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Author Tarrant, R. F.

Corporate Author Pacific Northwest Forest and Range Experiment Station,

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THE FUTURE ROLE OF CHEMICALS IN FORESTRY

PROTECT

Use Pesticides Safely

FOLLOW THE LABEL

U.S. DEPARTMENT OF AGRICULTURE

R.F. Tarrant
H.J. Gratkowski
and W.E. Waters

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION PORTLAND, OREGON
FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

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R. F. Tarrant is assistant director, and H. J. Gratkowski is project leader, Pacific Northwest Forest and Range Experiment Station. W. E. Waters is chief, Forest Insect Research Branch, USDA Forest Service, Washington, D. C.

PESTICIDE PRECAUTIONARY STATEMENT

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers--out of reach of children and pets--and away from foodstuff.

Apply pesticides selectively and carefully. Do not apply a pesticide when there is danger of drift to other areas. Avoid prolonged inhalation of a pesticide spray or dust. When applying a pesticide it is advisable that you be fully clothed.

After handling a pesticide, do not eat, drink, or smoke until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. If the pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Dispose of empty pesticide containers by wrapping them in several layers of newspaper and placing them in your trash can.

It is difficult to remove all traces of a herbicide (weed killer) from equipment. Therefore, to prevent injury to desirable plants do not use the same equipment for insecticides and fungicides that you use for a herbicide.

NOTE: Registrations of pesticides are under constant review by the Federal Environmental Protection Agency. Use only pesticides that bear the EPA registration number and carry directions for use.

SUMMARY

As a result of an increasing population, our reduced acreage of forest land will be called upon to produce maximum amounts of wood fiber, to satisfy an ever-increasing demand for recreational use, and to produce maximum amounts of clean, pure water. Under such demands, forestry must be practiced with an intensity that is beyond our ability to conceive at present. Of necessity, every tool, including chemicals, must be used in this intensive management for the good of mankind. To achieve these aims, it will be also necessary that we quickly acquire a detailed and intimate knowledge concerning the interactions that occur within forest ecosystems--not only natural interactions among plants, but also those that occur when we artificially induce changes in structure or composition in communities or ecosystems by artificial means. Such changes may not only affect vegetation; they may also affect atmospheric, wildlife, and microbiological conditions as well.

Chemicals are useful, necessary tools for helping to meet needs for food, wood fiber, and water, while man readjusts his numbers and modes of life to the rapidly dwindling resources of the earth. The more selective, less persistent chemicals will continue to play an important role in forest resource management, probably for several decades. However, chemical use must eventually be minimized, for it is simply a system of treating symptoms of unhealthy ecological conditions created by nature or man in the past.

Technological, environmental, and socioeconomic factors will add new dimensions to chemical use, placing greater demands on the research and development process.

Our pressing need, aside from solutions to problems of population pressures and extravagance in natural resource use, is rapid development of the ecological knowledge necessary to manage and maintain a healthy biosphere with minimum use of chemical tools.

KEYWORDS: Chemical control (pests), forest management, pesticides.

INTRODUCTION

We live in a chemical-oriented society. The chemical industry, one of the largest single segments of the world economy, continuously presents us with new materials intended to improve some aspect of human existence. These contributions are viewed as technological advances by some people; others view them as instruments of impending doom. In the moderate view, it is clear that new advances in chemistry are helping support our increasing world population, but some products may have unforeseen adverse effects on humans or their environment.

Although the use of chemicals in forest management goes back a century or more, large-scale use of these materials is a comparatively recent development. Much of the impetus for employing chemicals as silvicultural and pesticidal tools resulted from the availability and effectiveness of materials such as DDT and the phenoxy herbicides whose development was spurred by World War II. Although these new materials were developed with other uses in mind, many proved helpful in controlling insects and unwanted vegetation on forest lands. For the first time, materials that were highly effective against target organisms, relatively inexpensive, and compatible with aerial application methods were available to treat large areas of relatively inaccessible forest lands.

These new materials, especially pest control chemicals, were quickly adopted by forest managers responsible for increasing productivity of forest lands to meet rapidly increasing demands for timber and other forest resources. From 1946 to 1960, use of pesticidal chemicals in forests expanded greatly. However, even at its height in 1960, the total use of pesticides in forest applications was never more than a small fraction of the total use of such materials worldwide. Hall (1962) noted that during the period of greatest insecticide use in the United States, less than 0.03 percent of our 630 million acres of forest lands was treated in an average year; that 95 percent of our forest lands were never treated with an insecticide; and that the average application rate on treated land was less than 1 pound per acre.

