro CO, CH4, and PM2.5 from the burning of cereal straw.  
  
This paper is not available. It was referenced in Schaaf.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Cereal straw

Baseline/Type of ERT(s)

Variables

Time of year burn performed

Location of burn

Annotated Author Designation

Jenkins (2)

Author

Johansen, R.W.

Date of Publication

December 1976

Original Research

Additional Authors

McNab, R.W., Hough, W.A., Edwards, M.B.

Date study was performed

Compilation

Other

Title

Southern Forestry Smoke Management Guidebook, Chapter IV: Fuels, Fire Behavior, and Emissions

URL Address

Publication Reference

USDA Forest Service General Technical Report SE-10

Annotation

This paper presents a system for predicting and modifying smoke concentrations from prescribed fires. Forestry smoke constituents, variables affecting smoke production and dispersion, and new methods for estimating available fuel are presented. Amount of particulate matter and rate of heat release are determined using amount of fuel, rate of fire spread, emission factor, and heat yield of fuel. The particulate emission factor reported for advancing (backing fire) is 25 lb/ton of palmetto-galberry fuel while the particulate emission factor reported for head fires (combustion particulate emissions) is 125 lb/ton palmetto-galberry fuel. Practices and fuel conditions that minimize particulate matter production from burning forest fuels were noted. These practices and conditions include backing fire where possible, cutting to low stumps and felling dead snags, burning when fuel moisture is low, minimizing amount of logging debris through utilization to small top diameters, and burning scattered logging debris rather than piled debris.

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Grass with pine overstory, pine needle litter and light brush fuel types, palmetto-galberry with pine overstory, pine logging debris fuel

Baseline/Type of ERT(s)

heading and backing fire

Variables

Fuel loading  
Fuel moisture  
Rate of spread  
Burning method

Time of year burn performed

Location of burn

Southeast US

Annotated Author Designation

Johansen

Author

Meland, Bruce R.

Date of Publication

September, 1966

Original Research

Additional Authors

Richard W. Boubel

Date study was performed

Summer, 1965

Compilation

Other

Title

A Study of Field Burning Under Varying Environmental Conditions

URL Address

Publication Reference

Journal of The Air Pollution Control Association. Vol. 16, No. 9. Sept. 1966. pp.481-484

Annotation

The purpose of this experiment was to determine the effect of environmental variables such as time from harvest to burning, time of day, air temperature, relative humidity, soil and straw moisture, wind speed and direction and fuel density on grass field burning emissions. The study took place in an open field in Willamette Valley, Oregon during the summer of 1965. It attempted to determine if conditions exist when significant air pollution reduction can be achieved. Particulate emission and size distribution as well as combustion temperature, burn rate, amount of ash, percent organics in particulate and smoke appearance were recorded. It was found that the amount of residue left after burn depended on soil moisture. Burn rate depended on wind speed, air temperature and number of days after the harvest. In addition, smoke color depended on straw moisture. The results were analyzed statistically to determine the significant variables and their relationships.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Ryegrass, common ryegrass, English

Baseline/Type of ERT(s)

Burn Before New Fuels Appear - Before Green Up, Site Conversion

Variables

Time from harvest to burn  
Time of day  
Air temperature  
Relative Humidity  
Moisture  
Wind speed and direction  
fuel density

Time of year burn performed

Summer, 1965

Location of burn

Open field in Willamette Valley, OR

Annotated Author Designation

Meland

Author

Miller, George

Date of Publication

Fall, 1973

Original Research

Additional Authors

John Carrol, James Thompson, John Goss, and Ellis Darley

Date study was performed

Fall, 1971-Spring, 1973

Compilation

Other

Title

Minimizing Visible Emissions from Agricultural Burning

URL Address

Publication Reference

California Air Environment. Vol.4 # 1 Pg. 4-6 Fall 1973  
University of California

Annotation

This report utilized research conducted between 1970 and 1973 in Riverside, California, to discuss minimization of visible emissions from burning rice and straw. It concluded that temperature, humidity and wind speed may influence particulate production, but not as strongly as fire management techniques and fuel moisture. It also determined that single-line backfires in rice field residues reduced particulate emissions over head fires by half at moisture contents greater than 10 - 12 percent on a wet basis. Burning at moisture contents less than 10 - 12 percent reduced particulate emissions significantly over burning at higher moisture levels. It was determined that about 90 % of particulate is less than 1 micron. Also, head fires and light wind speeds were found to produce much greater plume rise than for back fires.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

rice

Baseline/Type of ERT(s)

spread straw, windrowed straw, raked straw, piled straw, headfire, line backfire, into-the-wind strip fire

Variables

Time of year burn performed

September, June

Location of burn

Riverside, CA

Annotated Author Designation

Miller (2)

Author

Miller, George E.

Date of Publication

June 30, 1973

Original Research

Additional Authors

Goss, John R.

