# Distribution of 2, 4-D and Picloram Applied by a Mist Blower

Logan A. Norris[1], Marvin L. Montgomery[2], Warren L. Webb[3], Henry J. Schroeder, Jr.[3], and Fred Gross[4]

[1]*Pacific Northwest Forest and Range Experiment Station*
*Forest Service, U.S. Department of Agriculture*
*Corvallis, Ore. 97331*

[2]*Department of Agricultural Chemistry*

[3]*Department of Forest Management*
*Oregon State University*
*Corvallis, Ore. 97331*

[4]*Bonneville Power Administration*
*U.S. Department of the Interior*
*Vancouver, Wash. 98660*

Large, truck-mounted mist blowers have been successfully used for vegetation management on powerlines by the Bonneville Power Administration (BPA); however, concern about drift has raised doubts about the suitability of this technique.

In this paper we report the distribution of two herbicides in a test grid and an evaluation of three methods for estimating the total amount of herbicide deposited in the sampling area after a mist blower application.

## MATERIALS AND METHODS

A truck-mounted, John Bean Rotomist[1] mist blower was used to apply the chemicals to a vegetation-free section of powerline right-of-way in southwest Washington.[2] The single D-4 jet nozzle (without spinners or screens) was elevated $10^{\circ}$ above horizontal and was rotated slowly back and forth between the far left- and right-hand corners of the grid. The application of 8.5 liters of solution was made at 200 psi over a period of 2 min while the truck was stationary. The spray solution contained 296 ml of Tordon 101®[3] and 44 ml Lo-Drift[4] in 9.46 liters of water.

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[1]The use of trade, firm, or corporation names does not constitute endorsement by the U.S. Department of Agriculture or the U.S. Department of the Interior.

[2]Field work was conducted with the assistance of BPA Seattle Area transmission line maintenance personnel.

[3]Tordon 101 contains picloram (4-amino-3,5,6-trichlor opicolinic acid) and 2,4-D (2,4-dichlorophenoxyacetic acid) in a 1:4 ratio.

[4]Lo-Drift™ (Amchem Products Incorporated) is a polyvinyl polymer spray adjuvant for drift reduction.



Bulletin of Environmental Contamination & Toxicology,
Vol. 16, No. 6 

The rectangular test grid was 32.9 m by 67 m and contained 108 spray deposit sampling stations (Fig. 1) Each station consisted of three 11-cm-diameter filter paper discs 0.3 m to 1.5 m from the station center on lines 120° apart (MAKSYMIUK 1959). Immediately after application, the discs were collected into pyrex tubes and frozen. The wind was 1.6 km per hour from Column 9 to Column 1 at 90° to the direction of application. Air temperature was 21° C at 0.6 m and 20° C at 1.2 m above the ground. Relative humidity was 53.5 percent.

Herbicide residues were extracted with NaOH and, after acidification to pH 1, were extracted into ether.

The extracts were methylated with diazomethane and diluted with benzene as appropriate.[5] These procedures resulted in 100% recovery of both herbicides.

The Varian 2100 gas chromatograph had an Infotronics microcoulometric detector and a 1.83 m by 0.32-cm i.d. column packed with 6% OV-1 on 60/80 mesh Gas Chrom-Q. Picloram was run at 165° C with a flow of 40 ml $N_2$/min, and 2,4-D was analyzed at 145° C with a flow of 34 ml $N_2$/min. The retention time in both cases was about 3 min.

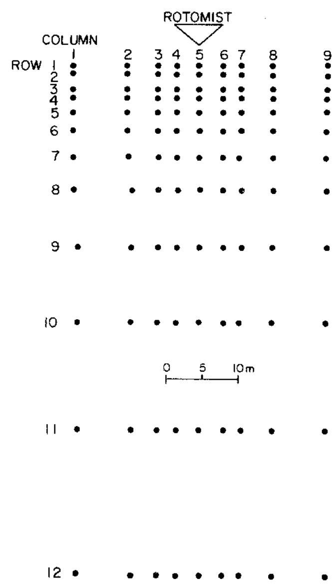


Figure 1. Location of mist blower and spray deposit sampling on the test site.

## RESULTS

### Distribution of Herbicide on Test Grid

Both herbicides were deposited in a fan-shaped pattern largely contained by the test grid (Figure 1, Tables 1 and 2). More than 90% of the herbicide was in a triangle with the apex 4 m and the base 27 m from the

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[5]Detailed method available from authors.

