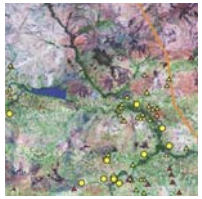

Modeling the Effect of a Riparian Buffer Strip on Off-Field Entrapment of Pesticides Using REMM2008

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Objectives

- Discuss basics of REMM2008
- Review results of measured versus REMM2008 predicted concentrations for atrazine and alachlor. Measured values from a 1992-1994 field study conducted in Georgia.
- Using same field study site modeling parameters and weather conditions, compare REMM2008 predicted pesticide % entrapments for atrazine, alachlor, and cypermethrin

Conservation Buffers

- As defined in the USDA-NRCS document, "Conservation Buffers to Reduce Pesticide Losses" (March 2000),

"**Conservation buffers are areas or strips of land maintained in permanent vegetation to help control pollutants and manage other environmental problems**".

- Conservation buffers have historically been used to entrap sediment and nutrients from agricultural field runoff.
- Now being evaluated as means of entrapping pesticides from agricultural field runoff and eroded sediment.

Riparian Ecosytem Management Model 2008 (REMM2008)

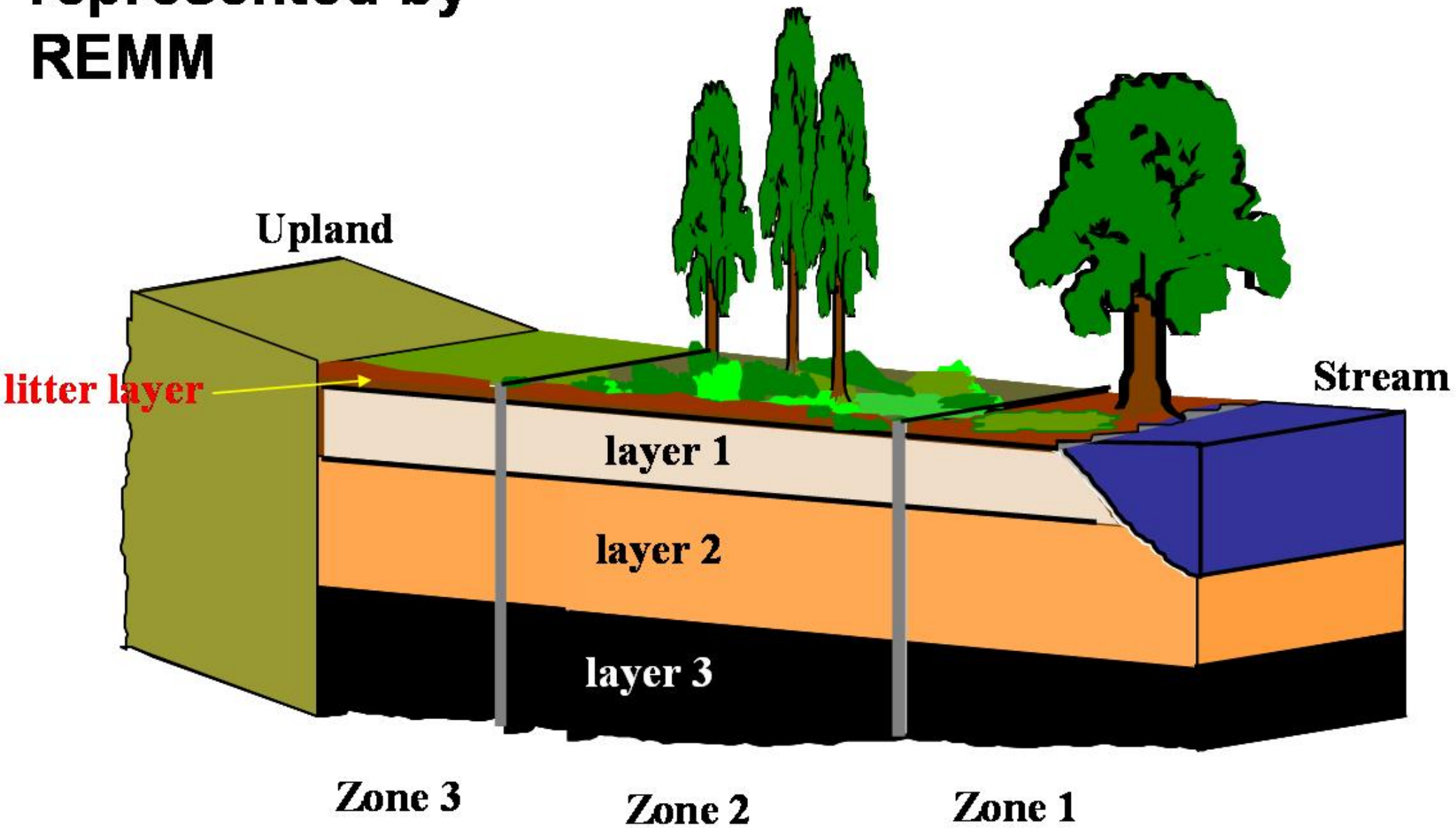
REMM2008:

- Is a process-based digital simulation model
- Originally based on buffer system specifications recommended by USDA-Forest Service and the USDA-NRCS as a national system.
- Simulates nutrient cycling, vegetation dynamics, water quality, and hydrology in riparian buffers

Riparian Ecosytem Management Model 2008 (REMM2008) continued

- Used to predict buffer strip effectiveness for entrapment of non-point pollutants in surface and subsurface water flows which drain into and through a buffer.
- Daily time-step numeric model
- Latest version has improved hydrology algorithm and pesticide simulation module

Spatial structure represented by REMM



To estimate riparian buffer effectiveness, REMM2008 simulates the movement through a buffer of

- Water
- Sediment
- Carbon
- Nitrogen
- Phosphorous
- Pesticides

Crop plant growth is also simulated

Hydrology in REMM2008

Water movement and storage characterized by:

- Interception by vegetation (canopy and litter layer)
- Evapotranspiration
- Vertical drainage
- Surface Runoff
- Subsurface Lateral Flow
- Upward flux from the water table
- Deep seepage

Water movement through each REMM2008 zone is controlled by a combination of mass balances and transport rates.