Date study was performed

Fall, 1971, Spring, 1972

Compilation

Other

Title

Study of Abatement Methods and Meteorological Conditions for Optimum Dispersion of Particulates from Field Burning of Rice Straw: Rice Straw Incinerator Evaluation

URL Address

Publication Reference

Annotation

The purpose of this research was to determine the potential of mobile incineration as a practical means of reducing particulate emissions from combustive disposal of rice field residues. To perform this study, a mobile field sanitizer was used in California rice fields during the Fall of 1971 and Spring of 1972. Particulates, hydrocarbon and carbon monoxide emissions were observed. It was found that the mobile field sanitizer reduced carbon monoxide and hydrocarbon emissions but particulate emissions were high. Results are compared to rice burns using both head fire and back fire technique in burn towers in Riverside, California. The author cautioned that his sampler was only capable of determining particulates greater in size than 0.43 microns though about 70 percent of mass of particulates less than 7 microns were less than 0.43 microns

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Rice Straw residue

Baseline/Type of ERT(s)

Mobile field sanitizer

Variables

Time of year burn performed

Fall, Spring

Location of burn

Riverside Laboratory

Annotated Author Designation

Miller (1)

Author

Najita, Theresa

Date of Publication

2001

Original Research

Additional Authors

Scientists from California Air Resources Board

Date study was performed

Compilation

Other

Title

Progress Report on the Phase-down and the 1998-2000 Pause in the Phase-down of Rice Straw Burning in the Sacramento Valley Air Basin

URL Address

Publication Reference

Found in California Air Resources Board . California Department of Food and Agriculture. "2001 Report to the Legislature" August 2001

Annotation

The purpose of this report was to provide an update on the state of the phase-down of rice straw burning in the Sacramento Valley of California. It discusses progress made in meeting phase-down requirements, status of alternatives to burning, environmental and ecological effects, and economic effects of phase down. Phase down was conducted from 1992 to 2001. In 1992, 303,000 acres of rice straw fields were burned. In 2000, 139,000 acres were burned. Particulate emissions (PM10) were reported to have decreased from 2863 tons per year in 1992 to 1313 tons per year in 2000. Phase-down requirements were determined to have been met satisfactorily, but lack of viable alternative uses for rice straw are still a large problem. Soil incorporation of rice straw is the most widely used alternative, but costs approximately \$43/acre as compared to \$3/acre to burn rice straw. Particulate emission size distribution is reported for rice straw.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

rice straw

Baseline/Type of ERT(s)

backfiring

Variables

Time of year burn performed

Location of burn

Sacramento Valley, California

Annotated Author Designation

Najita

Author

OMNI Environmental Services

Date of Publication

May, 1989

Original Research

Additional Authors

Date study was performed

1988

Compilation

Other

URL Address

Title

Preliminary Modeling of the Air Quality Impacts of Propane Flaming and Straw Residue Stack Burning in the Willamette Valley, Final Report

Publication Reference

Annotation

The purpose of this study was to conduct a preliminary modeling analysis of the particulate emissions from wide-spread propane flaming and stack burning activities, in order to estimate the impacts on the population of the Willamette Valley. Another goal of the study was to attempt to compare the impact of propane flaming and open field burning. This study used particulate emission factors from Freeburn (2), which showed that particulate emission factors (mass of particulate matter per mass of dry residue) from propane flaming were about three times higher than those for open field burning. The emission factors for burning of straw stacks were found to be about 40% of the open burning value. Overall, emissions from propane flaming activities (propane flaming and straw stack burning) were slightly less than those from the same area treated with open field burning. Measurements of the plumes downwind from fields where propane flaming was conducted showed that the exposure of individuals at nearby locations was on the order of 10 times greater than that experienced due to open field burning. This was not unexpected due to the lower plume rise and slower rate of treatment of propane flaming activities.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Grass Straw

Baseline/Type of ERT(s)

Propane flaming with straw stack burning

Variables

Time of year burn performed

July-September

Location of burn

Fields in Willamette Valley

Annotated Author Designation

OMNI (1)

Author

Oregon Advisory Comm. on Env. Science and

Date of Publication

1971

Original Research

Additional Authors

Date study was performed

1968

Compilation

Other

Title

Air Quality in Oregon

URL Address

Publication Reference

Environmental Quality in Oregon 1971: A Summary of Current and Future Problems; the Advisory Committee on Environmental Science and Technology

Annotation

This report discusses the magnitude of air quality issues in Oregon and how to reduce impacts on air quality for agricultural and wildland burning. The principal air pollution problem associated with field burning is suspended carbon and ash particulates of smoke. The report recommends reducing the amount of materials burned through finding beneficial uses for straw and then using mobile field incineration of the residue. It also discusses improving smoke management practices and improving soil incorporation of plant materials. Monitoring data show that the volume of suspended carbon and air particulates average 15 pounds per ton of straw burned for field burning.

Agricultural or Wildland

Agricultural and Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

grass and cereal straw, timber

Baseline/Type of ERT(s)

Baseline

Variables

Time of year burn performed

Not specified

Location of burn

Western Oregon

Annotated Author Designation

Oregon (1)

Author

Oregon State

Date of Publication

1995

Original Research

Additional Authors

Date study was performed

Compilation

Other

Title

Field Burning Fact Sheet

URL Address

Publication Reference

Annotation

[this reference needs to be relocated to finish the annotation]

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Field, Grass and Straw Stubble

Baseline/Type of ERT(s)

Baseline

Variables

Time of year burn performed

Location of burn

Oregon

Annotated Author Designation

Oregon (4)

Author

Ottmar, Roger D.