Since 1960, concern for the environment has intensified greatly. One effect of this concern, with its attendant controversy, has been to greatly reduce the use of chemicals in forestry. Some chemicals have been banned by law. Others have been withheld from use pending further evaluation of their effects on nontarget organisms and food chains. Others, under development, have been set aside until society and governments determine the future role of silvicultural chemicals.

It is important that the future role of chemicals in forestry be clarified and that criteria be established for assessing their need, effectiveness, and safety. These criteria and related determinations must be based on factual data. Limitations in our knowledge must be clearly spelled out, so that more specific research can be directed to obtain the necessary information.

FOREST PEST CONTROL

Protection against destructive pests is necessary in forest resource management. The cumulative, damaging effects of insects, diseases, and animals seriously limit the productivity, usefulness, and value of forests. In many ways, these pests disrupt management planning and operations throughout the lifespan of a tree crop. In both ecological and economic terms, they represent a component that must be fully understood and controlled in order to obtain optimum outputs and benefits from the forest resource.

Pesticides have long been a primary means of defense against forest insects. They have played a less important role in preventing damage by microorganisms and animals.

Since World War II, significant changes have occurred in the kind and complexity of chemicals used, in equipment and techniques of application, and in general strategies and patterns of use. There has been a phenomenal increase in the number of pesticidal compounds synthesized by commercial manufacturers. These have varied greatly in their chemical and physical properties and in their biocidal capabilities. Until recently, emphasis has been given to compounds that were toxic to and potentially useful against a wide spectrum of target pests. New and sophisticated airborne and ground equipment has been developed for applying pesticide formulations, and new techniques of treatment have evolved. Aerial application of insecticidal sprays to forest areas, for example, now involves aircraft formations, turning patterns, and navigational systems derived directly from military operations. These technological improvements have been an important factor in advancing the use of chemicals against forest pests.

Socioeconomic factors also have had a considerable influence. A worldwide increase in demands for timber products and increased values placed on forests for watershed protection, wildlife habitat, and recreational use have resulted in intensified forest resource management and attention to protection against destructive pests. These new considerations in forest management will probably have a greater effect in determining the future role of pesticidal chemicals in forestry than will the purely technological developments.

Universal concern about the environmental safety of pesticidal chemicals is now having profound effects on the types of chemicals allowed and the manner in which they may be used. This concern involves both their hazards to man and other nontarget organisms in the environment and dangers inherent in processing and handling the materials. Many governments have initiated legislation to regulate pesticide use, and additional statutes are under consideration. Severe restrictions have been imposed on the use of some materials, especially DDT and other chlorinated hydrocarbon insecticides. Some restrictions are categorical, most are provisional. Greatly expanded efforts are being made by a number of agencies in the United States to better evaluate the safety of major pesticides now in use and to develop improved standards for evaluating new chemicals. Other countries are also attempting to establish sound scientific criteria for evaluating the environmental safety of pesticidal chemicals. In the United States, mechanisms have been established for public involvement in the review and decisionmaking processes.

Governmental actions, guided by public opinion as well as technical considerations, undoubtedly will increase in scope and intensity. Research and operational use of pesticides will be affected accordingly.

We can anticipate that the present trend toward more selective, less persistent chemicals will continue. In the United States, DDT has not been used by the Forest Service in forest insect suppression projects since 1967. Use of other broad-spectrum, long-term toxicants has also been reduced. Moreover, we can expect more emphasis to be given to techniques and strategies that will minimize the need for repeated treatments. This will reduce the chances of unexpected and adverse changes in the balance and structure of forest ecosystems.

Research on alternatives to toxic chemicals for pest control has increased significantly during the past 20 years, and results are beginning to appear. For insect control, much attention has focused on attractants, repellents, and feeding deterrents. Attractant compounds include chemicals produced by the insects themselves (pheromones) and host-produced chemicals. The primary attractants of more than 20 major forest insects have been identified, and means of synthesizing them have been developed. Most insect repellents and feeding deterrents are synthetic chemicals discovered through routine screening or trial-and-error testing programs. Large-scale field experiments are underway in the United States and Canada with attractants of the gypsy moth, spruce budworm, western pine beetle, mountain pine beetle, and southern pine beetle to determine what formulations, trapping techniques, release times, and deployment patterns are most effective.

