

TMDLs & Phosphorus & Models

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Overview

- **Introduction to TMDLs**
- **Linking land and water**
- **The Wisconsin PI**

I. The TMDL

- Clean Water Act
 - Water quality to support fish, recreation, drinking
 - ***Water Quality Standard***
 - The water “use”
 - The “criteria” to support that use
 - Discharge permits for point sources
 - Based on “technology limits” or “water quality based”

The TMDL

- If *Water Quality Standard* not met
 - “impaired”
 - Required to determine the *Total Maximum Daily Load* that could enter water (and meet the standard)

The TMDL

- ***Total Maximum Daily Load***
 - Identify pollutant sources
 - Determine relationship between “load” and “criteria”
 - Quantify acceptable “load” with margin of safety
 - Allocate “load”

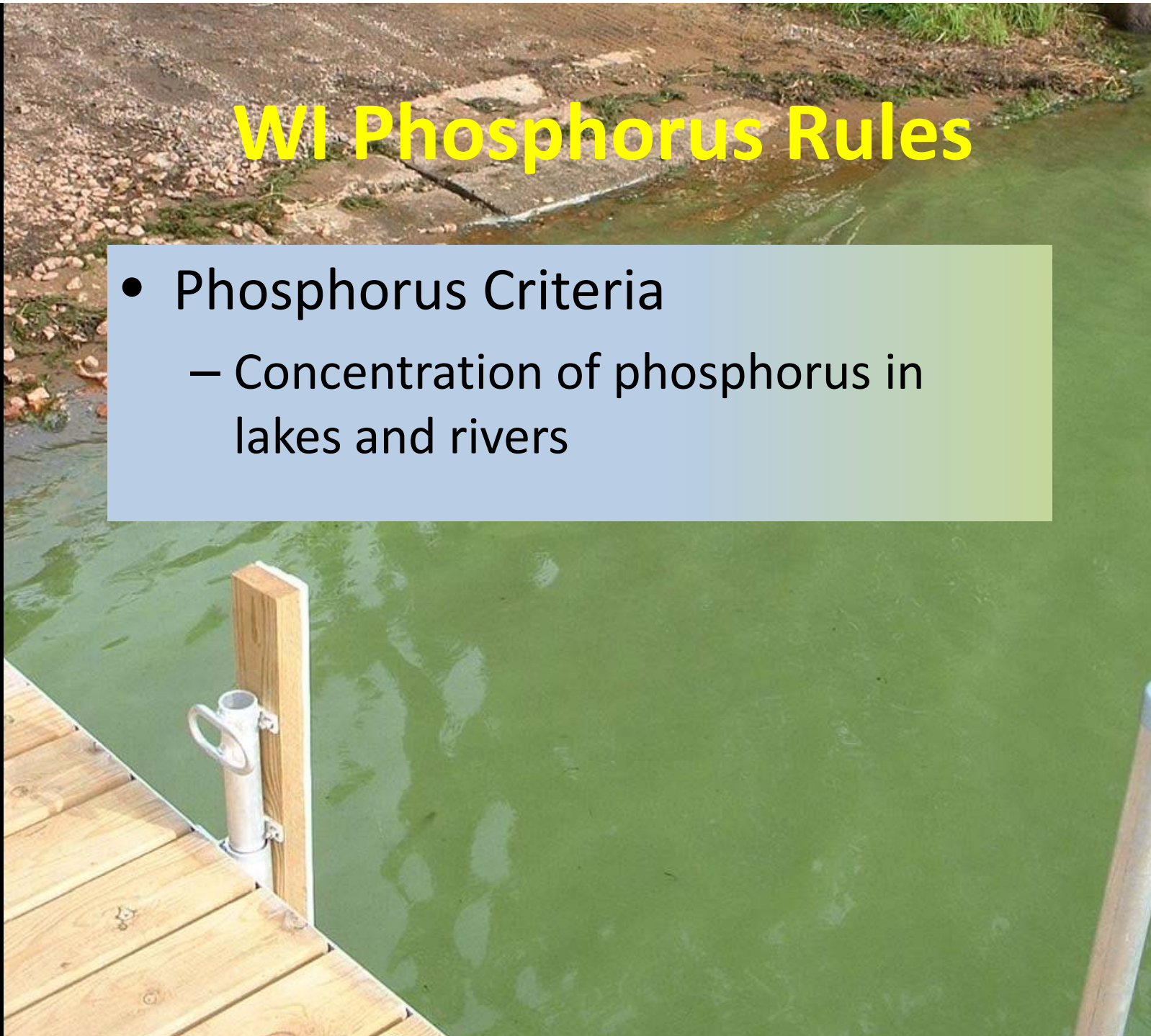
The TMDL

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WI Phosphorus Rules

- Phosphorus Criteria
 - Concentration of phosphorus in lakes and rivers



WI Phosphorus Rules

- Phosphorus Criteria
 - Concentration of phosphorus in lakes and rivers

| | |
|--------------------|--------------------|
| Streams & Rivers | 0.075-0.1 mg/l |
| Lakes & Reservoirs | 0.015 – 0.040 mg/l |
| Great Lakes | 0.005-0.007 mg/l |