Hydrology (continued)…

- Typically upland runoff and throughfall is less than infiltration capacity of soil in buffer. Thus, most runoff infiltrates the soil profile in the receiving zone.
- For high intensity storms, infiltration is simulated using a modified Green-Ampt equation. Excess water is added to surface runoff.
- Subsurface lateral movement of water over an impeding soil horizon is calculated using Darcy's Equation
- Preferential flow is not calculated
- Excess subsurface flow is released to the surface as surface seepage.

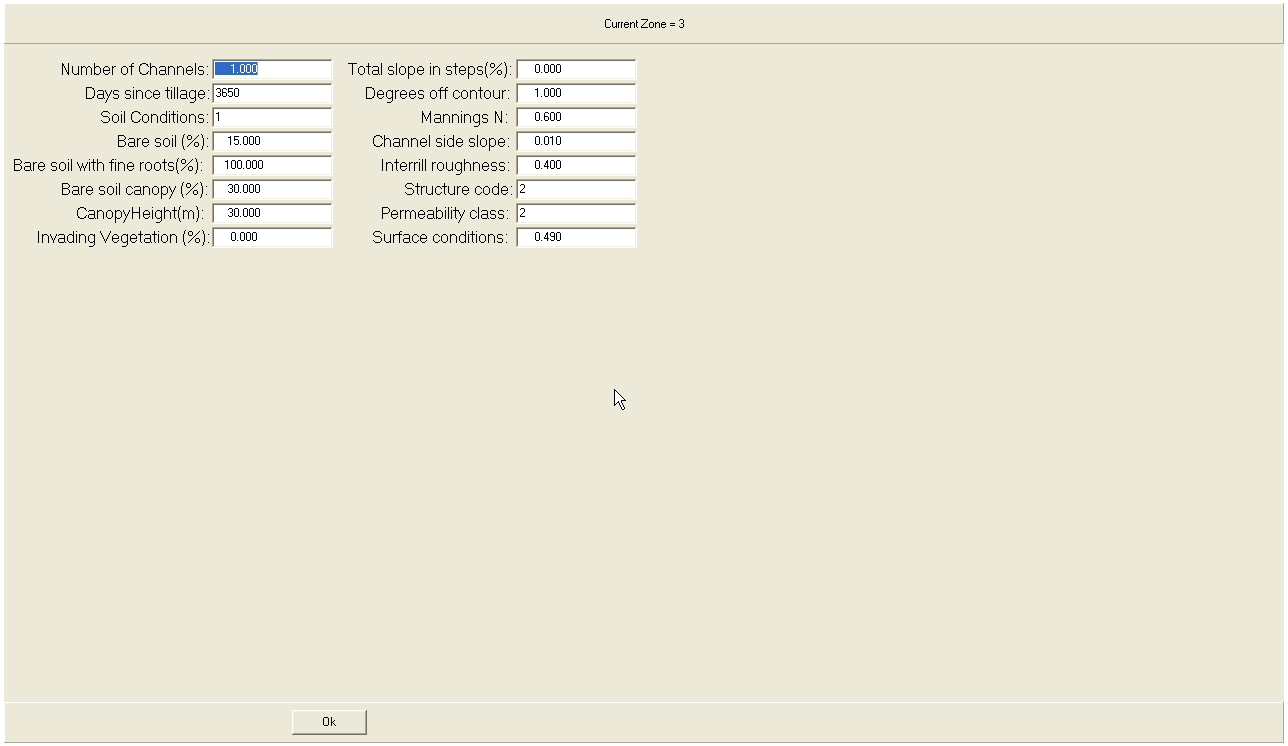
Erosion

- Simulated using Universal Soil Loss Equation (USLE)
- Fraction of sand, silt, clay, small aggregate, and large aggregate particle size classes at the point of detachment determined using the Foster approach.
- Separated into rill and interrill areas. Assumes straight channels which run parallel to each other downslope. Interrill areas lie between adjacent rills.
- Channel shapes are triangular, constant within a zone, determined by channel side slopes, and have interrill areas sloping toward the channels.
- Channel length and slope are assume identical to zone length and slope.
- User-specified zone width, number of channels and channel widths.

Erosion (continued)

Simulated Sediment Processes:

- Erosion
- Transport
- Deposition



Vegetation

- On a stand basis.
- Up to 12 types of vegetation can be simulated

Deciduosu Fall Upper Canopy
Deciduous Spring Live Upper Canopy
Deciduous Spring Dead Upper Canopy
Coniferous Quick Upper Canopy
Coniferous Medium Upper Canopy
Coniferous Slow Upper Canopy
Deciduous Fall Lower Canopy
Deciduous Spring Live Lower Canopy
Coniferous Quick Lower Canopy
Coniferous Medium Lower Canopy
Herbaceous Annual
Herbaceous Perennial