TABLE 1

Recovery of 2,4-D ($mg/m^2$) at spray deposit sampling stations on the test grid[a]

| Rows | Columns 1 | 2 | 3 | 4 | 5[b] | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0[c] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0.06 | 0.04 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0.04 | 0.35 | 0.58 | 0.62 | 0.03 | 0 | 0.02 |
| 5 | 0.06 | 0.09 | 2.01 | 4.38 | 3.75 | 6.15 | 0.86 | 0.02 | 0.15 |
| 6 | 0.05 | 0.38 | 36.2 | 43.5 | 40.2 | 42.4 | 21.6 | 0.05 | 0.01 |
| 7 | 0 | 15.0 | 135 | 228 | 251 | 344 | 214 | 11.7 | 0.14 |
| 8 | 0.26 | 87.6 | 244 | 334 | 260 | 632 | 277 | 63.6 | 0.07 |
| 9 | 0.09 | 23.3 | 24.8 | 41.8 | 40.7 | 42.4 | 44.1 | 28 | 0.88 |
| 10 | 0.20 | 1.99 | 2.66 | 3.67 | 6.25 | 6.85 | 5.16 | 4.10 | 0.84 |
| 11 | 0.08 | 0.60 | 0.71 | 0.58 | 1.17 | 1.14 | 1.14 | 0.93 | 0.77 |
| 12 | 0.03 | 0.07 | 0.20 | 0.18 | 0.22 | 0.23 | 0.28 | 0.22 | Lost |

a See Figure 1 for location of spray interception stations on the test grid.

b Location of mist blower.

c 0 means less than 0.01 $mg/m^2$.

TABLE 2

Recovery of picloram ($mg/m^2$) at spray deposit sampling stations on the test grid[a]

| Rows | Columns 1 | 2 | 3 | 4 | 5[b] | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0[c] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0.01 | 0.17 | 0.18 | 0 | 0 | 0 |
| 5 | 0 | 0.02 | 0.67 | 1.42 | 1.10 | 1.91 | 0.26 | 0 | 0.04 |
| 6 | 0.03 | 0.11 | 12.5 | 14.8 | 11.0 | 14.5 | 6.86 | 0.02 | 0 |
| 7 | 0 | 4.80 | 39.0 | 71.4 | 62.9 | 94.3 | 71.4 | 3.90 | 0.03 |
| 8 | 0.10 | 25.3 | 63.2 | 117 | 87.3 | 177 | 72.4 | 18.4 | 0 |
| 9 | 0.12 | 5.83 | 7.24 | 13.2 | 13.4 | 13.7 | 16.0 | 10.1 | 0.29 |
| 10 | 0.02 | 0.69 | 0.81 | 1.01 | 1.73 | 1.92 | 1.47 | 1.09 | 0.20 |
| 11 | 0.02 | 0.12 | 0.28 | 0.20 | 0.33 | 0.38 | 0.39 | 0.25 | 0.14 |
| 12 | 0.01 | 0.03 | 0.05 | 0.08 | 0.07 | 0.07 | 0.06 | 0.05 | Lost |

a See Figure 1 for location of spray interception stations on the test grid.

b Location of mist blower.

c 0 means less than 0.01 $mg/m^2$.

mist blower. The width of the base of the triangle was 19 m. POTTS (1958) also reported a fan-shaped pattern of deposition which was about 16 m wide, 30 m from a mist blower.

The distribution of herbicide in our test grid had two distinct peaks and a slight skew toward Column 1. We believe the peaks represent momentary pauses by the mist blower as it reversed direction at each end of the traverse. The skew could be the result of air movement across the test site or slightly longer pause by the blower at one end of the traverse. Only small quantities of herbicide were found along both edges and the back of the test grid (Tables 1 and 2). The highest level of herbicide recovered along the perimeter of the grid was 0.88 mg 2,4-D/$m^2$ (less than 0.008 lb/acre) which should cause little or no adverse effect on most vegetation adjacent to BPA rights-of-way.

Vegetation on a right-of-way would further confine the chemical. Intercepting surfaces and the rapid reduction of the velocity of the air stream as it moves through the brush would contribute to this effect.

## Total Herbicide Deposit on the Test Grid

Three different techniques were used to estimate the total amount of 2,4-D and picloram deposited on the test grid.

The Continuous Concentration Surface (CCS) Method. In this method, the grid was divided into rectangles with a spray deposit sampling station at each corner. To define rectangles around the perimeter of the grid, we extended the grid to an area of 90 m by 48 m and assumed that no chemical occurred at the outer extension of this boundary. The amount of herbicide recovered at the corners of the rectangle defined the continuous concentration surface which was integrated over the area of the rectangle. Two integrations were performed which differ in the assumptions made in the construction of the CCS (Fig. 2). These two assumptions yielded maximum and minimum values for herbicide deposit in a given rectangle. In calculating total herbicide deposit in the test grid, we summed the high value for herbicide deposit in all rectangles to give an estimate of maximum herbicide deposit over the grid. The sum of low values gave an estimate of minimum herbicide deposit over the grid (Table 3).