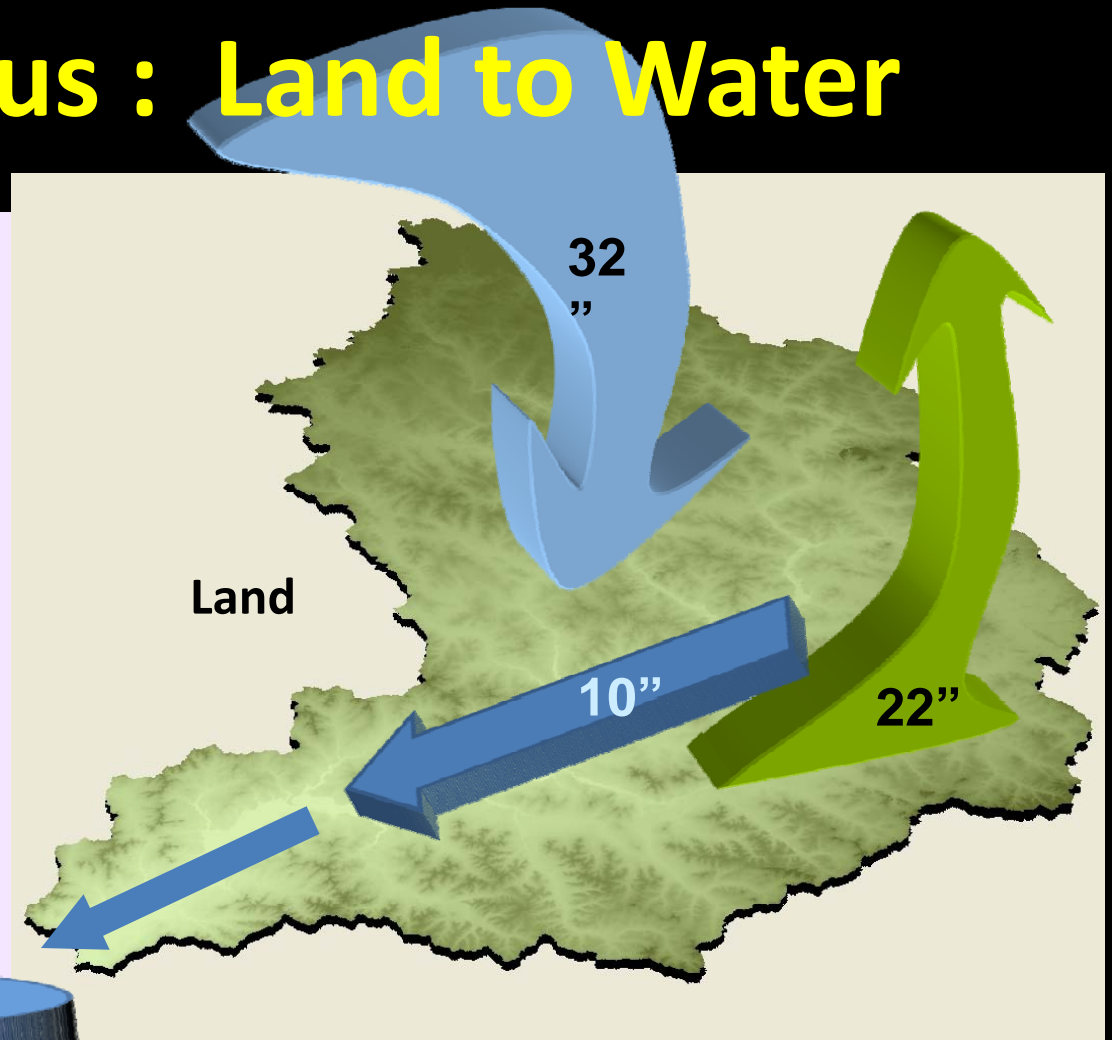


WI Phosphorus Rules

- New Point Source Limits
 - Water Quality Based P Limits
- Cropland Performance Standard
 - $PI < 6$
- Targeted Performance Standard
 - Promulgated by Rule

