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Disposal of Logging Residues Without Damage to Air Quality

Owen P. Cramer

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A western Indian symbol for rain. It also symbolizes man's dependence on weather and environment in the West.

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Weather Bureau Technical Memorandum WR-37

DISPOSAL OF LOGGING RESIDUES WITHOUT DAMAGE TO AIR QUALITY

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WESTERN REGION
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PREFACE

The atmosphere has great capacity for carrying gases and suspended particulate without becoming noticeably polluted, and without significant effect on air quality. But not exceeding this capacity has been more a matter of chance than plan. Atmospheric management can no longer be left to chance. We are reaching the point when activities that affect the atmosphere must be regulated to conform to the atmosphere's varying capacity and rate of cleansing.

The meteorologist should be at the forefront of the atmospheric management effort. Meteorological management of activities that affect air quality may require highly detailed, accurate forecasts of parameters and conditions not heretofore regularly predicted. The potential for use of such air management forecasts is particularly great in the Western Region for application to fire hazard abatement, silvicultural burning, and solid waste disposal.

/s/ *Owen P. Cramer*

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DISPOSAL OF LOGGING RESIDUES WITHOUT DAMAGE TO AIR QUALITY 1/

"Forest fires are the most frequent causes of widespread pollution of the atmosphere". So said a Forest Service report issued in 1912.[1] Though clearing the smoky air was not their primary objective, it became apparent to foresters and lumbermen in the early 1900s, following a series of disastrous forest fires in the Pacific Northwest, that a concerted effort was necessary to prevent large forest fires. Many steps were taken. One was to remove the fuels which were often responsible. They found that when weather and fuel conditions were right, these fuels could be safely removed by prescribed burning. In those days as well as today, the most dangerous fuels in terms of both rate of fire spread and resistance to control efforts are the great accumulations of flammable, dry residue left after logging and overripe, virgin, old-growth forest. Over the years the use of fire to remove this logging slash has developed into a skillful art guided by an improved but still incomplete scientific basis. Large wild fires in the forest and attendant pollution episodes are now less frequent, but planned hazard reduction burning to prevent conflagrations is being severely criticized for its contribution to air pollution. One of our important problems today is then: How can we dispose of logging residues with minimum damage to air quality?

The logging residues or slash we are speaking of consists of branches, treetops, broken pieces, rotten wood, underbrush, litter of the forest floor, trees too small for harvest and logs that have such a high proportion of decay that it is uneconomical to take them to the mill. Slash is particularly heavy in old-growth Douglas-fir stands which characteristically have many rotten trees, both fallen and standing. In these multihundred year-old forests, it is not uncommon for a third of the total volume of standing trees to be cull material. This is not the situation in younger forests, particularly young managed ones from which the poorer trees or those that have died are selectively removed periodically in salvage and improvement cuttings. Though we have a gradually increasing area of young managed forests, it is estimated that we will be logging in some of the present old-growth Douglas-fir forests for another fifty years. During that time old-growth decay likely will about equal growth. So the problems of heavy volumes of slash will be with us for some time.

1/ Presented at the National Science Teachers Association, Portland, Oregon, October 11-12, 1968.

It is an old forestry rule that you can't practice forestry if you can't protect forests from fire. And if you are raising a flammable crop that takes 80 to 100 years to mature, you don't want it to be intermixed with one of the most dangerous forest fuel types. A wildfire that gets into logging slash is rarely stopped in the slash, particularly under the severe fire-weather conditions under which wildfires usually occur. Because of the long history of disastrous fires in which slash fuels played a major part, the states of Oregon and Washington have both required that the logging slash hazard be abated. The resulting hazard reduction fires have come to be a regular part of good forestry practice over much of the Douglas-fir region.

Considerable preparation goes into a slash burn: A detailed burning plan is prepared, fire trails are constructed around the clearcut area, usually a patch of 30 to 100 acres, water sources are prepared and hose lines are strung out, devices for measuring the moisture content of the slash fuel and the moisture content of the adjoining green forest are set out and observed daily. The actual burning is done when the measured moisture content of the slash itself permits fire to spread in the slash but without becoming difficult to control. The moisture content of fuels in the adjoining forest must be sufficiently high so that fire will not spread there. The detailed fire-weather forecast must indicate a period of 24 to 48 hours with comparatively light winds and no severe fire weather in sight. This necessary combination of weather and fuel conditions does not occur very often, possibly on 10 to 15 days in the year, mostly in early autumn.

