Transport of Agricultural Chemicals: Atmosphere to Land Surface

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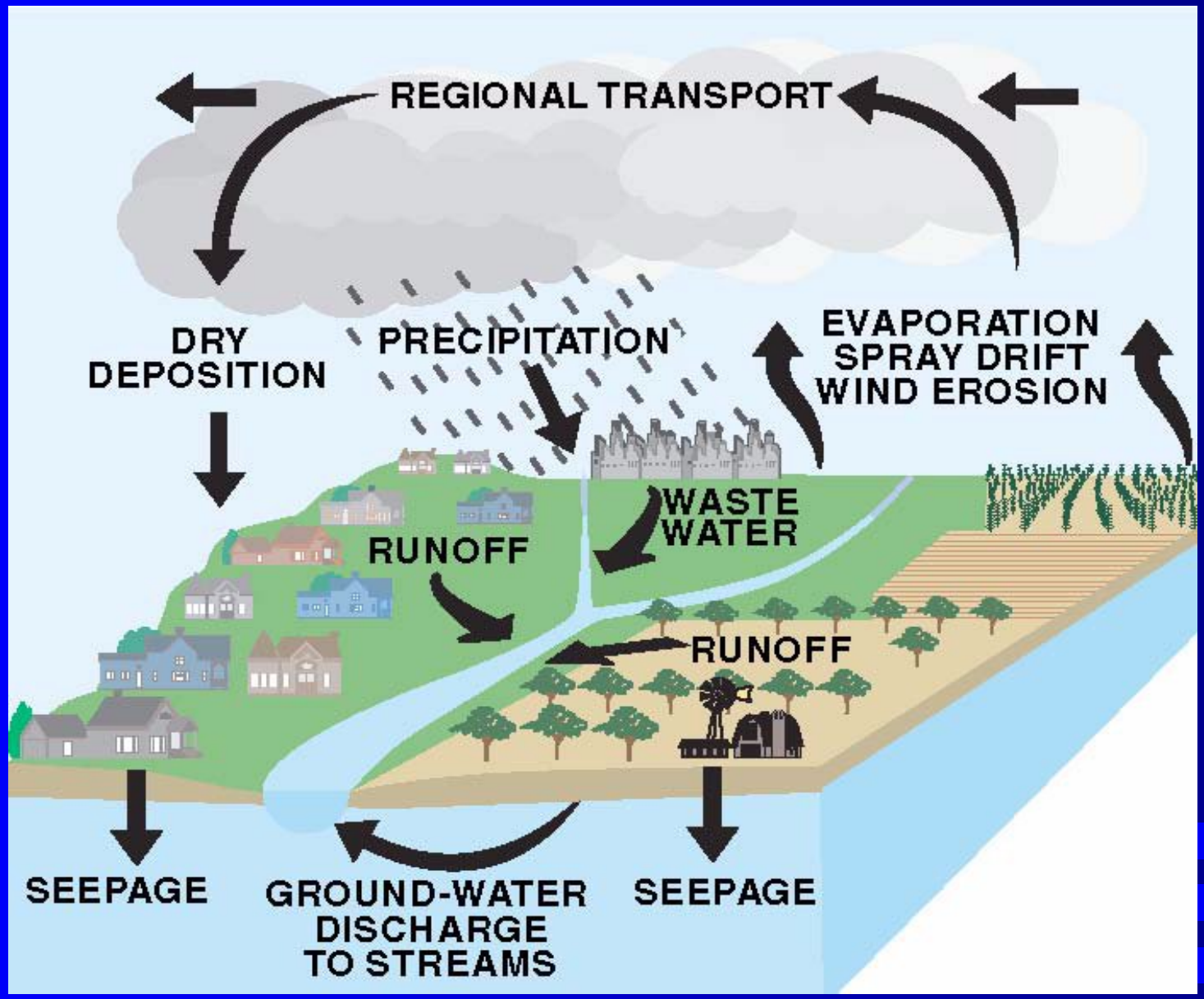
The Hydrologic Cycle



How do Pesticides Become Airborne and What Happens to Them Once They are Up There?

