EPA Modeling Approaches for Wetland Plants

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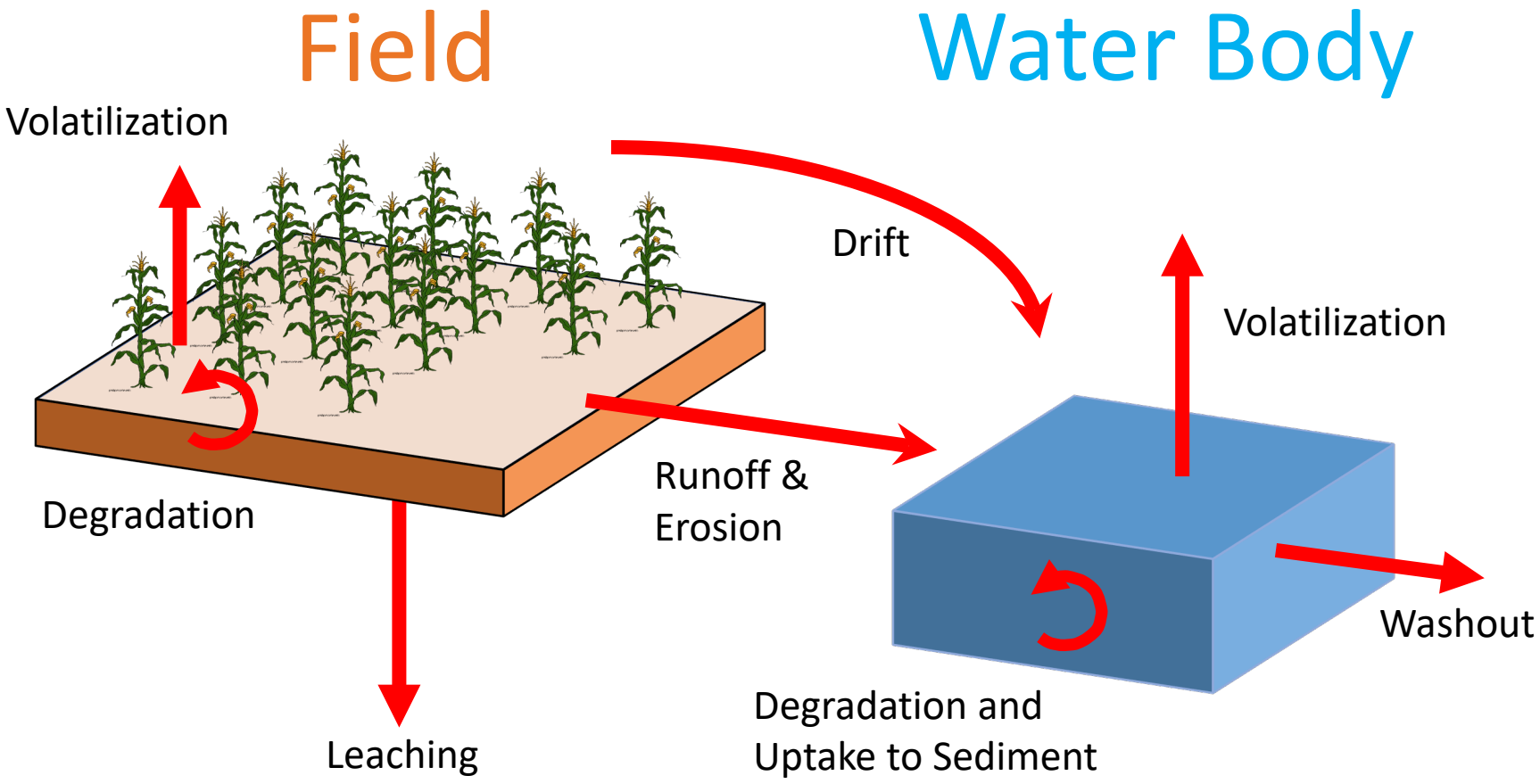
Modeling Fate and Transport in Wetlands

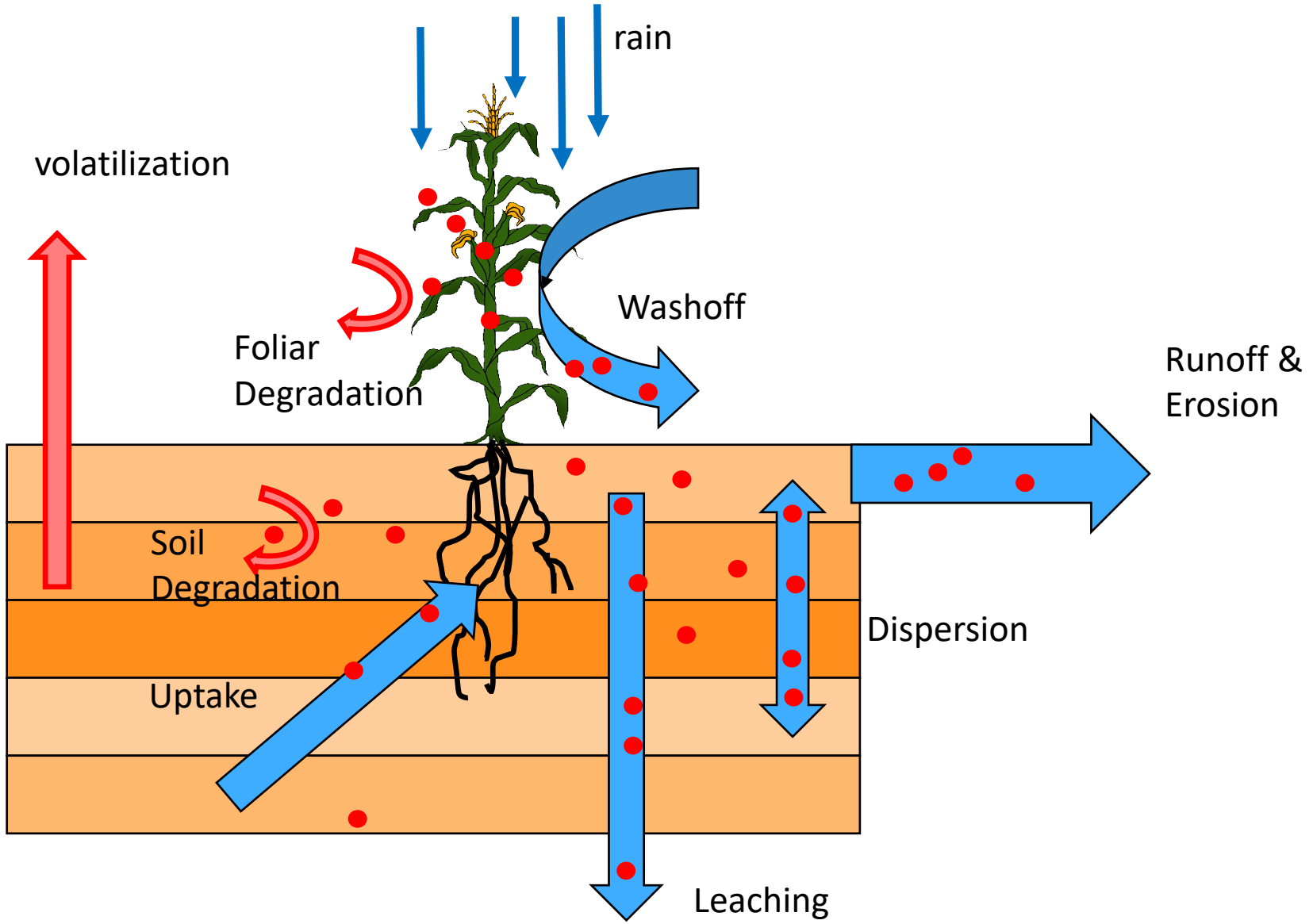
- Pesticide in Water Calculator (PWC)
  - Simulates pesticide applications to land surfaces and the pesticide's subsequent transport to and fate in water bodies
    - Constant volume with flow-through (EPA reservoir)
    - Constant volume, no flow-through (EPA pond)
    - Groundwater
  - Consists of a graphical user interface, the Pesticide Root Zone Model (PRZM), and the Variable Volume Water Model (VVWM)
- Plant Assessment Tool (PAT)
  - Estimates pesticide exposures to plants inhabiting dry and semi-aquatic areas that are adjacent to treated sites.
  - Improves upon and replaces TerrPlant v1.2.2
  - Incorporates PWC output files for more geographically-definable model output

Pesticide Water Calculator (PWC)