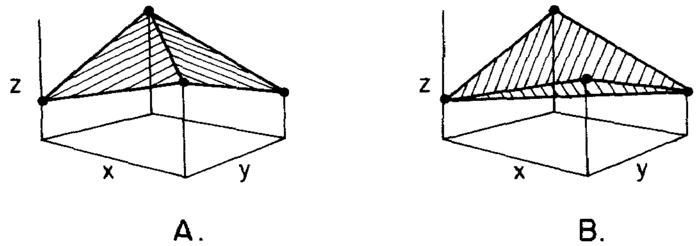


Figure 2. The two methods used to construct the continuous concentration surface (CCS). Each corner is a spray deposit sampling station. The vertical axis (z) represents magnitude of deposit. A. The two opposite corners of maximum concentration are joined. B. The two opposite corners of minimum concentration are joined.

TABLE 3

Recovery of 2,4-D and picloram on the test grid.[a]

| | 2,4-D | | Picloram | |
|---|---|---|---|---|
| | Grams | % of applied | Grams | % of applied |
| CCS Method | | | | |
| Maximum deposit | 66.2 | 105.4 | 19.2 | 98.0 |
| Minimum deposit | 56.2 | 89.5 | 16.8 | 85.7 |
| Average deposit | 61.2 | 97.4 | 18.0 | 91.8 |
| Exponential model method | 80.6 | 128.3 | 23.6 | 120.4 |
| Rectangular summation method | 61.6 | 98.1 | 18.3 | 93.4 |

[a] Analysis of spray mixture showed 62.8 g, 2,4-D, and 19.6 g picloram were applied to the test grid.

The Exponential Model Method. Picloram and 2,4-D deposits were represented with the following continuous function:

$$\text{micrograms of herbicide/cm}^2 = B_0 e^{(-B_1/X_2)} e^{-[B_2(Y-B_3) - e^{-B_4(X-B_5)}]}$$

where:

X = cm in cross-range direction from the mist blower
(-1600 $\leq$ X $\leq$ 1600) and

Y = cm in down-range direction from the mist blower
(0 $\leq$ Y $\leq$ 6740).

Herbicide deposit data and corresponding coordinate pairs of X and Y on the grid were used with Marquardt's algorithm to optimize the values of the parameters which gave the best fit to the data by the least squares method (MARQUARDT 1963). The $r^2$ was 0.87 for both herbicides which does not indicate the predictive value of the equation because of the nonlinear nature of the function but shows data sets for both chemicals gave the same variance.

The distribution of 2,4-D and picloram over the grid was estimated using the following values:

| | Constant | |
|---|---|---|
| Parameter | 2,4-D | Picloram |
| $B_0$ | 10.8 | 1.25 |
| $B_1$ | $5.93 \times 10^5$ | $5.64 \times 10^5$ |
| $B_2$ | $7.32 \times 10^{-3}$ | $7.82 \times 10^{-3}$ |
| $B_3$ | $2.63 \times 10^3$ | $2.86 \times 10^3$ |
| $B_4$ | $1.13 \times 10^{-3}$ | $1.00 \times 10^{-3}$ |
| $B_5$ | $3.19 \times 10^3$ | $3.60 \times 10^3$ |

This model shows most of the chemical deposited in a symmetrical peak centered approximately 15.5 m in front of the blower (Fig. 3). The function was integrated over the limits of the grid to give an estimate of the total residue deposit. The integration was performed numerically since the first exponential term cannot be integrated in closed form (Table 3).