- Applications
- Post-Application
- Atmospheric Movement
- Removal/Deposition
- ACT Data

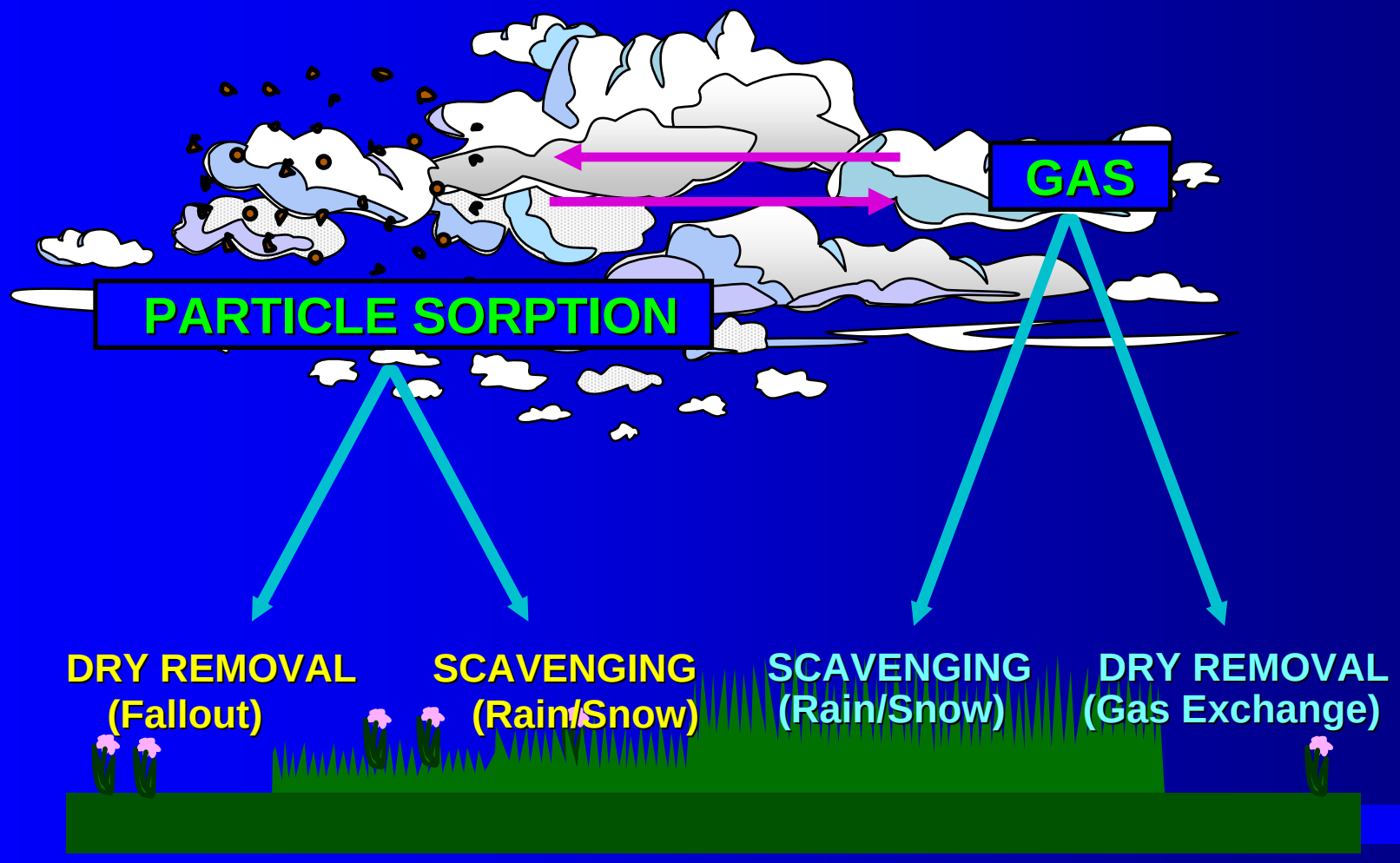
Agricultural Application Methods

- **Irrigation – Very little, if any**
- **Ground Rig - < 0.5 to 10%**
  - Injected (Fumigation)
  - Surface
  - Surface-Incorporated
- **Aerial - 10 to 30, > 50%**
- **Orchard Mister/Blowers - 2 to 3 times greater than aerial methods**