Experiments are also being conducted with repellent and feeding deterrent compounds. The prime objective with these materials is to provide tree protection, not insect control *per se*.

Since these behavioral chemicals are pesticides in the legal sense (in the United States at least), they are subject to the same requirements of safety evaluation for registration as conventional toxic insecticides. Because they are limited to only one target pest and may be required for operational use only sporadically, commercial manufacturers have little or no interest in them. The entire research and development task, including safety testing, must be borne by governmental agencies or universities. The nature of these materials, the many variables affecting their operational use, and the need to evaluate environmental and human safety require a greatly expanded research effort and increased funding and organizational support. In general, the development of more selective, safe, and biologically efficient pesticidal chemicals will require broader participation by public agencies and corresponding increases in expenditures for research and education (Brady 1972).

Another factor that will affect the future of pesticidal chemicals in forestry is the emerging concept of integrated control or, more broadly, pest management. Reliance on chemical treatments as the sole, or primary, means of protection is hardly defensible today. Chemical control of destructive forest pests will be increasingly considered, planned, and conducted as part of a comprehensive, long-term management plan in which pesticide treatments are only one of a number of options available to the forest resource manager. Chemical treatments undoubtedly will have continued high priority, however, in protecting trees in special-use areas such as nurseries and seed orchards.

To make forest pest management practicable and acceptable, clearly cut thresholds for action must be established. Decisions--especially with chemicals--should not be arbitrary or capricious. The criteria for decisionmaking must be understood by the governmental regulatory agencies concerned, by the public, and especially by the forest resource manager himself. The kind, extent, and degree of impact that is acceptable will depend on the pest involved, its effect on the forest stand, and the resource values at stake. Ecological and socioeconomic factors relevant to each case must be identified, analyzed, and thoroughly evaluated. For every destructive insect, disease, or animal, then, there will be many thresholds for action depending upon circumstances. Above all, we can be sure that the social, economic, and legal pressures for sound, defensible decisions on pesticidal chemical use will increase in the future.

FOREST VEGETATION CONTROL

Herbicides and other vegetation control chemicals have assumed an important role in forestry throughout the world. We have derived great benefits from the use of chemicals in culture of forests, rangelands, and croplands. On forest lands, we have increased the growth of desirable tree species by releasing them from competition of undesirable vegetation; through reclamation and reforestation, hundreds of thousands of acres of formerly nonproductive lands are now producing young vigorous forests; and large areas are producing tree species more useful to man than the scrub trees and shrubs that formerly occupied those sites.

Development of the phenoxy herbicides 30 years ago provided foresters with an effective and economical way to modify structure and composition of plant communities. Today, chemicals for vegetation control include well over 100 herbicides, silvicides, growth regulators, growth inhibitors, desiccants, soil fumigants, and soil sterilants. In 1967, at least 30 major companies in North America, Europe, and Japan were producing such compounds (Day 1967). In addition, about a dozen new biologically active compounds become available each year--far more than can be adequately tested and introduced with proper techniques for safe use. Until the past few years, the expanding literature indicated that this rate of growth might continue. Then, increasing costs and more stringent regulation took their toll. The chemical pesticide industry is increasingly discouraged with prospects for the future; some have closed their plants and others have curtailed research and development (Hollis 1972). Despite this, we continue to seek more selective, more effective, less expensive, and less persistent herbicides for specific problems.

During the same period, our ever-increasing population, the industrial expansion required to satisfy its needs, and our increasingly complex technology have had dangerously adverse effects on our biosphere. Throughout the world, people are becoming more and more concerned about deterioration of our environment and are quickly antagonized by any public or industrial activity that may have such adverse effects.

Herbicides, with their very obvious effects on forests and woodlands, receive an ever-increasing share of this public antagonism. Despite this hostility, research, experience, and use of vegetation control chemicals on forest lands are increasing and must continue to do so for at least the next few decades. Our rapidly expanding population and the concomitant need for more intensive silviculture will require that we use such chemicals--although with increasing caution--in the future.