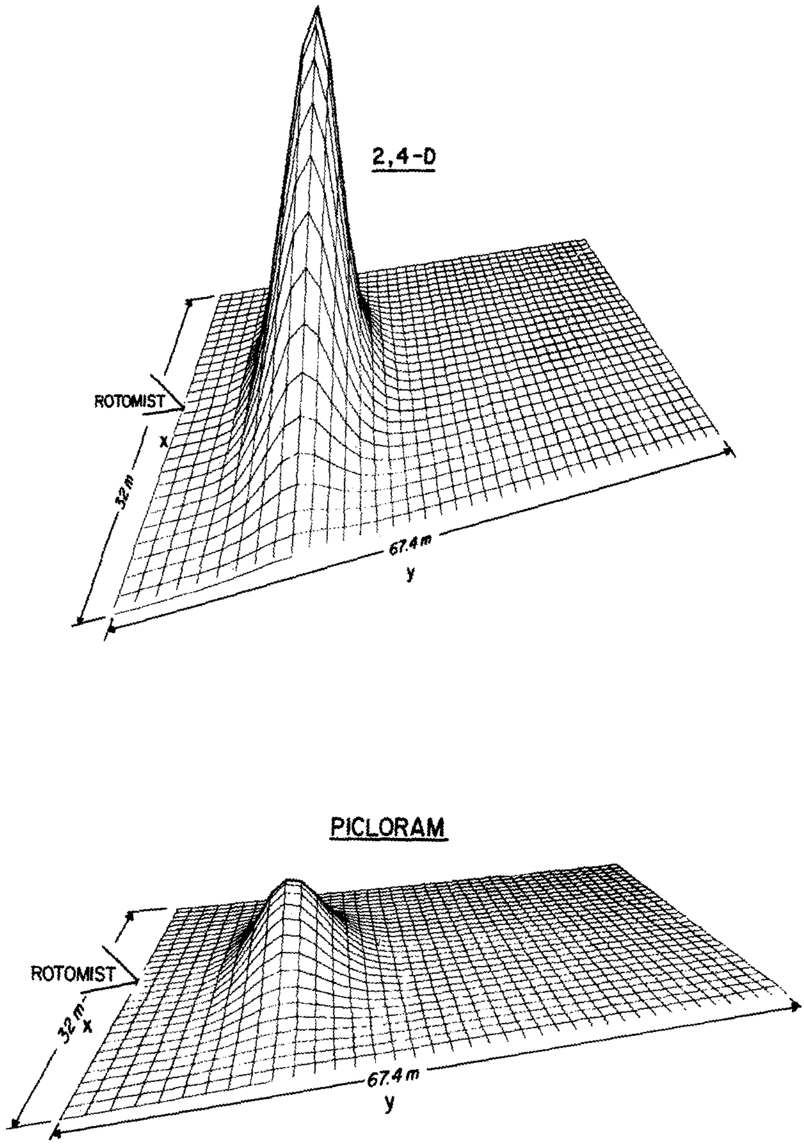


Figure 3. Herbicide distribution on the test grid predicted by the exponential model. The vertical dimension is micrograms of herbicide/$cm^2$ and has the same scale for both 2,4-D and picloram.

The Rectangular Summation Method. In this method, the test area was divided into 108 rectangles with boundaries at half the distance between adjacent sample points (Fig. 1). Each rectangle contained one spray deposit sampling station. The amount of herbicide recovered at each station was assumed to be representative of deposit over the rectangle. Deposit was summed over all rectangles to give an estimate of total deposit within the test grid (Table 3).

## DISCUSSION

The CCS method gave maximum or minimum spray deposit values, depending on the technique used in constructing the continuous concentration surface (Table 3, Fig. 2). An average of the maximum and minimum values approximates the amount of herbicide applied. These averages are 61.2 g or 97.4% of the 2,4-D and 18.0 g or 91.8% of the picloram applied to the test grid.

The rectangular summation method is easy to visualize, and calculations are simple. The results are almost identical to those derived by averaging the maximum and minimum deposits calculated with the CCS method.

The exponential method considerably overestimated herbicide deposit. Some refinement is required for the model to be of maximum value for estimating total chemical deposit. The exponential method has the greatest potential for estimating deposit when few actual measurements are available, or when estimates must be projected beyond the area covered by deposit measurements. Future deposit testing conducted under various atmospheric and operating conditions could use a refined version of this model, thereby reducing the number of spray deposit sampling stations required.

We do not know why more picloram than 2,4-D was lost in this experiment since both chemicals are amine salts and are intimately mixed in the spray solution. Perhaps some photodecomposition of the picloram occurred while the spray material was in the air or briefly exposed to the sun on the filter paper.

Our results suggest that relatively little herbicide was lost from the treated area. JOHNSON et al. (1974) and AKESSON et al. (1974) report the polyvinyl polymer spray adjuvants are highly effective drift control agents. The confinement of the spray mixture inside our test site may have been markedly influenced by this material. BRADY and WALSTAD (1973) reported 2.24 kg/ha of 2,4,5-T as low volatile esters caused injury to soybeans more than 152 m from a large mist blower. However, their test was conducted over a large area during a 2-day period when temperatures ranged from $23^{\circ}$ to $32^{\circ}$C, relative humidity ranged from 30% to 65%, and wind velocity averaged 5 km/h with gusts to 11 km/h. These conditions seem particularly conducive to both drift and volatilization of spray materials.

Our data indicate it is possible to safely apply herbicides on powerline rights-of-way using a truck-mounted mist blower. However, adequate attention must be given to atmospheric conditions, method of application, and the use of effective drift control agents. Additional research to identify these items is needed.

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