Date of Publication

December 2001

Original Research

Additional Authors

Janice L. Peterson, Bill Leenhouts, John E. Core

Date study was performed

Compilation

Other

Title

Smoke Management: Techniques to Reduce or Redistribute Emissions

URL Address

Publication Reference

Chapter 8 in Smoke Management Guide for Prescribed and Wildland Fire, 2001 Edition

Annotation

This chapter presents a summary of techniques available to smoke managers to reduce or redistribute smoke emissions from wildland and prescribed burning. The chapter presents estimates of PM10 and PM2.5 and estimates of PM10 and PM2.5 emission reductions for eight different vegetation types and one emission reduction technique for each vegetation types (two for PNW Douglas fir/hemlock). The emission factors and emission reductions are based on using the Consume 2.1 model (see Ottmar (1)).

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Southern pine, north central red and white pine, midwest grassland, interior mixed conifer, Alaska black spruce, PNW Douglas-fir/hemlock, southwest Ponderosa pine, California chaparral

Baseline/Type of ERT(s)

mosaic burning, mechanical removal, ungulates, high moisture in large fuels, moist litter and/or duff, burn fuels after large fuels cure, piled fuels, mass ignition, and burn less frequently

Variables

Time of year burn performed

not applicable

Location of burn

"see fuel types"

Annotated Author Designation

Ottmar (3)

Author

Ottmar, Roger D.

Date of Publication

1987

Original Research

Additional Authors

Date study was performed

Compilation

Other

URL Address

Title

Reducing smoke from prescribed fires: research solution to a management problem.

Publication Reference

Proceedings of the Northwest Forest Fire Council Annual Meeting, 1986, November 18-19, Olympia, WA.

Annotation

A series of 40 demonstration units were burned in the Pacific Northwest to verify foresters' ability to reduce emissions from slash burns on harvested areas. In 25 of the demonstrations, extra effort was taken to harvest more of the small and defective woody material than economically recoverable. Emissions were reduced 18 to 35 percent compared to emissions from stands harvested to the economic standard, depending on the minimum size of the pieces removed, the steepness of the terrain, and the thickness of the duff layer.  
  
This paper is not available. It was referenced in Sandberg (5).

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

slash

Baseline/Type of ERT(s)

increased utilization

Variables

steepness of terrain, duff thickness, minimum size of pieces removed

Time of year burn performed

Location of burn

Pacific Northwest

Annotated Author Designation

Ottmar (2)

Author

Ottmar, Roger D.

Date of Publication

2001

Original Research

Additional Authors

Date study was performed

Compilation

Other

Title

Smoke Source Characteristics

URL Address

Publication Reference

Found in "2001 Smoke Management Guide"

Annotation

This work discusses the characteristics of emissions from wildland fire and the necessary inputs to obtain source strength and heat release rate for assessing smoke impacts. It examines prefire fuel characteristics, fire behavior, fuel consumption, smoke emissions, total emissions, source strength, and heat release rate. A chart of emissions factors is provided for particulate matter (PM, PM10, PM2.5), carbon dioxide, carbon monoxide, methane, and nonmethane hydrocarbons for various fuel and fire types. The factors are broken out by phase (flaming, smoldering) and as an average. This chart references Ward 1989, Hardy 1996, and Hardy and Einfield 1992. This chart is also found in Ottmar (1).

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Douglas fir/hemlock, hardwoods, ponderosa, pole pine, mixed conifer, juniper, Sagebrush, Chaparral

Baseline/Type of ERT(s)

broadcast pile and burn

Variables

Time of year burn performed

Location of burn

Annotated Author Designation

Ottmar (4)

Author

Ottmar, Roger D.

Date of Publication

2001

Original Research

Additional Authors

Anderson, Gary K, De Herrera, Paul J., and Reinhardt, Tim E.

Date study was performed

Compilation

Other

Title

Consume 2.1 User's Guide

URL Address

Publication Reference

Annotation

Consume is a computer program designed for resource managers. The software predicts the amount of fuel consumption and emissions from the burning of logged units, piled debris, and natural fuels based on weather data, the amount and fuel moisture of fuels, and a number of other factors. Consume can be used for most forest, shrub and grasslands in North America.

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Southern pine, north central red and white pine, midwest grassland, interior mixed conifer, Alaska black spruce, Pacific northwest douglass fir/hemlock, ponderosa pine, California chaparral

Baseline/Type of ERT(s)

mosaic burning, non-mosaic burning, mechanical removal, ungulates, burn after large fuels cure, piled fuels, mass ignition, frequent burning

Variables

Time of year burn performed

Location of burn

Annotated Author Designation

Ottmar (1)

Author

Radke, L.F.

Date of Publication

April, 1991

Original Research

Additional Authors

D.E. Ward

Date study was performed

Compilation

Other

Title

Prescriptions for Biomass Smoke Reductions

URL Address

Publication Reference

Paper presented at 11th Conference on Fire and Forest Meteorology, April 16 -19, 1991, Missoula, MT.