The objective of the fire is not to remove all burnable material, but merely the flashy fuels and fuel concentrations, and to kill back brush that would compete with young trees of the next crop. When a slash burn has been completed, the area is hardly what one would describe as a thing of beauty, but it is accessible for planting crews, there is little fuel left which would support a fire, and competing vegetation has been set back. The fire has not been so severe as to completely remove a soil's protective cover of forest duff. By contrast, a wildfire besides not confining itself to any prescribed area, is usually quite destructive to the basic soil resource, first by direct damage from excessive heat, and second, by leaving the soil unprotected and open to erosion.

Most foresters would be quite happy if it were not necessary to burn slash, because fire always carries with it some risk of spread to areas not intended to be burned. In addition, there is the risk of hold-over fire from which wildfire might later start during severe fire-weather conditions. But up to the present time prescribed burning has proved to be the only economical way to do the job on many areas.

For the past 20 years at least, unburned slash has been the primary fire control problem in the Pacific Northwest. Some research is presently under way to explore and develop other procedures for removing the logging residue. More is needed. Also, the efforts to develop more efficient logging equipment that permits economic handling of progressively smaller material should be strengthened. Higher prices for wood fiber and an increasing market for wood chips have resulted in the removal of more lower grade material. And we can look forward to continued progress along these lines. Up to the present, however, there has not been a market for rotten wood, branches, tops, brush, broken small pieces, and excessive litter. New techniques are being tried for treating this remaining material to render it less hazardous and to speed its natural deterioration, but these in general do not apply to the heavy slash of old-growth Douglas-fir forests. Despite these gains, every active fire season proves again the necessity of removing old growth logging slash, and up to the present time the best method seems to be by prescribed burning.

What is the Problem?

All right, so foresters have improved their skills in the application of fire for removal of dangerous fuel concentrations prior to planting the next crop. But where is the problem? In western Oregon and Washington some 125,000 acres of old growth slash are burned annually. Each acre is about the size of a city block and on the average may be covered with some 140 tons of burnable material. About half of this, or 70 tons, may be consumed by the slash fire. This is a big burning job and makes a lot of smoke, particularly when the job is crammed into a comparatively few days. At this particular time, we are all aware of and applaud the great effort to reduce air pollution. The problem is doing this tremendous burning job without causing serious deterioration of air quality.

Fortunately smoke from logging slash fires has certain distinct differences from the usual sources of pollution:

1. It originates in large, high-energy convective columns.
2. It is mostly remote from populated areas.
3. Its source is usually already at a high elevation.
4. Each smoke lasts only a few hours.
5. It has some scheduling flexibility.

What is the usual pollution situation? Most aerial pollutants originate in the more densely populated areas, which are normally situated on flat terrain or in valleys where the lower layers of air are most likely to be stratified. In stratified or stable air, the lower strata tend to stay near the surface and upper strata tend to remain aloft.

Since the usual pollution sources, such as transportation, heating, and industrial plants, are more or less continuous day after day, when the low-level air becomes markedly stratified and stops moving, the pollutants tend to accumulate in readily noticeable proportions.

One of the most frequently suggested solutions to common pollution situations is to discharge the effluent at a higher elevation through use of taller stacks. Several have suggested that industries with an effluent problem move into the hills where the effluent would enter higher layers of air that would remain above the valley air. Most slash areas are already in the hills. A glance at a forest-type map of northwest Oregon shows the areas of commercial Douglas-fir forest to be primarily in the Cascade and Coast ranges, well away from population centers. A large red area in the Coast range is the Tillamook Burn, a reminder of the futility of practicing forestry in the midst of hazardous fuels. But the main point here is that our forests are primarily in the hills.

You are all familiar with the principle that warm air being lighter than cold air tends to rise. Warm smoke rises above a fire. The hotter the fire, the faster the smoke rises. Smoke from a large, hot fire will rise farther than smoke from a small fire. Because of the nature and the amount of the fuel, a slash fire is a high energy fire that produces a large, hot convective column which usually transports the smoke several thousand feet above the fire. The height to which it rises depends also on weather--if the temperature of the surrounding air decreases rapidly with elevation, column height will be comparatively great. On the other hand, if the air temperature decreases slowly with elevation, or not at all, or even increases with height, the air is markedly stratified, and the rise of a smoke column would be severely restricted. Fortunately, stability of the air or its tendency toward stratification, is a predictable quality and one that is or should be considered in selecting favorable burning conditions.