Increasing Drift Potential

Post-Application Volatilization And Wind Erosion of Soil

Aerial Distribution and Removal of Trace Organic Chemicals



ACT Study

Atmospheric Transport and Deposition of Pesticides

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- **Objectives**
  - **Quantify the concentration and load of pesticides in rain, and determine the contribution of pesticides from wet deposition to runoff.**
  - **Determine the seasonal, and in-season variation of pesticides in rain.**
  - **Identify the important pesticide transformation processes in air and determine if these differ from those in water.**

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Central Nebraska
Basins
San Joaquin-Tulare
River Basins
White-Great and
Little Miami
River Basins
Delmarva Peninsula
9/5/03

- **Sampling Methods**
  - **Single location (except California)**
  - **Wet/Dry Autosampler (modified)**
    - **Weekly Integrated Samples (except in California)**
  - **Fully instrumented meteorological station at each site**
- **Analytical Methods**
  - **21 Insecticides**
  - **18 Herbicides**
  - **3 Fungicides**
  - **36 Transformation Products**

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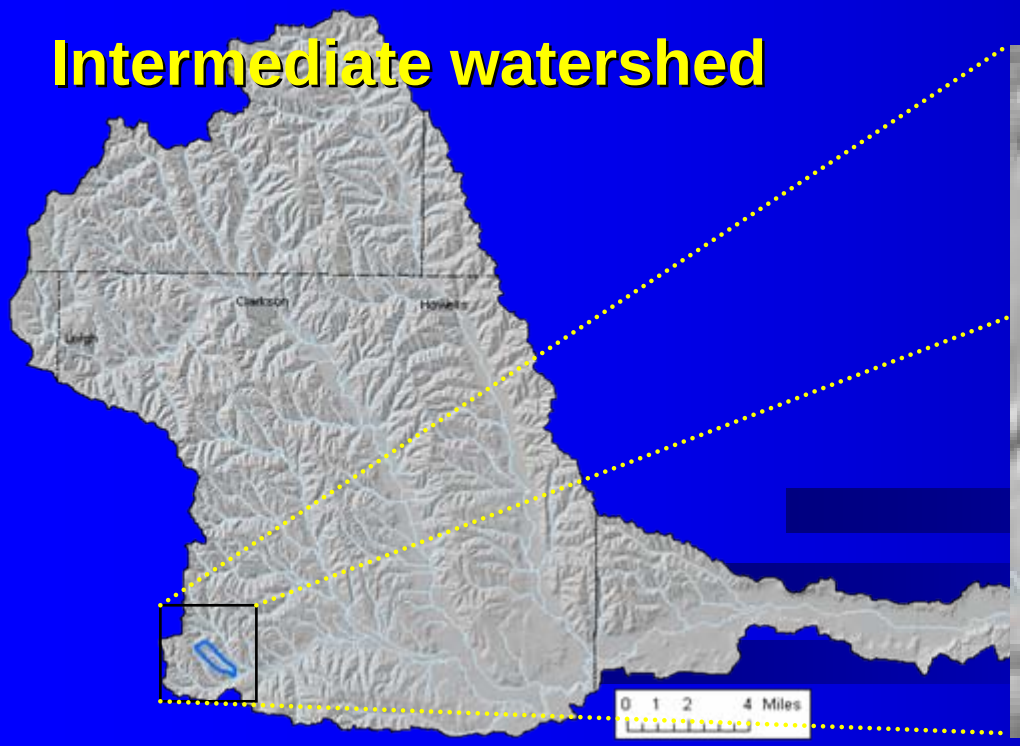
Pesticide Use by Scale

