User's Guide

TerrPlant Version 1.2.2
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Acknowledgements

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1. Model Description

TerrPlant was created by the Plant Technology Team and is used by the Environmental Fate and Effects Division (EFED) as a Tier 1 model for screening-level assessments of pesticides. The model is implemented in Microsoft Excel. The purpose of TerrPlant is to provide screening-level estimates of exposure to terrestrial plants from single pesticide applications. The model does not consider exposures to plants from multiple pesticide applications. TerrPlant derives estimated exposure concentrations (EECs) of a pesticide in runoff and in drift. Risk quotients (RQs) are developed for non-listed and listed species of monocots and dicots inhabiting dry and semi-aquatic areas that are adjacent to treatment sites.

2. Model History

TerrPlant was originally used in EFED in 2002 as version 1.0. The model was developed to automate existing methods for calculating RQ values for non-listed and listed terrestrial plants, including wetland species (USEPA 2002a). In 2005, TerrPlant was modified to v1.2.1 to remove an assumption that aerial applications result in 60% application efficiency. TerrPlant v1.2.1 assumed 100% efficiency in ground and aerial applications (USEPA 2005). The current model version (1.2.2) includes the same assumptions and equations as v1.0, with the exception of the application efficiency assumption for aerial applications. TerrPlant v1.2.2 represents a cosmetic update of v1.2.1. No model assumptions or equations were altered from v1.2.1. Version 1.2.2 automates the calculation of EECs and RQ values according to current EFED guidance.

3. Definitions

Dicot: A flowering plant with 2 seed leaves or cotyledons (e.g., carrot, bean). Flower parts (e.g., petals) are generally in fours or fives.

Dry area: terrestrial habitats that do not have standing water during much of the year and do not tend to puddle.

EC_{05}: The "Effective Concentration" of a chemical that is estimated to produce a specific adverse effect in 5% of test organisms. In the case where no suitable NOAEC (No Observed Adverse Effects Concentration; see definition below) is available for a specific endpoint (e.g., when the NOAEC exceeds the EC_{25}), this value is used to derive RQ values for listed plant species.

EC_{25}: The "Effective Concentration" of a chemical that is estimated to produce a specific adverse effect in 25% of the test organisms. For terrestrial plants, the EC_{25} level was selected because it is considered to be the lowest level at which some species may be affected (SAP 2001). This is the toxicity value used for derivation of RQs for non-listed plant species.

EEC: Estimated environmental concentration of a pesticide used as an estimate of potential exposure.

Listed Species: Federally-listed threatened and endangered species.

LOC: The Agency's Level of Concern for comparison to RQ values. RQs that exceed the LOC, which is 1.0 for plants, indicate potential risk (USEPA 2004).

Monocot: A flowering plant with one seed leaf or coleoptile (e.g., grass, corn). Flower parts are in threes or specialized (e.g., grasses, sedges).

NOAEC: No Observed Adverse Effects Concentration. This is the test concentration where no adverse effects to test organisms are observed. This is the toxicity value used for derivation of RQs for listed plant species.

Non-target plants: Any plant species to which a pesticide is not intentionally applied. Non-target plants include desirable or undesirable plants outside of the target area (USEPA 1996).

RQ: Risk Quotient. This value is derived by dividing the EEC by the toxicity value for the taxa of concern.

Semi-aquatic area: low-lying areas of terrestrial habitats that are wet but may dry up at times throughout the year. These areas are also known as wetlands.

Target area: A use site to which a pesticide is applied.

Terrestrial habitat: a land area in which organisms live. These habitats may have standing water for part but not all of a year. Examples of terrestrial habitats include deserts, forests, grasslands, and wetlands.

