An Evaluation of the Windows Pesticide Screening Tool (WIN-PST)

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Executive Summary

Pesticide losses from agricultural fields have impaired water quality nationwide. The use of pesticide decision or assessment tools may help characterize and reduce the environmental risk posed by pesticide applications. The Institute for Agriculture and Trade Policy (IATP) has developed such a tool, the Pesticide Decision Tool (PDT). The PDT consists of a set of documents designed to accompany and supplement a screening tool software program developed by the USDA Natural Resource Conservation Service. The Windows Pesticide Screening Tool (WIN-PST) was developed by the NRCS Water and Climate Center (Amherst, MA) and the USDA Agricultural Research Service. The objective of this project was to evaluate WIN-PST (version 7-19-99) by conducting a comparative study with a validated model, the National Agricultural Pesticide Risk Analysis (NAPRA), also developed by the USDA-NRCS.

Two counties in Michigan were chosen for the study. Agricultural soils typical for the area and three commonly used herbicides were selected. Similar scenarios were run with both models. The study showed that WIN-PST can provide the same or similar results as NAPRA for most cases, especially for pesticides with low toxicity. WIN-PST slightly over-estimated the risk associated with pesticides of high toxicity and low application rate. These results are consistent with the conservative design of this qualitative screening tool. WIN-PST has a user-friendly interface and requires a modest input data set. With the aid of the PDT documents, the user can more easily implement WIN-PST on-farm, while achieving results similar to those obtained with more complicated models such as NAPRA.

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INTRODUCTION

The movement of agricultural pesticides to surface and ground water from the site of application in agricultural production continues to be an environmental concern. The U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) and Agricultural Research Service (ARS) have developed a screening procedure to evaluate the potential risk of pesticide loss from soils. WIN-PST is a Windows-based computer program developed by the USDA National Water and Climate Center (NWCC). Based on the properties of pesticides and soils, climate, and cultural practices, WIN-PST evaluates the likelihood of pesticide loss and its potential risks to both human and fish. The purpose of this project was to evaluate WIN-PST (version 7-19-99) by comparing it with a quantitative simulation model, the National Agricultural Pesticide Risk Analysis (NAPRA).

The Institute for Agriculture and Trade Policy in Minneapolis, Minnesota uses WIN-PST as a central component of its Pesticide Decision Tool (PDT). The PDT is a set of documents designed to help farmers and agricultural professionals integrate environmental factors in their pesticide decision making. The PDT includes materials designed to accompany or substitute for WIN-PST. It includes reference tables, a soil-pesticide interaction worksheet, and a user's guide. Because WIN-PST is a core component of the PDT, it is important to assess and characterize its accuracy and reliability. This study aims to provide such an assessment and make recommendations for the future refinement of WIN-PST.

METHODOLOGY

Modeling approaches

WIN-PST uses qualitative ratings to classify the relative likelihood of pesticide loss from field boundaries via runoff and from below the root zone via percolation. The overall or interaction rating is based on the interaction of two separate ratings, one for pesticides and one for soils. Simple rule-based algorithms developed by Don Goss and R. Don Wauchope, USDA, are used to determine the ratings for pesticides and soils. These basic ratings are then adjusted by case-specific conditions such as the method and rate of pesticide application, field slope, soil macropores, water table, and probability of rainfall. In consideration of pesticide toxicity, pesticide hazard or the risk from its applications is then assessed and rated into four classes. The possible rating classes are "high," “intermediate,” and “low,” plus an additional category for leaching, “very low.”

Another approach developed by NRCS-USDA is the National Agricultural Pesticide Risk Analysis (NAPRA) model, a quantitative assessment tool for analysis of the relative pesticide risk. NAPRA uses the USDA environmental fate model GLEAMS (Groundwater Loading Effects of Agricultural Management Systems) to estimate the potential loss of pesticides from fields via runoff and percolation, and potential environmental risks. The probability of pesticide loss that exceeds the EPA’s Health Advisory Level (HAL) is calculated for a period of many years to assess the risk. The NAPRA process considers climate, soils, pesticide properties, tillage practices, field slope and length, and the method and rate of pesticide applications.