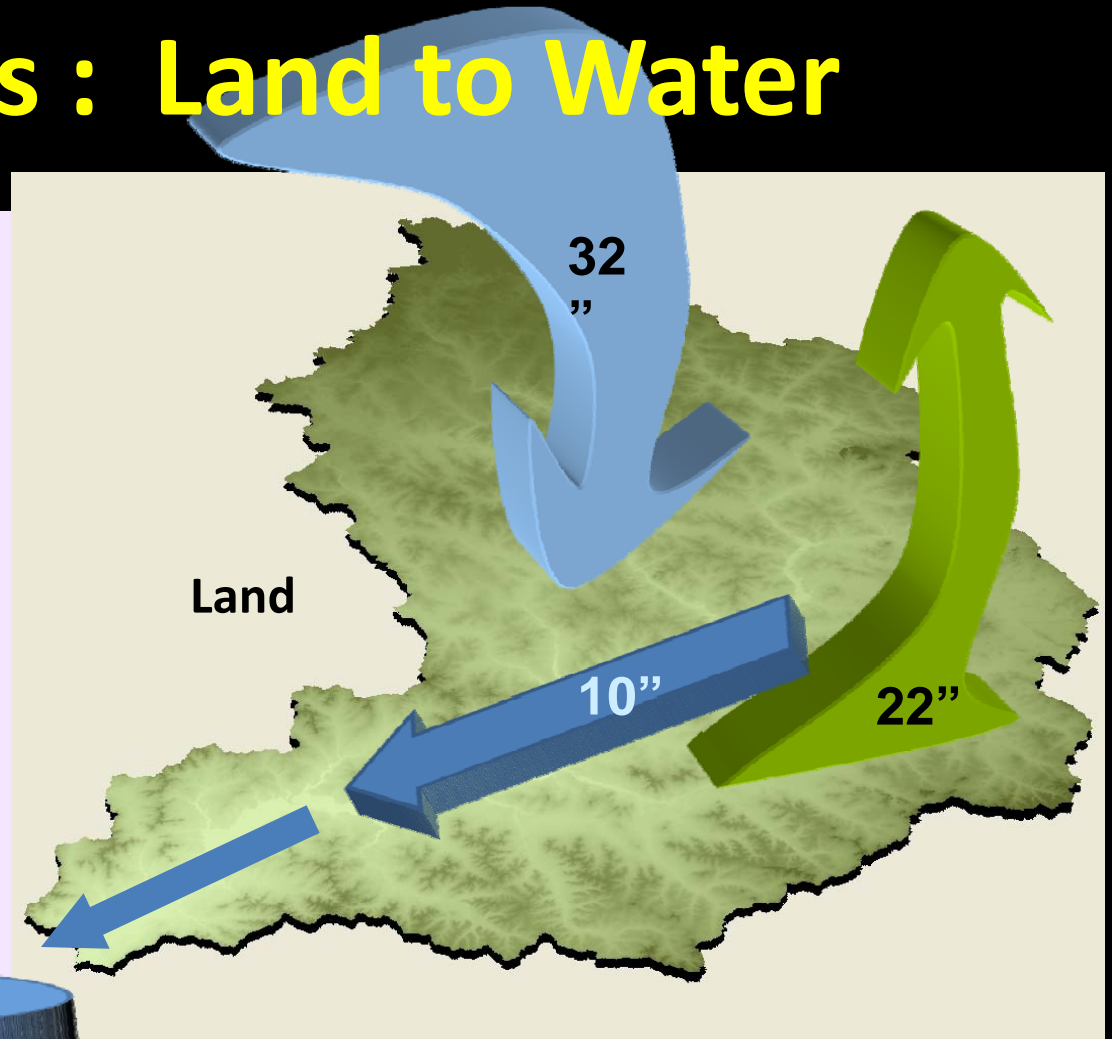
II. Phosphorus : Land to Water

- Land is a concentrated P source (compare to water)
- 10"/year (+/-) is a powerful connection
- What happens in the water?



Phosphorus : Land to Water

- Models
- A mathematical description
- Help us visualize something
- Land models
- Water models



80 lb
Phosphorus/yr

325 million
gallons/year

A model for
the
phosphorus
concentration
in a lake

Amount of
Phosphorus
= $\frac{\text{-----}}{\text{Amount of
Water}}$

80 lb
Phosphorus/yr

Simple... but
not a very
good model

325 million
gallons/year

= 80 lb/ 3 billion lbs water

= 0.027 mg/l

80 lb
Phosphorus/yr

Still simple...
used with
reasonable
success for
30+ years

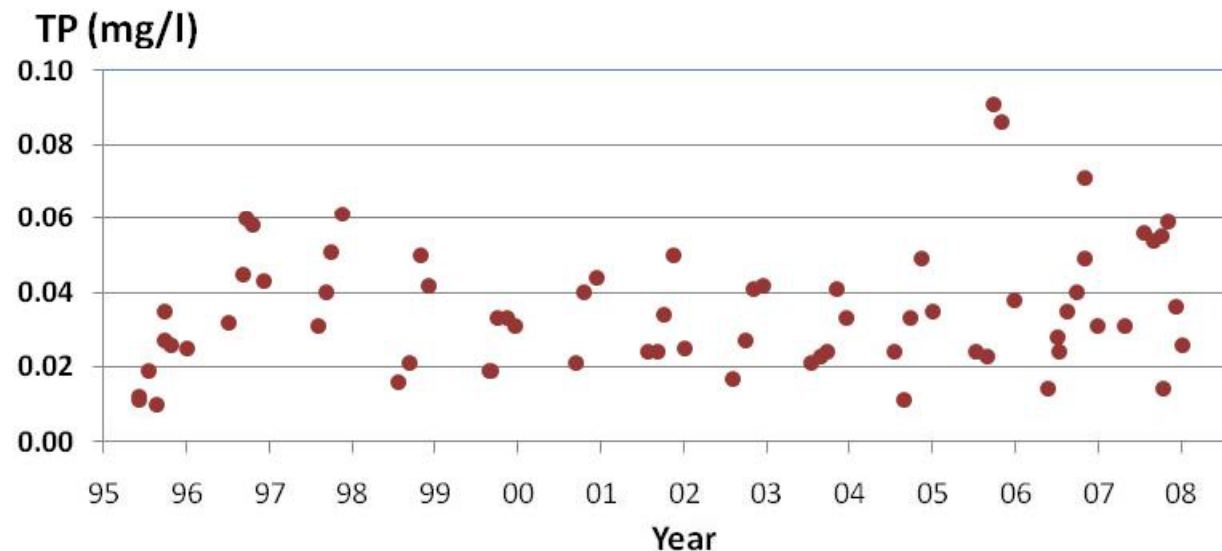
325 million
gallons/year

Annual
Phosphorus
Settling

$$= \text{P Load} / (\text{Water Out} + \text{P Settling})$$
$$= 0.015 \text{ mg/l}$$

