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

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Abstract

AgDISP is a model used to estimate ground spray off-field drift of pesticides from treated fields and to derive buffer zones required to reduce risk to biota from ground spray 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 ground spray 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 the conservative distributions, particularly in the tails of the distributions, were selected. Predictions from the selected distributions are being compared against data from independent ground spray 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 ground spray drift curves using an independent dataset.

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

Objective of Study

Based on data from Wolf and Caldwell, 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 2000, Wolf and Caldwell conducted a field study to estimate off-field drift deposition from ground spray application of pesticides. Using data from this study, individual drift curves were estimated for four different ASAE nozzle classes and two different wind speed ranges.

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 two parameters of the negative exponential can be interpreted from a physical perspective and not just as shape curves for this data. The form of the negative exponential used in this study is:

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

where:

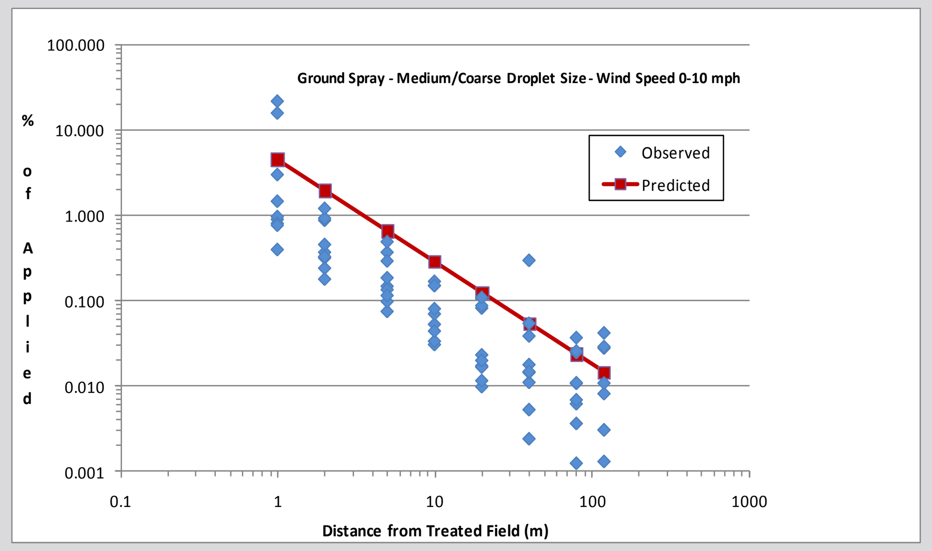
d = distance from the edge of a treated field (m)

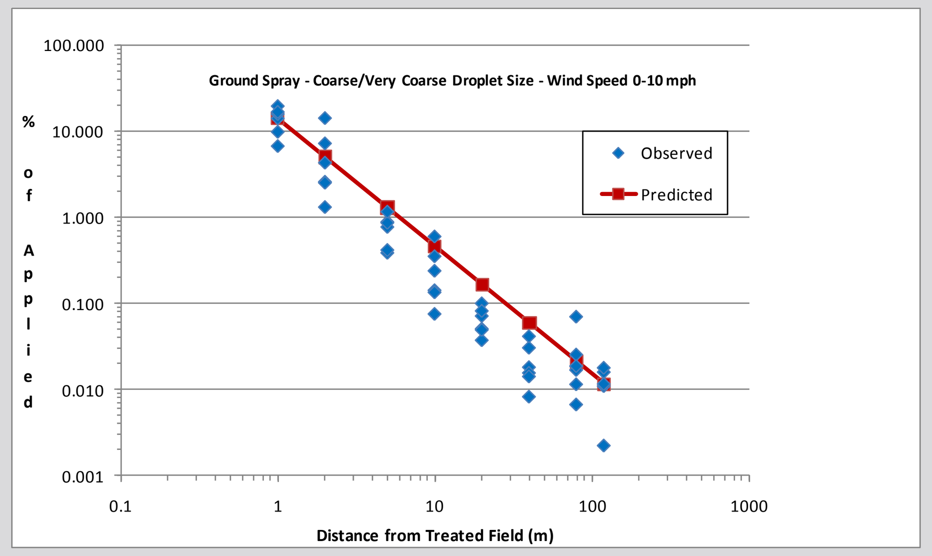
P0 = % of applied depositing at the edge of a treated field

