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Resource Statements Regarding Forestry Uses of 2, 4, 5-T

by Michael Newton
On behalf of U.S. Department of Agriculture

The following comments relate to: 1) Deposition of 2, 4, 5-T in forest watersheds in reforestation brush control operations, 2) Degradation of 2, 4, 5-T in soils, with specific reference to effects on plants growing therein, 3) Effects of 2, 4, 5-T and related mixtures on forest plant communities in the Pacific Northwest, 4) Specific effects of 2, 4, 5-T and alternative herbicides on woody species of New England and the Pacific Northwest, 5) Relationship between the environmental and socio-economic aspects of herbicides used in reforestation and non-chemical means, and 6) The general role of undesirable woody plants in management of renewable forest resources, and the place of 2, 4, 5-T relative to resource condition.

Deposition of herbicide in forest spray operations

Phenoxy herbicides are used in the Pacific Northwest for control of brush only insofar as brush interferes with growth of coniferous trees. This treatment is needed on a fraction of the forest land being harvested, ranging from negligible to perhaps half, in the national forests of the region; the proportion is probably greater among private holdings. On the acreage treated, sprays may be applied once or twice during the establishment of the stand, after which retreatment in the remainder of the growing cycle, and perhaps in subsequent cycles, is unnecessary. Such events are not, therefore, repetitious, and are not of the kind in which pesticide build-up has been reported.

In each spray application, rates of use range from one to four pounds of active ingredient per acre. This material is intercepted by canopy foliage, and by undergrowth and soil. Of the total applied, the fraction of greatest interest from the standpoint of hazard is that which comes into the food supply of various animals.

My work has been shared with that of Dr. Logan A. Norris, of the U.S. Forest Service Forestry Sciences Laboratory, in Corvallis. We conducted a five-year study of the toxic hazard of phenoxy herbicides, including 2,4,5-T, in forest spray operation (Public Health Service Grant WP-00477). This study emphasized the aquatic environment, which will be reported in the testimony of Dr. Norris. It is appropriate to note here, however, that we also examined twelve blacktail deer that had been living in areas treated with 2,4,5-T or atrazine. Despite the contamination of their entire food supplies, none of the deer contained in its stomach more than about a part per million of herbicide for each pound applied on an acre; 2,4,5-T was substantially lower in intake than atrazine. The various gland systems and tissues indicated that the biological life of 2,4,5-T was very short, resembling the findings of St. John, in 1964. This study was published, and a copy attached (Newton and Norris, 1968).

Degradation of 2,4,5-T in soils, and effects of soil residues on plants

My studies of herbicide degradation in soil were conducted as part of the activities of the National Academy of Sciences Committee on Effects of Herbicides in Vietnam. This Committee's report has recently been made public. The studies were extensive, and provide a clear description of the general degradation pattern of several herbicides in warm environments, and its biological significance. This report is available from the National Academy of Sciences; I am free to discuss it in detail.

Effects of 2,4,5-T and related mixtures on forest plant communities

The effect of 2,4,5-T on a forest plant group can be evaluated by itself, or in the context of a previously existing man-caused, biological anomaly. It is my contention that the latter approach is more valid.

Forest herbicides are used only where an environmental impact is needed, usually to reverse a man-caused problem. Their purpose in forest management is to make space in the biological community for a tree to grow. The lack of space, in the first place, is attributable to trees having been removed and not replaced, in which situation the void is filled by brush or whatever trees remain after logging. The environmental impact, then, is needed to de-stress a situation created by earlier mis-management, where de-stressing consists of re-establishing the original species composition.

Space can be created in several ways so that reforestation can proceed. Vegetation can be bulldozed, cut or sprayed with herbicide. Among herbicides, selection can be made among those that kill all or part of the vegetation. Two, 4, 5-T is among the most selective herbicides used in forestry, in that it suppresses a wide variety of species with low economic value, while leaving a wide variety of valuable species virtually unharmed.

The use of 2, 4, 5-T must be separated, in its effects, from the practice of reforestation. Once the decision has been made to reforest, success demands that some space in the plant cover be provided the seedlings. This can be furnished by any of the means cited, but selective herbicides accomplish the job with a minimum of destruction of neutral species and wildlife habitat. The fact that some destruction occurs is the result of the decision to reforest; the possibility of selective destruction in a constructive cause is made possible only by herbicides, of which 2, 4, 5-T is frequently the least destructive per unit of effectiveness. My paper in the Journal of Forestry, March 1973, summarizes these ecological concepts.