Annotation

The purpose of this study was to show the efficiency of cloud scavenging in reducing transport of biomass smokes. If was found that a 50% removal of particles could occur if fire is capped by, or smoke introduced into, a modest size cumulus cloud. Even if rain failed to form, it was reported that particles caused less of a visibility problem and had a shorter atmospheric life. The author warned that this research is preliminary. (See Radke (1))

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Not specified

Baseline/Type of ERT(s)

Clouds, precipitation

Variables

Time of year burn performed

(See Radke 1)

Location of burn

Ontario, Canada

Annotated Author Designation

Radke (2)

Author

Radke, Lawrence F.

Date of Publication

2001

Original Research

Additional Authors

Darold E. Ward and Phillip J. Riggan

Date study was performed

Compilation

Other

Title

A Prescription for Controlling the Air Pollution Resulting from the Use of Prescribed Biomass Fire: Clouds

URL Address

Publication Reference

International Journal of Wildland Fire, 2001, 10, 103-111.

Annotation

This report utilized data from several prior experiments which aimed to measure the benefits of burning on days with thick, low cumulus clouds. The report states that it should be possible to reduce particulate smoke emissions in all size classes by 30 - 50 % by further restraining burning according to meteorological conditions and by introducing smoke to fire-capping cumulus cloud. The authors examine information on four fires that occurred in August 1987, 1988, and 1989 in Ontario, Canada.

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Not specified

Baseline/Type of ERT(s)

Clouds, precipitation

Variables

Time of year burn performed

August 1987, 1988, 1989

Location of burn

Ontario, Canada

Annotated Author Designation

Radke (1)

Author

Ryan, P. W.

Date of Publication

July 1977

Original Research

Additional Authors

C. K. McMahon

Date study was performed

Compilation

Other

Title

Some chemical and physical characteristics of emissions from forest fires.

URL Address

Publication Reference

Proceedings of the Annual Meeting of the Air Pollution Control Association, 76-2.3, Portland, OR.

Annotation

Backing fires were found to emit 67% less TSP than did heading fires.  
This paper is not available. It was referenced in Sandberg (4).

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

grass or pine-litter

Baseline/Type of ERT(s)

backing fire

Variables

Time of year burn performed

Location of burn

Annotated Author Designation

Ryan

Author

Sandberg, D. V.

Date of Publication

1986

Original Research

Additional Authors

Date study was performed

Compilation

Other

Title

Progress in Reducing Emissions from Prescribed Forest Burning in Western Washington and Western Oregon

URL Address

Publication Reference

In Proceedings, 1986 annual meeting of the Pacific Northwest International Section, Air Pollution Control Association; 1986 November 19-21.

Annotation

This paper described the progress in reducing particulate (TSP) emissions in western Washington and western Oregon and includes a projection for future improvement. Sections of the paper include: cooperative research efforts are more efficient; a new emission inventory system; emission reduction baseline; emissions were reduced by 30% by 1984 (relative to 1978-1979 baseline); and how can additional reduction be achieved. The paper discusses increased utilization and "spring" burning (burning under wetter conditions) as two methods to achieve additional reduction. For the reduction achieved by 1984, the paper states that increased utilization is responsible for a 16% reduction in emissions in Oregon and a 20% reduction in Washington since the baseline period. The paper reports that each increase of 1 percent fuel moisture reduces emissions by 3 percent and burning within 3 weeks of heavy rainfall reduces emissions as much as 25 percent or more. Mass ignition of broadcast burn areas to improve combustion efficiency and limit biomass consumption decreased emissions by 2% in Oregon and by 5% in Washington. The effectiveness of this technique, however, has not been conclusively proved. The modest assertions are based on preliminary research results.

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

slash

Baseline/Type of ERT(s)

increased utilization  
moisture content  
mass ignition

Variables

Time of year burn performed

not specified

Location of burn

Oregon, Washington

Annotated Author Designation

Sandberg (6)

Author

Sandberg, D.V

Date of Publication

March, 1975

Original Research

Additional Authors

S.G. Pickford and E.F. Darley

Date study was performed

Not stated

Compilation

Other

URL Address

Title

Emissions from Slash Burning and the Influence of Flame Retardant Chemicals

Publication Reference

Journal of the Air Pollution Control Association, Vol. 25, No. 3. March 1975. 278-281.

Annotation

This study, conducted in a burning tower in Riverside, California, compared the emissions of carbon monoxide, hydrocarbon gas and particulate matter for burning ponderosa pine to the emissions from burning ponderosa pine treated with diammonium phosphate flame retardant. It was found that diammonium phosphate increased all pollutants, especially the particulate fraction, even though less treated fuel was burned.

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Ponderosa Pine

Baseline/Type of ERT(s)

flame retardant

Variables

Time of year burn performed

Not stated

Location of burn

Burning tower in Riverside, CA

Annotated Author Designation

Sandberg (2)

Author

Sandberg, D.V.

Date of Publication

July 15, 1989

Original Research

Additional Authors

D.E. Ward, R.D. Ottmar, C.C. Hardy, T.E. Reinhardt, and J.N. Hall

Date study was performed

1985-1987

Compilation

Other

URL Address

Title

Mitigation of Prescribed Fire Atmospheric Pollution Through Increased Utilization of Hardwoods, Piled Residues, and Long-Needled Conifers

Publication Reference

Annotation

The purpose of this research was to assess reduction in emissions of atmospheric pollutants from prescribed burning through increased utilization of harvest residues in Oregon and Washington. This 3 year study targeted hardwoods, pine and mixed conifers. Emissions measured include carbon monoxide, carbon dioxide, methane hydrocarbons, nonmethane hydrocarbons and particulate matter. Results were broken down according to combustion phase (smoldering or flaming). It was found that emission factors for carbon monoxide for broadcast burns were similar between fuel types. Particulates emission factors were different for long-needled pine and hardwood.