The GLEAMS model is a widely tested continuous simulation field-scale model. Our assumption is that NAPRA/GLEAMS provides more accurate and reliable results than WIN-PST and thus, may be used to assess or even calibrate WIN-PST. In this study, the two approaches were used in the same study area and run for similar scenarios. The results were used for comparative analysis. The probability of risk from NAPRA was calculated for 40-45 years in the study area. The relative risk from NAPRA was compared with ratings from WIN-PST. Selected scenarios included different soils, management practices (soil incorporated and surface application), rates of pesticide application, and pesticide toxicity levels.

Study areas

Two Michigan counties, Clinton and Cass (Figure 1), were used as the study areas. Clinton County is located in south central Michigan, while Cass County is located in southwestern Michigan. Major agricultural soils were chosen for the two models. Capac and Marlette soils are predominant in Clinton County and account for approximately 40% of the total acreage. The Capac series are nearly level to gently sloping and somewhat poorly drained. The Marlette soils are gently sloping to steep and moderately to well drained. Annual precipitation in the county is about 30 inches, of which approximately 18 inches is received during the growing season (May - October). Corn, soybeans, and wheat are the major field crops in the county.

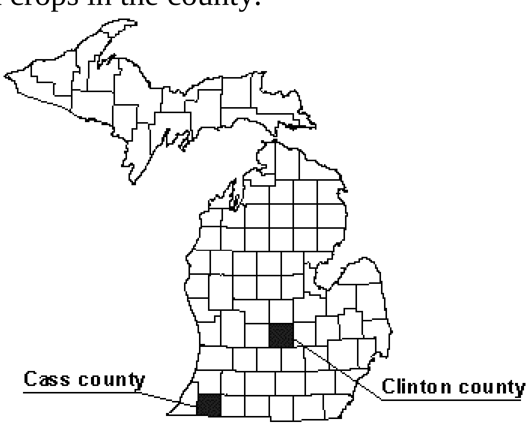

Fig. 1 Study areas in Michigan

Kalamazoo loam is the predominant soil in Cass county (30%), followed by Oshtemo sandy loam (15%) and Spinks loamy sand. The Kalamazoo soils are formed in loamy and sandy material, and are well drained. Permeability in these soils is moderate in the upper part of the profile and rapid in the lower part. The Oshtemo soils are also formed in loamy and sandy material, with moderate permeability. The Oshtemo series are well drained soils. Spinks soils are formed in sandy material and are well drained. These soils are moderately to highly permeable. Annual precipitation in the county is about 33.6 inches, of which approximately 19.7 inches is received during the growing season.

Data sources

Input data required for both WIN-PST and NAPRA models include soils, climate, crop, tillage practices, and pesticide properties.

Soil: WIN-PST software includes soil databases provided by the NRCS-USDA. For NAPRA, a program called Prepsoil (Hesketh et al, 1994) was used to calculate soil attribute values. Soils used in this study are shown in the following table.

Table 1. Characteristics of selected soils in Clinton and Cass County, Michigan

Soil series	Soil texture	Hydrologic group	Slope (%)	Organic Matter (%) in top horizon
Clinton				
Capac	Loam	C	0 – 4	2 – 6
Capac	Sandy Loam	C	0 – 4	1 – 2
Marlette	Clay Loam	B	6 – 12	0.5 – 1
Marlette	Loam	B	1 – 6	2 – 6
Marlette	Sandy Loam	B	2 – 6	1 – 2
Cass				
Kalamazoo	Loam	B	0 – 2	1 – 3
Oshtemo	Sandy Loam	B	0 – 2	0.5 – 3
Schoolcraft	Loam	B	0 – 2	1 – 3
Spinks	Loamy Sand	A	0 – 6	0.5 – 3

Climate: For water inputs, WIN-PST allows the user to choose from two categories of rainfall—high or low probability—and from three categories of irrigation—no irrigation, low efficiency irrigation, and high efficiency irrigation. For the scenarios compared in this study, a combination of high probability of rainfall and no irrigation was used. This is similar to the conditions used in NAPRA. For NAPRA, climate data were downloaded from the Climate Data Access Facility System (CDAFS) maintained by the National Water and Climate Center, USDA Natural Resources Conservation Service. At least 30 years of climate data are recommended to calculate probabilities on a statistical basis (Plotkin et al, 1994). For this study, 46 years of climate data from 1949-1995 were used to run NAPRA for Clinton County. Forty-one years of climate data from 1954-1994 were used for Cass County. Data include daily precipitation, temperature, and monthly average maximum and minimum temperatures. In a few cases, missing data were replaced by data from the nearest weather stations.