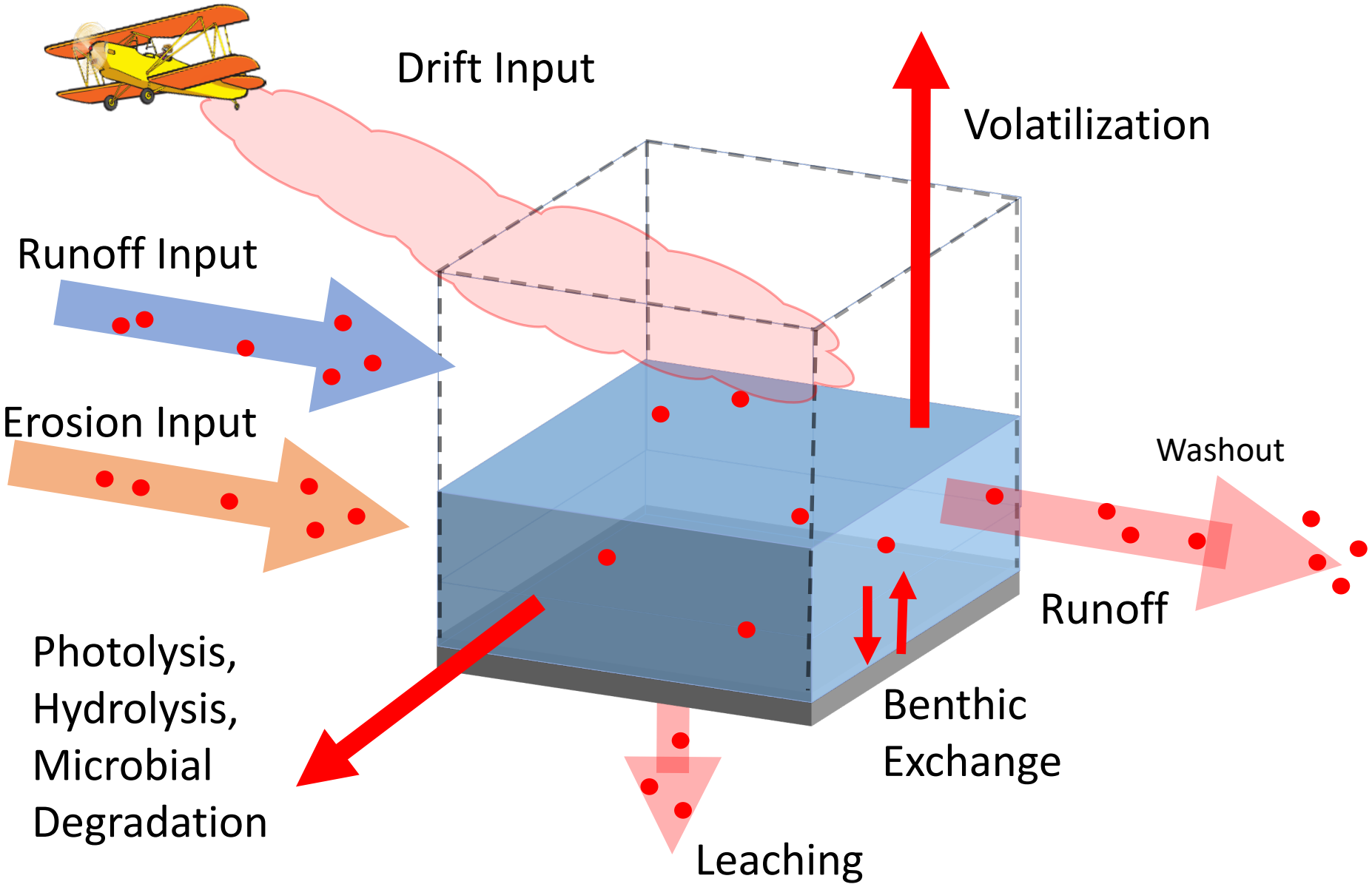
USEPA Concept of Pesticide Transport to Surface Water: "Scenario"