I have monitored specific changes in vegetation after several types of forest disturbance. Typically, logging removes the economically valuable trees, and leaves shrubs, herbs and defective trees. The remaining plants grow vigorously, and utilize all the soil resources soon after logging. If the tree species removed in logging do not re-establish themselves soon after logging, it may be decades before they find a foothold. But planting immediately after logging tends to be successful, because there is space.

Similarly, removal of a shrub community presents an opportunity for young trees to become established. Successful establishment of trees will result in the trees maintaining themselves by shading out their competitors. As long as trees are dominant, there will be no major brush problem.

In short, a disturbance that destroys part of the forest vegetation creates a niche in which plants become established. Those which grow must vigorously become dominant, and form a new forest. The process of introducing certain species of trees into these niches determines the long-run composition and structure of the forest; whatever is dominant tends to remain dominant, as does the failure to do so. Failures to reforest result in derelict forests of shrubs and rotten trees; control of these while introducing the seedlings of previously-dominant species restores the original forest type. The choice of chemical or non-chemical tool to this end has little bearing on the end point.

In several studies of 2, 4, 5-T-modified vegetation in western coniferous forests, the following specific short-term changes were noted: 1) the incidence of soft-hardwood trees decreased, 2) the incidence of conifers increased, 3) the incidence of non-sprouting shrubs decreased, 4) the incidence of sprouting shrubs remained the same, but reduced to sprout stature, and 5) the incidence of ferns and other herbs increased substantially. After several years, the same communities had developed substantially, with sprouting shrubs and soft-hardwoods assuming a co-dominant role, but not pre-emptive, mixed with conifer saplings. By the age of ten years, conifers have generally become dominant. It is evident that another fifteen years will demonstrate that the conifers will have shaded out all other species nearly to extinction. Thus, the 2, 4, 5-T has begun by making a niche for a persistent and growing conifer, the success of which is responsible for reduction of other species to normal proportions. The western coniferous species typically grow in pure stands in nature, and these phenomena associated with their successful establishment are not abnormal. The life history of a typical shrubby associate of Douglas-fir has been described by one of my students, Mr. David Russel. His Master's thesis (1974) is available, if needed, in support of the above point.

Specific effects of 2, 4, 5-T and alternative herbicides on woody species of the Pacific Northwest

Comparisons among herbicides are made easily with treatments to individual trees. Such tests have shown consistent patterns of effectiveness on several Oregon hardwood species.

Oregon white oak has been treated with silvex, 2, 4, 5-T, mixtures of 2, 4-D and 2, 4, 5-T, 2, 4-D, trichlorobenzoic acid, picloram and organic arsenicals. Of these, 2, 4, 5-T was the most consistently effective as a basal spray, comparing favorably with silvex and 2, 4-D and 2, 4, 5-T mixtures. Cacodylic acid or picloram were shown to be effective in injections, but no comparison was made with 2, 4, 5-T in this method. Among the effective herbicides tested on oak, 2, 4, 5-T has the shortest residual effect in the environment, and has the least likelihood of affecting other vegetation or causing concern among workers.

Bigleaf maple has been subjected to comparisons similar to oak. Silvex, monsodium methanearsonate and picloram are equally or more effective than 2, 4, 5-T, and 2, 4, 5-T is not specifically recommended for its control with ground application equipment.

Salmonberry has been treated by several others with broadcast ground sprays. Gratkowski (1971) recently observed that 2, 4, 5-T is the most effective among several choices of herbicide, with amitrole also effective. I have observed also that picloram is effective at high rates of application. Injury to conifers resulting from amitrole or picloram suggests 2, 4, 5-T as preferable in operations involving selectivity. Krygier and Ruth, in 1961, also observed silvex to be effective.

Blackberries of several species have been shown susceptible to 2, 4, 5-T. My studies have suggested that amitrole and silvex are suitable substitutes in the absence of conifers, but are less selective.

Poisonoak is controlled by 2, 4, 5-T, silvex and amitrole, with the latter herbicides being equally or more effective than 2, 4, 5-T.

Red alder was shown by Madison and Ruth (1962) to be more sensitive to 2, 4, 5-T than to silvex or 2, 4-D. Red alder is one of the most common of the Oregon brush-hardwood problem species, and this and my observations are mutually supporting. This species is also highly sensitive to injections of picloram and cacodylic acid.