Crop/tillage management: Through questionnaires**,** interviews and telephone queries, we collected information about tillage practices from county Extension, Conservation District, and NRCS staff. Conservation District staff in the St. Johns field office in Clinton and Cass Counties provided most of the information.

Pesticide data: A pesticide database is included in both WIN-PST and NAPRA. The input data for pesticide application, including rates, timing and methods, were provided by the NRCS-USDA field office staff in the study areas. Three commonly used herbicides were used in this study (Table 2).

Table 2. Properties of selected pesticides

Pesticides	**Half-life in soil (days)**	**Water solubility (ppm, or mg/l)**	**EPA drinking water guideline (lifetime-health advisory level) (ppb, or ug/L)**
Atrazine	60	33	3
Metolachlor	90	530	70
Metribuzin	40	1,220	100

Risk rating criteria

Both WIN-PST and NAPRA have their own rating schemes. WIN-PST's risk or hazard ratings are based on a set of simple algorithms that combine ratings for soils and pesticides along with pesticide toxicity. The algorithm's outputs are often presented in a matrix. NAPRA's risk ratings are based on the probabilities of pesticide loss exceeding EPA's Health Advisory Level (HAL). Similar classifications of risk ratings are used in both models such as "High," "Medium"/ "Intermediate," and "Low."

WIN-PST: Ratings for potential pesticide loss from soils were based on soil properties (the hydrologic group, percent organic matter, horizon #1 depth, and soil K factor), and pesticide properties (half-life, KOC, and solubility). WIN-PST includes an algorithm for determining an interaction rating, using the separate soil and active ingredient ratings. It is convenient to present the Soil-Pesticide Interaction ratings with a matrix (Table 3).

Table 3. Loss potential ratings for soil-pesticide interaction ("Very Low" is only used for leaching potentials)

Soil rating	**Pesticide rating**			
	High	**Intermediate**	**Low**	**Very Low**
High	High	High	Intermediate	Low
Intermediate	High	Intermediate	Low	Very Low
Low	Intermediate	Low	Low	Very Low
Very Low	Low	Low	Very Low	Very Low

During the rating procedure, adjustments were made for case-specific conditions for the soil and pesticide base (unadjusted) ratings and for the soil-pesticide interaction ratings. Conditions leading to adjustments are listed in Table 4. The rating can be adjusted to increase by one class (+1) such as from "Intermediate" to "High," or to decrease by one class (-1) such as from "Intermediate" to "Low." For leaching with "Ultra Low" application rate, the risk rating decreases by two classes (-2).

Table 4. Conditions for rating adjustments in WIN-PST

Rating conditions	Adjustments for		
	Leaching	**Solution in runoff**	**Adsorbed in runoff**
Soil base ratings			
Field slope > 15%	None	None	+1
Macropores or cracks deeper than 24 in.	+1	None	None
High water table during growing season (< 24 in. from the surface)	+1	None	None
Pesticide base ratings			
Banded application	-1	-1	-1
Soil incorporated	+1	-1	-1
Foliar application	-1	-1	-1
Low rate (0.1-0.25 lb a.i./acre)	-1	-1	-1
Ultra low rate (< 0.1 lb a.i./acre)	-2	-1	-1
High residue/CT	None	-1	-1
Soil-pesticide interaction ratings			
High probability of rainfall and low efficiency irrigation	+1	+1	+1
Low probability of rainfall and no irrigation	-1	-1	-1
Low probability of rainfall and high efficiency irrigation	-1	-1	-1
Other rainfall-irrigation combinations	None	None	None

The loss potential of pesticides is then adjusted for hazard ratings by using an additional matrix with pesticide toxicities. Risk ratings of pesticide hazards to human are used in this study.

NAPRA: The EPA's drinking water standards (Lifetime Health Advisory Levels, HALs) were used in the relative risk rating procedure. The probabilities of pesticide concentrations in runoff and percolation that exceed the EPA's drinking water standard were used to rate the risk level for surface and groundwater. The maximum 4-day and annual concentrations were used to assess the potential acute and chronic risks. Four risk levels (low, medium, high and very high) were used in the risk ratings (Table 5).

