Development of Empirically-Derived Drift Distributions to Predict Deposition of Pesticides from Aerial Applications

Tammara L. Estes (Stone Environmental Inc., Montpelier, VT), Roger L. Breton (Intrinsik Environmental Sciences Inc., Ottawa, ON), Thomas M. Wolf (Agriculture and Agri-food Canada, Saskatoon, SK), Paul Whatling (Cheminova, Inc. Arlington, VA) John Schupner (Cheminova, Inc. Arlington, VA), John Hanzas (Stone Environmental Inc., Montpelier, VT), Dwayne R.J. Moore (Intrinsik Environmental Sciences Inc., New Gloucester, ME)

Abstract

AgDISP is a model used to estimate aerial off-field drift of pesticides from treated fields and to derive buffer zones required to reduce risk to biota from aerial applications. The outputs from this model, however, have been shown to over-estimate far-field drift deposition. This presentation describes an analysis conducted to improve upon the drift curves currently used in AgDISP. The drift curves in this analysis were developed using the results of recent field studies conducted in Canada to quantify spray drift from aerial application of pesticides.

Data from these field studies were empirically fit to a series of negative exponential distributions. The negative exponential distributions were tested for goodness-of-fit and conservative distributions, particularly in the tails of the distributions, were selected. Predictions from the selected distributions are being compared against data from independent aerial pesticide drift deposition studies conducted by the Spray Drift Task Force in the United States in 1992. These comparisons are being made to evaluate model performance of this study's empirically-derived aerial drift curves using an independent dataset.

The predicted results from the final selected negative exponential distribution spray deposition curves are being compared against the predictions made by AgDISP using similar input parameterizations.

Objective of Study

Based on 2004 data from Caldwell and Wolf, the objective of this study is to generate conservative drift curves that fit both edge of field measured drift deposition and far field measured drift deposition.

Methods and Materials

In 2004, Caldwell and Wolf conducted a field study to estimate off-field drift deposition from aerial application of pesticides. Using data from this study, individual drift curves were estimated for each of the four Treatments in the field study.

The negative exponential distribution was selected to simulate the drift curves. The negative distribution was selected due to its ability to simulate left-skewness which is the natural shape of drift deposition. Further, the one of the parameters of the negative exponential can be interpreted from a physical perspective and not just as shape curve for this data. The form of the negative exponential used in this study is:

$$f(d) = P0\ e^{(-\ln(d)*r)}$$

where:

d = distance from the edge of a treated field (m)

