THE U.S. FOREST SMOKE POLLUTION PROBLEMS RELATED TO WESTERN AUSTRALIA

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INTRODUCTION

The intent of this report is to make West Australian foresters more aware of the problems associated with forest fire smoke. This report was prompted by my growing conviction that the problems faced today by the forest industries and the public over air quality legislation in North America might soon become a reality in Western Australia.

Over the last ten years, public pressure for clean air has led to the establishment of restrictive smoke management legislation in the U.S. These forbid industry and forest management groups from conducting burning practices during days of possible air pollution accumulation. Unfortunately, many of these regulations were set up on the basis of emotional reaction rather than true scientific inquiry. In the past, forest burning was carried out with little regard for public inconvenience or opinion. Even less was done to investigate the ever-increasing chances of health endangerment and atmospheric fouling by wood smoke. As a result, forest industries are today forced to accept restrictive prescribed burning regulations which, in the present light of knowledge, many feel are unjustified.

In this report I have gathered togather some of the latest findings on the measured effects of wood smoke components on human health and the atmosphere. I have taken the liberty to present my ideas on a future course that Western Australian forest managers might follow in order for the Forests Department to prepare itself against future criticism of the prescribed burning policy.

THE PROBLEM

Wood smoke has always been an inevitable and natural part of man's environment since he learned to use fire. However, in recent decades, smoke from forest wildfires and prescribed burns has been considered on a par with any other emission that might effect air quality. The present crusade to reduce air pollution points an accusing finger at all burning that utilizes forest fuels. The general public believes that anything in the air except air is dangerous pollution that must be prevented. The more visible it is, the more dangerous, and the smoke from the burning of forest fuels is certainly visible, especially to the vocal 'city man' who is driving through forested country.

The criticism that smoke from prescribed burning practices is a visual nuisance might be acceptable, but it is questionable that this smoke is a public health hazard. From the several reports I have read on the topic, there is little medical evidence to support the notion that wood smoke is dangerous to public health, although it seems that the current amount of knowledge on the products of wood combustion is less than the ignorance on this topic.

COMPONENTS OF WOOD COMBUSTION

There is general agreement that, in burning forest fuels, the hottest fires with ample oxygen and longest possible residence time of combustion lead to the most complete combustion. The products of complete combustion of wood are mostly water vapor and carbon dioxide. However, this reaction rarely occurs, even in the fiercest wildfire. More commonly, the combustion is incomplete, and the products, which are dependent on the fire temperature and the chemical make-up of the fuels, are mostly complex organic molecules. These result from the thermal decomposition of wood which occurs in several ill-defined stages. Each thermal stage results in the emission of varied gaseous products such as formic and acetic acids, methane, ethane, formaldehyde, carbon monoxide, and various hydrocarbons. All of these products are greatly diluted by the major emissions of carbon dioxide and water vapor. A normal fire will burn at a very wide range of temperatures and will emit some of all the possible mixtures. Although the emissions are many and varied, there are only a few that need concern us in this discussion. These include carbon monoxide, particulates, nitric oxides and both simple and poly-nuclear hydrocarbons (PNH). These have received a great deal of attention because of their well-known toxic qualities or nuisance effects.

Carbon Monoxide (CO)

Aside from carbon dioxide, not considered a pollutant, CO constitutes, in tonnage, by far the largest percentage of air pollution components. Since its toxic nature has long been recognized, an enormous amount of reference literature has been written on it. However, very few actual measurements of CO production per ton of forest fuel have been carried out. Countrymen, in 1964, working on large fires in piles of heavy fuels arranged in systematic patterns, found, as expected, lethal concentrations of CO in the active part of the fires studied. However, these CO concentrations were very much lower towards the edge of the fire. He reported that "no significant concentrations were found in the 'streets' of the test fire." Several other reports confirm this finding, so it seems that increased concentrations of CO do not persist for more than a short distance from the going fire.

Interestingly enough, the concentration of CO does not seem to be increasing in the atmosphere despite the great amounts produced in modern times mainly by the incomplete combustion of petroleum fuels in motors. Several theories have been offered as to the disappearance of the newly produced CO, the most convincing of which suggests that micro-flora (fungi and bacteria) in the soil may be the major CO sink.