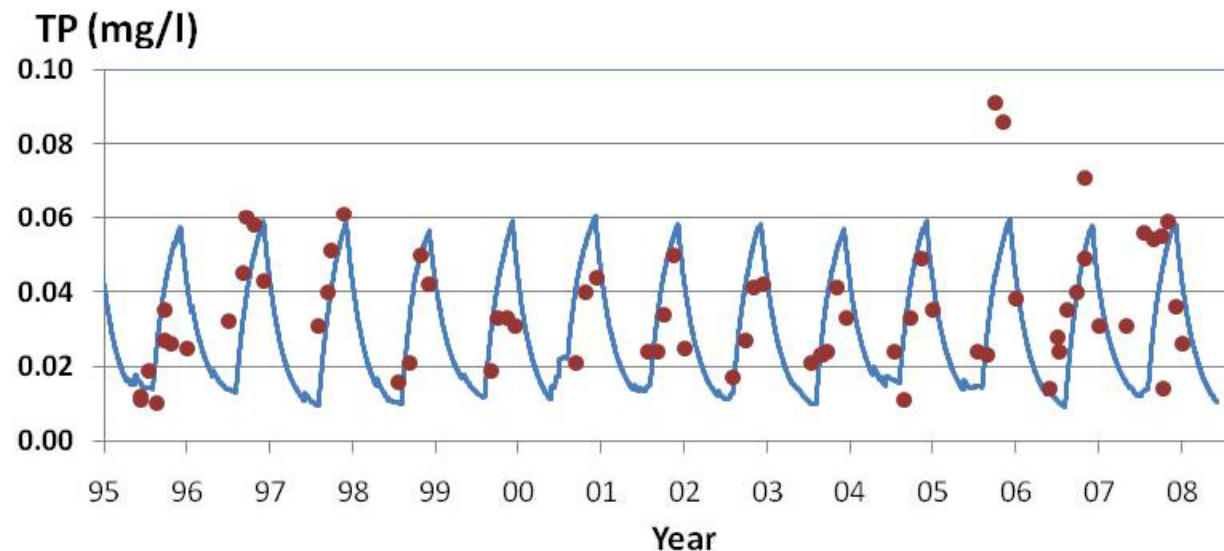
“Simple” Surface Water Model

- Simple, but successful
 - Yearly time-step, average condition
 - Relatively empirical approach
- Doesn't describe every situation



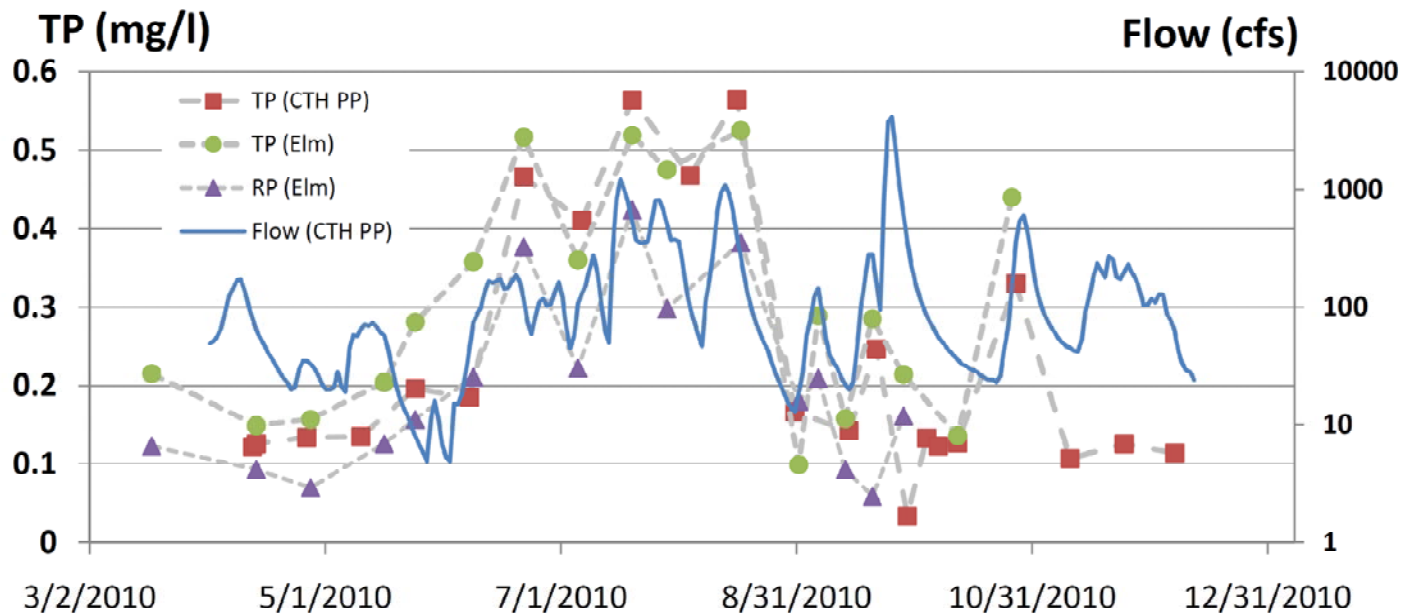
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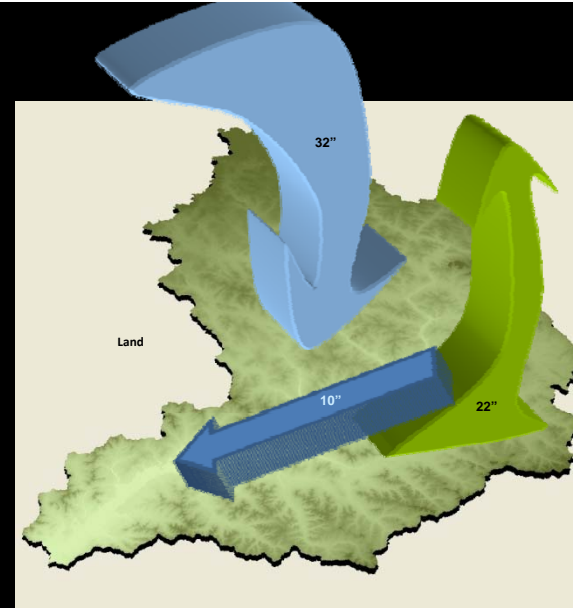