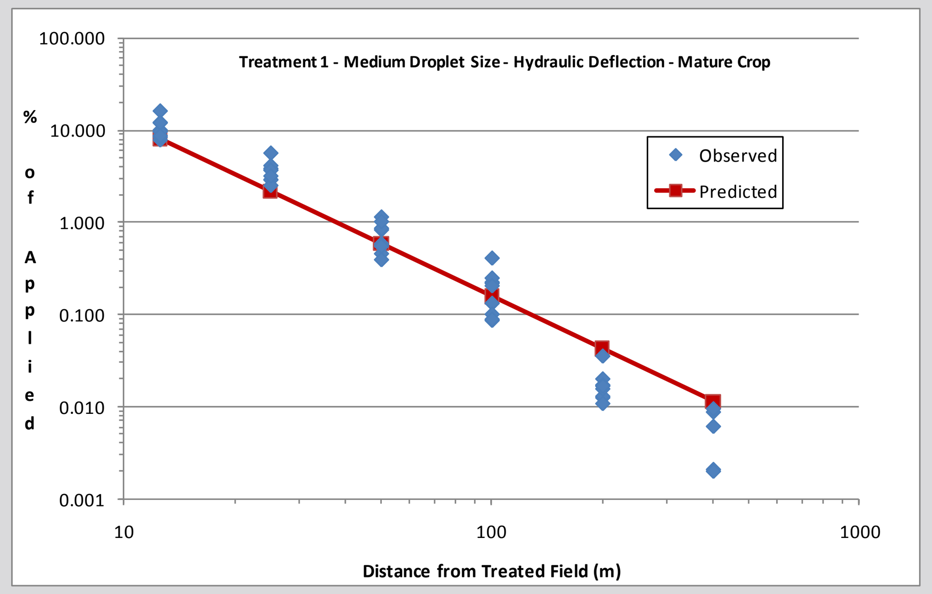
P0 = scale parameter

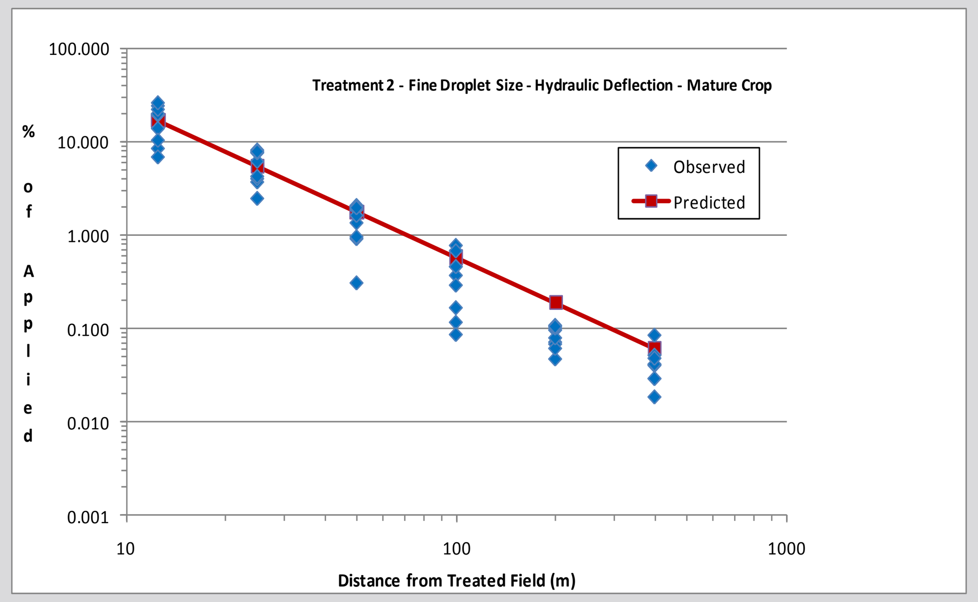
r = rate of deposition as a function of ln(distance from the edge of a treated field)

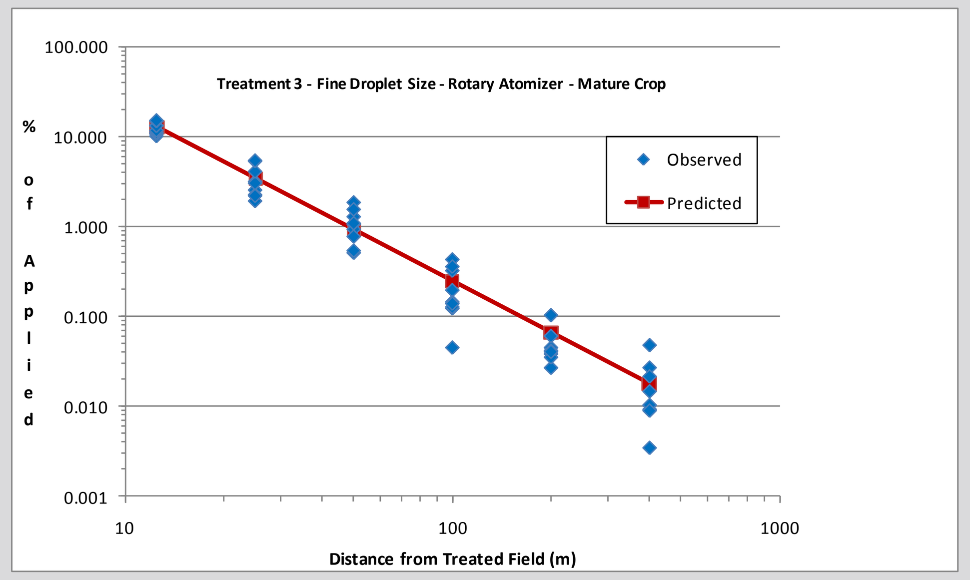
Preliminary fits of the negative exponential distribution to the aerial data are presented here. Fits were obtained by minimizing the sums of squares of error between predicted and observed values. Initial attempts to set the P0 parameter to represent the % applied at the edge of field failed, since the P0 parameter needs to be much larger so that the curve bends sufficiently to represent the data.

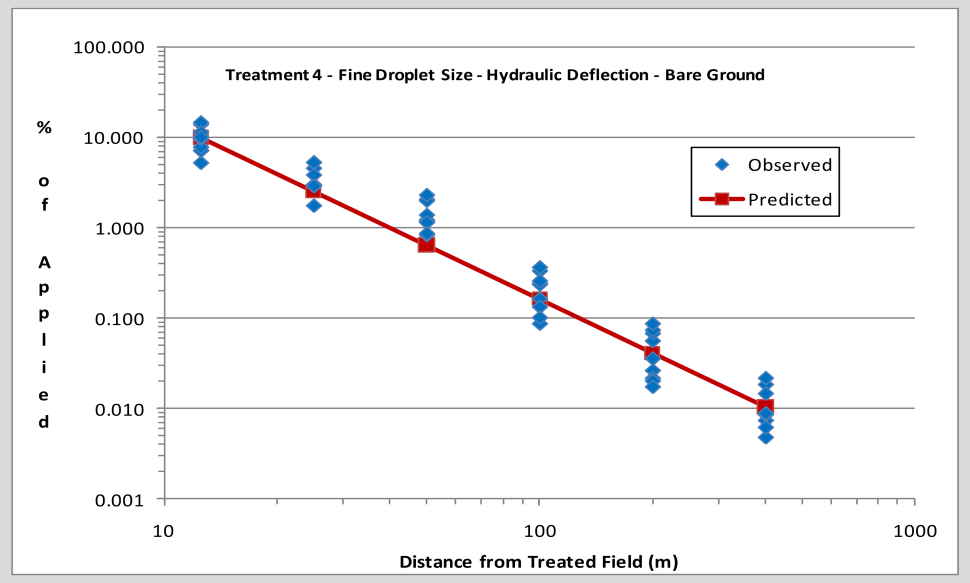
Observed Versus Predicted Results for Negative Exponential Distribution fit to Four Different Treatments in the Caldwell and Wolf 2004 Field Study