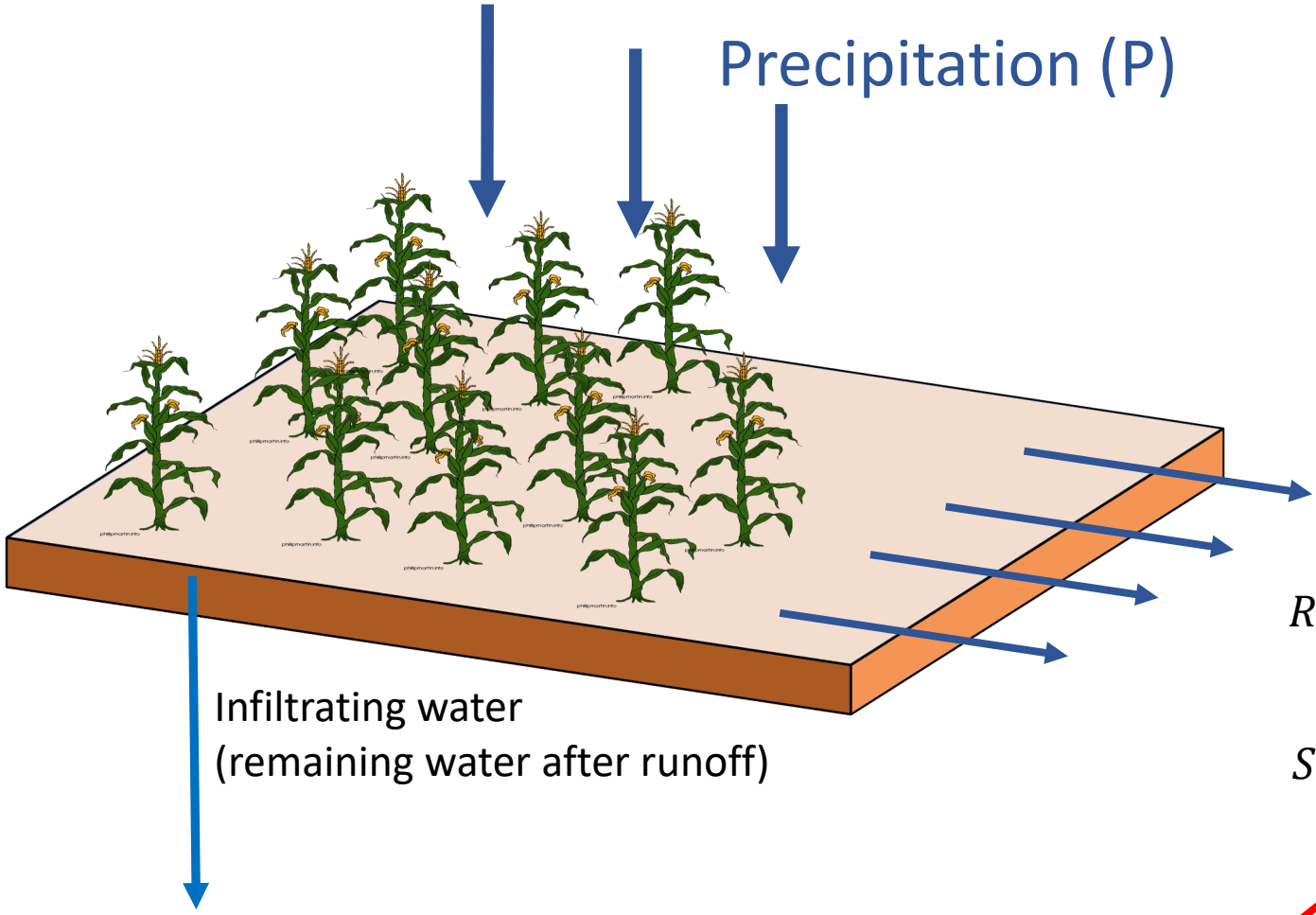
Pesticide Field Overview



Pesticide Waterbody Overview



Field Runoff



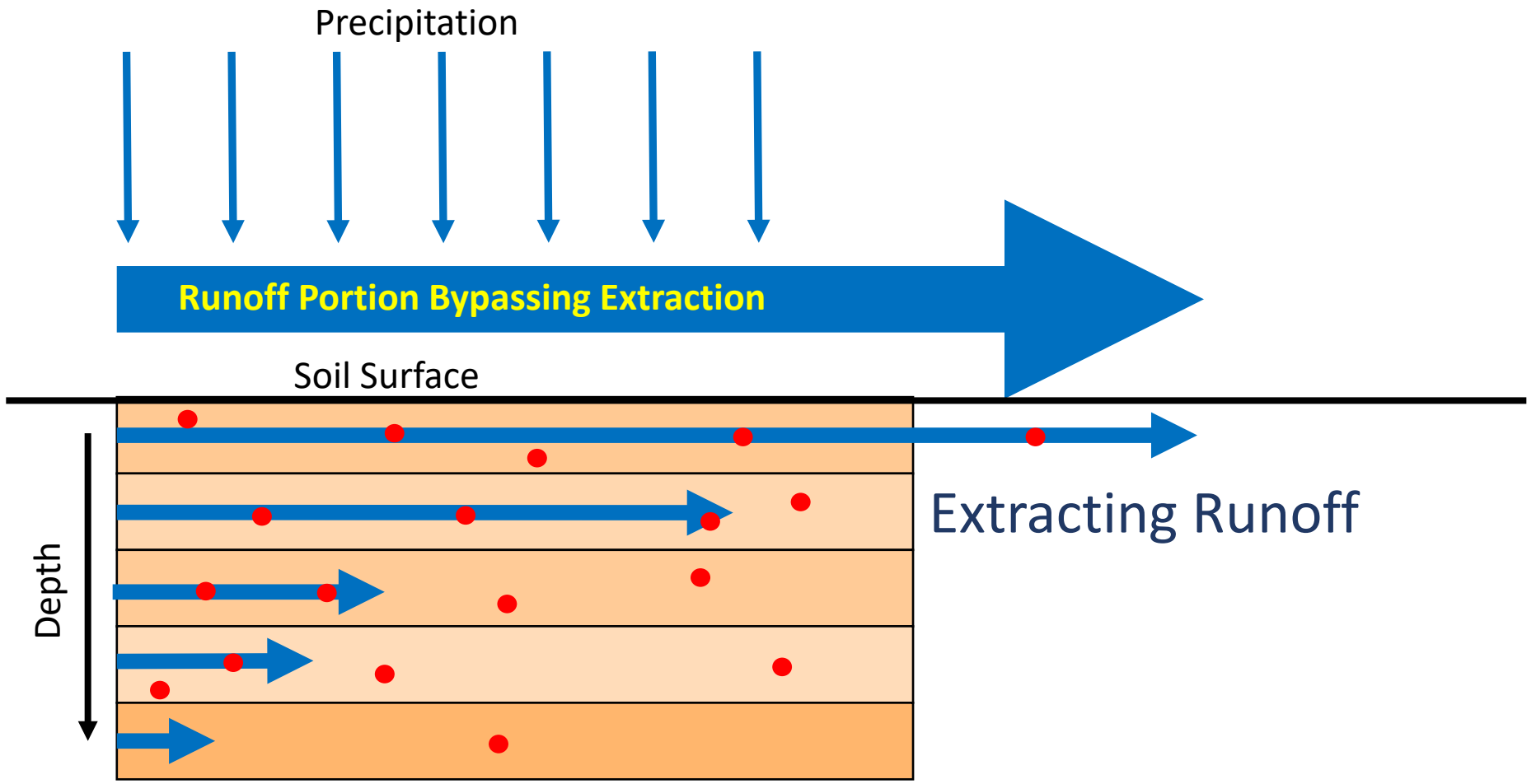
$$R = \frac{(P - S)^2}{(P - 0.8S)}$$

$$S = \frac{100}{CN} - 10$$

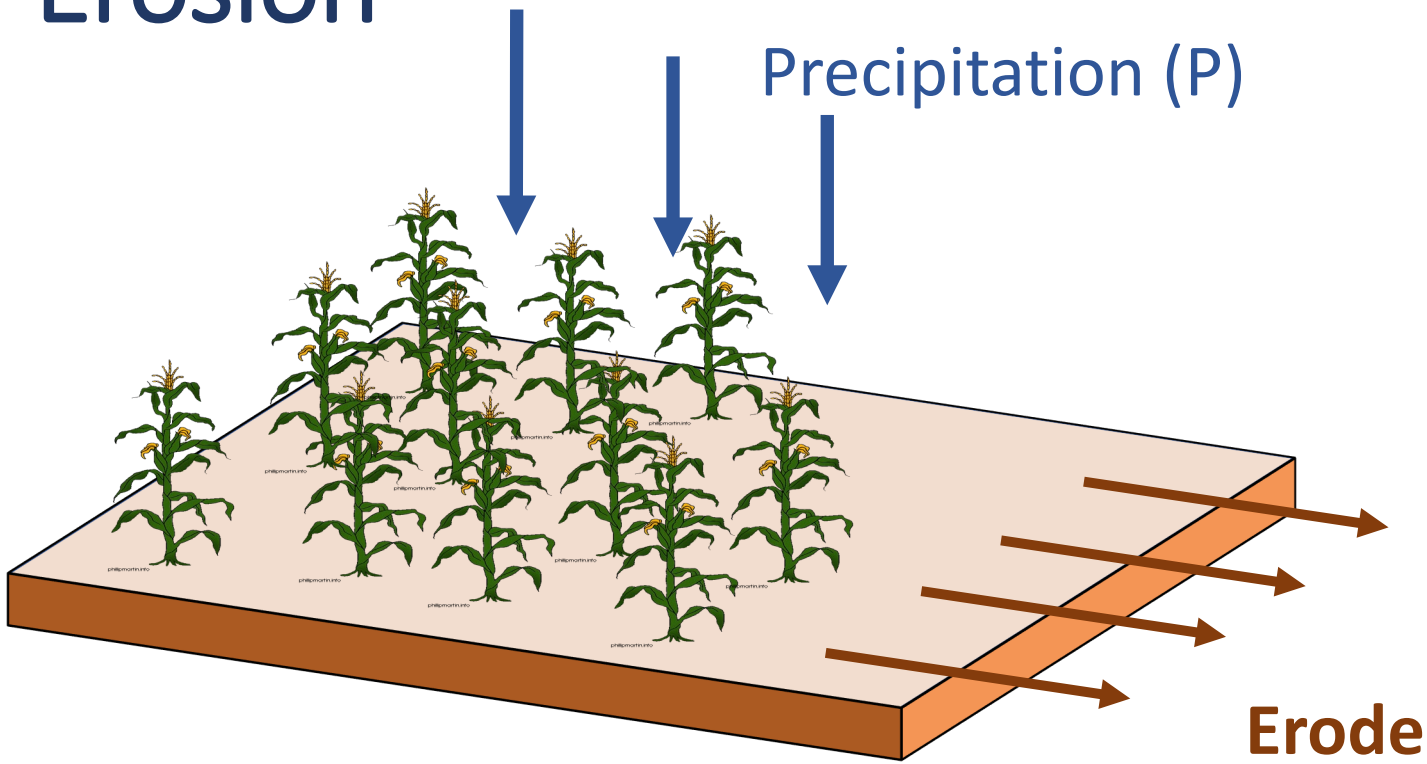
Curve Number (CN):
tabulated values based on
Soil Classification & Crop

Runoff Extraction of Pesticide

Hypothetical Subsoil Runoff Distribution &
Corresponding Extraction Potential
Newly calibrated per Young and Fry (2017)