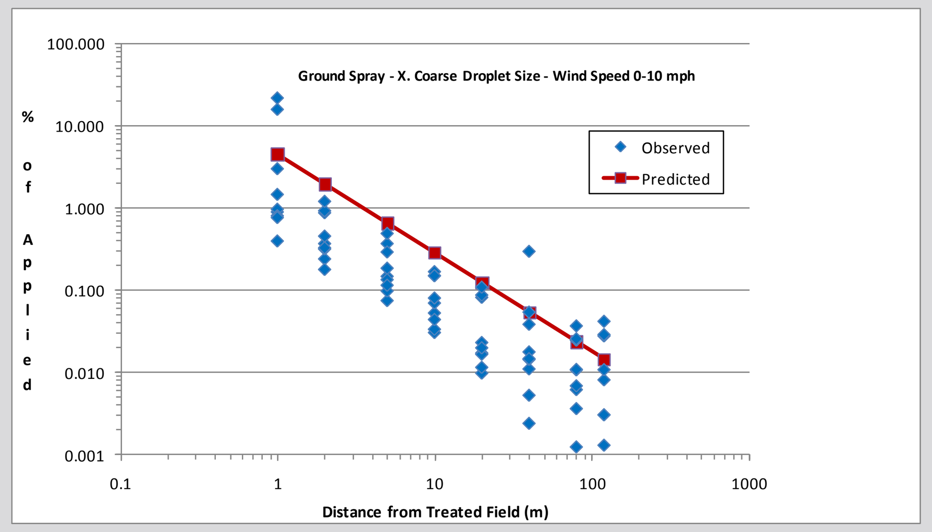
r = rate of deposition as a function of ln(distance from the edge of a treated field)

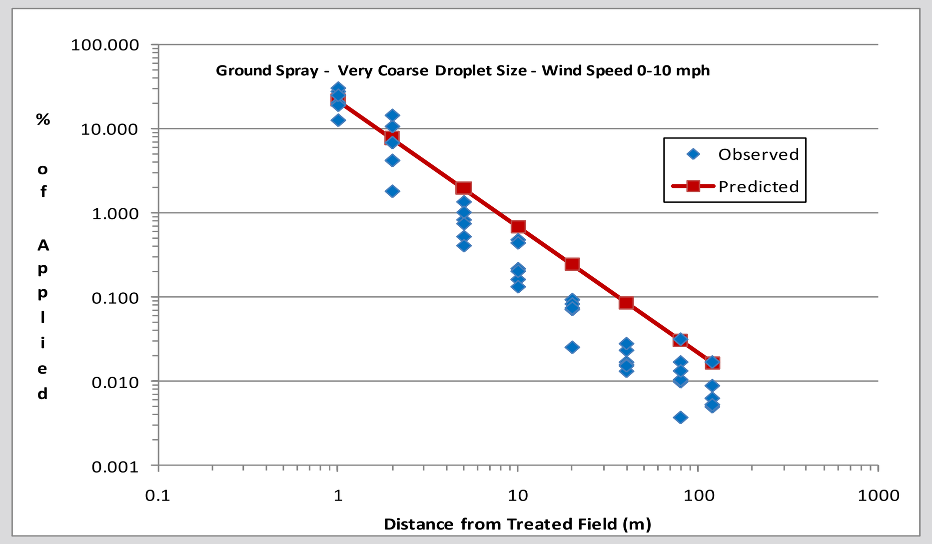
Preliminary fits of the negative exponential distribution to the ground spray drift data are presented here. Fits were obtained by minimizing the sums of squares of error between predicted and observed values while constraining r, the rate of deposition to be between 1.1 and 1.5. The reason for the constraint is to extenuate the curve so predicted deposition values at 120 m distance sufficiently match observed values.