Off-Field Movement of Pesticides

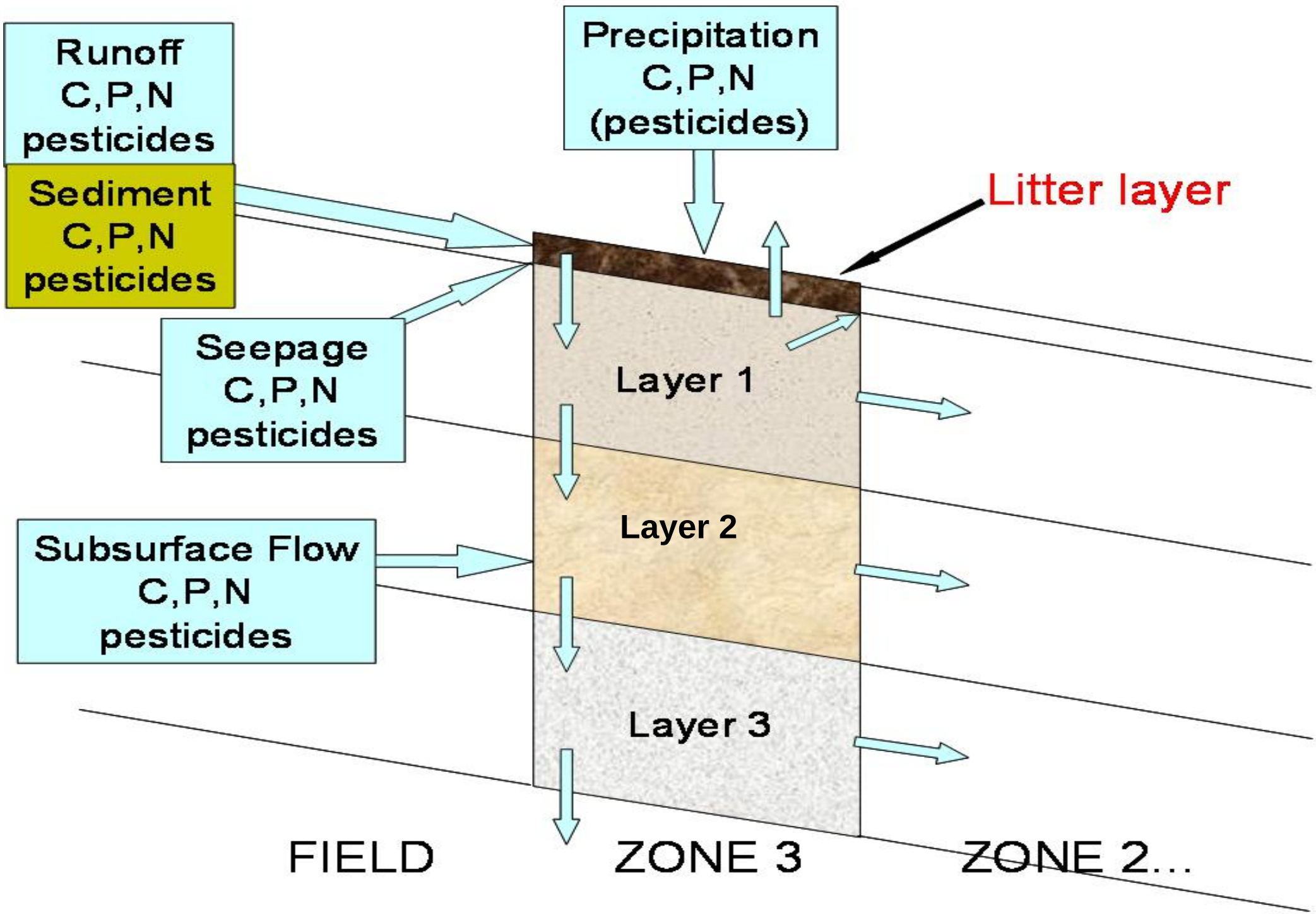
Off-field movement of pesticides from agricultural fields can occur due to a combination of:

- Dissolved residues in runoff water from an agricultural field
- Sorbed residued bound to eroded sediment from an agricultural field
- Dissolved residues in off-field laterally moved water from an agricultural field's soil profile
- Drift from pesticide application to an agricultural field

Conservation Buffers and Pesticide Trapment

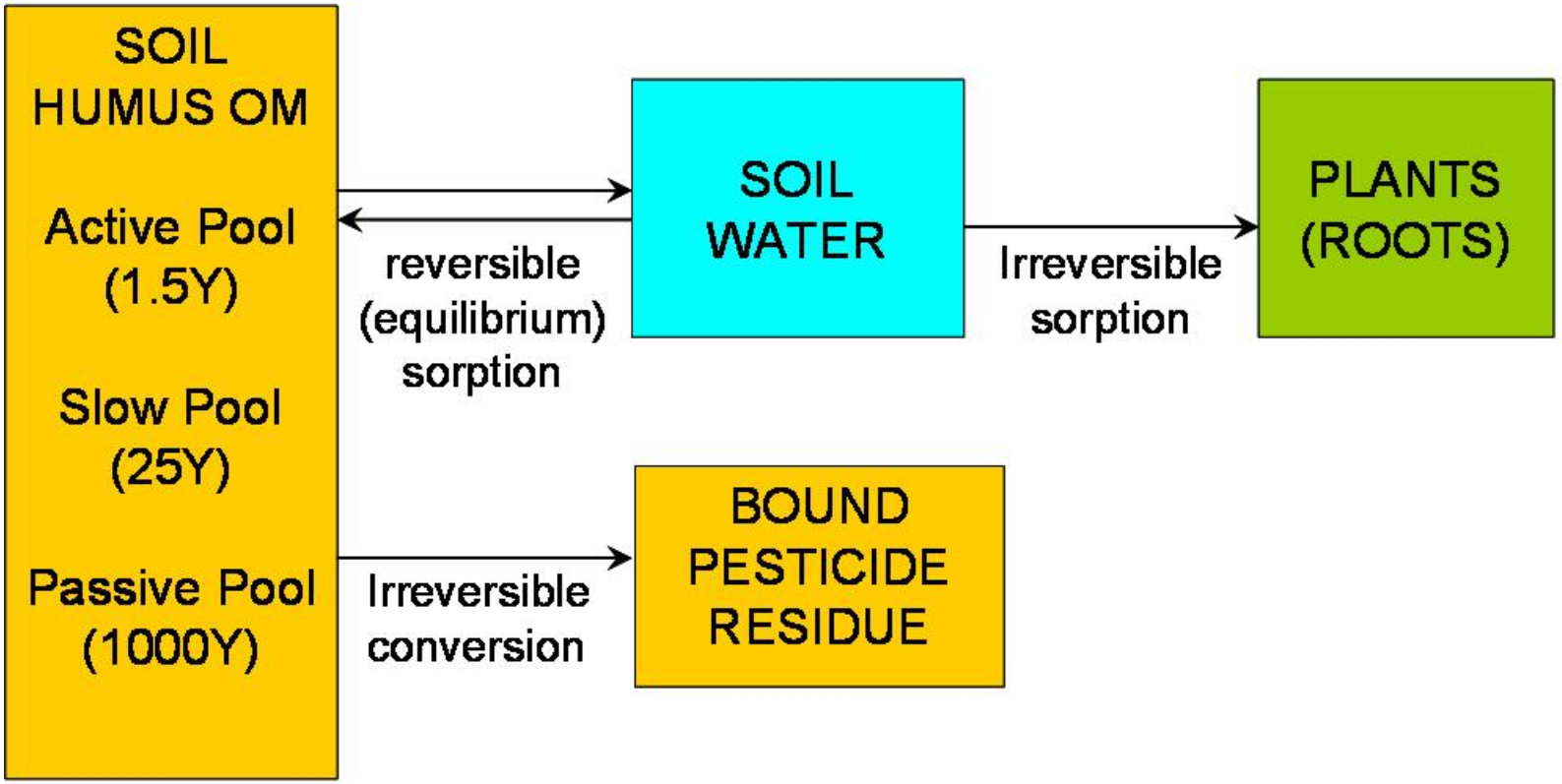
- Sorbed pesticide residues on eroded sediment can be trapped in the buffer in the same way that the eroded sediment is trapped.
- For a buffer to be effective in removing dissolved pesticide residues in runoff water, the runoff water must either infiltrate the soil in the buffer or the pesticide residues must be removed from the runoff water via contact with soil or vegetation.
- Buffers can also be used to intercept off-field drift from pesticide application