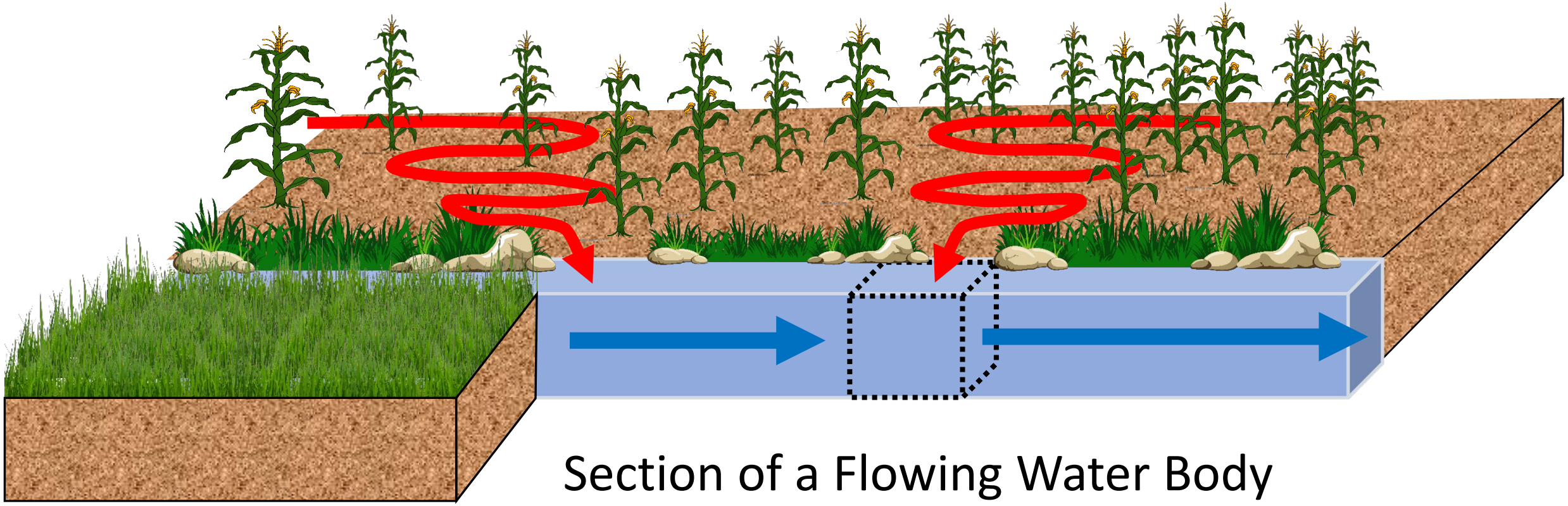
Erosion



Event Erosion: Modified Soil Loss Equation for Small Watersheds

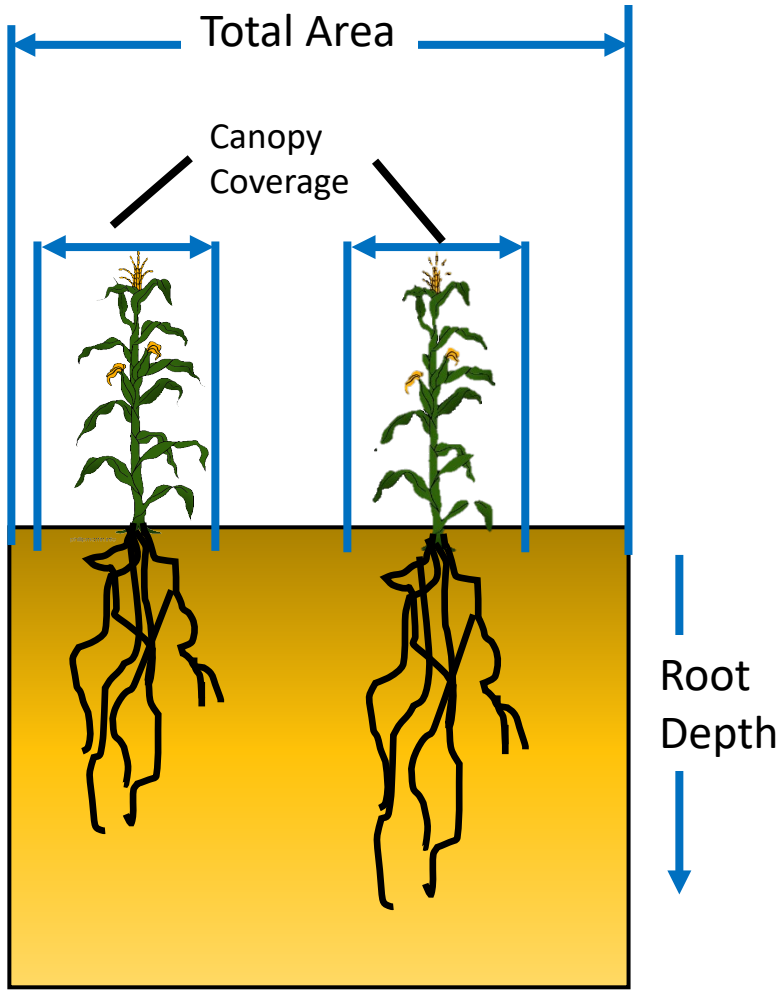
$$\text{Mass} = 0.79(R * q_p)^{0.65} * A^{0.009} * LS * C * P$$

Flowing Water



Section of a Flowing Water Body

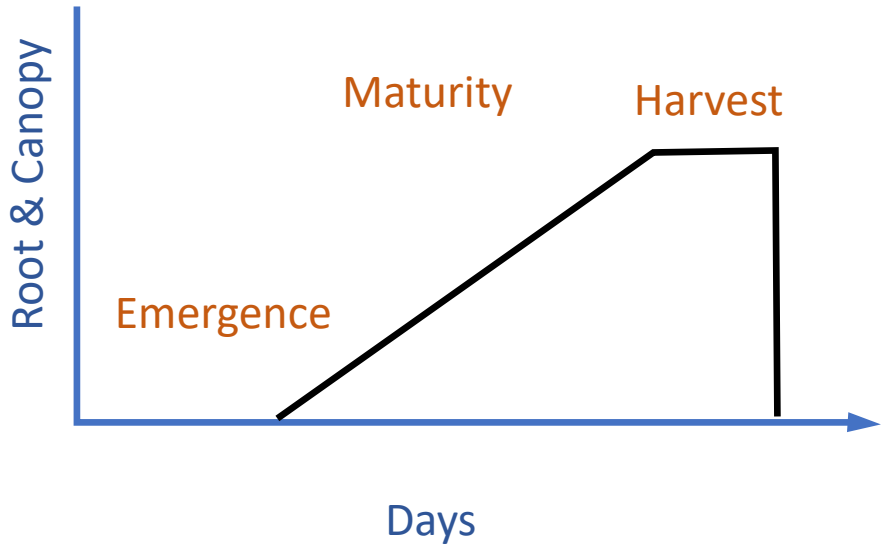
General Crop Growth in PWC



Plant Characteristics Modeled:

Root depth

Canopy Coverage

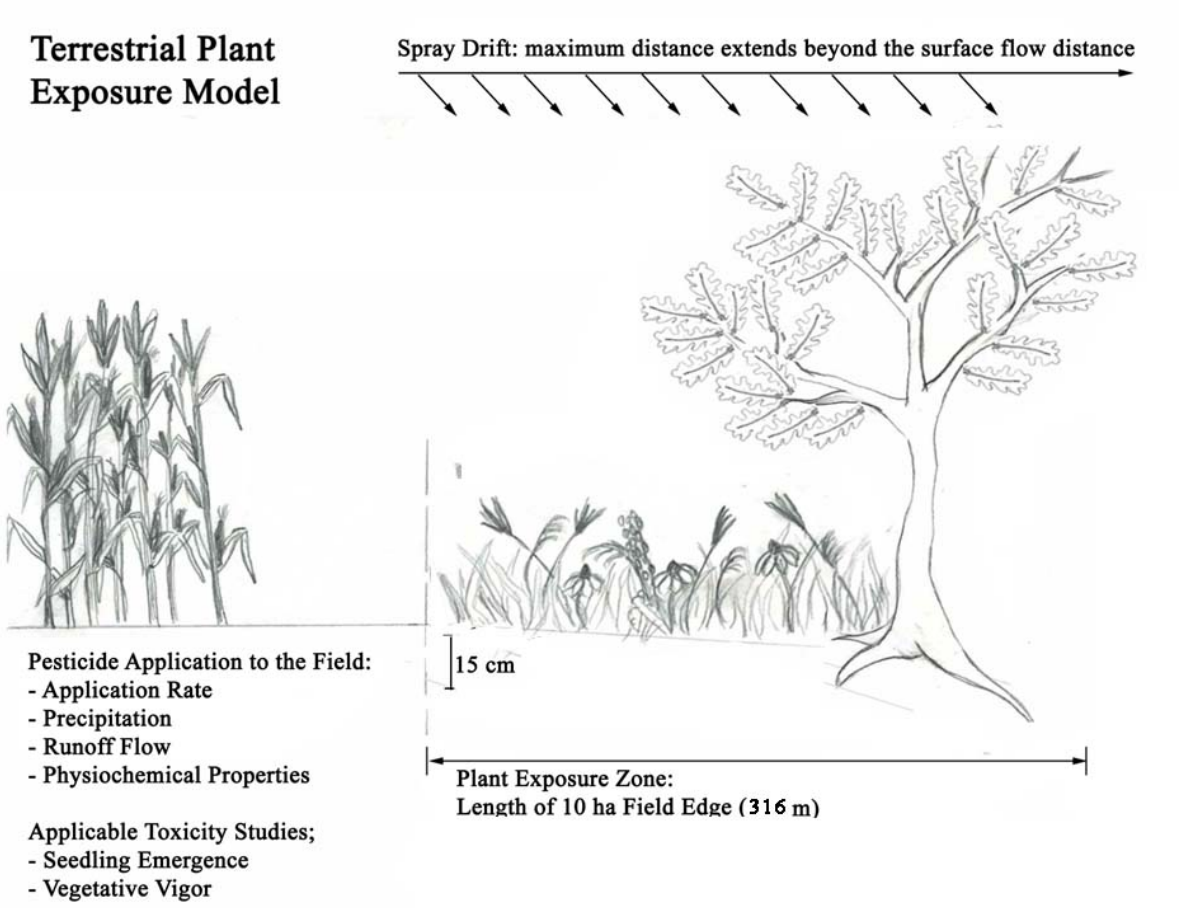


Background: History of Plant Exposure Models in EFED

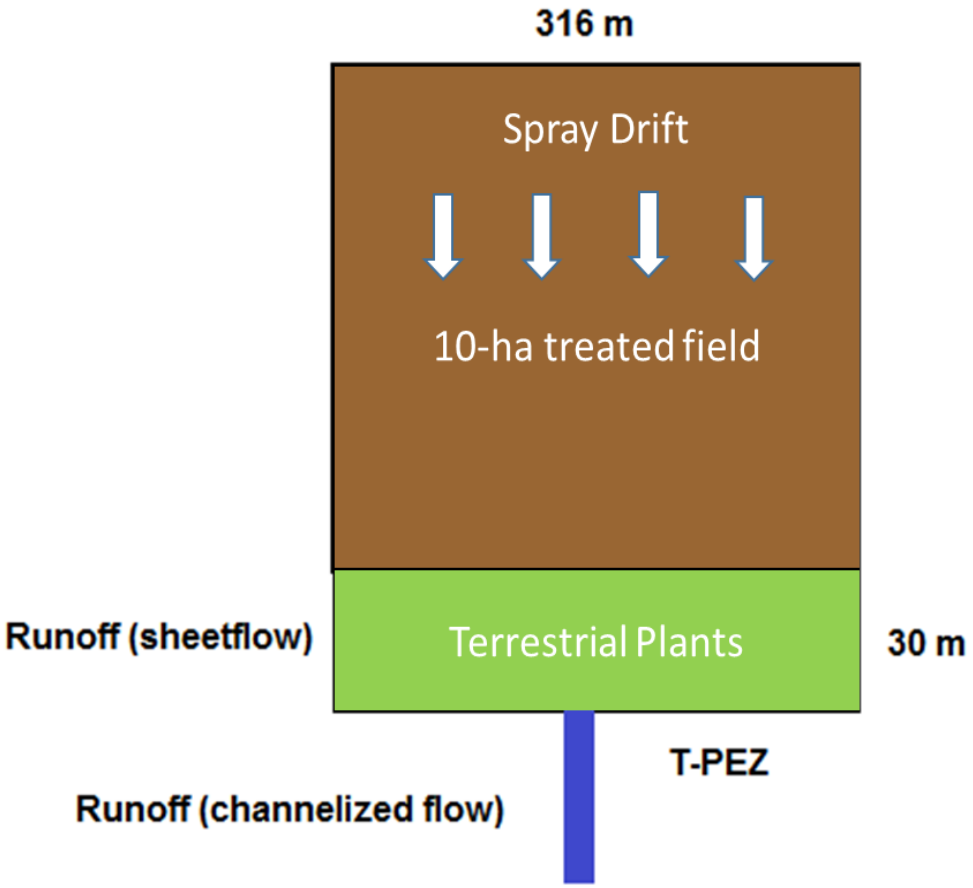
- TerrPlant developed in early 1990s
  - Developed from ‘Back of the Envelope’ aquatic model
  - Coded into a spreadsheet 2005
- PAT first drafter as replacement in 2008 by Garber and Kiernan
- Three modules
  - Terrestrial Plant Exposure Zone (T-PEZ)
  - Wetland Plant Exposure Zone (W-PEZ)
  - Aquatic Plant Exposure Zone (A-PEZ)
- Focus on conceptual models, algorithm development, and streamlined assessment workflow
- Coded in Python for efficient, reproducible runs

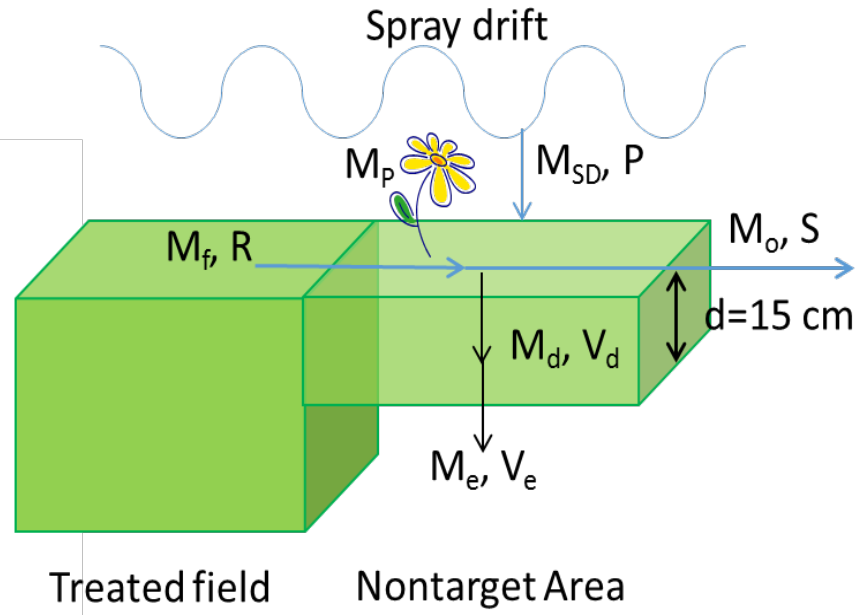
PAT Exposure Modules

Terrestrial Plant Exposure Zone (T-PEZ)



- Accounts for the pesticide loading to the non-target area via transport by runoff, erosion and spray drift. Runoff and erosion are modeled using PRZM and spray drift is modeled using AgDRIFT® deposition curves.
- Uses a mixing cell approach to represent water within the active root zone area of soil, and accounts for flow through the T-PEZ caused by both treated field runoff and direct precipitation onto the T-PEZ.
- Losses from the T-PEZ occur from transport (*i.e.*, washout and infiltration below the active root zone) and degradation.





M_d	mass in nontarget area (PEZ) on day (kg)
M_f	mass from treated field (kg)
M_o	mass leaving nontarget area (kg)
M_{SD}	spray drift (kg)
M_e	mass in exfiltration (kg)
M_p	mass on plants (kg)
V_d	volume of water retained in nontarget area (cm^3)
R	runoff flow (cm^3)
P	precipitation (cm^3)
S	sheet flow leaving nontarget area (cm^3)
V_e	volume of water in exfiltration (cm^3)
k	aerobic soil rate constant (day^{-1})

$$M_t = M_r + M_e + M_{sp} + M_p - M_e - M_o$$

Comparison of Model Considerations and Assumptions: T-PEZ

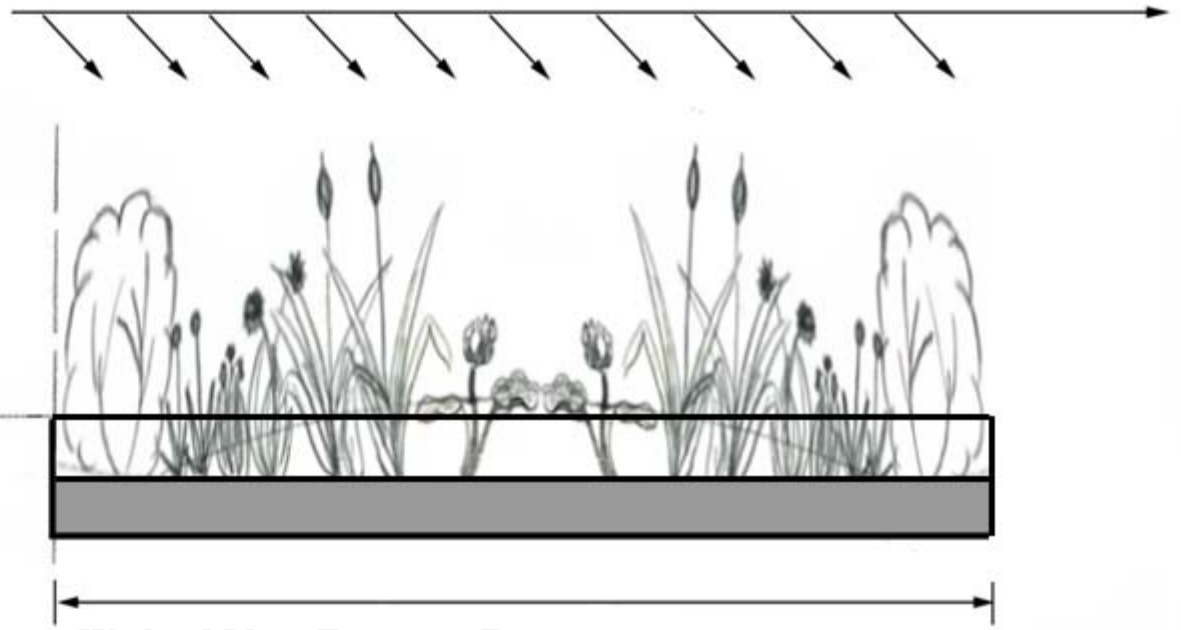
PAT

- Sheetflow Runoff EECs:
  - All of the functionality of PWC
    - Single and multiple applications
    - Precipitation
    - Runoff flow
    - Physiochemical properties
    - Physical processes
  - Geographically definable based on PWC scenario
  - Water volume and holding capacity accounted for
  - Water & Pesticide allowed to overflow (*i.e.,* leave T-PEZ)
- Spray drift EECs:
  - Based on AgDrift curves