In any case, the impression in the public mind that highly toxic quantities of CO accumulate in the atmosphere should be allayed. And furthermore, it appears that the contributions of CO by forest fire smoke are at the most insignificant, especially when compared to those made by car engines and industries.

Particulates

The visible smoke from a fire is actually water vapor made visible by its condensation on to fine particulate matter. Particulates are formed by the combining of hydrocarbons emitted from wood fire with each other or with molecules of oxygen or formaldehyde. The fine particulates appear to aggregate rapidly into larger particles, contributing to the bluish smoke from a fire after most of the water has been driven off. Such material does not remain suspended indefinitely in the atmosphere, for the smaller particles combine further to form even larger particles which fall out in a relatively short time. In a moist air mass, the particulates act as condensation nuclei forming droplets of moisture. If the smoke column is within existing clouds, the droplets will grow along with the cloud drops and will fall out with the first rain. Under dry atmospheric conditions the moisture vapor in the smoke column will evaporate leaving the particulates visible. Thus, particulates will remain suspended in a dry air mass longer than in moist conditions.

Of all the properties of particles in the air, none dominate the behaviour of a particle more than its size. Research on this aspect indicates that smoke particulates are of two major size groups. In general, sub-micron particles are dominated by Brownian motion and remain suspended for many days. Larger particles will settle out of still air.

The effect on visibility in a particulate emission depends more on the size of the particles than on the concentration of them. Sub-micron particles have a much greater ability to scatter light than do the larger particles, and are therefore more visible to the eye.

The fate of the particulates in lung tissues is not well known although there is some evidence that coarse particles are well taken care of by the mucociliary system in the respiratory tract, while finer particles probably enter the alveolar tissues of the lungs. Medical experts at several air quality conferences are of the opinion that such materials are rendered soluble by enzymic action, and are able to enter the blood stream where they are eliminated.

Obviously, any conclusion as to the impact of fine particulates on human health is premature, as a great deal of research still needs to be done. However, present signs are promising, and if proven correct, will help to alleviate that source of public concern.

<u>Hydrocarbons</u>

Unsaturated hydrocarbons are produced by the incomplete combustion of organic fuels, especially petroleum fuels and coal. These compounds, due to the absence of a hydrogen atom in the molecule from adjacent carbon atoms, have a very high affinity for oxygen or other oxidation elements. If such a reaction occurs in their presence, there is a photo-chemical oxidation. The result is photochemical pollution, as is found in Los Angeles. This can be quite dangerous to health. There is strong evidence that the hydrocarbons produced from forest burning are for the large part not photochemically reactive. Nor have they been shown to be a health hazard. The worst that can be said of them is that they may condense to form visible aerosols of particulates.

In 1966, Darley and others measured the yields of hydrocarbons during the burning of such woody fuels as natural brush, wood chips, and fruit tree prunings. By comparing these with average hydrocarbon emissions from petroleum exhausts, he found that for the San Francisco Bay area the <u>annual</u> yield from agricultural burning practices approximated the <u>daily</u> yield from automobiles in that area. Measurements on forest fuels by Fritschen and others (1971) confirmed the findings that the wood smoke contributions of hydrocarbons were insignificant beside those from automobiles and large industries.

<u>Polynuclear Hydrocarbons</u> (PNH)

The PNH compounds have been shown to produce cancer in susceptible strains of experimental animals and are therefore suspected of causing human cancer. In general, PNH result from combustion of fossil fuels such as coal and petroleum although they are probably released in relatively small amounts in the combustion of forest fuels (Hall, 1972). Urban communities have more PNH in the atmosphere than rural areas, with the highest figures reported from coal burning cities. However, all this information is not meant to frighten anybody since we are, have been, and always will be exposed to PNH. These compounds occur widely in the plant world, including many items of the human diet. Researchers find it indeed difficult to envision any significant increase in urban exposure to PNH attributable to the burning of forest fuels.