PESTICIDE INPUTS INTO BUFFER



Pesticide Environmental Fate Property	Units
Aqueous solubility	mg/L
Soil OM binding half-life	d
Soil aerobic degradation half-life	d
Reference soil moisture content	%
Walker exponent	--
Reference soil temperature	^{0}C
Aerobic energy of activation	kJ/mol
Soil anaerobic deg. half-life	d
Ionization constant	--
Soil OM sorption coef (Koc)	L/Kg
High-*pH* soil OM sorpt. coeff.	L/Kg
Octanol-water partition coeff.	--

PESTICIDE POOLS IN SOIL AND LITTER LAYERS



Pesticide Adsorption / Desorption

- Simulated as two pools in equilibrium (water phase and soil phase)
- Adsorption/desorption based on pesticide K_{OC}
- Water phase pool can

  - adsorb to soil phase if equilibrium disturbed

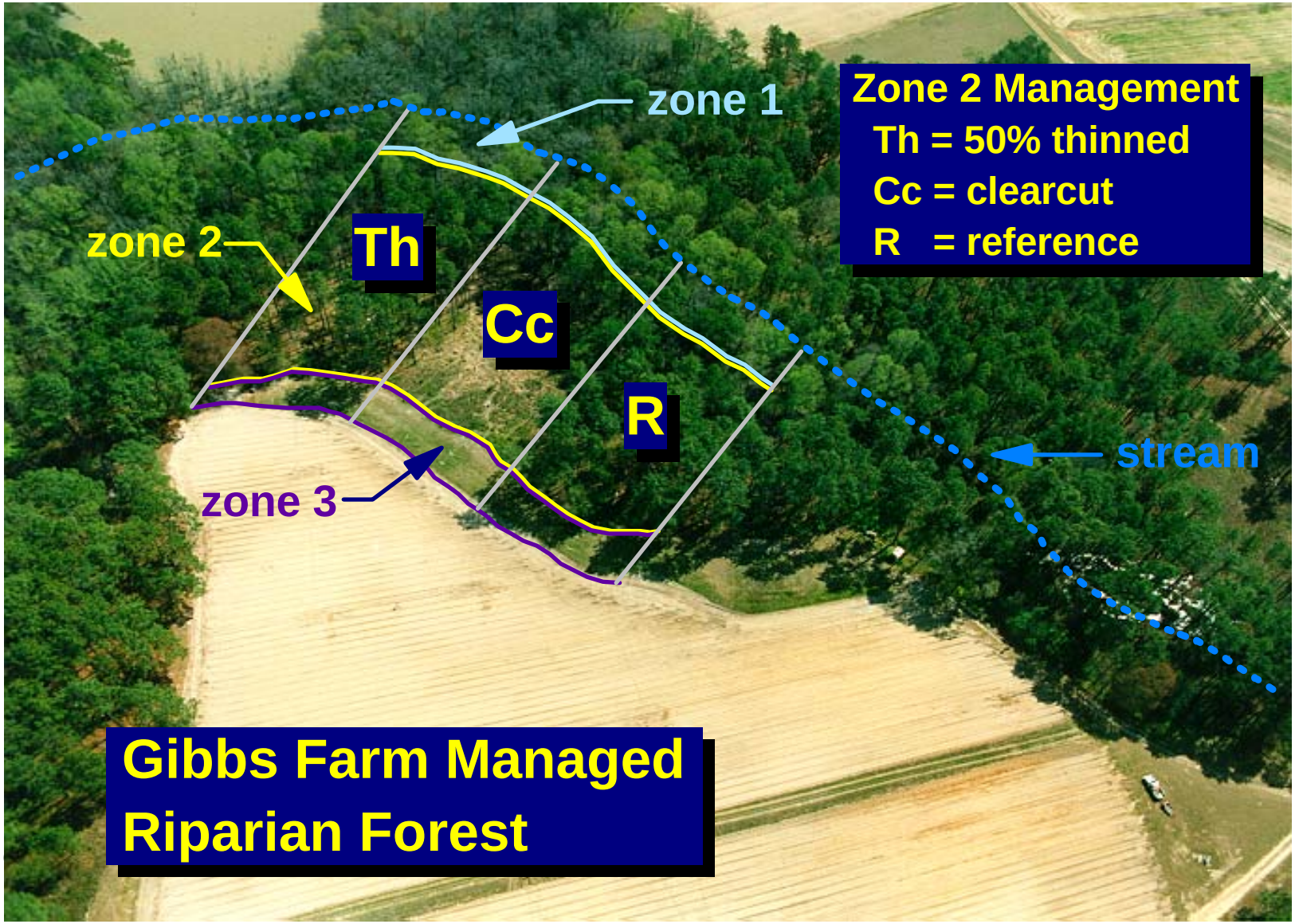
  - taken up into plant roots with water uptake if plant uptake simulated