TerrPlant

- Sheetflow Runoff EECs:
  - Single application
  - Incorporation depth
  - Default values based on solubility
  - Not geographically definable
  - No consideration for water volume or holding capacity
- Spray drift EECs:
  - Default values based on application method

Wetland Plant Exposure Model



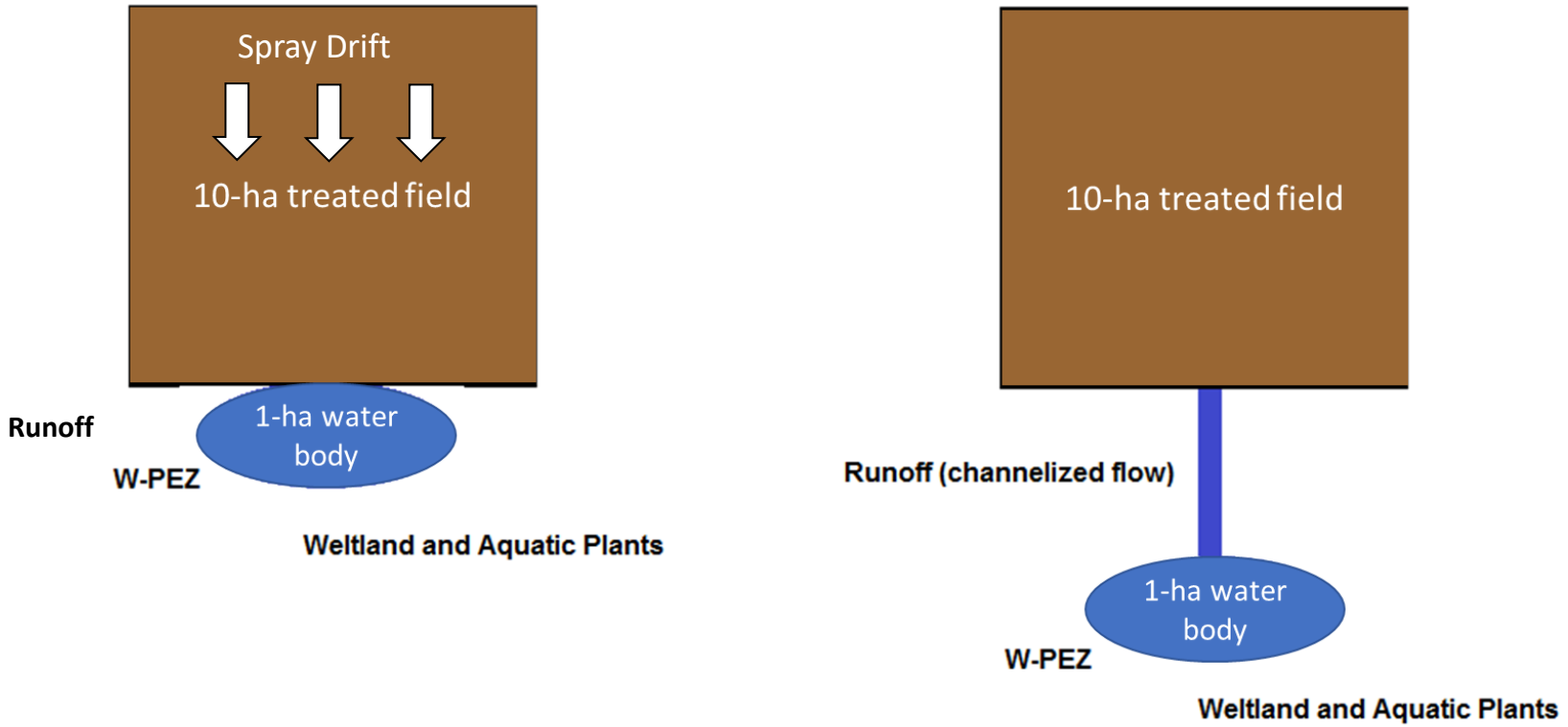
Pesticide Application to the Field:
- Application Rate
- Precipitation
- Concentrated Runoff Flow
- Physiochemical Properties

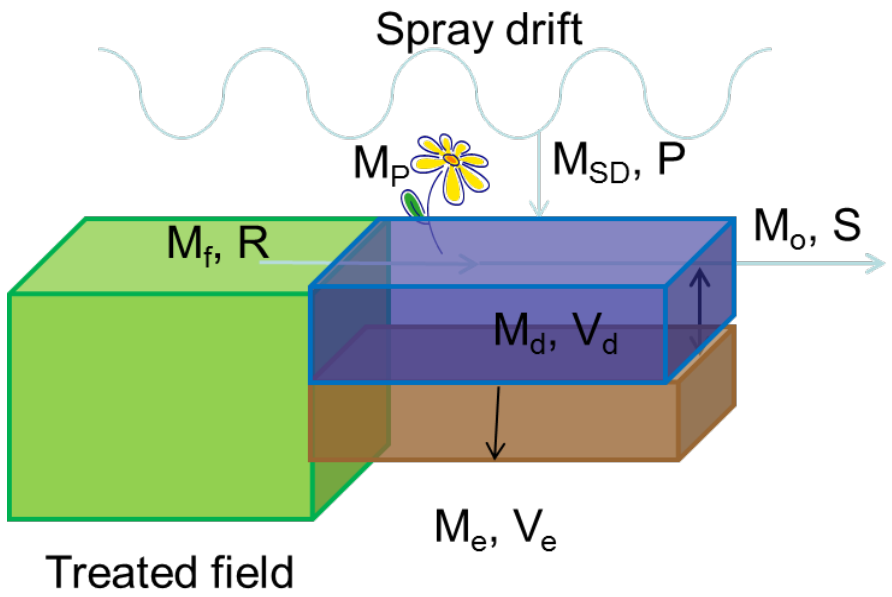
Applicable Toxicity Studies
- Vegetative Vigor
- Seedling Emergence
- Aquatic Vascular Plants
- Aquatic Non-Vascular Plants

Wetland Plant Exposure Zone:

Area = 10000 m^2 Water Depth = 15 cm Sediment Depth = 15 cm

Wetland Plant Exposure Module





d= 30 cm
(15 cm sediment + 15 cm water)

M_d mass in nontarget area (PEZ) on day (kg)
M_f mass from treated field (kg)
M_o mass leaving nontarget area (kg)
M_{SD} spray drift (kg)
M_e mass in exfiltration (kg)
M_p mass on plants (kg)
V_d volume of water retained in nontarget area (cm^3)
R runoff flow (cm^3)
P precipitation (cm^3)
S sheet flow leaving nontarget area (cm^3)
V_e volume of water in exfiltration (cm^3)
k aerobic soil rate constant (day^{-1})

$$EEC\ \left(\frac{lb}{A}\right) = (M_s + M_{pw} + M_{wc} + M_{wc}) - A\ x\ 10{,}000\ m^2 / \text{ha} / 1.12$$