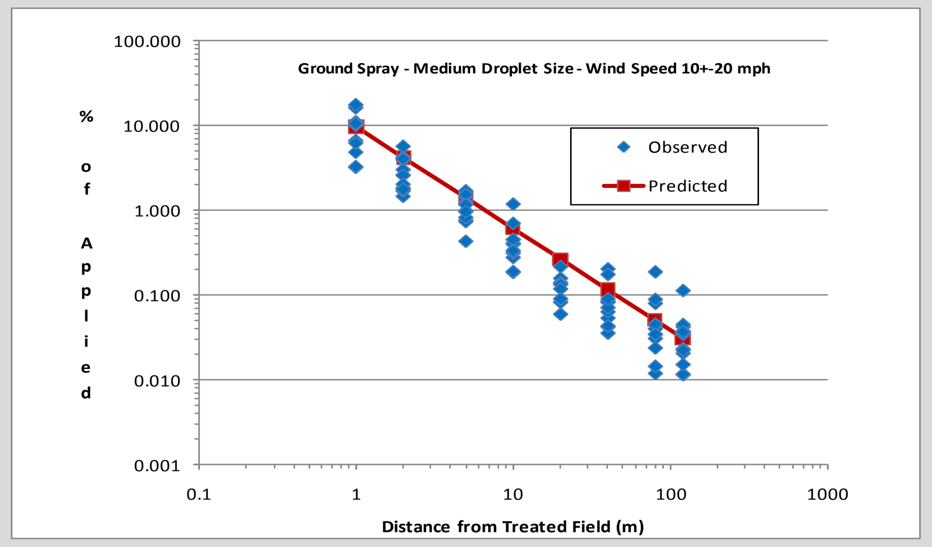
Observed Versus Predicted Results for Negative Exponential Distribution fit to Four Different Droplet Size Distributions and Two Different Wind Speeds