Bitter cherry is readily controlled by mixtures of 2, 4-D and 2, 4, 5-T or 2, 4, 5-T in summer, but is resistant during the dormant season. Injections of picloram, 2, 4-D amine or cacodylic acid are also effective.

Pacific madrone, an important species in southwestern Oregon and northern California, was more sensitive to 2, 4, 5-T than to silvex, 2, 4-D and 2, 4, 5-T or 2, 4-D, as foliage sprays.

Varnishleaf ceanothus, also widespread in southwestern Oregon, was similar in response to madrone.

Aerial application accounts for nearly all the operational use of 2, 4, 5-T in the Pacific Northwest. Evaluations of 2, 4, 5-T in relation to alternatives need to be extended to this basis. Comparisons must accomodate the fact that dosage is imprecise for any given plant, however, and the following ratings are averages for many test plots. Species are listed in order of abundance as regeneration obstacles in the Oregon Coast Range.

Red alder has been treated with many combinations of herbicides in experiments and in forest operations. In my experiments, it has been clear that substitutes for 2, 4, 5-T have not been satisfactory for general use. Of the alternative materials tested, only picloram and dicamba provide adequate control, and these both injure conifers severely during their seasons of effectiveness. Mixtures of 2, 4-D and 2, 4, 5-T; 2, 4-D and 2, 4-DP and straight 2, 4-D have been less effective than 2, 4, 5-T in the order listed. A report of this series of experiments was forwarded to Dow Chemical Co. and Amchem Products Inc. in 1971. (Mr. L. E. Warren and James McKinley, respectively) among others. (Copy attached).

<u>Vine maple</u>, one of the most widespread brush species on our highly productive coastal forest sites, is highly specific in its sensitivity to 2,4,5-T. This herbicide and silvex provide good control when applied as a spring dormant spray. Injury to conifers by silvex is cause for relying exclusively on 2,4,5-T in areas where vine maple is abundant. Mixing 2,4,5-T with 2,4-D reduces dormant-spray effectiveness per pound of phenoxy herbicides. Picloram is effective when mixed with 2,4,5-T as a foliage spray. Dicamba, amitrole and 2,4-D are ineffective.

<u>Salmonberry</u> is very common in coastal clearcuts. This species has been treated with picloram, picloram plus 2,4-D, picloram plus 2,4,5-T; 2,4,5-T alone; amitrole and combinations of dicamba with various phenoxy additives. Picloram plus 2,4,5-T combinations were superior to others. The effect of 2,4,5-T alone lasted roughly 2 years, following which re-treatment was necessary. Amitrole was comparable to 2,4,5-T, or more effective on an absolute basis. But 2,4,5-T was still the most effective on salmonberry in relation to its effect on conifers.

<u>Hazel brush</u> has been observed in many aerial spray operations. During the dormant season, the effects of 2,4-D and 2,4,5-T appear to be similar to those of 2,4,5-T alone or silves. During the foliage season, a mixture of 2,4-D and 2;4,5-T appears close to optimum among the phenoxy herbicides being used. This observation is not supported by solid numbers, but is the best judgment estimate I can provide.

<u>Thimbleberry</u> is not controlled by any herbicide currently in use during the dormant (spring) spray season. Summer applications of 2,4-D and 2,4,5-T have provided temporary control. Silvex and 2,4,5-T alone have not proven satisfactory.

<u>Bigleaf maple</u> is not controlled as well by silvex in aerial treatments as ground tests would suggest. This species is controlled poorly by aerial sprays of any sort in current use. Of the mixtures useful on other species and selective on conifers, 2,4,5-T is the only one moderately useful in holding maple back.

As a general statement, 2, 4, 5-T has been the most effective herbicide for general brush control of the type needed in reforestation. Seldom do brush-fields exist as pure stands of one brush species. It is necessary to select the herbicide that will provide the most capacity for reducing the ability of all common brush species to compete with conifers. This requires general effectiveness on the widest range of brush species, yet demands virtually no effect on conifers. My work in the Pacific Northwest indicates that we would choose 2, 4, 5-T often simply on the basis of effectiveness; my studies on growth rates of conifers after application of 2, 4, 5-T indicate that it can be used effectively on brush at rates that produce no effect on Douglas-fir and grand fir. This work is published (Newton, 1967, Dormant spray requirement for Douglas-fir and grand fir, copy attached).