More Dynamic & Distributed Systems?

- Short residence times
- Reactions that vary over time & space
- Stream Concentrations



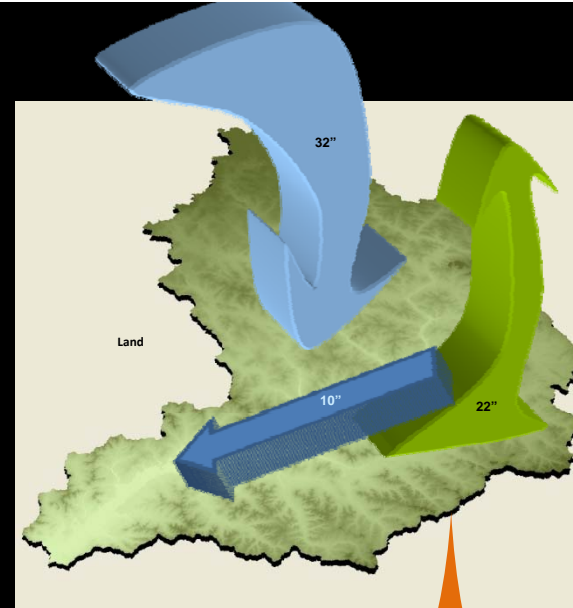
Modeling the Land?



Very Simple

Very Complex

Modeling the Land?



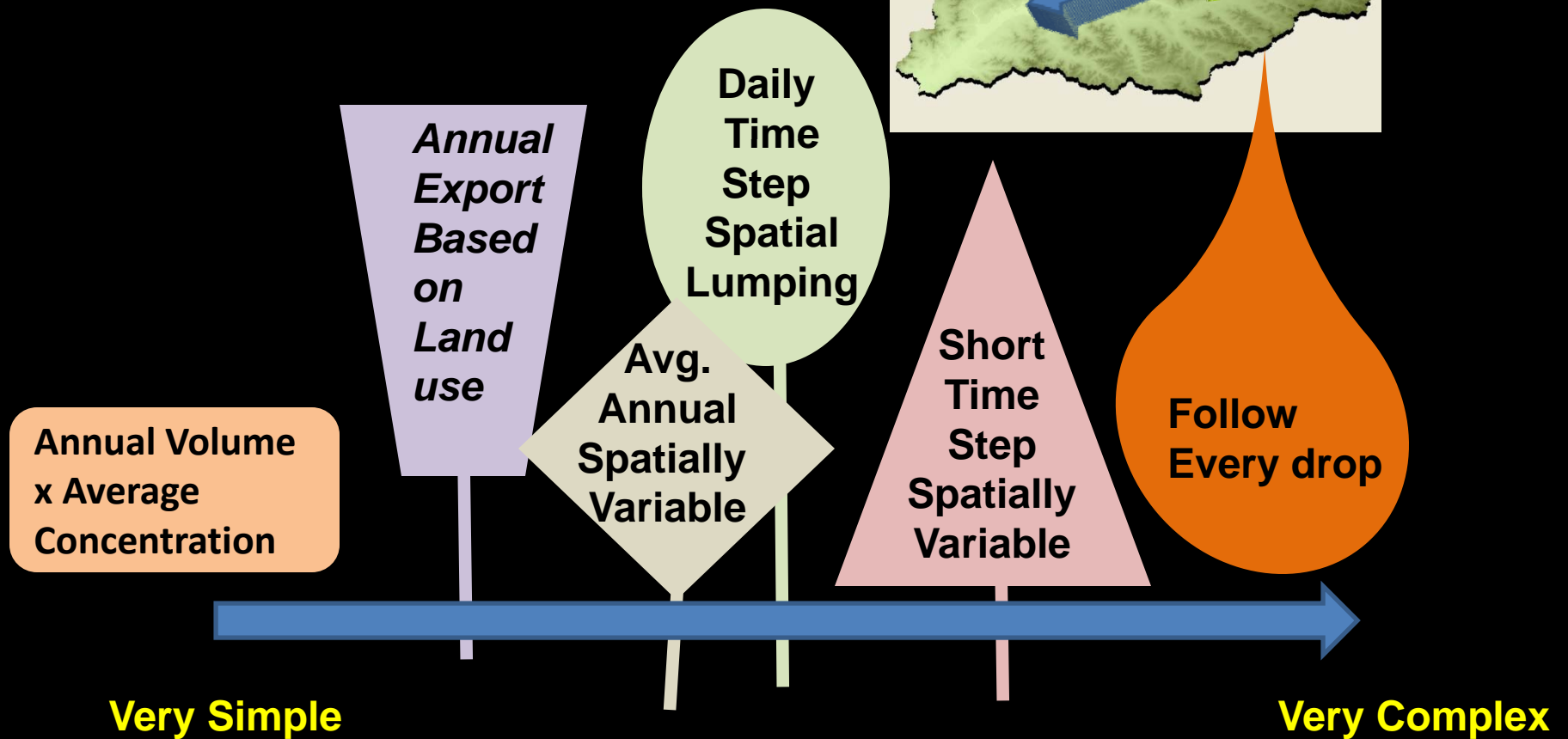
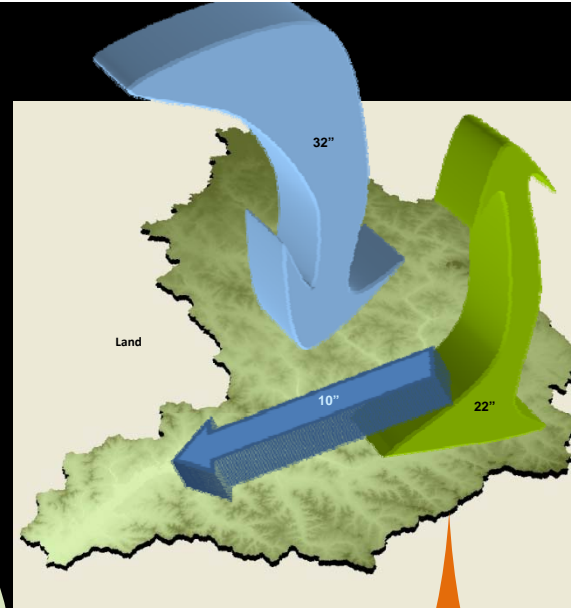
Annual Volume
x Average
Concentration