Scale-	Small	Intermediate	Large
Maryland	33 km²	724 km²	5280 km²
Indiana	7.2 km²	243 km²	29,400 km²
Nebraska	1.5 km²	955 km²	15,200 km²
California	17.5 km²	831 km²	9300 km²



Pesticide Use by Scale

Use-	Small (33 km²)	Intermediate (724 km²)	Large (5280 km²)
Maryland	Atrazine, Metolachlor, Simazine, Dimethoate	Acetochlor, Alachlor, Dimethenamid, Hexazinon, Metribuzin, Pendimethalin, Carbaryl, Chlorpyrifos, Diazinon, Methyl Parathion, Permethrin	DCPA, Malathion, Methidathion, Phosmet, Iprodione, Metalaxyl, Myclobutanil
Total	4	4 + 11	4 + 11 + 7

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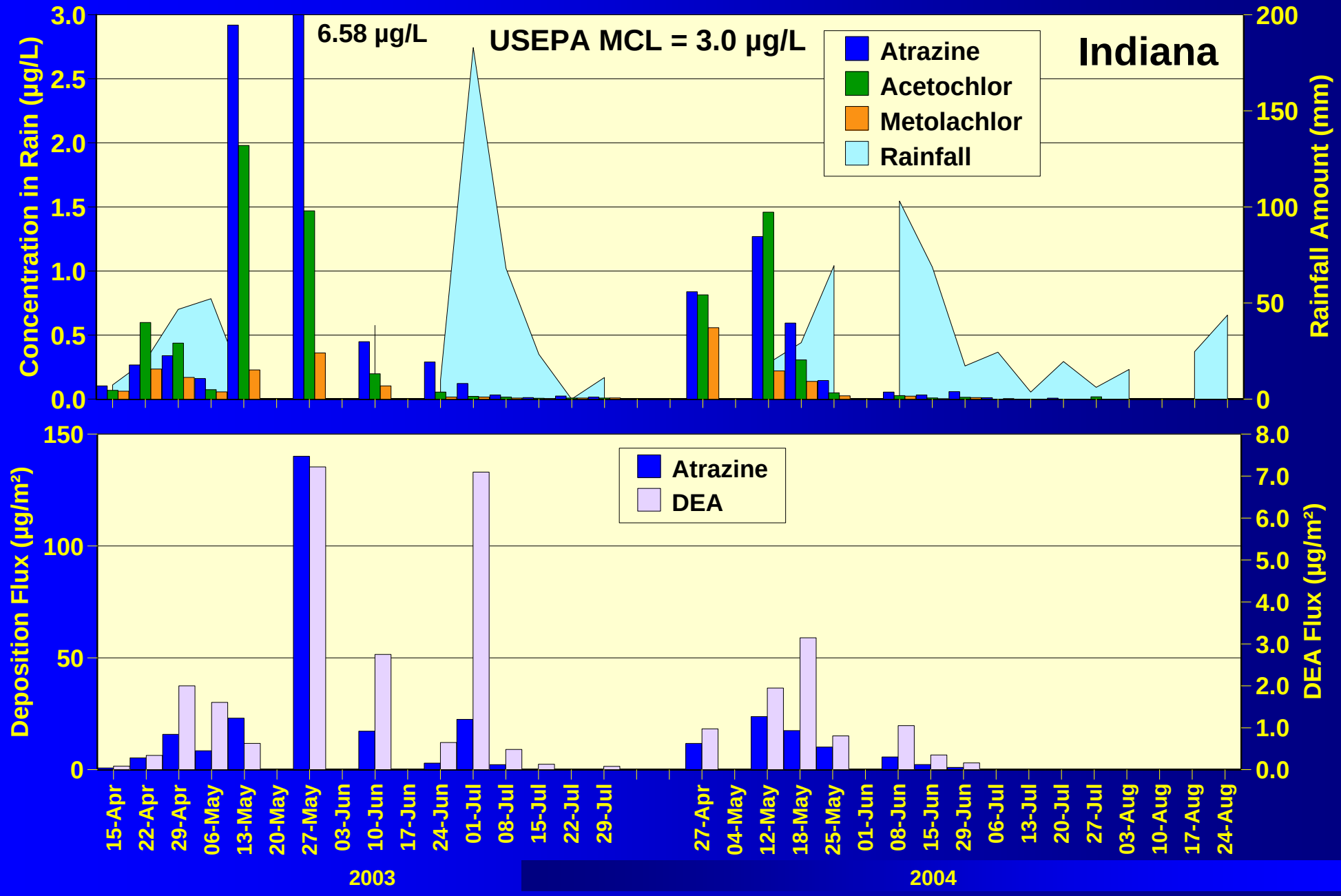
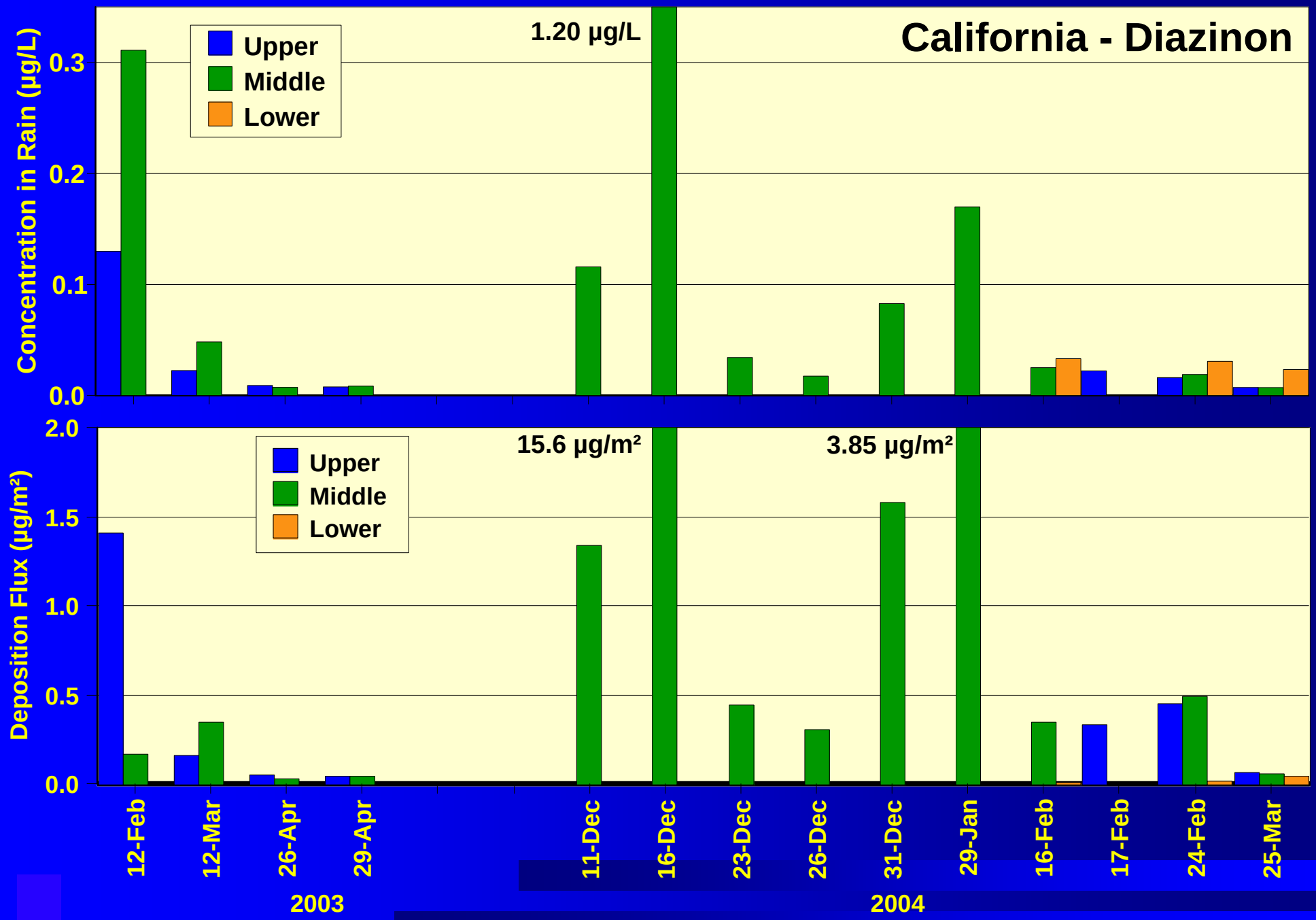