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Hardwood, Pine, Mixed Conifer

Baseline/Type of ERT(s)

Broadcast, Pile Burning

Variables

Time of year burn performed

Summer - Fall

Location of burn

Western Oregon and Western Washington

Annotated Author Designation

Sandberg (1)

Author

Sandberg, David V.

Date of Publication

1985

Original Research

Additional Authors

Date study was performed

1985

Compilation

Other

Title

Scheduling Prescribed Fires for Wetter Periods Reduces Air Pollutant Emissions

URL Address

Publication Reference

Presented at the Society of American Foresters/American Meteorological Society, 8th National Conference on Fire and Forest Methodology, Detroit, Michigan, April 29-May 2, 1985.

Annotation

This paper presents a simplified model for predicting total biomass consumption and particulate emissions for slash burning in western Washington and western Oregon based on three input variables (large woody fuel loading, large fuel moisture, and duff moisture regime). Emission factors were measured along a 200-foot transect over each subunit during the flaming and smoldering stages. A single EF was calculated for each combustion stage using the arithmetic average of emission factors from all fires. The paper presents data on fuel moisture and fuel consumption for each burn. Four units were selected to demonstrate the effectiveness of meteorological scheduling (moisture content) to reduce particle emissions by limiting the amount of large woody fuel and duff consumed. Four "wet" units were burned an average of 8 days after saturating rainfall compared to "dry" units burned an average 38 days after rainfall. The moisture content of the "wet" units averaged 6 percent higher. There was virtually no difference (3 percent) in the average emission factor (lbs/ton) between the wet and dry conditions because the proportion of biomass consumed in the flaming stage did not differ consistently. Fine particle emissions averaged 970 lbs per acre on the dry unit vs. 447 lbs per acre on the wet unit for a 54-percent difference. The demonstrations were designed to achieve maximum effect of scheduling the burns and should not be used to infer average effects. The paper states that emission reduction of up to 25 percent is expected by during a "wet" duff moisture regime.

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Slash

Baseline/Type of ERT(s)

Variables

moisture

Time of year burn performed

Location of burn

Western Washington, western Oregon

Annotated Author Designation

Sandberg (3)

Author

Sandberg, David V.

Date of Publication

1983

Original Research

Additional Authors

Date study was performed

Compilation

Other

Title

Emission Reduction for Prescribed Burning

URL Address

Publication Reference

Paper presented at 76th Annual Meeting of the Air Pollution Control Association, Atlanta, GA. June 19-24, 1983. Paper 83-45.3

Annotation

Paper summarizes research on emerging techniques for reducing emissions from prescribed burning at the source and presents hypotheses regarding the effectiveness of techniques for reducing emissions. For simple fuel beds, backing fires were found to emit 67% less total suspended particulates than did heading fires. Maintaining optimum fire line intensity has been shown to reduce emissions by as much as 50% from heading fires. Emission factors were lowest when reaction intensity was highest regardless of the type of fire. Burning under moisture content ranges between 10 and 20% could reduce emissions by approximately 30%. For complex fuel beds (southern rough), backing fires, which reduce the smoldering stage, and burning on a shorter rotation could reduce emissions by more than 50%. For logging slash, increased utilization, can reduce emissions 30 to 50%, depending on the conditions that promote flaming or smoldering combustion. Increase utilization is less effective in very dry periods. Removal of material larger than 20 cm x 3m can reduce TSP by about 15% for units burned in midseason. Removal of material larger than 5 cm x 3 m could reduce emissions by 67%. The technique is less effective in drier or wetter months. Burning when large fuels are moist can produce about a 3% emission reduction for each 1% increase in moisture content. In extreme cases, emissions from slash burning could be reduced by 75% by burning when large fuels are moist and small fuels are dry. Mass ignition may reduce emission by 25%. Shorter mop-up times (80 reduced to 53 minutes) would reduce total emissions by at least 10%.

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

pine needle litter  
woody fuels, short-needled conifer duff,  
coarse brush  
logging slash

Baseline/Type of ERT(s)

backing fire  
fireline intensity  
moisture content  
increased utilization  
rapid mop-up

Variables

Time of year burn performed

various

Location of burn

various

Annotated Author Designation

Sandberg (4)

Author

Sandberg, David V.

Date of Publication

1988

Original Research

Additional Authors

Date study was performed

Compilation

Other

Title

Emission Reduction from Prescribed Forest Burning

URL Address

Publication Reference

In Transactions - PM10: Implementation of Standards: An APCA/EPA International Specialty Conference; 1988 February 22-25.

Annotation

This paper presents an overview of prescribed burning in the Pacific Northwest, discussing techniques and strategies for reducing air pollution from prescribed forest burning. Limitations of the BACT, or Best Available Control Technology approach, are discussed. The range of conditions that determine the production of fine particulate matter (PM10) from prescribed fires is described, and the opportunity to modify those conditions to achieve a reduction of emissions is discussed.

