

PESTICIDE RISK INDICATORS

Over the past four years, AFT has analyzed 15 pesticide risk indicator models from the U.S. and other countries. Four models have emerged that effectively evaluate the environmental effects of agricultural pesticide applications, SYNOPSIS_2, EYP, MATF, and EIQ. They have different purposes, methodologies, and data requirements.

Indicators such as MATF (Benbrook) and EIQ (Cornell) use simplified straightforward equations, often comparing toxicity and chemical property information, to predict environmental risk. Less quantitative than their European “cousins,” SYNOPSIS_2 and EYP, these indicators are easier for project leaders and growers to use and understand.

The German SYNOPSIS_2 and the Dutch Yardstick, EYP rely on environmental engineering equations to calculate how much pesticide active ingredient remains in the soil, surface water, and groundwater over time. This potential concentration is then compared to toxicity data to predict environmental risk due to pesticide applications. These models are more rigorous so they can be used to compare projects within regions. They can also help validate the more easily used MATF and EIQ indicators. So far, where we’ve run the indicators side by side with actual field data, they trend in the same direction. Only SYNOPSIS-2 has been validated by actual environmental sampling (in two watersheds in South Africa).

SYNOPSIS_2

Researchers from Germany’s Federal Biological Research Centre for Agriculture and Forestry and the Institute for Technology Assessment in Plant protection developed SYNOPSIS_2 (Synoptisches Bewertungsmodell für Pflanzenschutzmittel) to assess the potential environmental risk of a pesticide application strategy within a region. The indicator calculates a predicted concentration of the pesticide’s active ingredient in soil and surface water. This concentration is then divided by toxicity data to determine the environmental risk to certain organisms in the environment. As a result, SYNOPSIS_2 assesses potential environmental risk by including site-specific information on soil, field characteristics, precipitation, and toxicity data in various equations. These equations allow SYNOPSIS_2 to consider the potential effects of pesticides on soil, surface water, and even air. In addition, potential effects on groundwater can also be considered by combining aspects of SYNOPSIS_2 with a groundwater leaching program (PELMO: The Pesticide Leaching Model).

EYP

The Dutch research team of J. Reus and P. Leenderste developed EYP (the Environmental Yardstick for Pesticides) to help Dutch growers and technical advisors select the least damaging pesticides. In addition, EYP was designed to compare different pesticide application strategies across regions in The Netherlands. The indicator calculates a potential concentration of the pesticide’s active ingredient in groundwater, surface water, and soil. After the concentration is calculated, it is divided by toxicity data to determine the environmental risk to certain organisms in the environment. Much like SYNOPSIS_2, EYP relies on an external leaching program to calculate a pesticide’s active ingredient concentration in groundwater (in this case, the program is PEARL: the

Pesticide Emission Assessment at Regional and Local Scales Model, and PESTLA: the Pesticide Leaching and Accumulation Model).

MATF

Chuck Benbrook and contributing researchers developed and refined the MATF indicator (Multi-Attribute Toxicity Factor) as a tool for Wisconsin potato farmers to calculate the toxicity of pesticides used in the Wisconsin Potato IPM Project (a collaboration of the World Wildlife Fund, the Wisconsin Potato and Vegetable Growers Association, and the University of Wisconsin). This indicator depends on equations that manipulate or rank data such as chemical property and toxicity to arrive at an approximation of environmental risk due to pesticide applications. This often includes ranking data characteristics on an MATF specific scale. In addition, MATF relies on researchers to determine how pesticide applications will affect beneficial insects and insect resistance. While using the specific MATF design outside of Wisconsin potato farms remains in question, the basic MATF design has been updated to reflect new localized concerns (e.g. groundwater concerns in Florida). The MATF design must be adapted before it becomes applicable to new areas.

EIQ

J. Kovach, C. Petzoldt, J. Degni, and J. Tette at Cornell University developed the EIQ indicator (Environmental Impact Quotient) as a way to calculate the potential environmental impact from common fruit and vegetable pesticides. Much like MATF, this indicator also depends on manipulating or ranking data such as chemical property and toxicity to arrive at an approximation of environmental risk due to pesticide use.

Data Requirements

As shown in Tables 1 and 2, SYNOPS_2 and EYP require a lot of data to generate an assessment of potential risk. Fewer data requirements and simplified straightforward equations make indicators such as EIQ and MATF more applicable to projects where growers or advisors do not have expertise in operating pesticide risk indicators. However, researchers and governmental agencies should rely on indicators such as SYNOPS_2 and EYP to compare projects on a regional scale or to demonstrate that indicators such as EIQ and MATF are valid.