Smith (1970) estimated that roughly one-third of the world's land surface is occupied by forests. It seems clear, however, that forests of the future will be reduced in area and that many areas will be reserved for limited use rather than full production of all forest products. This problem is already evident in demands by special interest groups that more and more acreage be set aside for special uses, zoned for housing, reserved for recreation, etc. It seems very clear that foresters of the future will be faced with much reduced acreages of forest land that must be managed most intensively, with the utmost care, and with ever-increasing scrutiny by the public.

Throughout the world, we have a wide variety of forest types ranging from needle-leafed boreal species in the cooler habitats to broad-leafed species that dominate in tropical climates. Such forests may occupy sites for hundreds of years, but they are not static. Whenever a forest is removed or destroyed, a pattern of vegetational change occurs on the site. In the course of this process, many species that were present in earlier stages disappear. But this is all a part of the natural process of succession. When foresters use herbicides, they are simply controlling the natural process of succession. We may reduce the length of time that earlier, less productive seral stages occupy a site and insure an earlier dominance by forest species more useful to man. Or we may retard succession and maintain dominance of a seral forest type that is more productive of wood, water, or recreation desired by man.

The future role of vegetation control chemicals in forest and other land management seems adequately insured in attaining and maintaining these conditions. Chemicals must of necessity be used to reduce competition of undesirable species and increase growth of those more useful to man. Chemicals must also be used to speed succession and insure regeneration of cutover areas. They will be used to improve the composition of our forests, to improve wood quality, and to control rates of growth. Diameter growth will be controlled to provide wood with desired qualities. But silvicides will probably be used less in the future as more of the finer materials are macerated and used as wood fiber.

In the relatively near future, herbicides and desiccants will probably be used to prepare sites for reforestation and to convert chapparal areas to grasslands for a greater production of protein, but their role will also decline. To a more limited extent, desiccants and herbicides may also be used to remove foliage of deciduous species when lives of these trees or plants are threatened by continued transpiration during extensive periods of drought--an extension of what occurs normally in many species in arid areas.

Vegetation control chemicals will probably be increasingly used in improvement of roadsides and recreation areas by selective removal of ugly or undesirable species, while favoring more esthetically desirable plants. Growth inhibitors will be used to control height of plants along roadways for better visibility and before lookout points for better viewing of scenic areas by the public without the ugly scars that accompany cutting of vegetation.

In the future, forests will probably be visited and used much more frequently by the public than they are now. And having passed through the period of excessive depletion, despoilation, and the traumatic adjustments needed to bring mankind into equilibrium with his biosphere, foresters will be faced with a better educated and more aware public. Although now subjected to public pressures and demonstrations, foresters of the future will be under even greater pressure and must be much better educated to justify the silvicultural practices that they deem necessary. The more intensive use of forest areas and the increased awareness of their importance to mankind will cause the public to question any activity that appears to threaten the forest resource.

Although the future of chemicals in silviculture seems assured, we must increase our study of the ecological effects of these chemicals. Further, we must drastically increase our studies of all interactions within forest ecosystems for an even more important purpose. Man must learn that--although he can live with and slightly modify nature--he cannot overcome long-term natural processes.

OTHER FOREST CHEMICAL USES

In regard to chemical forest management tools other than pesticides, we are perhaps now in much the same situation as we were about a quarter-century ago with pesticides--new chemicals are being offered and used to accomplish management objectives. With the exception of fertilizers and fire retardants, these chemicals are being used in relatively small amounts, just as chemical pesticides were used only a few years ago. However, research will continue to develop new tools with which to accomplish forest land management jobs effectively and economically over wide areas of inaccessible territory where aerial application of chemicals is the only feasible approach. And, doubtless, we will use them. However, we are now well aware that determination of efficacy of new chemicals must be complemented by assurance of their safety.

In terms of present and potential volume of all forest chemical use, fertilizer ranks first. Intensification of forest cultural practices aimed at producing more wood from less forest land must include the use of supplemental plant food. Forest fertilization is now practiced in many parts of the world, and much research is underway to extend the practice. Results of many studies indicate trees and range plants may respond significantly to fertilizer, but that response varies greatly between different sites.