Comparison of Model Considerations and Assumptions: W-PEZ

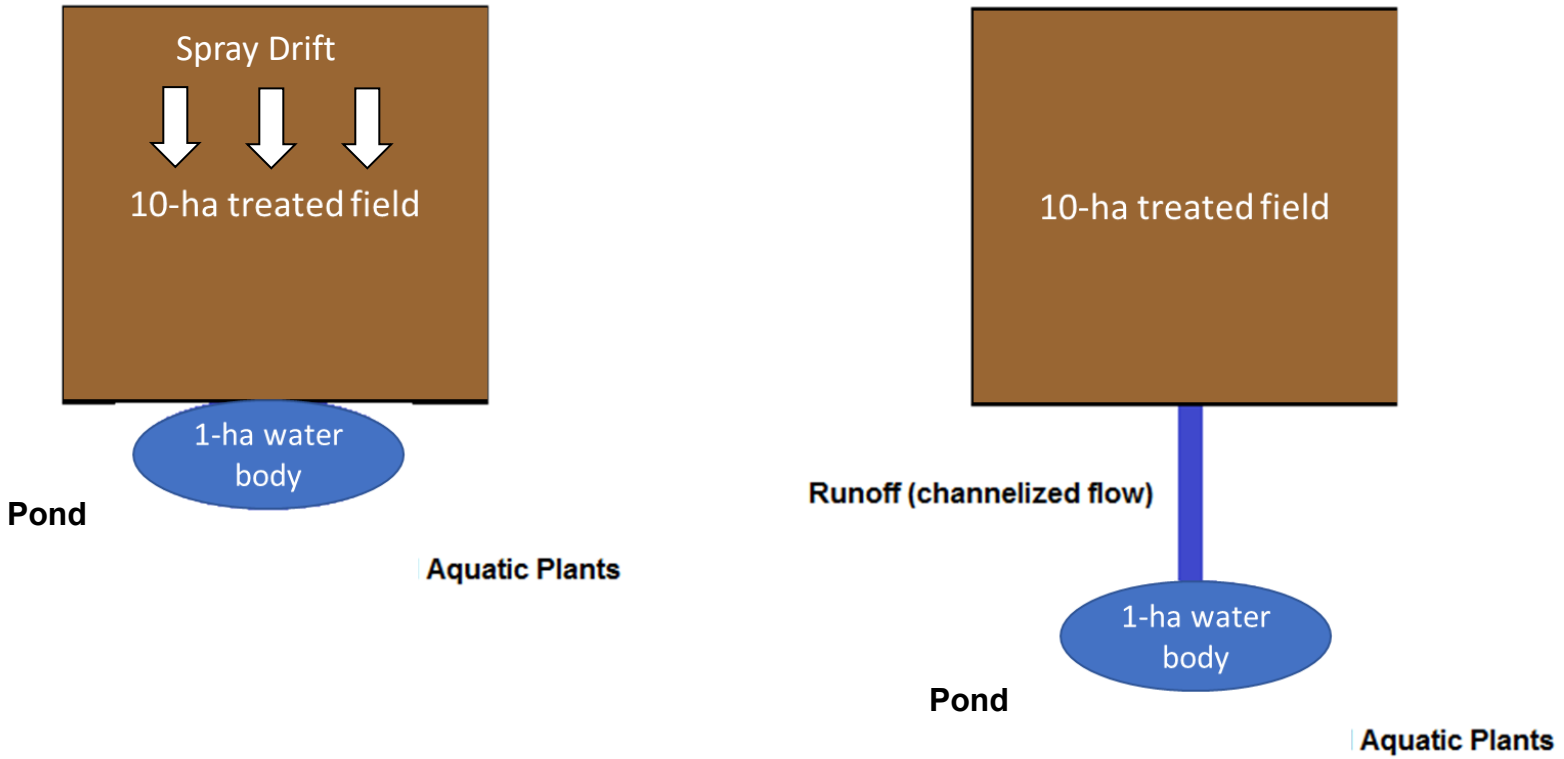
PAT

- Channel Runoff EECs:
  - All of the functionality of PWC
  - Geographically definable based on PWC scenario
  - Wetland exposure assumes 10:1 area relationship
  - Wetland depth fluctuates based on climate, runoff, and rainfall
  - The only way water and pesticide leave the wetland is via overflow of the wetland volume, degradation and evaporation; infiltration beyond sediment layer is not considered
- Spray drift EECs:
  - Based on fraction of applied material (same as with the standard pond)

TerrPlant

- Channel Runoff EECs:
  - Single application
  - Incorporation depth
  - Solubility
  - Not geographically definable
  - Semi-Aquatic exposure assumes 10:1 area relationship (simply multiplies terrestrial runoff EEC by 10)
  - Semi-Aquatic waterbody undefined
- Spray drift EECs:
  - Default values based on application method
  - AgDrift required to calculate drift

Aquatic Conceptual Model



No CHANGE!

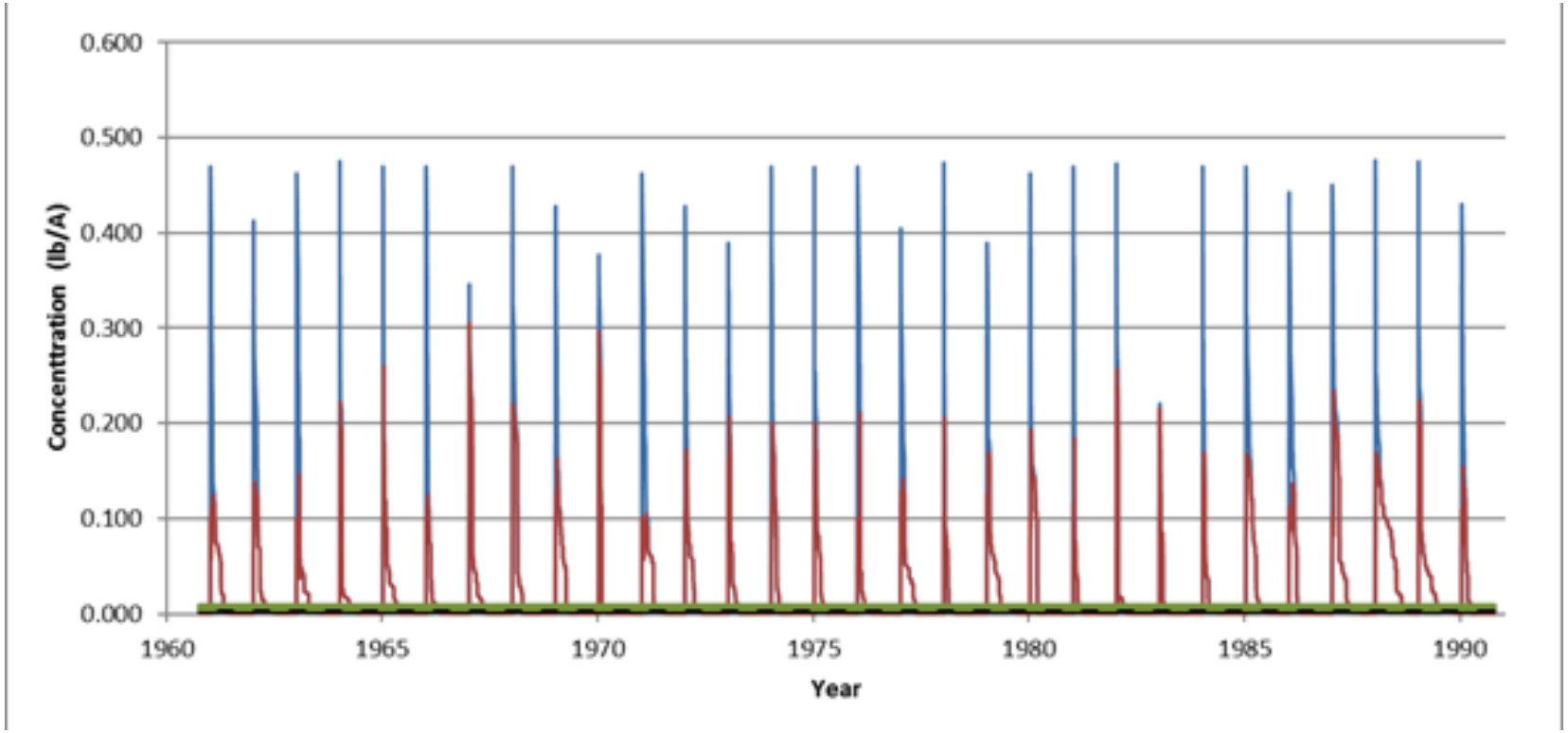
PAT outputs

Standard Outputs

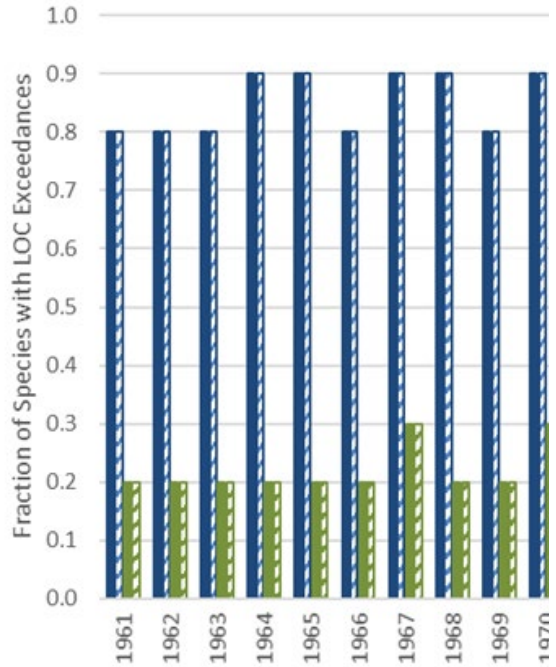
- Initial output
  - Based on most sensitive for each exposure zone (similar to TerrPlant)
- When needed
  - Output for all species of tested plants
- Outputs are
  - RQs, Number of LOC exceedances, Drift distances
  - For T-PEZ, breakdown of risk by distance from edge of field