Atrazine Use:	Small-	Intermediate-	Large-
kg/yr	244/NR	12,242	836,930



Diazinon Use:	Small-	Intermediate-	Large-
kg/yr	NR/NR	6273	32,782

Detected Pesticides

Detection in Rain Ranking	Pesticide	2003 Rain Samples (% Detections)	2004 Rain Samples (% Detections)	2003 & 2004 Rain Samples (% Detections)	Stream Detection Frequency[a] (1991-2001)
	Total Sample #	54	62	116	
1	Metolachlor	85%	71%	78%	83%
2	Atrazine	64%	63%	64%	80%
3	Dacthal	62%	62%	62%	11%
4	Chlorpyrifos	58%	59%	58%	11%
5	Simazine	58%	46%	52%	57%
6	Acetochlor	49%	52%	51%	31%
7	Pendimethalin	42%	48%	45%	7%
8	Alachlor	38%	51%	45%	37%
9	Carbaryl	35%	33%	34%	9%
10	Diazinon	42%	22%	31%	13%

[a] Martin, J.D., Crawford, C.G., Larson, S.J., 2003, Pesticides in Streams: Summary statistics, 1992-2001. http://ca.water.usgs.gov/pnsp/pestsw/Pest-SW_2001_Text.html

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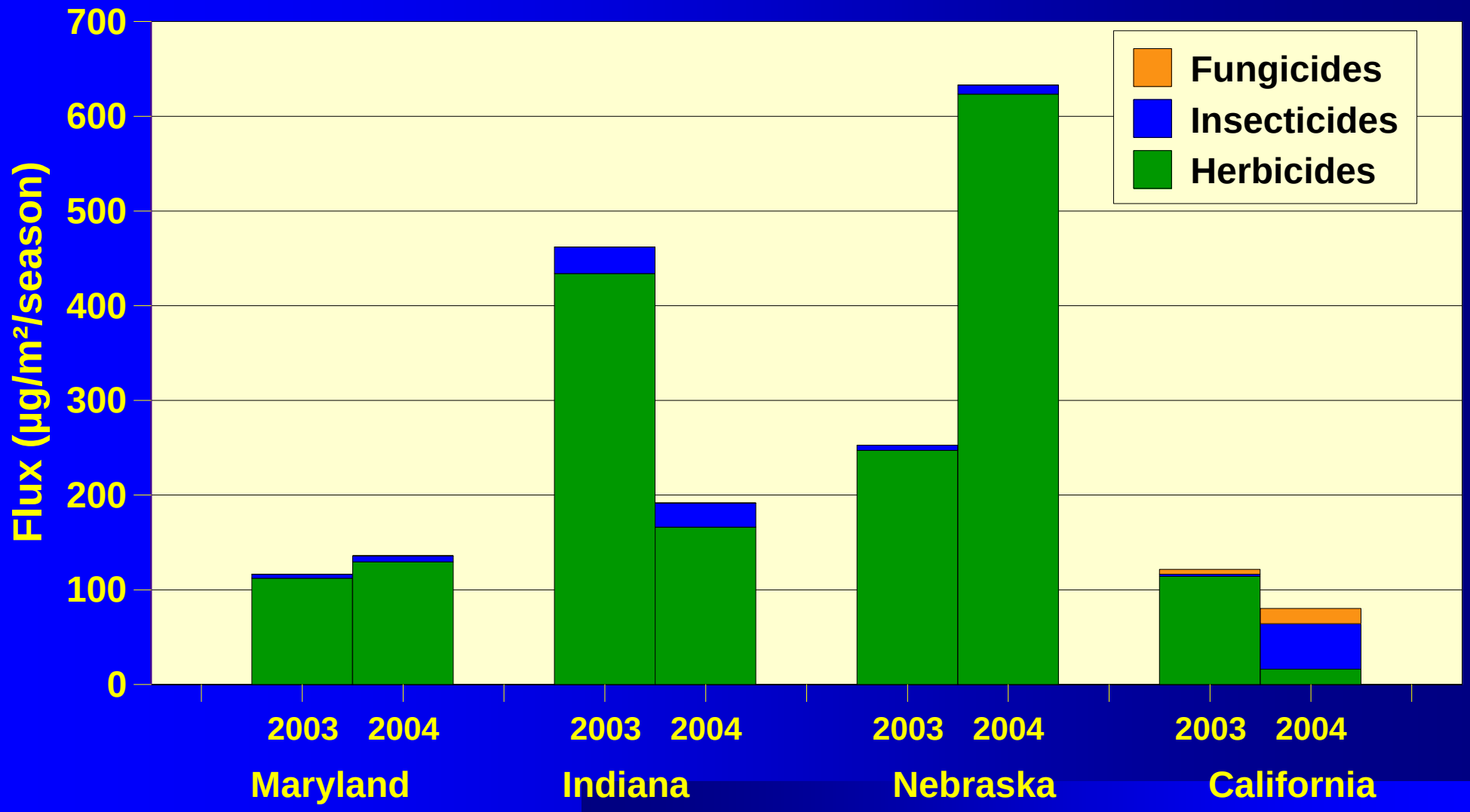
Seasonal Pesticide Loading



1 µg/m² ~ 10^{-5} lb/ac

Transformation Products

Organophosphorus Insecticides

Oxygen Analog of:	Maryland	Indiana	Nebraska	California
Chlorpyrifos	**1, (0.006 µg/L)**	**2, (0.012 µg/L)**	**1, (0.009 µg/L)**	**16, (0.022 µg/L)**
Diazinon	**0**	**0**	**0**	**16, (0.023 µg/L)**
Malathion	**0**	**8, (0.071 µg/L)**	**3, (0.027 µg/L)**	**5, (0.027 µg/L)**
Me-Parathion	**0**	**0**	**2, (0.025 µg/L)**	**0**

[# detections, (mean concentration)]

Acetanilide Herbicides

Acetochlor	ESA, OXA, SAA
Alachlor	ESA, OXA, SAA
Matolachlor	ESA, OXA

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Summary

- A wide variety of pesticides were detected in every rainfall sample collected
  - Herbicides detected more frequently and at higher concentrations than insecticides
- Detection frequencies and concentrations were closely related to their use
  - Atrazine concentrations in rain exceeded EPA MCL value for drinking water in IN & NE
- Transformation Products
  - Oxygen analogs of organophosphorus insecticides
  - No acetanilide herbicide metabolites detected

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Summary, continued

- Depositional fluxes ranged from:
  - Herb. - 1.6 to 623 µg/m²
  - Insect. - 2.2 to 48 µg/m²
  - Fung. - ND to 16 µg/m²
- What is the significance of pesticides in rainfall?
  - Many of the same pesticides detected in rainfall are also detected in surface and groundwater
  - A wide variety of pesticides are being transported and deposited into non-target areas where their use was not intended

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