I have also done some studies in Vermont that reinforce our estimates of the general effectiveness of 2, 4, 5-T. In cooperation with Amchem Products Inc., I installed aerial spray plots with various herbicides to improve species composition in northern hardwood forests. Comparisons of 2, 4, 5-T with 2, 4-D and 2, 4, 5-T; 2, 4-D and 2, 4-DP and 2, 4-D alone illustrated the same general pattern as did similar comparisons in the Pacific Northwest. Hard hardwoods, (sugar maple and white ash) and conifers were not affected by 2, 4, 5-T alone, but most of the soft hardwoods and shrubs were severely suppressed. White pine, spruce, hemlock and the hard hardwoods gained substantially in dominance as the result of treatment. The same pattern was observed with the substitutes, but with less control of the soft hardwoods and more damage to desirable species. This study is to be published, and has been submitted to the Northern Logger for printing.

My studies have indicated that other herbicides can be used effectively on many species. Several, namely, 2, 4-D and 2, 4, 5-T, silvex and amitrole, involve some of the same considerations as 2, 4, 5-T in reference to safety of use, and nothing would be gained by offering them as substitutes for general use. In addition to this, greater care is needed in using them to avoid damage to desirable species. I would therefore submit that no useful purpose would be served by substituting these materials for present uses of 2, 4, 5-T. Other substitutes, including picloram and dicamba, do not carry the adverse public image of the phenoxy herbicides, but are associated with adverse environmental impacts of a different kind. Both are mobile in soil, and are highly active regarding roots. Both are persistent in soil, and are damaging to conifers at very low rates of application. Both herbicides are more likely to migrate into waters than are the phenoxys, and to produce concentrations in water with measurable biological effects. Neither can be used in the presence of conifers at rates that are effective for brush control without seriously damaging the conifers.

Perhaps the strongest case for the effectiveness of 2, 4, 5-T regarding forestry objectives relates to the innate conservatism of professional foresters. Foresters recognize that an investment in reforestation must be carried for 30-100 years, and are loath to invest more than is necessary. It is significant that they are willing to invest in brush control as necessary to protect the investment in reforestation. And it is also significant that the choice of 2, 4, 5-T predominates in reforestation when it is not the least costly herbicide. Thus our research points to the general utility of 2, 4, 5-T, and the applicability of our findings is being verified in the field.

Relationship between the environmental and socio-economic aspects of herbicides used in reforestation and non-chemical means

A comparison of herbicides with cutting or bulldozing can be based on ecological and socio-economic bases. Ecologically, the point needs to be clarified as to what organisms are affected by the various treatments. Socio-economic analyses must consider costs to both the practitioner and to society at large.

In our work on toxic hazard, Dr. Norris and I have observed concentrations of 2, 4, 5-T in deer that are perhaps less than 1/1000 of the dosage reported to be acutely toxic. The content of 2, 4, 5-T in freshly treated habitat is an indication of TCDD, as well. Given the TCDD/2, 4, 5-T ratio of $\leq 10^{-7}$, the intake of TCDD by deer in treated areas is likely to be no greater than $10^{-5}$ micrograms per kilogram of body weight. This is far below levels reported as "no effect" in EPA testimony.

In aquatic habitat, we have observed concentrations of less than 0.1 part per million as the maximum within sprayed areas; concentrations were generally down to .001 part per million within two days (See Norris testimony). Extending these concentrations to TCDD at the $10^{-7}$ ratio, the water concentration of TCDD probably never exceeds $10^{-14}$, and is more typically in the range of $10^{-15}$ to $10^{-16}$. Our observations were made in watersheds where no effort was made by helicopters to avoid open waters. Such avoidance is now required by law, and concentrations as high as the low levels we reported are unlikely to be repeated. Considering the estimates of Meselson that $10^{-12}$ may be the threshhold of biological activity, there appears substantial margin of safety with respect to fish habitat. This evidence, though confined to few organisms, suggests that direct toxic effects of phenoxy herbicides on wildlife are highly unlikely.

The use of bulldozers obviously has an appreciable direct effect on wildlife. Operation of a bulldozer on mountainous terrain, in general, stirs up and compacts soil to the detriment of its hydrologic properties. Increased runoff from bulldozed soils can be expected to carry an appreciable silt load to streams. We must consider the possibility that the substitution of scarification for chemical brush control will have an adverse effect on fisheries, where mud can interfere with spawning. Felling of undesirable vegetation would not have this effect.