When fertilizer is carefully broadcast on forested lands, the nutrient balance of the ecosystem is changed, but little environmental damage appears possible. Charges that forest fertilizing is harmful to water quality appear to be unfounded (Norris and Moore 1971, Cole and Gessel 1965, Cooper 1969).

With an increasing demand for wood products and a decreasing forest land base, it is highly probable that fertilizer use on forest lands will increase greatly. As a renewable resource, wood fiber certainly will continue to occupy a leading and increasing role in world industry. Intensification of management must include the use of chemical fertilizer in many situations.

Forest fire retardants rank next to fertilizer in volume of use. In 1970, more than 13 million gallons of fire retardant chemicals were aerially applied to wildfires in the United States. About one-fourth of the retardant solution is composed of chemicals, most of which is diammonium phosphate or ammonium sulfate, both used widely as fertilizers and not in themselves considered to be toxic to higher organisms (Sauchelli 1964, Bell et al. 1968).

There is ample evidence upon which to predict increasing use of chemical fire retardants. In 1969 alone, wildfires burned over 2.7 million hectares of forest and associated rangeland in the United States. Such fires often cause serious damage to the forest environment, both in terms of direct economic loss and from the standpoint of scenic and other esthetic values.

Chemical retardants are used to reduce the environmental damage from wildfire. Further research and product development will undoubtedly result in retardants that are effective and safe. We predict increased use of such materials in the future.

Additional new chemical tools may be offered for use in intensive forestry. A few examples of such chemicals and their uses include alkylpolyoxyethylene ethanol as a soil wetting agent to reduce erosion (Krammes and Osborn 1969); hexadecanol, a saturated fatty alcohol, for use as a transpiration retardant on planting stock (Stoeckeler 1966), on forest stands (Waggoner and Hewlett 1965), and to reduce soil water loss (Gardner 1969); asphalt and wax emulsions as agents for speeding slash disposal by fire (Schimke and Murphy 1966); and tyrosine, a free-amino acid, as a possible stimulator of tree growth and frost resistance (Gagnon 1964). Soil fumigants may also be used to eliminate undesirable pathogens such as *Poria weirii* from the soil and forest floor before planting or seeding areas where such organisms were prevalent before harvest.

Seed production may also be favored by new chemicals that become available in the future, producing not only more but better and more viable seeds. And although our view may be somewhat limited by a lack of experience, we believe that colchicine and similar genetic-modifying chemicals may prove less useful than thought at present. Considering the great number of natural hybrids produced by nature each year for the past hundreds of thousands of years, this chemical approach does not seem too promising.

We can also expect a growing introduction of chemical substances into the forest environment in connection with efforts to raise the permanent road system to higher standards (Tarrant 1967). Bituminous materials for surfacing, dust abatement chemicals, sodium or calcium chloride to reduce icing, and resins or asphalt emulsions for roadbed stabilization all are in use now.

An interesting development of which foresters must be aware is that of potential introduction into the forest environment of exotic chemicals not specifically aimed at land management goals. Two examples should suffice to illustrate this point.

Forest soils, in general, have superior water-absorbing capabilities and can serve excellently as receptacles for the assimilation and utilization of fluid wastes, including urban sewage (Evans 1970). In the United States, requests are now reaching the Forest Service for sewage disposal sites on forest and range lands. The demand for sewage disposal-recycling sites on "wild" land is expected to increase. Such lands are often available at low cost, potential health hazards and esthetic objections are usually less serious than for lands near populous centers, and forest and range cropping practices permit long, uninterrupted irrigation schedules. Development of large-scale sewage disposal on forest lands is, indeed, a growing possibility and could be a major source of chemical input into the forest environment.

Attempts to manipulate precipitation frequently include the release of chemicals such as silver iodide and zinc sulfite into the atmosphere. In at least one current attempt to alter precipitation patterns, concern over the ultimate fate of chemicals used in weather modification has led to monitoring of plants, soils, and water to determine presence, amount, and distribution of such chemicals and their impact on organisms of the forest environment (Cooper and Jolly 1970).

We could continue indefinitely to list chemicals and their present and potential use. But the real point is that we are constantly presented with chemical materials that promise to achieve intensive forest management objectives in a new, efficient manner. The question is not whether chemicals have a role in forestry during the next few decades, but what uses will be made of them and how these will affect forest management.

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