  - degrade

Pesticide Degradation

- First-order reaction constant and soil water concentration
- Binding calculated using first-order rate constant and soil phase concentration
- Plant uptake of pesticide calculated using Briggs “translocation stream concentration factor” which is a function of K_{OW}.
- Can perform temperature dependent degradation
- Binding, plant uptake, and degradation are all loss functions.

Managed Three-Zone Buffer: Gibbs Farm Site



Field Surface area = 0.32 ha
Field Subsurface area = 0.32 ha

		Zone		
		1	2	3
Layer Thickness (cm)	1	30	30	30
	2	70	70	70
	3	150	150	150
Vegetation		Hardwood	Pine	Grass
Length (m)		15.00	50.00	8.00
Width (m)		(50 ft)	(167 ft)	(27 ft)
Slope (%)		43.83	43.83	43.83
		2.0	3.8	2.6

Atrazine Modeling Parameters

- Water Solubility:

  33 ppm

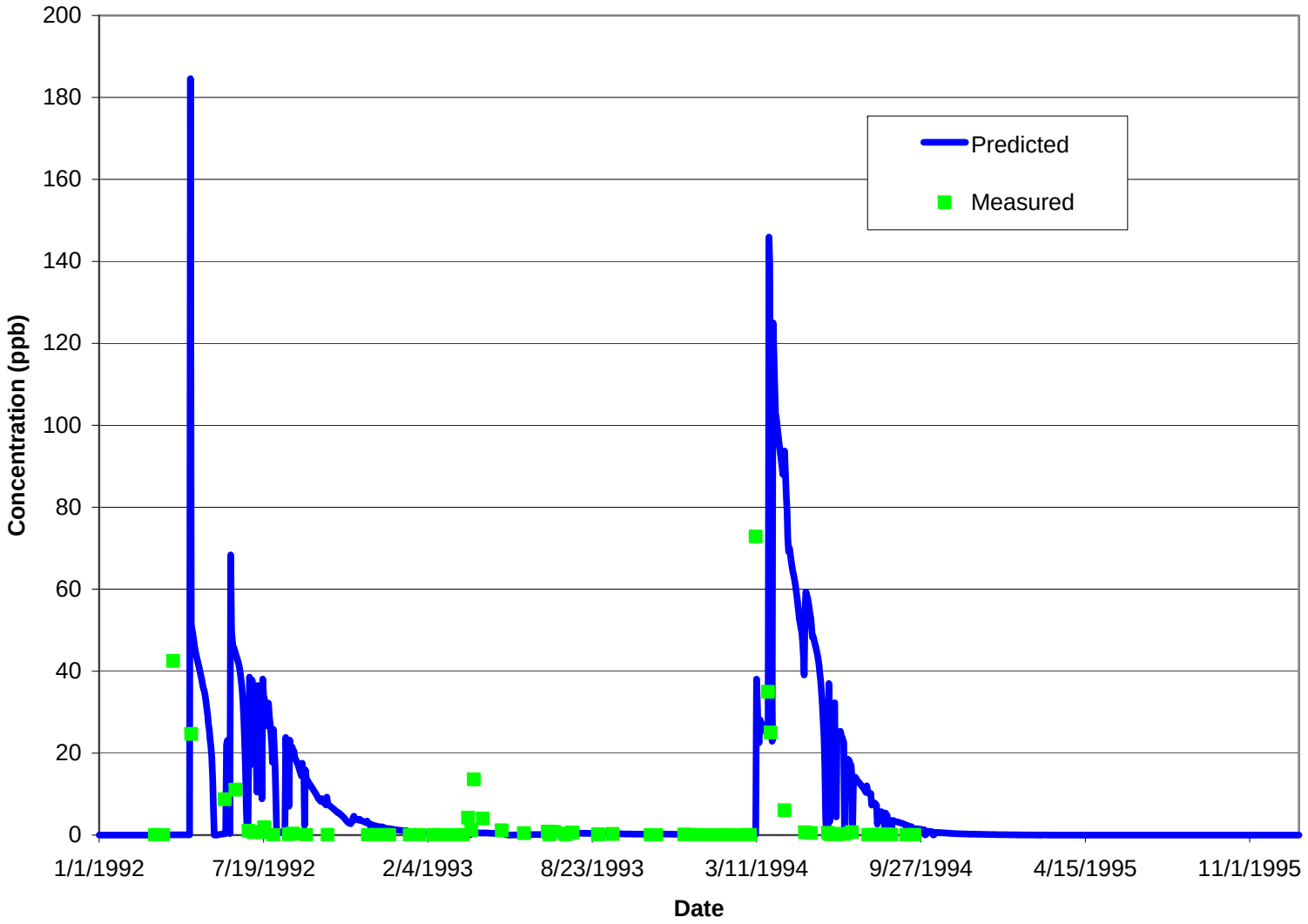
- Aerobic Soil Half-life:

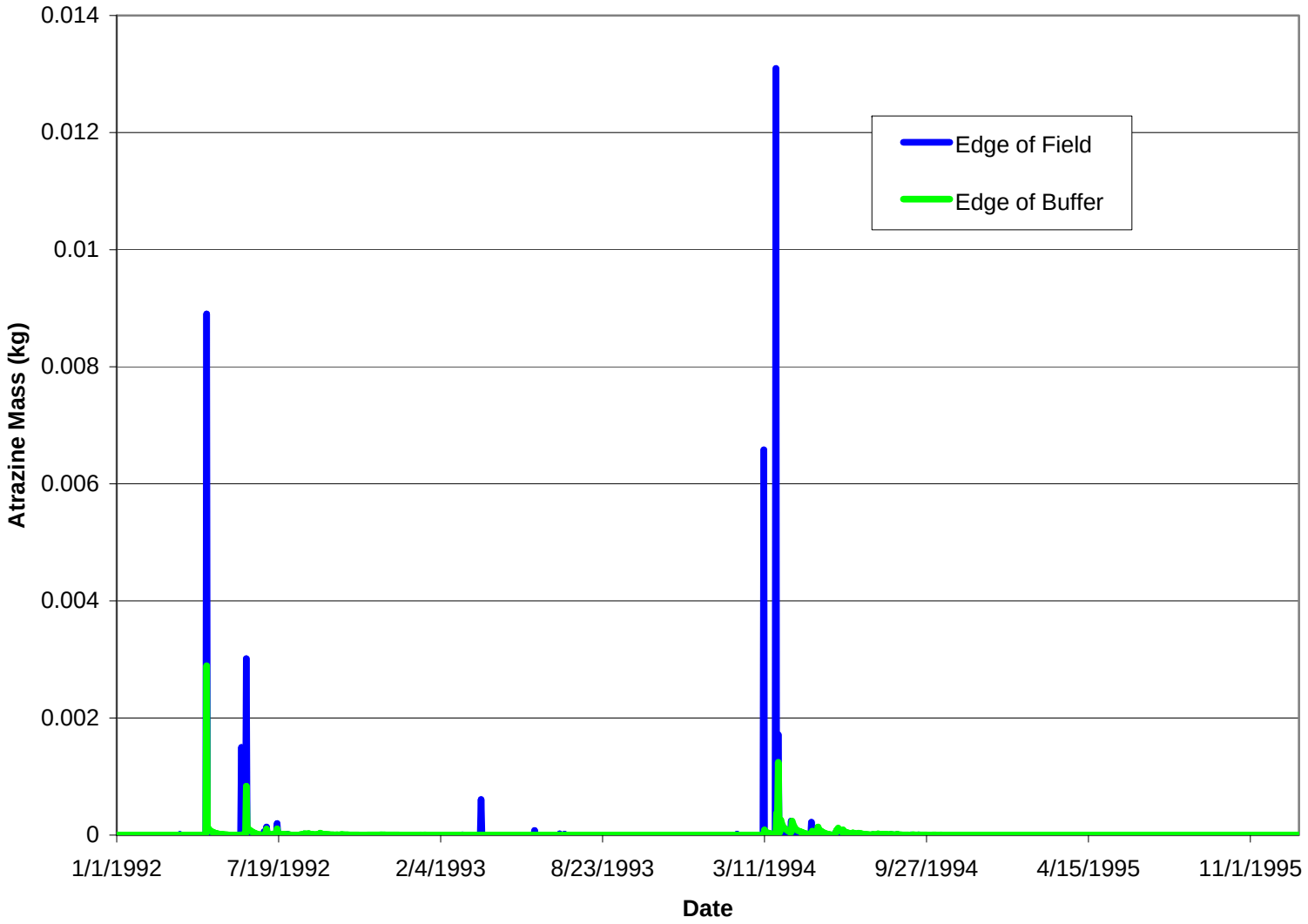
  60 days

- Anaerobic Soil

  Half-life: 60 days

- K_{OC}: 100
- K_{OW}: 437


Atrazine - Edge of Zone 3 Concentrations
Concentration (ppb)
200
180
160
140
120
100
80
60
40
20
0
1/1/1992
7/19/1992
2/4/1993
8/23/1993
3/11/1994
9/27/1994
4/15/1995
11/1/1995
Date
Predicted
Measured


Atrazine - Edge of Field versus Edge of Buffer Predicted Mass
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
Atrazine Mass (kg)
Edge of Field
Edge of Buffer
1/1/1992
7/19/1992
2/4/1993
8/23/1993
3/11/1994
9/27/1994
4/15/1995
11/1/1995
Date

Alachlor Modeling Parameters

- Water Solubility:

  24 ppm

- Aerobic Soil Half-life:

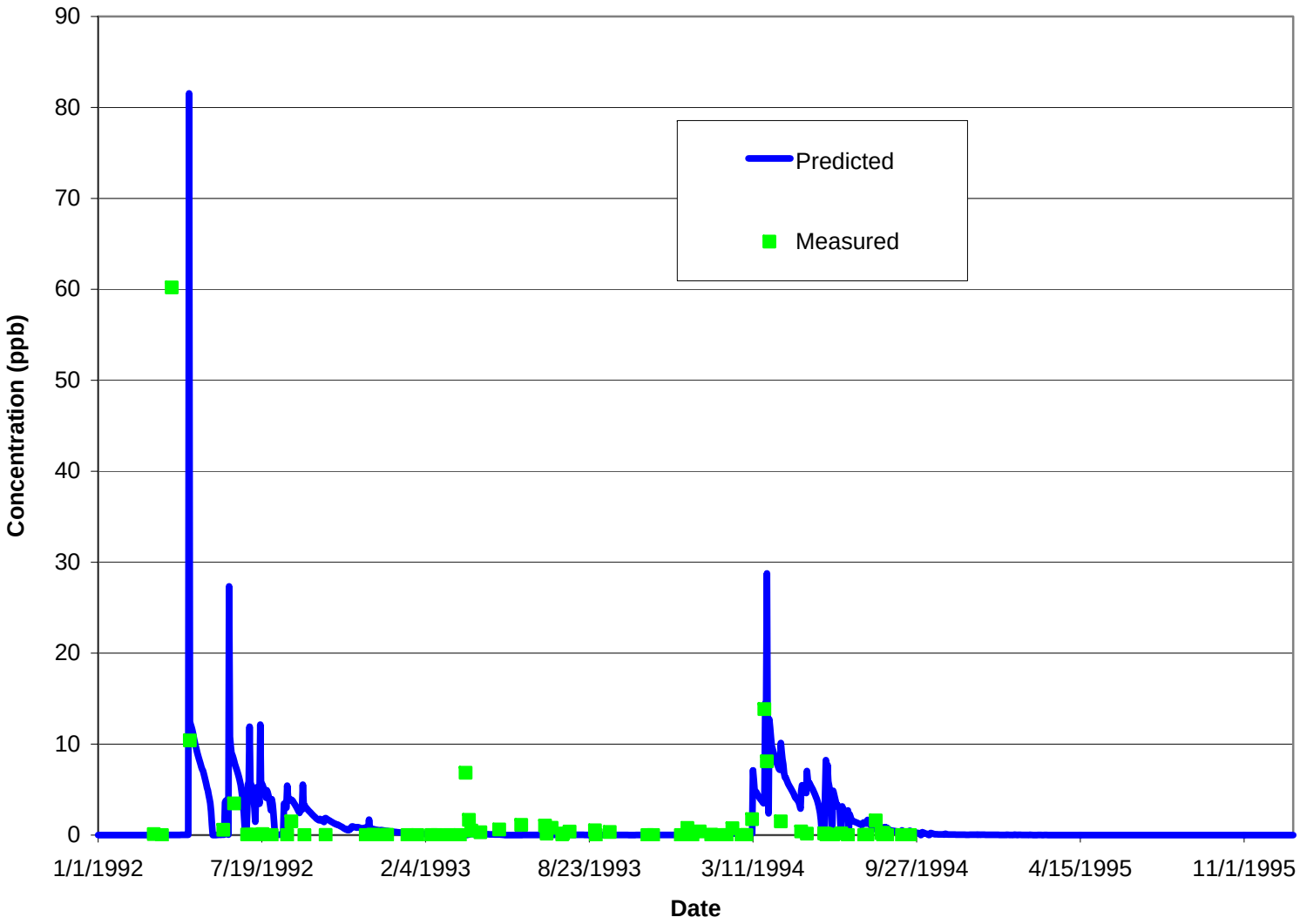
  15 days

- Anaerobic Soil

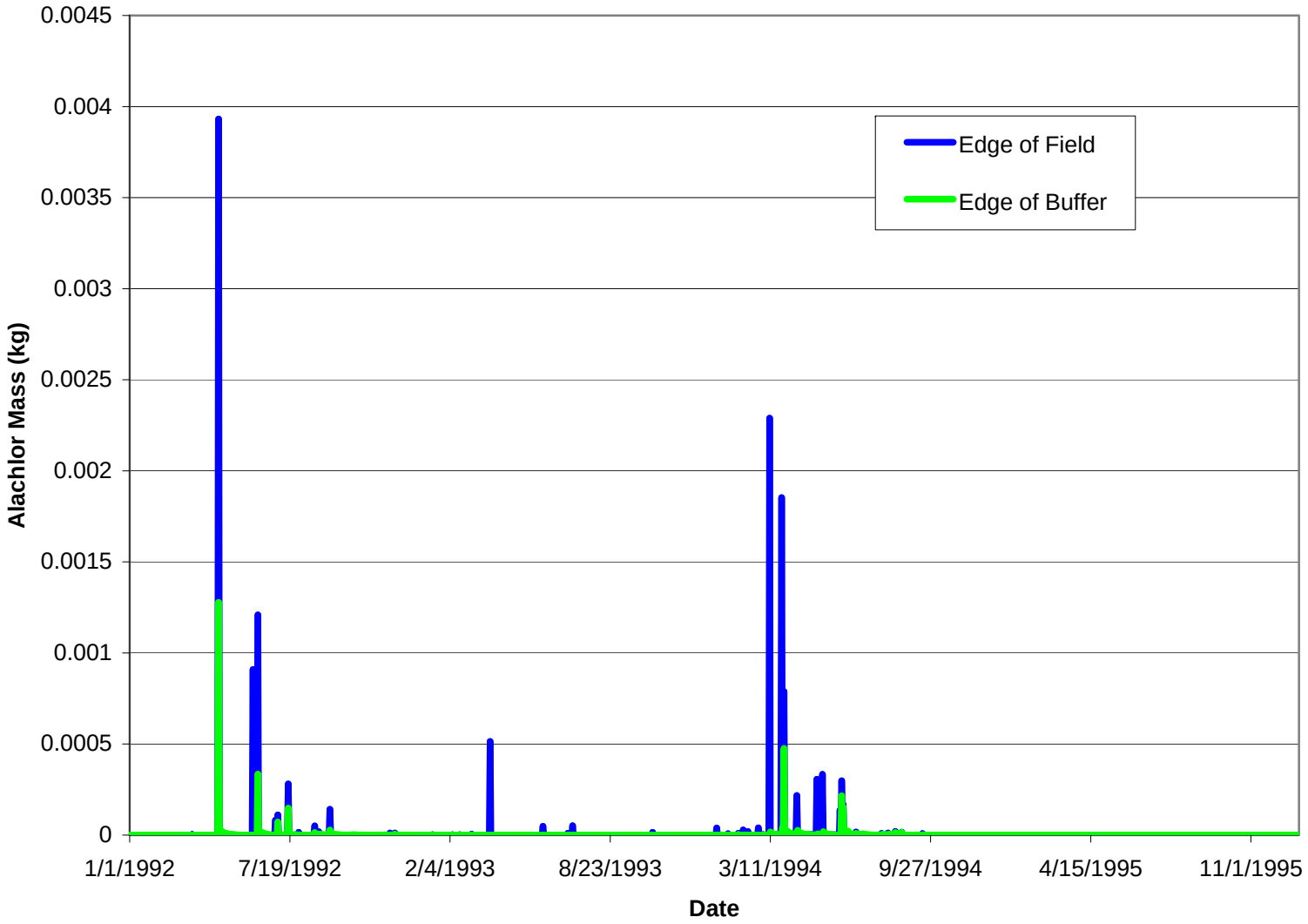
  Half-life: 15 days

- K_{OC}: 100
- K_{OW}: 794

Alachlor - Edge of Zone 3 Concentrations



Alachlor - Edge of Field versus Edge of Buffer Predicted Mass



Cypermethrin Modeling Parameters

- Water Solubility:

  24 ppm

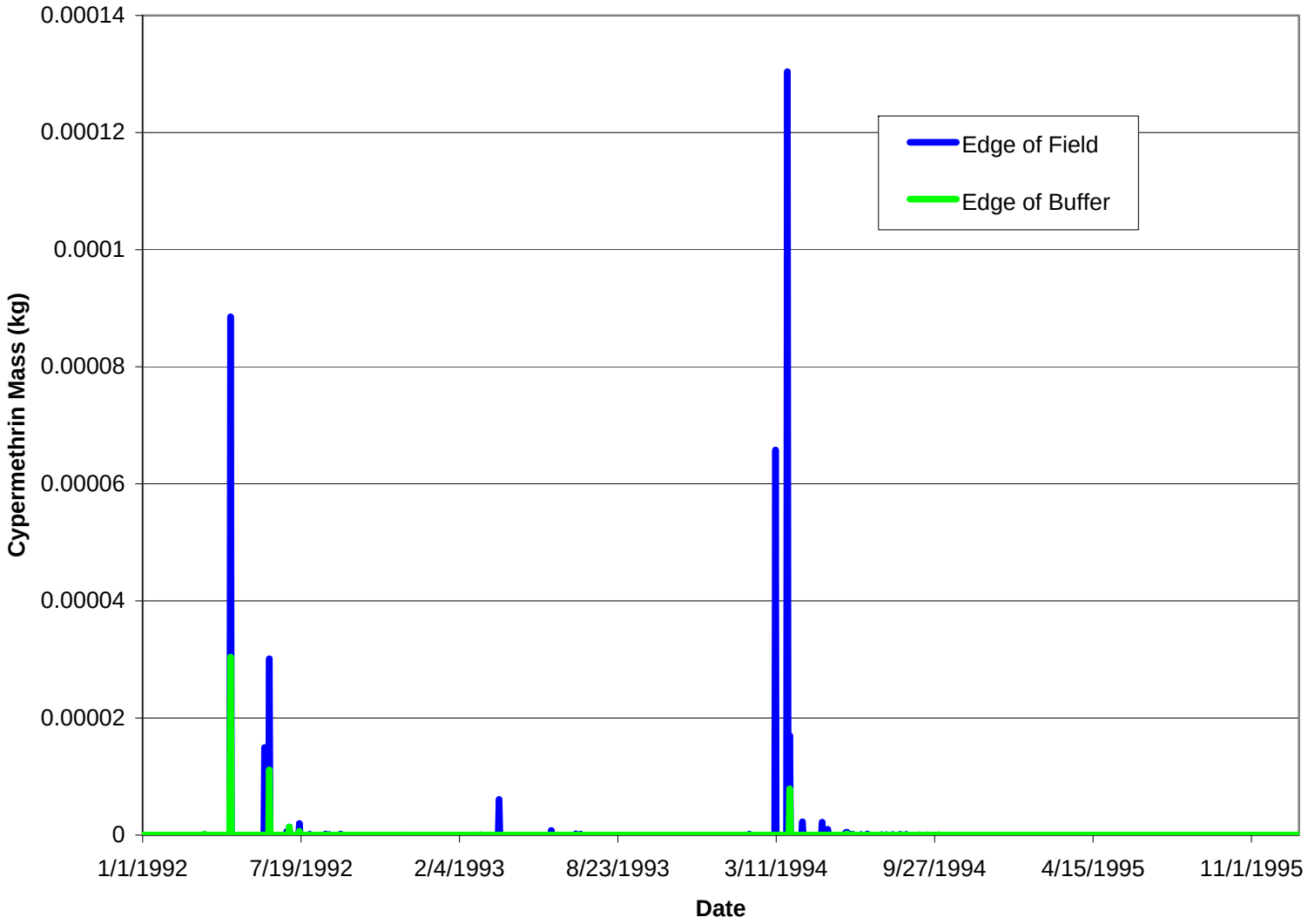
- Aerobic Soil Half-life:

  30 days

- Anaerobic Soil

  Half-life: 30 days

- K_{OC}: 10,000
- K_{OW}: 400,000


Cypermethrin - Edge of Field versus Edge of Buffer Predicted Mass
0.00014
0.00012
0.0001
0.00008
0.00006
0.00004
0.00002
0
Cypermethrin Mass (kg)
Edge of Field
Edge of Buffer
1/1/1992
7/19/1992
2/4/1993
8/23/1993
3/11/1994
9/27/1994
4/15/1995
11/1/1995
Date

% Entrapment by 27’ Buffer

Pesticide	1992	1993	1994
Atrazine	49.3	91.9	60.0
Alachlor	63.2	97.1	73.3
Cypermethrin	68.4	99.7	96.1

Conclusions

- REMM2008 can be a useful tool for estimating buffer entrapment of pesticides. Allows for varying e-fate parameters, buffer vegetation, and buffer widths.
- New pesticide module exhibits good fit between measured and predicted off-buffer concentrations with slight over-estimation for water soluble compounds.
- % Pesticide entrapment is dependent on rainfall distribution and intensity in conjunction with environmental fate parameters.

Potential Future Work

- Need for comparison of measured versus REMM2008 predicted concentrations for high and medium K_{OC} compounds.
- Examination of channel effect on buffer entrapment. Current modeling simulated sheet flow.
- Development of turf vegetation scenarios for regions outside of U.S. southeast.
- Development of standardized REMMM2008 scenarios for use with EPA standard scenarios for surface water risk assessments.