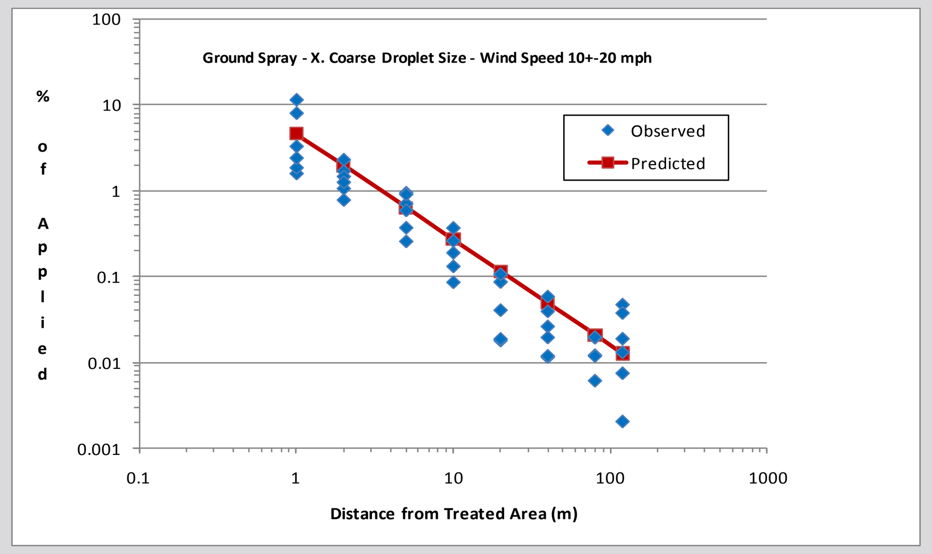


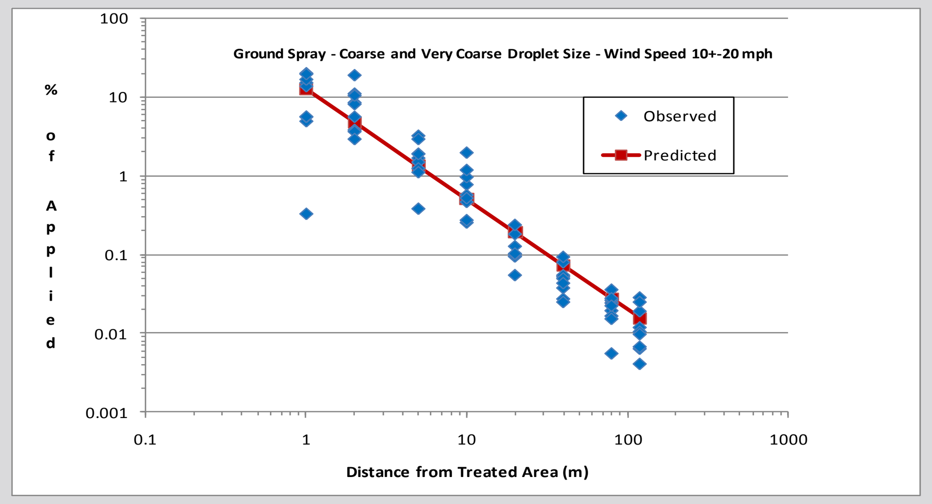


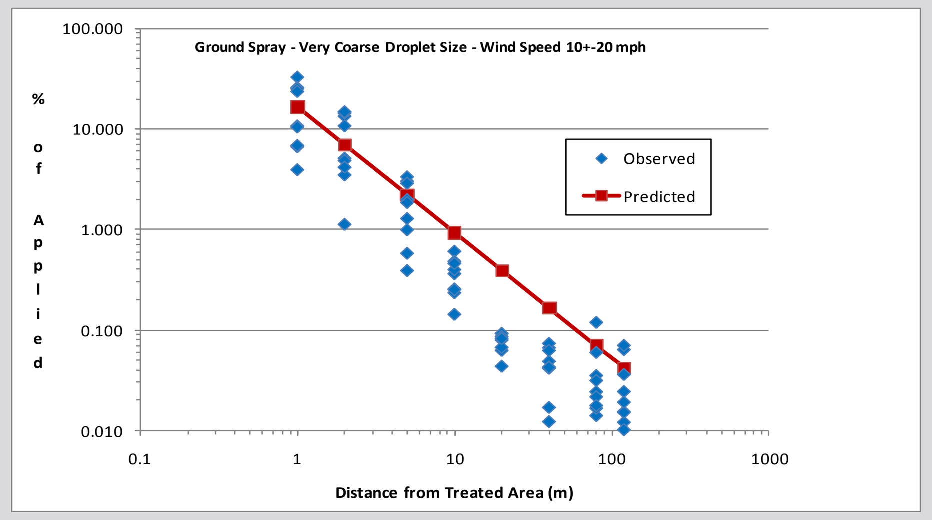












Conclusions

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

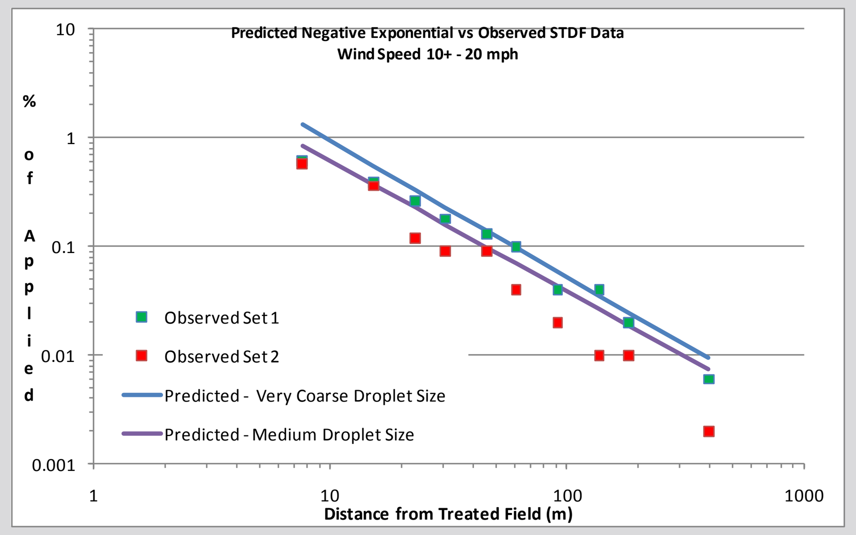
The shape parameter in the Negative Exponential Distribution can be used to represent the rate of deposition as a function of the ln(distance from the edge of a pesticide treated field)

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.