4. Conceptual models

TerrPlant incorporates two similar conceptual models for depicting dry and semi-aquatic areas of terrestrial habitats. For both models, a non-target area is adjacent to the target area. Pesticide exposures to plants in the non-target area are estimated to receive runoff and spray drift from the target area. For a dry area adjacent to the treatment area, runoff exposure is estimated as sheet runoff. Sheet runoff is the amount of pesticide in water that runs off of the soil surface of a target area of land that is equal in size to the non-target area (1:1 ratio of areas). For semi-aquatic areas, runoff exposure is estimated as channel runoff. Channel runoff is the amount of pesticide that runs off of a target area 10 times the size of the non-target area (10:1 ratio of areas). Exposures through runoff and spray drift are then compared to measures of survival and growth (e.g., effects to seedling emergence and vegetative vigor) to develop RQ values.

5. Calculation of EECs

In TerrPlant v1.2.2, user inputs for EECs are indicated by **green text** and are located in **Tables 1 and 2**. **Table 1** contains reference information for the user that is relevant to the identity and use of the pesticide but does not directly affect EEC calculations. **Table 2** is used to input parameter values for deriving drift and runoff EECs. Example inputs and results are found in **Tables 1-5**, below.

Table 1. Chemical Identity.	
Parameter	**User Input**
Chemical Name	**Pesticide X**
PC code	**000000**
Use	**Turf**
Application Method	**Aerial**
Application Form	**Liquid**
Solubility in Water (ppm)	**5**

Table 2. Input parameters used to derive EECs.			
Input Parameter	**Symbol**	**Value (user input)**	**Units**
Application Rate	A	**3**	**lbs ai/A**
Incorporation	I	**1**	none
Runoff Fraction	R	**0.01**	none
Drift Fraction	D	**0.05**	none

In cases where multiple application methods (ground and aerial/airblast/spray chemigation) and/or application forms (liquid and granule) are possible for a pesticide, multiple drift fractions are possible for a pesticide. This impacts the calculation of EECs of the pesticide. To calculate the different EECs and resulting RQs for the different possible drift fractions, the user should complete the following steps: 1) input all relevant data for the pesticide according to one relevant type of application method and form (Tables 1, 2 and 4); 2) copy the worksheet within the Excel file; 3) alter the relevant application method and/or form to represent another application scenario; and 4) repeat as necessary.

In **Table 2**, the application rate should be entered in units that are consistent with units of plant survival and growth data entered in **Table 4** (e.g., lbs active ingredient (a.i.)/A, lbs acid equivalent (a.e.)/A). This value represents the maximum rate per single application according to the label. If multiple applications are allowed by the label, only the application rate per single application should be entered, not the total annual application rate.

The incorporation value is based on the depth of pesticide incorporation in inches. Incorporation depth is dependent upon label directions. In TerrPlant, this value is unitless and is related to the proportion of applied pesticide that is available for runoff. The default value for this parameter is 1, which is entered for ground applications with no incorporation and for aerial applications. When the incorporation depth is >1 inch, the specified value is entered. If the value is > 6 inches, 6 should be entered. In cases where labels give a range of incorporation depth, the user should model RQs resulting from both the minimum and maximum depths as indicated by the label.

The magnitude of runoff is assumed to be dependent on the water solubility of the pesticide active ingredient. For pesticides with a solubility of <10, 10 to 100, or >100 ppm, runoff fractions of 0.01, 0.02 or 0.05, respectively (Aquatic Effects Dialogue Group 1992), are selected by the model user.

It is assumed that, for a liquid formulated pesticide applied by ground methods, 1% of the applied mass of pesticide per acre will drift to the non-target area. For a liquid formulated pesticide which is applied through aerial, airblast, or spray chemigation methods, 5% of the applied mass of pesticide per acre will drift to the non-target area (USEPA 2002). In cases where a pesticide is in granular form, drift is assumed to be 0%.