Table 1: Site Specific Data Requirements for Pesticide Risk Indicators

	SYNOPS 2	EYP	MATF	EIQ
LOCATION DATA				
Application Method	•	•		
Application Rate per Acre	•	•	•	•
Crop Emergence / Harvest Dates	•	•		
Ditch Depths		•		
Field Size	•	•		
Field Slope	•			
Percentage of Fields Bordering Water	•			
Percentage of Clay, Organic Matter, Sand, & Silt in Soil		•		
Soil Bulk Density		•		
Soil Horizons (number and thickness)		•		
Soil Organic Content	•	•		
Soil pH Level		•		
Width of Buffer Strips	•			
METEROLOGICAL DATA				
Average Relative Humidity		•		
Daily High / Low Temperature		•		
Daily Precipitation	•	•		
Daily Solar Radiation		•		
Wind Speed		•		

Table 2: Pesticide Active Ingredient Data Requirements for Pesticide Risk Indicators

	SYNOPS_2	EYP	MATF	EIQ
PESTICIDE ACTIVE INGREDIENT PROPERTY DATA				
Estimation of Endocrine Disrupting Effects			•	
Estimation of Systemic Effects				•
Half Life (hydrolysis)	•			
Half Life (photolysis)	•			•
Half Life (soil)	•			•
Henry's Law Constant	•			
Octanol / Water Partition Coefficient (K_{ow})	•			
Oncogenic Potency Factor			•	
Organic Matter Sorption Coefficient (K_{om})		•		
Organic Content Sorption Coefficient (K_{oc})	•			
Molar Mass	•	•		
Reference Dose (RfD)			•	
Vapor Pressure		•		
Water Solubility		•		
PESTICIDE ACTIVE INGREDIENT TOXICITY DATA				
Algae (LC_{50} , NOEC)	•	•		
Bees (LD_{50} Oral)			•	
Bees (LD_{50} Contact)			•	•
Beneficial Impact Estimation			•	•
Bluegill Fish / Rainbow Trout (LC_{50})			•	
Daphnia (LC_{50})	•	•	•	
Daphnia (NOEC)	•	•		
Earthworm (LC_{50} , NOEC)	•	•		
Estimation of Developmental Effects				•
Estimation of Leaching Potential				•
Estimation of Runoff Potential				•
Fish (LC_{50})	•	•		•
Fish (NOEC)	•			
Mallard (LD_{50})			•	•
Insect Resistance Estimation			•	
Rat Oral (LD_{50})			•	•

Pesticide Risk Indicators (for Section 5)

Comparing the NRCS WIN-PST (Windows Pesticide Screening Tool) to Other Pesticide Risk Indicators

AFT has analyzed 12 pesticide risk indicator models. Some use a predicted environmental concentration methodology to estimate pesticide concentrations in soil, groundwater and surface water. They rely on actual weather data, application rates and soil data to predict pesticide concentrations in soil, groundwater and surface water. Other pesticide risk indicators use a ranking methodology based more on qualitative assessments about the application site and type of pesticide used. For example, qualitative indicators often calculate a pesticide's propensity to leach into groundwater and ability to runoff onto surface water based on a ranking of such variables as Koc and soil half-life values (e.g. half-life of 300 days = high propensity to runoff). In contrast, quantitative indicators often incorporate such variables directly into equations that consider specific weather and soil information from the application site. These equations allow the quantitative indicators to generate risk assessments that include actual predictions of pesticide concentrations. Such assessments *may* be more accurate than qualitative assessments based on rankings. However, qualitative indicators based on a ranking methodology are often easier to use than quantitative indicators that are data intensive and mathematical complex.

NRCS uses the WIN-PST indicator in its conservation programs. WIN-PST is a qualitative type of indicator that ranks a pesticide's potential to leach and runoff. These ranks are then combined with pesticide toxicological information from humans and aquatic life to arrive at final hazard potentials. WIN-PST uses many of the same variables required in the indicators we analyzed. For example, organic matter in soil, soil half-life and water solubility are used in WIN-PST and also in many of the indicators included in our research. As a result, WIN-PST is similar to many of the indicators that generate risk assessments from pesticide applications. Since the WIN-PST indicator is a qualitative type of indicator, it relies on a ranking methodology. For example, WIN-PST ranks rainfall events into categories of "high probability" and "low probability." In contrast, the quantitative indicators we analyzed (such as SYNOPSIS/PELMO and EYP/PEARL) use actual rainfall amounts from meteorological databases. Basing an indicator on a ranking methodology *may* result in a less accurate assessment of risk posed from pesticide use when compared to more quantitative indicators. However, WIN-PST has correlated fairly well with quantitative indicators such as NAPRA (National Agricultural Pesticide Risk Analysis)

WIN-PST has many novel and useful traits including a downloadable database of pesticides and soil types. Inaccurate database issues are a huge concern with both qualitative and quantitative indicators. Including this information with WIN-PST saves research time and will result in more accurate risk assessments. Although we have tested it with actual field data, other research shows that WIN-PST is a useful and accurate tool for risk assessment. The question we continue to have about all pesticide risk indicators, including WIN-PST, is which is best to use when assessing environmental risk from

pesticide use? Although harder to use, indicators built on a quantitative methodology may provide a better type of risk assessment to interested parties and auditing officials.