<u>Nitric Oxides</u>

The infamous photochemical smog of Los Angeles is a highly specialized smog, the ingredients of which are certain petroleum-based hydrocarbons, lots of sunlight and nitric oxide. In order for Nitric Oxide (NO) to form, temperatures are needed well above the probable maximum temperature of forest fires. In fact, the NO component in photochemical smog is derived from petroleum combustion.
Hall (1972) in his summary on the nature of combustion

products of forest fuels, stated that "it is inconceivable that the slight amounts, if any, of NO from combustion of forest fuels could have any measurable effects on the creation of photochemical smog or toxic effects on vegetation or humans."

SMOKE MANAGEMENT GUIDELINES

Education

During the last eight years there has been an accelerated research and development program in the U.S. to deal with the potential of air pollution problems from forest burning. The result of much of this work provided the few facts I have summarized above. Armed with these facts, foresters and forest researchers are trying to explain to a sceptical public the reasons for forest burning and what is known about its effects on the ecosystem. However, progress is extremely slow because of the lateness of these restoration efforts. The public is already convinced that fire and smoke are evil and harmful, and are unwilling to accept explanations from a defensive forest industry.

Fortunately for Western Australian foresters, this situation has not been reached as yet, and there is still time to develop a public education program on the role of fire in the environment. This must be done before legislation is created imposing restrictive burning limitations, which are now a way of life in many states of the U.S.A.

Education is the most powerful force available to shape opinion towards acceptance of fire and smoke in the environment. The success of the 'Smokey Bear' fire prevention campaign is a remarkable example of this. Forest authorities in W.A. would do well to follow this course of public education. However, education alone will not be enough to allay public concerns, and unless smoke management practices are followed diligently, all the prescribed burning promotion campaigns in the world will not succeed.

Meteorological Management of Smoke

When known and practical procedures are followed in prescribed burning of forest lands, troublesome pollution in large population centres, for example, can be reduced to a minimum that will not be objectionable. Such procedures involve proper integration of burning schedules with weather reports and close co-operation between meteorologists and forest managers.

Prescribed burning can be scheduled so that wind direction will take smoke away from 'smoke-sensitive' areas. Such areas would be defined by a smoke management plan, and would include heavily used recreation areas and major airports, besides dense population centres. Burning should be minimized when smoke could tend to accumulate, as in calm winds, under deep inversion layers, or when the air already carries a load of pollutants from other sources. Loading of the atmosphere can be minimized by burning into moist air that would remove particulates from the air through condensation and rain. With logging slash, it is of benefit to produce as hot and fast a combustion as is practical, as this not only leads to better site preparation and reduction in fuel hazards, but aids in the quick dispersion of smoke. Piled and dry fuels, atmospheric instability and moderate winds all ensure more complete combustion and rapid smoke dispersion; but, obviously, the advantages of good dispersion must be weighed against fire control and safety needs and the attainment of burning objectives.

Fuel Management Alternatives

There are many significant developments of techniques for ignition and burning of slash fuels which as yet are untried in W.A. Some of these are experimental and costly, but have helped solve some problems in the U.S. For example, electrical ignition systems, using wired circuits with prelocated ignition points have proved quite effective for quick ignition and fire establishment, and for achieving some measure of control over fire behaviour and smoke production. Napalm grenades have been tested with some success in difficult access areas as an incendiary device, and research is continuing on the development of other efficient ignition techniques.

Finally, there are developments related to alternative methods of slash disposal. Mechanical crushers, portable chippers, portable burners and burying equipment have all been developed as a result of severe burning restrictions in many logging areas. All these mechanical devices are extremely expensive and possess many limitations. However, they may conceivably be Western Australia's lot if events are allowed to parallel those of the U.S.A.

CONCLUSION

From my search of the literature I have found no evidence that links the combustive products of forest fuels with permanent injury to human health. In general, the only penalty inflicted upon the environment by prescribed burning is a temporary decrease in visibility. This is a slight cost for the rewards obtained in avoiding wildfires through the practice of prescribed burning techniques. This penalty can be decreased largely by the forest manager through the observation of smoke management guidelines and the close co-operation with meteorologists. The importance of public attitudes is stressed, and it is proposed that a public information campaign on the effects of fire and smoke on the environment be instigated as soon as is practical.

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