Even though most of the smoke from slash burning is either introduced at or rises to elevations far above the main communities in the Northwest, there is still a twofold objection to slash smoke. It is objectionable because it reduces visibility and sunlight in this region where some of our most treasured scenery is the distant mountains. Since much of our region's green beauty is a result of its abundant rainfall, there are many days when the mountains are obscured by the natural phenomena of clouds, rain or fog. On many other days the usual pollutants of the lower layers accumulate to such an extent as to limit low elevation visibility to only a few miles. Hence, we tend to resent any activity which may further limit our mountain viewing.

I mentioned that there was another objection. This is a rather general reaction that any smoke or other material that goes into the atmosphere is pollution regardless of what it contains or whether it actually gets into air layers that come in contact with people. But this is the subject of another session.

What Can Be Done?

So, what can we do about it? One answer suggested by air quality control agencies is to stop burning. Foresters feel that such a solution is similar to the discontinuance of sewage processing to avoid the odor from the sewage disposal plant, or the disbanding of the police force in order to eliminate police brutality. Prevention measures do sometimes involve somewhat unpleasant side effects as for example, the reaction some people get to a flu shot. But there are a number of things we can do to minimize the unpleasant side effects.

In the interest of good air conservation, slash burning guidelines could include: (1) avoid adding our smoke to already overburdened air layers, particularly the lower layer in which most of us live, and (2) avoid placing smoke in air that will have a daytime trajectory over sunshine sensitive areas. It would be desirable for the slash smoke column to exhaust into a rapidly moving air mass, which could quickly disperse the smoke and remove it from the area. Most desirable would be burning so that the smoke would soon enter an actively condensing and precipitating cloud system thereby assuring a very short air life for the combustion products most of which are either water soluble or act as condensation nuclei.

What is required to apply these air conservation guidelines? Success would require precision in scheduling the burn based on (1) very accurate prediction of the weather conditions that affect both the burning operation and the dispersion of the smoke, and on (2) detailed monitoring of the pollution load in various layers of the atmosphere in the regions from which the air is approaching, as well as in the areas toward which the air is moving.

Particularly in the West, fire control agencies already make intensive use of the Weather Bureau's highly specialized Fire-Weather Service, which prepares detailed predictions of weather conditions affecting all phases of the job of protecting the forests from fire. But to cover air quality aspects of the slash burning job, forecasts would need to be more detailed and to include information not presently available. Besides indicating expected surface weather details, the forecast would need to cover upper winds at various levels and upper-air temperatures indicative of the degree of air stratification over forest areas throughout the burning period.

From such an improved forecast, prescribed burning specialists of the fire-control agencies could estimate expected convective column heights from slash fires at various elevations. Only those areas might be burned which could produce a convective smoke plume high enough to exhaust into a layer where wind trajectories would provide adequate dispersion and transport of the smoke. The forecast would also indicate the time period during which favorable burning and smoke dispersal conditions might exist for the main convective column. A separate portion of the forecast would cover the trajectory and dispersion of low-level drift smoke from residual fires remaining after the main burning job is completed. This forecast would indicate the need for a special effort to extinguish sources of smoke that might enter the usual nighttime downslope air drainage that might eventually carry smoke down into populated areas or to lower layers where the smoke could not be tolerated.

This kind of a meteorological management approach, while it would not apply to most sources of air pollution, applies very nicely to slash burning in the Pacific Northwest. Meteorological management is feasible, first because of the flexibility in scheduling of the individual burns each of which requires only a period of a few hours for accomplishment. Second, most of the areas to be burned are already located at a high elevation, and the fire itself produces a high-energy convective column that carries the smoke during the most active part of the fire upward an additional 2,000 to 5,000 feet. Third, most of these burns are remote from populated areas. Finally, west of the Cascades we have the additional advantage, during most of what might be considered the potential burning season, of a two-layered atmosphere. The lower 2,000 to 4,000 feet is cool marine air from the Pacific and is separated from higher layers by a stable layer or inversion. This stable layer confines pollutants originating at lower elevations to the lower layers, but at the same time it also prevents higher elevation air with whatever it may carry from mixing with the air at lower levels. Most slash smoke either originates in or exhausts into the higher layer.