Follow
Every drop

Very Simple

Very Complex

Modeling the Land?

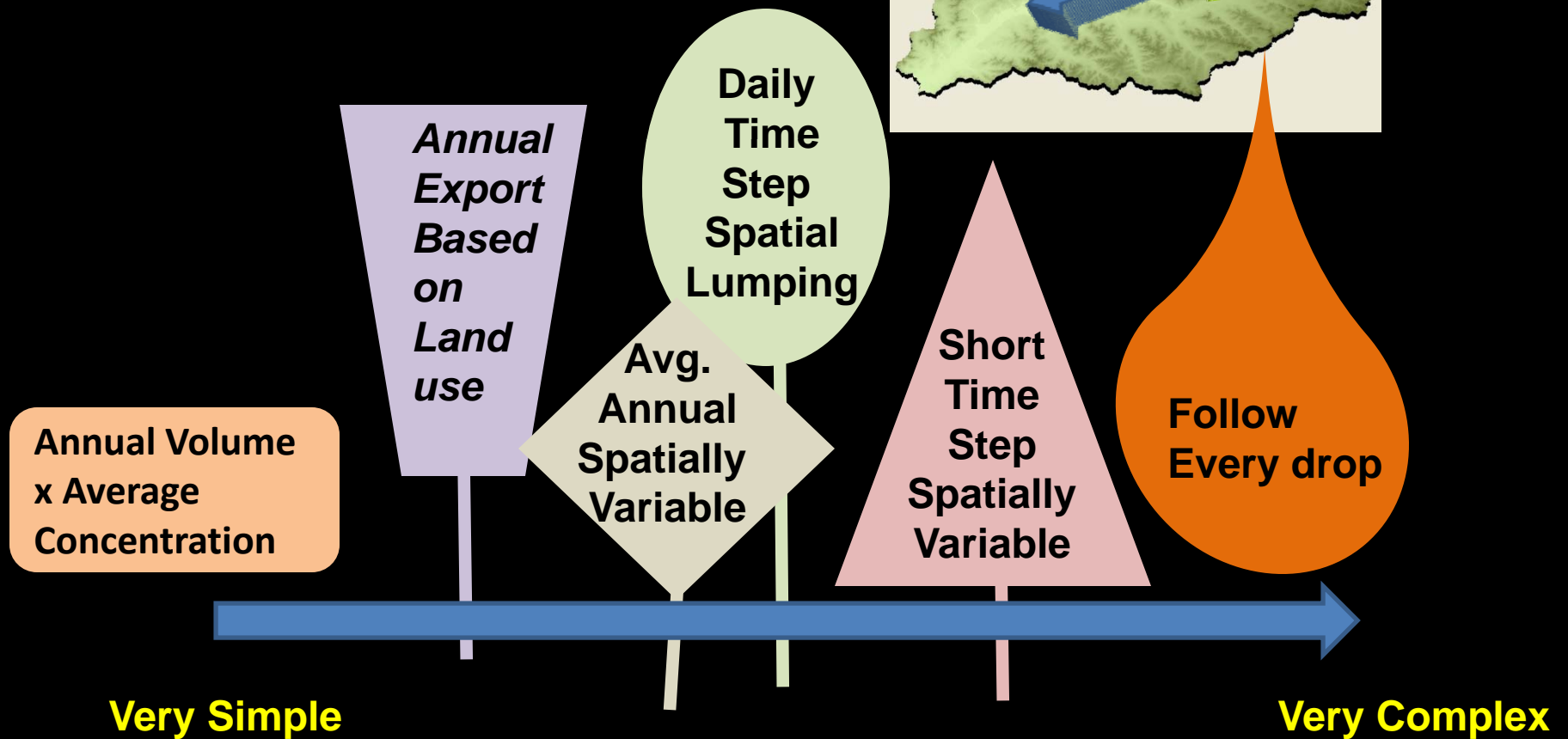
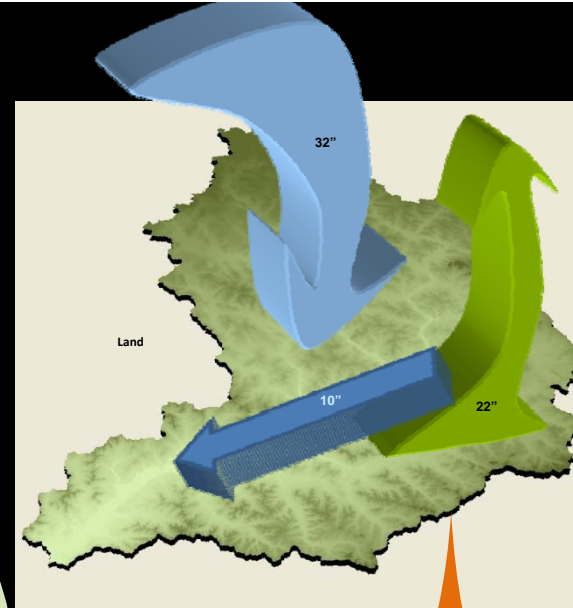