The paper reports on 40 demonstration units burned in the PNW to verify the ability to reduce emissions from slash burns on harvested areas. In 25 of the units, extra effort was taken to harvest more of the small and defective woody material than were economically recoverable. Emissions were reduced 18 to 35 percent compared to emissions from stands harvested to the economic standard, depending on the minimum size of the pieces removed, the steepness of the terrain, and the thickness of the duff layer. For seven units burned to evaluate the operational effectiveness of scheduling burns for wet, spring like conditions, emissions were reduced by an average of 54 percent. The remaining eight units were burned as experimental controls.

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

slash

Baseline/Type of ERT(s)

increased utilization  
moisture content

Variables

steepness of terrain  
duff layer thickness

Time of year burn performed

not reported

Location of burn

Pacific Northwest

Annotated Author Designation

Sandberg (5)

Author

Schaaf, Mark

Date of Publication

July, 2003

Original Research

Additional Authors

Date study was performed

April & October, 2000

Compilation

Other

URL Address

Title

Cereal-Grain Residue Open-Field Burning Emissions Study (Final Report)

Publication Reference

Annotation

The purpose of this study was to investigate opportunities for reducing the emissions of ten pollutant species including particulate matter, carbon monoxide and six polycyclic aromatic hydrocarbons from open field burning of cereal-crop residue. It was found that higher pre-burn loading provided higher absolute residue consumption. No reduction in residue consumption can be ascribed to any particular fire type or season of burn. No statistically significant differences in the PM2.5 emission factors were found among most of the alternative ignition patterns studied, nor were statistically significant differences found between the high loading (that is, greater than 8,000 lbs of residue per acre) and low loading (that is, 6,000 to 8,000 lbs of residue per acre) units. The mean PM2.5 emission factor for the spring backing fires was lower (statistically significant, 98-percent confidence level) than the mean PM2.5 emission factor for the fall baseline fires, but this difference may be driven more by differences in moisture content than by differences in the ignition pattern (the fall baseline fires are believed to have had more "green up" present than the spring backing fires).

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Cereal-Grain

Baseline/Type of ERT(s)

Backfire, Headfire, Strip Fire, High and Low Residue Loading

Variables

Residue loading level  
Fire ignition (mass, head, strip head or back fire)  
Season of burn  
Moisture

Time of year burn performed

Spring and Fall

Location of burn

Columbia County, Washington

Annotated Author Designation

Schaaf

Author

Terraglio, F.P.

Date of Publication

Summer, 1978

Original Research

Additional Authors

Date study was performed

Summer-Fall

Compilation

Other

URL Address

Title

Polynuclear Aromatic Hydrocarbon Study

Publication Reference

Found in "Open Field Burning: An Emission Factors Study of Alternative Firing Techniques," vol 6. Summer 1978.

Annotation

As a part of the 1978 Field and Slash Burning study, 30 high volume impactor back-up filters were analyzed by Rockwell International for presence of total particulate polynuclear aromatic hydrocarbons (PAHC) including benzo(e)pyrene, benzo(k)fluorathene, benzo(a)pyrene, benz(g h i) perylene, and chrysene. Fifteen of these filters were source samples and 15 were ambient samples. These samples were representative of head and backfire technique and high and low straw moisture levels. It was found that PAHC content in backfire smoke is higher than in headfire smoke. Within specific fire type, high straw moisture smokes contain higher percentages of PAHC than low moisture smoke.

Agricultural or Wildland

Agricultural and Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Slash, Field

Baseline/Type of ERT(s)

Headfire, Backfire

Variables

Time of year burn performed

August-September

Location of burn

Oregon

Annotated Author Designation

Terraglio

Author

Turn, S. Q.

Date of Publication

1997

Original Research

Additional Authors

B.M. Jenkins, J.C Chow, L.C. Pritchett, D. Campbell, T. Cahill, S.A. Whalen

Date study was performed

Compilation

Other

URL Address

Title

Elemental characterization of particulate matter emitted from biomass burning: Wind tunnel derived source profiles for herbaceous and wood fuels.

Publication Reference

Journal of Geophysical Research, 102 (D3): 3683-3699.

Annotation

Provides PM2.5 emission factor for burning of cereal straw.  
This paper is not available. It was referenced in Sandberg (4).

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Cereal straw

Baseline/Type of ERT(s)

Variables

Time of year burn performed

Location of burn

Annotated Author Designation

Turn

Author

Ward, D. E.

Date of Publication

April 1980

Original Research

Additional Authors

H. B. Clements, R. M. Nelson, Jr.

Date study was performed

Compilation

Other

Title

Particulate matter emission factor modeling for fires in southeastern fuels.

URL Address

Publication Reference

Proceedings of the Sixth Conference on Fire and Forest Meteorology, Society of American Foresters, Seattle, WA.

Annotation

Ward and others demonstrated that as much as a 50% reduction in emission factors from heading fires by maintaining an optimum (200 to 300 kw per meter) fire line intensity. They also showed that emission factors were lowest when reaction intensity (kw per square meter) was highest, regardless of the type of fire.

This paper is not available. It was referenced in Sandberg (4).