Runoff exposure is assessed in two scenarios: sheet and channel runoff. In the sheet runoff scenario, the treated area generating runoff is assumed to drain into an area with equal size containing seedlings, resulting in 1, 2, or 5% of the application rate being deposited. In the channel runoff scenario, a ten-to-one ratio of watershed area to receiving area results in 10, 20, or 50% of the application rate being deposited on soil with emerging or emerged seedlings. With pesticides which are ground incorporated, the runoff EEC is decreased because the application rate is divided by the incorporation depth before being multiplied by the runoff value. For RQ derivation, EECs for dry and semi-aquatic areas combine runoff and drift exposures. Drift only EECs are also used for RQ derivation (**Table 3**). All EEC values are in units consistent with those entered by the user for application rate (**Table 2**).

Table 3. EECs for Pesticide X. Units in lbs ai/A.

Description	Equation	EEC
Runoff to dry areas	(A/I)*R	0.03
Runoff to semi-aquatic areas	(A/I)*R*10	0.3
Spray drift	**A*D**	**0.15**
Total for dry areas	**((A/I)*R)+(A*D)**	**0.18**
Total for semi-aquatic areas	**((A/I)*R*10)+(A*D)**	**0.45**

6. Toxicity Data

Data from submitted seedling emergence and vegetative vigor studies are used to establish the toxicity of a pesticide to monocots and dicots. The EC_{25} values of a pesticide for the most sensitive tested monocot and dicot species are used to define the toxicity of this pesticide to non-listed species. The corresponding NOAEC values (or EC_{05} if a suitable NOAEC is unavailable) for the same species and endpoint are used to define the toxicity of the pesticide to listed plants (USEPA 2005b) (**Table 4**). Units for toxicity data must be consistent with application rate units.

Table 4. Plant survival and growth data used for RQ derivation. Units are in lbs ai/A. All values are user inputs.

	Seedling Emergence		Vegetative Vigor	
Plant type	**EC_{25}**	**NOAEC**	**EC_{25}**	**NOAEC**
Monocot	**100**	**100**	**100**	**100**
Dicot	**100**	**100**	**100**	**100**

7. RQ values

TerrPlant derives RQ values for non-listed and listed species of monocots and dicots inhabiting dry and semi-aquatic areas. The model compares the combined deposition estimates from runoff and spray drift to adverse effect levels measured in seedling emergence studies. RQs (**Table 5**) are derived by dividing the total EEC (**Table 3**) by the relevant seedling emergence value (**Table 4).**

Table 5. RQ values for plants in dry and semi-aquatic areas exposed to Pesticide X through runoff and/or spray drift.*				
Plant Type	**Listed Status**	**Dry**	**Semi-Aquatic**	**Spray Drift**
Monocot	non-listed	<0.1	<0.1	<0.1
Monocot	listed	<0.1	<0.1	<0.1
Dicot	non-listed	<0.1	<0.1	<0.1
Dicot	listed	<0.1	<0.1	<0.1
*If RQ > 1.0, the LOC is exceeded, resulting in potential for risk to that plant group.				

In addition, RQs are derived for plants with consideration for spray drift exposures. For monocots and for dicots, TerrPlant compares estimated spray drift deposition, without a runoff exposure component, to the more sensitive measure of effect, either seedling emergence or vegetative vigor (USEPA 2005b). The selection of the more sensitive measure of effect is automated by the model and is defined by the lowest EC_{25} value. The associated NOAEC value is selected to define RQ values for listed species exposed to drift. In cases where the EC_{25} values for seedling emergence and vegetative vigor studies are equal, the lowest NOAEC value is selected in calculation of the RQ value. The results of these calculations are RQ values for non-listed and listed monocots and dicots inhabiting adjacent and semi-aquatic areas and exposed to drift only (**Table 5**).

In TerrPlant v1.2.2, if an RQ value is <0.1, the model automatically indicates "<0.1" as the RQ.

8. LOC

EFED's LOC for non-listed and listed plant species is 1.0. RQ values exceeding 1.0 indicate potential risk to plants. RQ values less than or equal to 1.0 indicate that potential risk is minimal. In other words, if pesticide exposure (EEC) does not exceed the toxicity value (EC_{25} or NOAEC), the RQ is ≤ 1.0. This places the RQ below EFED's LOC and potential risk to that plant group is considered to be acceptable.