Meteorological management will also apply to the burning of slash areas located at low elevations, although the necessary conditions will be more exacting, and are likely to occur less frequently.

What Prevents the Solutions from Being Implemented?

Although the necessary forecasting techniques are probably already available, such detailed forecasting could not be accomplished without detailed reporting from both surface and upper-air observing stations in the mountainous terrain for which the forecasts would be prepared. We do not have these now. Also, new techniques would be needed for maintaining surveillance over the pollutant loading of various layers of air both upwind and downwind from intended burn areas. The necessary reporting could be provided if sufficient financing were available. But another obstacle is possible public pressure to eliminate all burning regardless of location, type, or consequences, and without regard to whether or not the smoke actually becomes or appreciably contributes to a nuisance. Absolute prohibition of slash burning will not solve the smoky air problem and might cause much more serious problems of forest fire control.

What's the Outlook?

Looking into the next 20 years, we can see a steady lessening of the old-growth Douglas-fir slash disposal problem:

1. A continuing increase in utilization of wood will leave less of the heavy slash that requires treatment by burning. Efficiency of logging equipment will continue to increase. The demand for wood fiber will continue upward and more material will be converted to chips in the woods. Pieces unsuitable for pulp chipping might be converted into fuel for generating thermal power in highly efficient combustion chambers that would contribute a minimum to air pollution.

2. Treatment of remaining fuels will change. Large material may be piled during logging for winter burning. Cheaper mechanical treatment will reduce the hazard from lighter slash without burning.

3. The burning job may become more efficient and less smoky. Research currently under way points to the possibility of altering the combustion process and thereby the combustion products. Electrical ignition systems will permit area ignition giving greater control over the rate of energy release and the height of the convection smoke column.

4. Finally, progressively less cutting will be done in the presently overmature old-growth forests while progressively more cutting will be in clean, managed younger forests.

Also during the next 20 years, there should be considerably greater research attention given to effects of air pollution other than on visibility, health, and damage to plant and animal life. The air has great capacity for cleansing itself through processes of coagulation and fallout of small particles, the dissolving of soluble gases in precipitation and in the oceans, and the cleansing by precipitation processes which utilize smoke particles as condensation nuclei. However, there are conditions, due to stagnation of air masses and long trajectories that do not intersect precipitating systems, when the atmosphere's load of particulate and gases may build up to proportions which might affect weather conditions. Particulate clouds intercept some of the sun's radiation thereby reducing heating of the surface of the earth and resulting in lower surface temperature. In contrast, many scientists have pointed out that a gradually increasing amount of carbon dioxide in the atmosphere can have the opposite effect, because of carbon dioxide's capacity for absorbing infrared radiation, thereby causing an increase in the temperature of the lower layers of the atmosphere. A great increase in particulate in the atmosphere might also alter cloud and precipitation patterns. This effect might come about as a result of too many condensation nuclei which would result in greater numbers of smaller cloud droplets which might not grow large enough to fall out as precipitation, thereby cutting down on the total amount of precipitation received in some areas. Though these three influences are today only possibilities, they must be taken seriously because of their potential for long-term alteration of the world's present climatic patterns.

It is likely during the next 20 years that the responsibilities for maintaining high-quality environment that are now exercised by separate air and water pollution control authorities and solid waste disposal authorities will be coordinated so that each waste problem can be reasonably considered from all angles. It is entirely possible that certain solid waste disposal problems, such as the problem of the old-growth Douglas-fir logging slash, can best be solved through carefully conducted high energy fires that exhaust their smoke at high elevations far above the air layers in which we live. Nevertheless, even this comparatively efficient type of burning might have to be conducted on a very strict quota basis which would permit only the most critical solid waste disposal problems to be taken care of by combustion.

In the meantime, the research needed to resolve this complex of problems should be carried on by scientists in the fields of:

1. Wood fiber and paper chemistry.
2. Forest utilization and logging engineering.
3. Combustion chemistry and physics.
4. Atmospheric chemistry and physics.
5. Fire-weather meteorology.
6. Combustion engineering.
7. Forest fire control.

Through their efforts, and your efforts, as teachers, to develop such competent researchers, we and future generations can look forward to continuing enjoyment of the economic and recreational values of this forested region, unscarred by large forest fires and not veiled by a pall of smoke.

Reference

[1] Plummer, Fred G. "Forest Fires". U.S.D.A. Forest Service Bulletin 117, 1912.

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