The Pros and Cons of Model Complexity

- “Make everything as simple as possible, but not simpler”

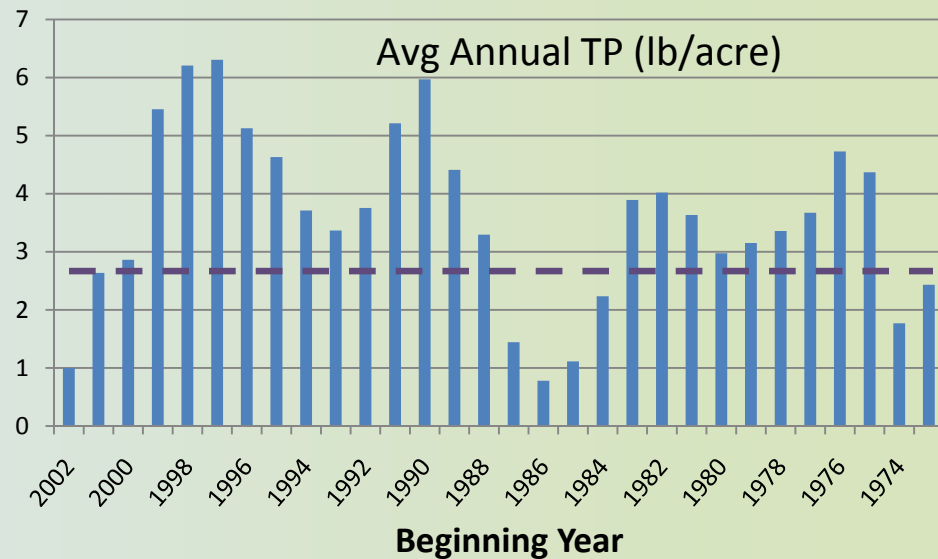
A. Einstein

Modeling the Land?



III. The WI PI

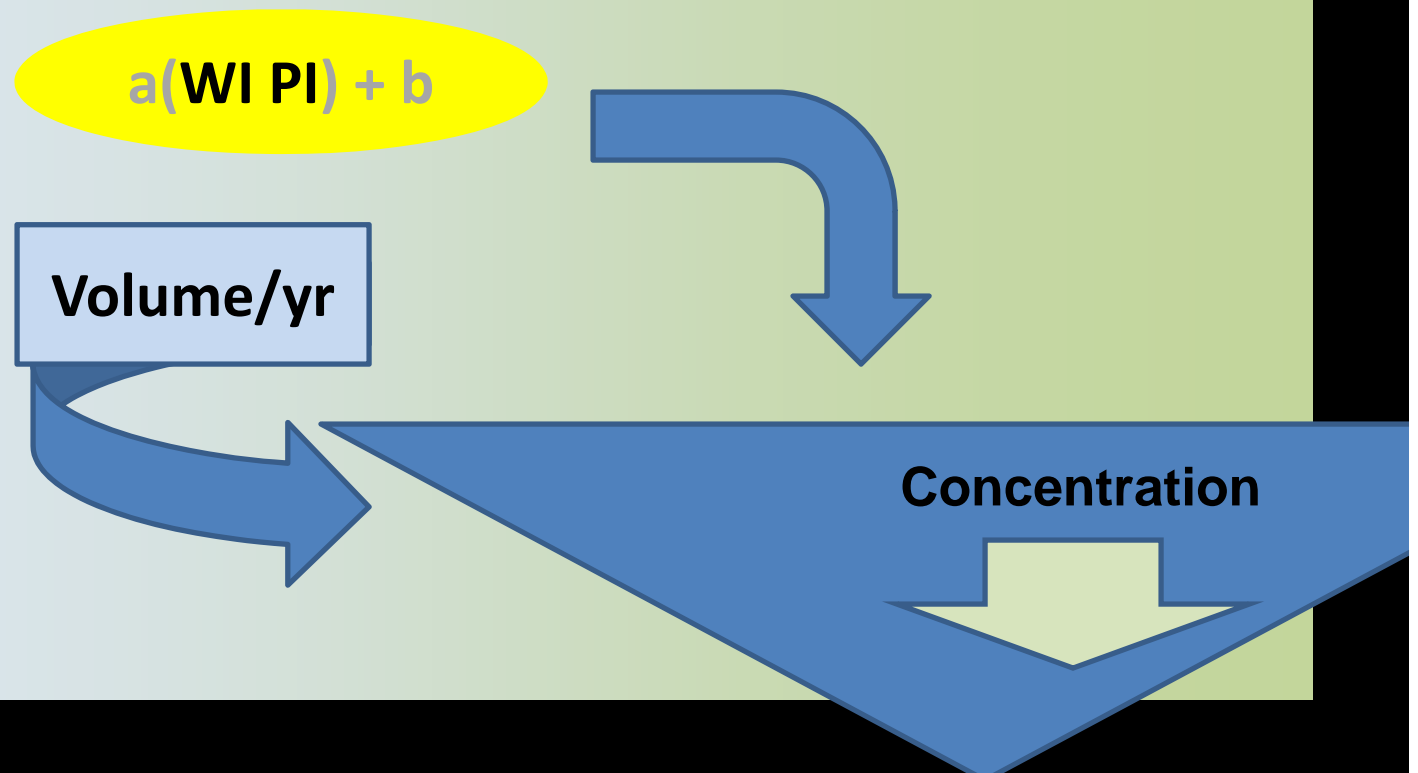
- Land Model
 - Event-based /Average Annual “Load”
 - Mgt/Hydrology/Sources
 - Load Allocation / Load Reduction