9. Discussion of Assumptions and Uncertainties

TerrPlant's 10 to 1 ratio of target area to semi-aquatic non-target area is based on research indicating a pond located in Georgia with a 6-7 foot typical depth and a requirement of 2-acre drainage areas per foot of depth (USDA 1997). Although the data are derived from observations of aquatic areas (e.g., farm ponds), it is assumed that this ratio is relevant to low-lying semi-aquatic areas. There is some uncertainty associated with the depth of the ponds used for modeling purposes and the expected depth of a semi-aquatic area.

Consistent with a screening-level approach, the application efficiency, which is the amount of applied pesticide reaching the target area, is assumed to be 100% for all applications. Application efficiency is considered separately from spray drift; the sum of the two does not necessarily equal 100%.

Spray drift is estimated based on application method alone, without consideration of other potentially influential factors related to application, such as droplet size, wind speed and release height.

The model assumption that granular applications have 0% spray drift may result in an underestimation of exposure.

TerrPlant assumes that drift and runoff concentrations are uniform over the non-target area. In the field, decreasing concentration gradients would be expected for each of these exposure pathways as the distance increases from the application site. If the dimensions (i.e., length and width) of the target area and non-target area were defined, the uncertainties associated with these assumptions could be explored.

For pesticides that involve ground incorporation applications (> 1 in), less of the pesticide applied is vulnerable to runoff. In TerrPlant, the application rate is divided by the incorporation depth. The basis for calculation of effects of ground incorporation on pesticide runoff also originated from former assumptions related to modeling aquatic EECs. The assumption is that the incorporation depth in inches is directly related to the proportion of runoff. For example, incorporation of a pesticide to a depth of 2 inches would result in ½ of the application rate being available for runoff. This proportion is considered relevant up to 6 inches. Thus, the model assumes that the amount of pesticide in runoff is directly related to the depth to which the pesticide is incorporated into the ground.

There are two assumptions related to temporal factors of exposure and effects. 1) The model assumes that a pesticide contained in drift and runoff reaches the non-target area at the same time. This assumption is conservative because it is unlikely that a pesticide would move at equal rates in drift and runoff. 2) The model does not consider the coincidence of drift pesticide and runoff pesticide reaching the non-target area in time to reach the emergence portion of the plant's life cycle. If applied later in the plant's life cycle, it is possible that the pesticide will reach the non-target plants at stages of different sensitivities. It is uncertain whether or not an exposure which occurs at a different life stage of the plant is relevant to the RQ derived based on the early seedling stage of a plant's lifecycle (i.e., this may have greater or lesser effect than indicated by the RQ).

Modeled pesticide concentrations in runoff are dependent solely upon solubility of the pesticide. The amount of pesticide in runoff does not consider other relevant transport properties of the pesticide (e.g., K_d). In addition, the model does not consider pesticide movement through the soil or contained in eroded soil.

The model does not incorporate parameters that would allow for photolytic, hydrolytic, or microbial degradation. In cases where degradation occurs, this leads to an uncertainty in the amount of pesticide that would be present in runoff and in drift.

The RQ values which are currently derived by TerrPlant represent the risk of effects for single maximum applications. It is assumed that each single application would expose different plants (i.e., due to different drift patterns). The modeling of EECs from single pesticide applications rather than multiple applications could result in underestimating pesticide exposures to plants.

For defining RQ values for plants exposed to runoff, measures of effect to seedling emergence are used; however, vegetative vigor could be affected by runoff (i.e. effects to plant roots). Because of limitations in the testing methods, these effects are not measured and cannot be incorporated into RQ development.

There is an absence of data comparing the field concentrations of pesticides to EECs generated by TerrPlant. Therefore, the relevance of TerrPlant predictions to pesticides concentrations in the field is uncertain.

10. References

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