Table 5. Risk rating criteria in NAPRA

Water contamination		**NAPRA outputs used for rating**			
Groundwater	Acute	Annual 4-day max. concentration in percolation			
	Chronic	Annual concentration in percolation			
Surface water	Acute	Annual 4-day max. concentration in runoff			
	Chronic	Annual concentration in runoff			
Probability of exceeding HAL		<30%	30-60%	60-90%	>90%
Risk rating		Low	Medium	High	Very High

The same soil series and pesticides were run with NAPRA. For the purpose of comparative analysis, the parameters in the two models were made as equivalent as possible. The two application methods for pesticides included soil incorporation and surface application. Application rates included 0.01, 0.05, 0.1, 0.15, 0.2, 0.25, 1.0, 2.0, and 3.0 lb/acre active ingredient. As defined in WIN-PST, rates less than 0.1 lb a.i./acre are "ultra low," 0.1- 0.25 lb a.i./acre are "low," and above 0.25 lb is "high." The crop was corn, with no irrigation.

RESULTS AND DISCUSSION

WIN-PST was administered for five soil series with different soil textures and hydrological groups and three pesticides with different half-lives and toxicity levels. Management practices include soil incorporation and surface application with ultra low, low, and high rates. Based on the situation in Michigan, we chose a high probability of rainfall, no irrigation, and high crop residues as inputs for WIN-PST.

Based on our assumption that NAPRA provides more accurate and reliable results, we compared the WIN-PST against NAPRA. The comparison criteria used to categorize the results are defined in Table 6. Discrepancies of ratings from the two models were categorized as "Over-estimated," "Under-estimated," "Similar" and "Same." "Over-estimated" means WIN-PST's rating is two classes higher than NAPRA's. Likewise, "Under-estimated" is used where WIN-PST's rating is two classes lower than NAPRA's. If there is one class difference (i.e., ±1), it is considered "Similar." When both models yield the same rating, they are considered "Same." The statistics from the two models are shown in Tables 7, 8, and 9.

Table 6. Comparison criteria for WIN-PST and NAPRA

Discrepancy descriptor	Discrepancy (WIN-PST class – NAPRA class)	Example of risk rating comparison or discrepancy	
		WIN-PST	NAPRA
Over-estimated	≥ 2	High	Low
Under-estimated	≤ -2	Low	High/Very High
Similar	±1	Intermediate	High/Low
Same	0	Intermediate	Medium

In table 6, cases were considered "Same" when the risk was "Low" or "Very Low", and "High" or "Very High."

Ratings for human hazards obtained by WIN-PST were compared to ratings in NAPRA since they both take into account the toxicity of pesticides. The consideration of toxicity is important because the hazard or risk associated with a pesticide depends on measures of both exposure and potency or toxicity. The data in Tables 7 through 9 show that the overall output patterns from the two models were fairly close for most cases, in terms of the number of cases that were "similar" and "same." The largest discrepancy occurred for the high toxicity herbicide atrazine. WIN-PST gave higher ratings to atrazine than NAPRA in some cases. As the application rate increased, however, ratings from both models became more similar.

Table 7 shows that with ultra low and low application rates of atrazine, most cases were "over-estimated." WIN-PST yielded similar ratings to NAPRA for high rates of atrazine application. For metolachlor, which is less toxic, WIN-PST ratings were one class higher than NAPRA ratings for most cases—most outputs were "similar" (see Table 8). Table 9 clearly shows that for almost all cases, WIN-PST had the same ratings as NAPRA for metribuzin, which is the least toxic herbicide among the three.

Toxicity and application rates are two of the most important factors affecting the ratings. Using less potent pesticides and lower application rates can directly reduce the associated risks. WIN-PST may yield a conservative (i.e., precautionary) assessment when pesticides are applied at a low rate. For the application method, both surface application and soil incorporation showed similar patterns for the different rates of pesticide application and for leaching/runoff.

Some of the detailed results summarized in Tables 7, 8, and 9 are given in the appendix.