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

pine-needle litter and/or fine, live fuels

Baseline/Type of ERT(s)

fire line intensity (increased combustion)

Variables

Time of year burn performed

Location of burn

South(?)

Annotated Author Designation

Ward (4)

Author

Ward, Darold

Date of Publication

February, 1988

Original Research

Additional Authors

Colin Hardy, and David Sandberg

Date study was performed

Compilation

Other

Title

Emission Factors for Particles from Prescribed Fires By Region in the United States

URL Address

Publication Reference

Presented at an APCA / EPA International Specialty Conference, San Francisco, CA. February 1988.

Annotation

This report draws on data from several studies to describe emission factors and the size distribution for smoke particles from prescribed fire. Data was collected by several methods including airborne sampling, burn towers and combustion hood systems. Particulate matter was broken out by size. It was found that 40 to 95 % of mass of particulate matter is less than 2.5 micrometers in diameter. The rate of heat release was found to have significant effect on size and mass of particles produced.

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Douglas Fir/Western Hemlock, Chaparral, Palmetto/Gallberry, Conifer, Grassland, Sawgrass

Baseline/Type of ERT(s)

Baseline - broadcast Piles (slash)

Variables

Time of year burn performed

NA - Compilation

Location of burn

Various locations in U.S.

Annotated Author Designation

Ward (1)

Author

Ward, Darold

Date of Publication

1989

Original Research

Additional Authors

Janice Peterson and Wei Min Hao

Date study was performed

Compilation

Other

Title

An Inventory of Particulate Matter and Air Toxic Emissions from Prescribed Fires in the USA for 1989

URL Address

Publication Reference

Annotation

This document presents estimates of emissions from prescribed burning in the United States. The product of fuel loading, fuel consumption, area burned, and an emission factor provided estimates of emissions in each State nationally. Emission factors are shown in the document for carbon dioxide, carbon monoxide, methane, PM2.5, PM, PM10, nonmethane hydrocarbons, formaldehyde, acrolein, acetaldehyde, 1,3-butadiene, and benzene. These factors were assigned based on fuel model and fuel bed component (e.g., fine woody, small woody, live vegetation).

NOTE: The document does not appear to define all of the fuel models (A through U). Fuel Model A represents western grasslands vegetated by annual grasses and forbes. Brush or trees may be present, but are sparse. The document refers to Peterson and Ward, 1993, for a complete listing of the fuel models.

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

various; based on fuel model

Baseline/Type of ERT(s)

Baseline

Variables

Time of year burn performed

not specified

Location of burn

not applicable? Document applies factors throughout US based on fuel model

Annotated Author Designation

Ward (3)

Author

Ward, Darold

Date of Publication

June, 1989

Original Research

Additional Authors

Colin C. Hardy

Date study was performed

1986

Compilation

Other

Title

Emissions from Prescribed Burning of Chaparral

URL Address

Publication Reference

Air and Waste Management Association. Presented at 82nd Annual Meeting and Exhibition, Anaheim, CA. June 25-30, 1989.

Annotation

This paper discusses a series of experiments measuring emissions from prescribed fires in three variations of chaparral fuel type. The objectives of the research were to measure emission factors for fine particles, combustion gases, trace gases, methyl chloride, percent carbon content of PM 2.5, trace element content of PM2.5, and describe emission factors as functions of fuel and fire behavior descriptors. Factors are presented by combustion phase.

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Chaparral; mix of other fuels (scrub oak, toyon, western mountain mahogany)

Baseline/Type of ERT(s)

Baseline

Variables

Time of year burn performed

September

Location of burn

California (Angeles National Forest)

Annotated Author Designation

Ward (2)

Author

Ward, Darold

Date of Publication

Original Research

Additional Authors

Charles K. McMahon, Ragnar W. Johansen

Date study was performed

Compilation

Other

Title

An Update on Particulate Emissions from Forest Fires

URL Address

Publication Reference

Presented at the 69th Annual Meeting of the Air Pollution Control Association, Portland, Oregon. June 27-July 1, 1976.

Annotation

The paper reviews published data on particulate emissions from forest fires. It discusses the wide range of emission factors being used, between 10 and 200 lbs per ton for different fire behavior and fuel characteristics. Grouped with the prescribed fire category are both low-intensity fires (used primarily in the South to reduce under story litter) and fires used for disposal of logging debris (slash fires). In addition, estimates summarizing particulate production on a seasonal-regional basis are also presented in order to underscore the need to recognize the cyclic and intermittent nature of the forest burning source.

Particulate emission factors for wildfire, prescribed fire - under story litter backfires, and prescribed fire - logging debris are presented. In addition, a summary of particulate emission factors for various logging residue, live under story, and pine needle litter fuel types from four references (not currently in this database) is presented.

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

slash; pine needles

Baseline/Type of ERT(s)

Baseline; backfire

Variables

Time of year burn performed

not specified

Location of burn

factors presented for different areas of the country

Annotated Author Designation

Ward (6)

Author

Ward, Darold

Date of Publication

1984

Original Research

Additional Authors

Colin C. Hardy

Date study was performed

1983

Compilation

Other

Title

Advances in the Characterization and Control of Emissions from Prescribed Fires

URL Address

Publication Reference

Presented at the 77th Annual Meeting of the Air Pollution Control Association, San Francisco, CA. June 24-29, 1984.