Terrestrial wildlife are very responsive to changes in habitat. In a comparison of herbicide versus felling and bulldozing, some phenomena are obvious enough to be mentioned in the absence of supporting data. After the application of phenoxy herbicides, an abundant ground flora usually develops rapidly (I have data). The physical structure of the brushfield is maintained, providing cover for both game and non-game terrestrial species, as well as nesting sites for birds. New growth of ground cover and sprouts is within reach of all herbivores, and deer tend to be abundant in the years following spraying. In contrast, felling creates a mass of slash that prevents big game from utilizing an area (also planters from reforesting it), and eliminates nesting sites. With either felling or bulldozing, cover is eliminated entirely, although slash and windrows provide habitat for rabbits.

On balance, my data and casual observations would suggest that substitution of physical brush removal methods for herbicides would be contrary to the management principles of a diverse and abundant wildlife resource.

In consideration of the socio-economic comparisons between herbicides, cutting and bulldozing, costs are borne in several ways.

The costs of herbicide application are generally somewhat lower than for other methods. Felling is the most costly. Operation of power saws and bulldozers in the vicinity of falling trees on steep terrain is also hazardous. Labor insurance costs for this work are among the highest of any industry. It is noteworthy that manpower requirements are high for both methods of physical removal, and are in competition with timber harvesting for the same labor force, with equipment. Even in labor-surplus areas, this is highly specialized, dangerous work where employment of pick-up crews could be expected to compound risk.

Perhaps the greatest cost of reliance on labor-intensive methods is tied to the delay in reforestation occasioned by inadequate present-day labor-capital resources. I have data (Zavitkovski, Newton and El Hassan, 1969) illustrating that delays in forest rehabilitation not only delay harvest, but also increase the difficulty in obtaining regeneration. The increase in cost is attributable to a natural tendency of plant communities to stabilize with time. Old, stable brushfields require more intense disturbances for reforestation than recently invaded areas. This is not only more costly now and later, but the more intense treatments amplify some of the original problems of control methods about which objections are raised.

In summary, herbicides would appear to be the least destructive of the common methods used for vegetation control in reforestation. They are also the least costly, not only in dollars per acre reforested, but perhaps in terms of occupational hazard. The rehabilitation task must be faced on tens of millions of acres. The use of labor-intensive methods is self defeating, because it postpones treatment, an effect which intensifies the labor requirement.

<u>The general role of undesirable woody plants in management of forest resources, and the place of 2, 4, 5-T relative to resource condition</u>

I recently did a literature review (attached) on the subject of the Status of Vegetative Pests in the Forests of the United States, as part of an assignment with the National Academy of Sciences, Environmental Studies Board. There is considerable evidence that the nation's forests are in a poor general condition of productivity and species composition, and that weeds figure prominently among the causes. Many of the weed problems are man-caused.

There is nothing innately bad about a weed. It happens that society has placed no value on a major component of the growing stock on 300 million acres of the nation's renewable resource land. Much of the weed growth is not aesthetically attractive nor is it the best possible game habitat. Much of it is present as the result of removing the commercial species. There is therefore no philosophical reason for perpetuating weeds on forest land on which the nation depends for its perpetual supplies of fiber and structural materials. It can be anticipated that restrictions on management tools will result in an increase in the weed problem. If the nation chooses to grow weeds in preference to commercial species, the issue of 2, 4, 5-T becomes unimportant in forestry.

Assuming a commitment to renewable resource management, many different procedures are involved in solving the many weed problems in the United States. The use of 2, 4, 5-T is one of the specific tools. Other chemicals will also be needed, and more effective management of harvesting and reforestation will be mandatory to avoid setting up more problems. Rehabilitation of down-graded forests is a difficult and expensive task. The chief incentive for doing this lies with generations yet to come. It has taken a major educational effort to bring society to grips with its obligations toward maintenance of forests; the evidence is not clear that this effort is gaining much success.

The issue of 2, 4, 5-T extends beyond the simple regulation of a toxic material to the much broader issue of the public interest in resource management. There is reason to believe that the public is served by the maintenance of high quality, productive forests; Oregon's Forest Practices Act of 1972 is an acknowledgement of this.

Two, 4, 5-T is a detail in the general issue of resource management. A decision to delete may well serve against the public interest by its effect of maintaining poor forests, or forcing less desirable means to promote healthy stands. Forest Practice laws existing in Oregon require prompt reforestation, and speak to the desirability of wise use of herbicides to ensure success. Restriction of the single herbicide with the widest applicability toward the objectives of this Act would appear to be a legal paradox.

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