Negative Exponential Parameter Results

Treatment	Wind Speed (mi/hr)	P0	r	Nash-Sutcliffe R2 for Goodness-of-fit
Medium Droplet Size - Low Boom height (60 cm) traveling at 13 km/h	0 - 10	4.87	1.20	0.31
Extremely Coarse Droplet Size - Low Boom height (60 cm) traveling at 13 km/h	0 - 10	4.49	1.20	0.75
Very Coarse Droplet Size - High Boom height (90 cm) traveling at 23 km/hr	0 - 10	14.17	1.49	0.19
Coarse/Very Coarse Droplet Size - High Boom height (90 cm) traveling at 23 km/hr	0 - 10	21.93	1.50	0.11
Medium Droplet Size - Low Boom height (60 cm) traveling at 13 km/h	10 - 20	9.68	1.20	0.28
Extremely Coarse Droplet Size - Low Boom height (60 cm) traveling at 13 km/h	10 - 20	4.60	1.23	0.44
Very Coarse Droplet Size - High Boom height (90 cm) traveling at 23 km/hr	10 - 20	12.65	1.40	0.40
Coarse/Very Coarse Droplet Size - High Boom height (90 cm) traveling at 23 km/hr	10 - 20	16.53	1.25	0.34

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



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

Initial comparisons find that the Negative Exponential Distribution is slightly over-estimating Spray Drift Task Force Data. This may be due to several reasons including:

- Differences between the Wolf and Caldwell versus the Spray Drift Task Force data
- Conservative bias built into the Negative Exponential distribution drift curves
- Selection of the specific set of data from the Spray Drift Task Force set of observations

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:

	Medium Droplet Size			
	Wind Speed 0-10 mph		Wind Speed 10+ - 20 mp	
Distance (m)	Negative Exponential	AgDISP	Negative Exponential	AgDISP
1	4.87	1.10	9.68	3.74
2	2.12	1.00	4.21	3.36
5	0.71	0.91	1.40	2.76
10	0.31	0.84	0.61	2.07
20	0.13	0.63	0.27	1.28
40	0.06	0.36	0.12	0.57
80	0.03	0.22	0.05	0.23
120	0.02	0.02	0.03	0.14

	X. Coarse Droplet Size			
	Wind Speed 0-10 mph		Wind Speed 10+ - 20 mp	
Distance (m)	Negative Exponential	AgDISP	Negative Exponential	AgDISP
1	4.49	n/a	4.60	0.72
2	1.95	n/a	1.96	0.64
5	0.65	n/a	0.64	0.53
10	0.28	n/a	0.27	0.41
20	0.12	n/a	0.12	0.25
40	0.05	n/a	0.05	0.12
80	0.02	n/a	0.02	0.06
120	0.01	n/a	0.01	0.03

	Coarse/Very Coarse Droplet Size			
	Wind Speed 0-10 mph		Wind Speed 10+ - 20 mp	
Distance (m)	Negative Exponential	AgDISP	Negative Exponential	AgDISP
1	14.17	0.96	12.65	5.13
2	5.06	0.85	4.79	4.68
5	1.30	0.83	1.33	3.85
10	0.46	0.84	0.50	2.78
20	0.17	0.68	0.19	1.49
40	0.06	0.37	0.07	0.59
80	0.02	0.22	0.03	0.23
120	0.01	0.16	0.02	0.15

	Very Coarse Droplet Size			
	Wind Speed 0-10 mph		Wind Speed 10+ - 20 mp	
Distance (m)	Negative Exponential	AgDISP	Negative Exponential	AgDISP
1	21.93	0.50	16.53	3.04
2	7.75	0.45	6.95	2.74
5	1.96	0.48	2.21	2.21
10	0.69	0.52	0.93	1.58
20	0.25	0.42	0.39	0.84
40	0.09	0.24	0.16	0.34
80	0.03	0.15	0.07	0.13
120	0.02	0.10	0.04	0.08

So the right tails of the negative exponential distributions are predicting less % of applied deposition at distances > 100 m than AgDISP. Work is continuing to compare the two modeling approaches.