Annotation

This paper presents an update on progress in assessing emissions from broadcast burning of logging slash in western Washington and Oregon. The paper presents emission factors for carbon dioxide, carbon monoxide, nonmethane hydrocarbons, methane, BaP, and particulate matter (total and 2.5). The emission factors are reported by phase (flaming, smoldering). Data on fuel loading, fuel consumption, and moisture content are also presented.

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Slash

Baseline/Type of ERT(s)

Baseline - broadcast

Variables

Time of year burn performed

July, August, September

Location of burn

Western Washington, Oregon

Annotated Author Designation

Ward (5)

Author

Wayne, L.G.

Date of Publication

November, 1975

Original Research

Additional Authors

M.L. McQuery

Date study was performed

1973

Compilation

Other

Title

Calculation of Emission Factors for Agricultural Burning Activities

URL Address

Publication Reference

EPA-450/3-75-087

Annotation

The purpose of this project was to determine emission factors for various agricultural burning activities. This report utilizes agricultural burning data from several studies, including those of Ellis Darley at the University of California, to determine emissions factors. Emission factors, broken out into particulate, carbon monoxide, and hydrocarbon, are reported for various field crops, vine crops, weeds, and orchard crops as well as a few forest products.

Agricultural or Wildland

Agricultural and Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Asparagus, Barley, Corn, Cotton, Safflower, Sorghum, Grasses, Pineapple, Rice, Sugarcane, Alfalfa, Bean, Hay, Oats, Peas, Wheat, Russian Thistle, Tules, Almond, Apple, Apricot, Avocado, Cherry, Citrus, Date palm, Fig, Nectarine, Olive, Peach, Pear, Prune, Walnut, Hemlock, Douglas Fir, Cedar, Ponderosa Pine

Baseline/Type of ERT(s)

Headfire, Backfire, Sidefire, Cold, Roll-on

Variables

Time of year burn performed

Location of burn

Riverside, CA

Annotated Author Designation

Wayne

Author

White, Jerry D.

Date of Publication

1987

Original Research

Additional Authors

Date study was performed

Compilation

Other

Title

Emission Rates of Carbon Monoxide, Particulate Matter, and Benzo(a)pyrene from Prescribed Burning of Fine Southern Fuels

URL Address

Publication Reference

USDA, Forest Service. Southeastern Forest Experimentation Station. Research Note SE-346, April 1987.

Annotation

Emissions of carbon monoxide, particulate matter, and benzo(a)pyrene were measured during prescribed burning of four fine fuels by both backing fires and heading fires. Emission factors (g/kg) and emission rates (g/kg/s) were determined and were found to be within the range found by other workers in similar fuels. Emission factors appeared to be influenced somewhat by fuel type and fire type for all three pollutants. The emission rates are meaningful only for the fuel and weather conditions under which they were monitored, and generally fluctuated more than emission factors.

The report presents information on the conditions of the fuel type (loading by layer, moisture, available fuel) and average wind velocity and fire characteristics (flame length, rate of spread, and fire line intensity).

Agricultural or Wildland

Wildland

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Pine, pine-hardwood, pine-grass, pine-palmetto

Baseline/Type of ERT(s)

Headfire and backfire

Variables

Time of year burn performed

Location of burn

Georgia

Annotated Author Designation

White

Author

Young, William C.

Date of Publication

1999

Original Research

Additional Authors

Mark E. Mellbye, Thomas B. Silberstein

Date study was performed

fall 1986 through 1991

Compilation

Other

Title

Residue Management of Perennial Ryegrass and Tall Fescue Seed Crops

URL Address

<http://agron.scijournals.org/cgi/content/full/91/4/671>

Publication Reference

Agronomy Journal 91(4)

Annotation

This document reports the results of experiments conducted on fields established in western Oregon to compare the effects of (1) mechanical straw removal and flail-chopping the stubble (flail-chop), (2) mechanical straw removal and propane-burning the stubble (propane burn), and (3) open-field burning the residue on seed yield the following year. Treatments were tested for three consecutive crops years on two types of perennial ryegrass and two types of tall fescue. Seed yield components were measured to identify the components through which treatments affect yield.

Treatments did not affect seed yield of Regal perennial ryegrass and Martin tall fescue in any crop year. Third-crop seed yield of Pleasure perennial ryegrass was 15% higher than for open-burn than for the flail-chop treatment; fourth-crop seed yield was 12% higher for the open-burn than for either flail-chop or propane-flaming. Across years, seed yields of Rebel II tall fescue for propane-burn and open-burn were 8 and 12% greater, respectively, than for flail-chop. Variations in seed yield were apparently due to treatment effects on the number of seeds per tiller. We conclude that the need for postharvest residue burning in perennial ryegrass and tall fescue is cultivar specific. Mechanical removal is apparently as effective as open-field burning for maintaining high seed yields in some cultivars of these grasses.

Agricultural or Wildland

Agricultural

Emissions Factors

Emission Reductions

Resource Effects

Type of Fuel(s)

Perennial ryegrass, tall fescue

Baseline/Type of ERT(s)

reduced loading and propane flaming

Variables

Time of year burn performed

summer (?)

Location of burn

Western Oregon (near Corvallis)

Annotated Author Designation

Young