Negative Exponential Parameter Results			
Treatment	P0	r	Nash-Sutcliffe R2 for Goodness-of-fit
Treatment 1 - Medium Droplet Size- Hydraulic Deflection Nozzle - Mature Crop	968.13	1.89	0.23
Treatment 2 - Fine Droplet Size - Hydraulic Deflection Nozzle - Mature Crop	1019.11	1.62	0.19
Treatment 3 - Fine Droplet Size - Rotary Atomizer Nozzle - Mature Crop	1552.41	1.90	0.30
Treatment 4 - Fine Droplet Size - Hydraulic Deflection Nozzle- Bare Ground	1500.00	1.98	0.09









Conclusions

Use of the Negative Exponential Distribution shows promise as method to simulate drift deposition from aerial application.

The shape parameter in the Negative Exponential Distribution can be used to represent the rate of deposition as a function of the ln(distance from the edge of a pesticide treated field)

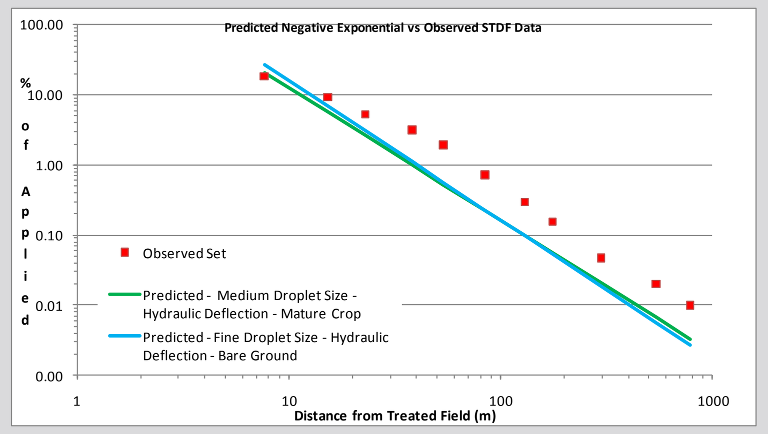
Using the ln(distance from the edge of a pesticide treated field) versus just using the untransformed distance from the edge of a pesticide treated field in the model parameterization allows the Negative Exponential Distribution to adequately represent the entire curve of drift deposition, both near the treated field and at distances farther away.

Comparison of Negative Exponential Drift Curves Against Aerial Spray Data from Spray Drift Task Force

Work has begun to compare predictions from the negative exponential distributions against aerial deposition data from the Spray Drift Task Force.

Initial comparisons find that the Negative Exponential Distribution is under-estimating the overall average deposition of aerial Spray Drift Task Force Data. This may be due to several reasons including:

- The Spray Drift Task Force studies used multiple swaths, whereas the Caldwell and Wolf study used a single swath. Multiple swaths overlay adjacent deposit patterns causing accumulation of deposition mostly at the further distances.
- Use of the deposition average of all aerial trials in the Spray Drift Task Force dataset. This dataset contains data from studies that are expected to generate higher deposition, for example, data from very fine droplet size deposition.
- Future work should align similar deposition scenarios for improved comparison.



Additional work has begun to compare predictions using the Negative Exponential Drift curves to predictions from the AgDISP model at distances far from the edge of a treated field. Preliminary assessments result in the following for Treatments 1, 2, and 4

	Treatment 1 - Medium Droplet Size- Hydraulic Deflection - Mature Crop	
Distance (m)	Negative Exponential	AgDISP
25	2.18	10.06
100	0.16	0.71
400	0.01	0.05

	Treatment 2 - Fine Droplet Size - Hydraulic Deflection - Mature Crop	
Distance (m)	Negative Exponential	AgDISP
25	5.50	11.22
100	0.58	0.92
400	0.06	0.06

	Treatment 4 - Fine Droplet Size - Hydraulic Deflection - Bare Ground	
Distance (m)	Negative Exponential	AgDISP
25	2.56	14.44
100	0.16	0.85
400	0.01	0.06

In general, the right tails of the negative exponential distributions are predicting less % of applied deposition at distances > 25 m than AgDISP. AgDISP overestimated deposits by at least 5x, with the exception of Treatment 2. Work is continuing to compare the two modeling approaches.