Concentrations over time at Edge of Field vs Edge of T-PEZ

- This figure illustrates:
  - the fluctuation of concentration from 30 annual runoff events
  - the difference in concentration at the edge of the field versus the far edge of the T-PEZ

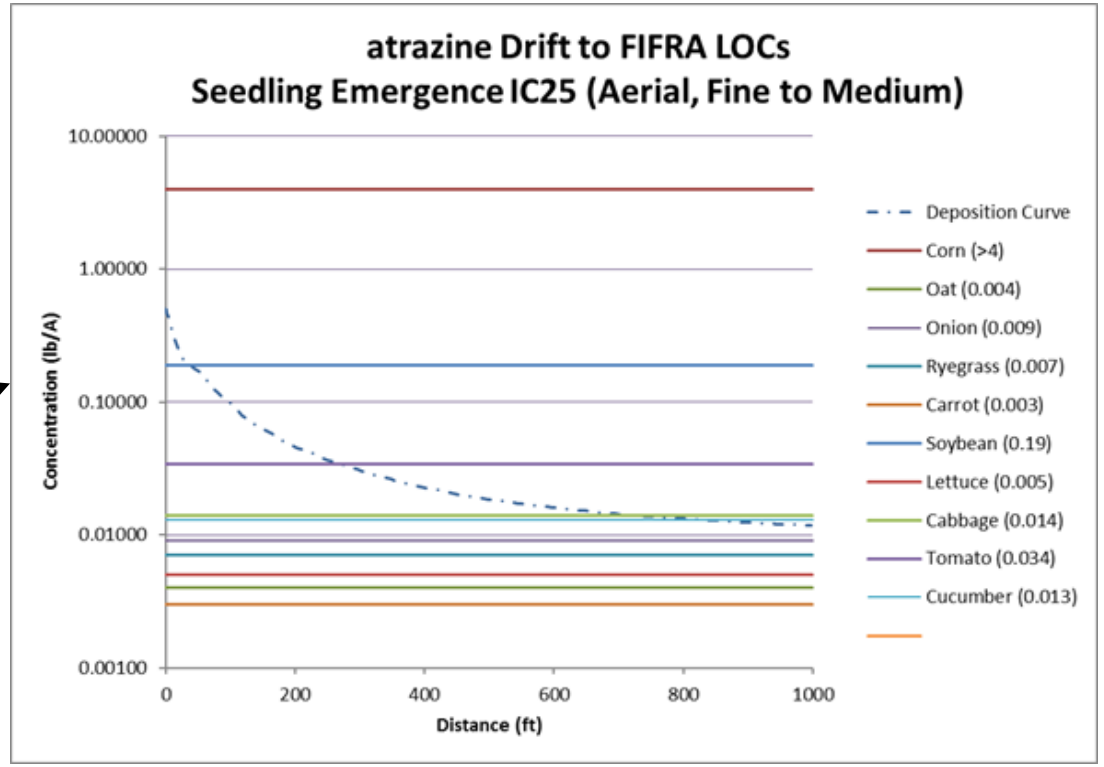


Temporal and Spatial Variability: T-PEZ

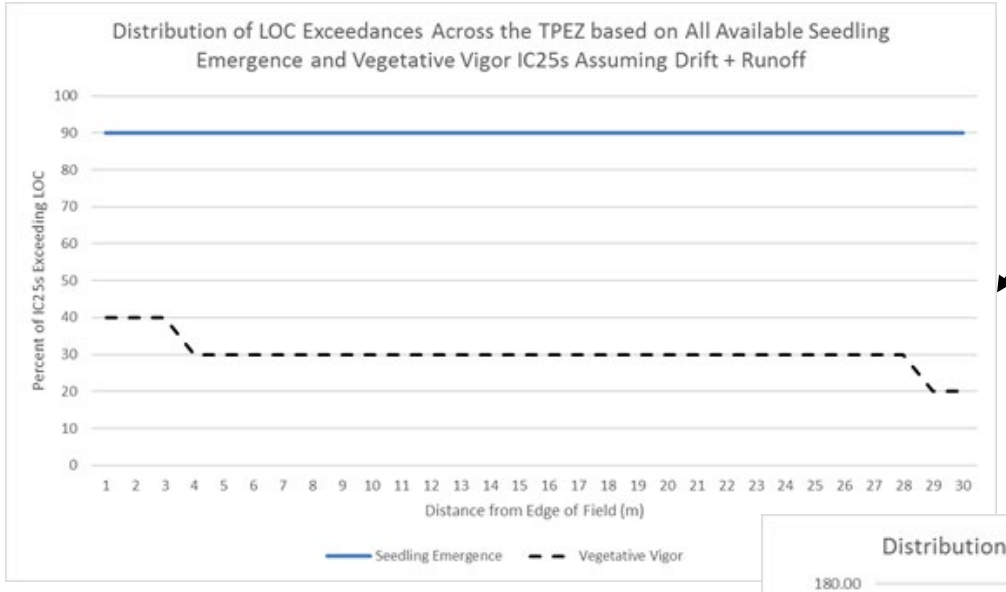


Frequency of annual exceedances of the LOCs for all tested species and illustrates some of the year-to-year variability.

The drift plot provides estimated distance to the point of LOC exceedance.

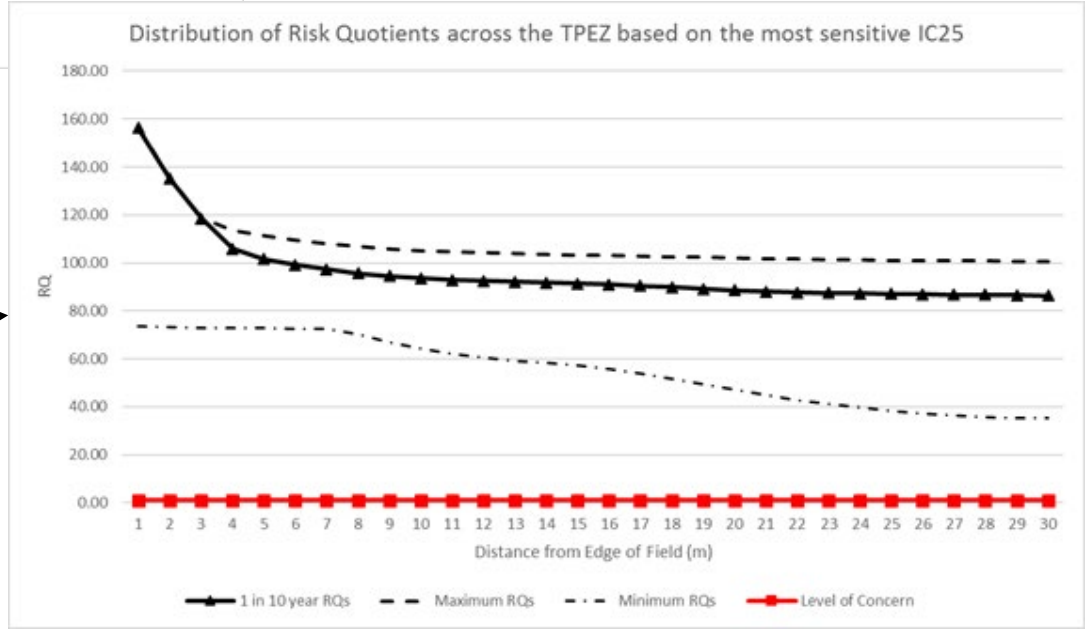


Risk at Distance from Field: T-PEZ



% of species exceeding the LOC from edge of field to edge of T-PEZ.

Maximum, minimum, and 1-in-10 year RQs across the T-PEZ.



Wetland Depth Variability: W-PEZ

- Overall trend of average W-PEZ depth over the 30-year period.
- Each PWC scenario will have its own unique W-PEZ annual depth profile.
- May be useful when discussing potential risks related to time of application.