Table 7. Comparison of WIN-PST and NAPRA risk ratings for atrazine

Application	Rate	Leaching					In solution runoff				
		Over-estimated	Under-estimated	Similar		Same	Over-estimated	Under-estimated	Similar		Same
				-1	+1				-1	+1	
Surface	Ultra low	30	0	0	24	0	35	0	0	13	6
	Low	41	0	0	7	6	24	0	0	15	15
	Standard rate	6	0	0	0	48	17	0	2	8	27
Soil incorporated	Ultra low	53	0	0	1	0	42	0	0	10	2
	Low	35	0	0	7	12	29	0	0	16	9
	Standard rate	6	0	0	0	48	20	0	1	5	28
Subtotal		171	0	0	39	114	167	0	3	67	87
Percent (%)		52.8	0	0	12.0	35.2	51.5	0	0.9	20.7	25.9

Table 8. Comparison of WIN-PST and NAPRA risk ratings for metolachlor

Application	Rate	Leaching					In solution runoff				
		Over-estimated	Under-estimated	Similar		Same	Over-estimated	Under-estimated	Similar		Same
				-1	+1				-1	+1	
Surface	Ultra low	0	0	0	6	18	0	0	0	18	6
	Low	0	0	0	24	0	0	0	0	18	6
	Standard rate	0	0	0	24	0	0	0	7	7	10
Soil incorporated	Ultra low	0	0	0	24	0	0	0	0	18	6
	Low	0	0	0	24	0	0	0	0	18	6
	Standard rate	0	0	0	24	0	0	0	1	14	9
Subtotal		0	0	0	126	18	0	0	8	93	43
Percent (%)		0	0	0	87.5	12.5	0	0	5.5	64.6	29.9

Table 9. Comparison of WIN-PST and NAPRA risk ratings for metribuzin

Application	Rate	Leaching					In solution runoff				
		Over-estimated	Under-estimated	Similar		Same	Over-estimated	Under-estimated	Similar		Same
				-1	+1				-1	+1	
Surface	Ultra low	0	0	0	0	24	0	0	0	0	24
	Low	0	0	0	0	24	0	0	0	0	24
	Standard rate	0	0	0	0	24	0	0	3	0	21
Soil incorporated	Ultra low	0	0	0	0	24	0	0	0	0	24
	Low	0	0	0	0	24	0	0	0	0	24
	Standard rate	0	0	0	0	24	0	0	0	0	24
Subtotal		0	0	0	0	144	0	0	3	0	141
Percent (%)		0	0	0	0	100	0	0	2.1	0	97.9

CONCLUSIONS AND RECOMMENDATIONS

In general, WIN-PST provides reasonably comparable results with the more quantitative model NAPRA; most scenarios are "similar" or "same." They correspond particularly well for pesticides with low toxicity and high application rates. WIN-PST somewhat over-estimates the risks for pesticides with high toxicity. In some cases, it may also over-estimate the risk for applications with low rates. This suggests that WIN-PST may have provided a conservative assessment for environment risk of pesticide applications.

Unlike NAPRA, which requires intensive data entry and good knowledge about the farming systems, WIN-PST has a more user-friendly interface and can be run with a few clicks. In other words, agency field office staff and other individuals should find it relatively easy to use. A pesticide database is included in the package and a soils database can easily be installed for each state. Explanations regarding the adjustments are included in its help documents, glossary, and footnotes. With the PDT documentation provided by the Institute for Agriculture and Trade Policy, most ag-professionals and many farmers could learn how to use WIN-PST fairly quickly.

While WIN-PST may produce similar results as NAPRA for most cases, this study makes the following recommendations to be considered for future refinement.

1. Make an adjustment for ratings on pesticides with high toxicity such as atrazine. The ratings should be lower, especially for low rate applications.
2. Adjust the ratings for runoff with "ultra low" rates by lowering two (2) classes, similar to the adjustment on "ultra low" rates for leaching where the rating is reduced by two classes. [This adjustment has already been included in the latest WIN-PST version.]
3. Divide the application rate range into more categories. Application rates greater than 0.25 lb/acre are considered as high rates which are used as a default in the current version of WIN-PST. This range is too wide and should be divided into two categories such as "medium" and "high." Making this change should increase the accuracy of WIN-PST.

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APPENDIX

The appendices are currently not available electronically. To request a copy or for more information, contact:

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