8 Year Simulation
Last Six: AACCCA
Calibration Pioneer Farm
30 6 year simulations
Average TP 3.6 kg/ha/yr
PI Rotation Average 2.8

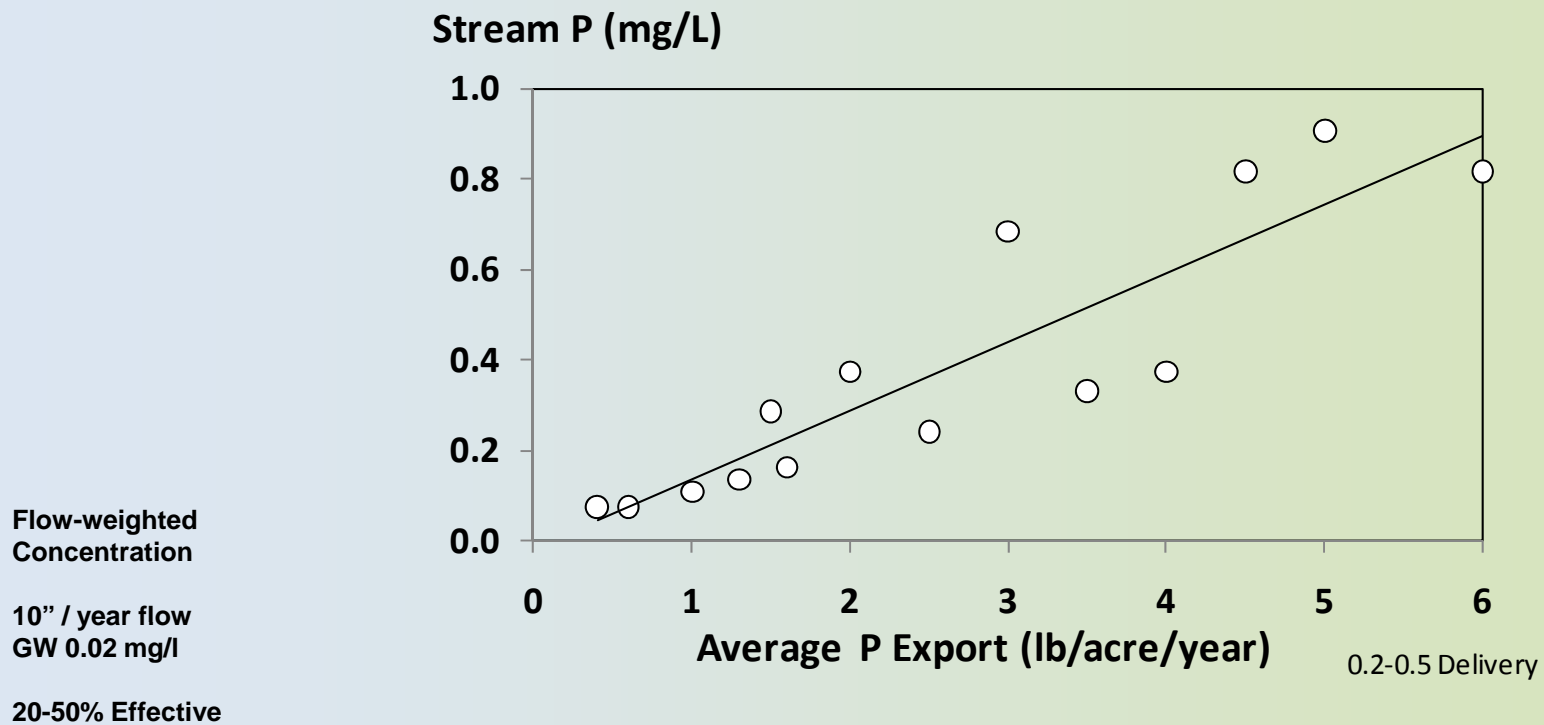
The WI PI

- Water Body Response
 - Relationship to Concentration?



The WI PI

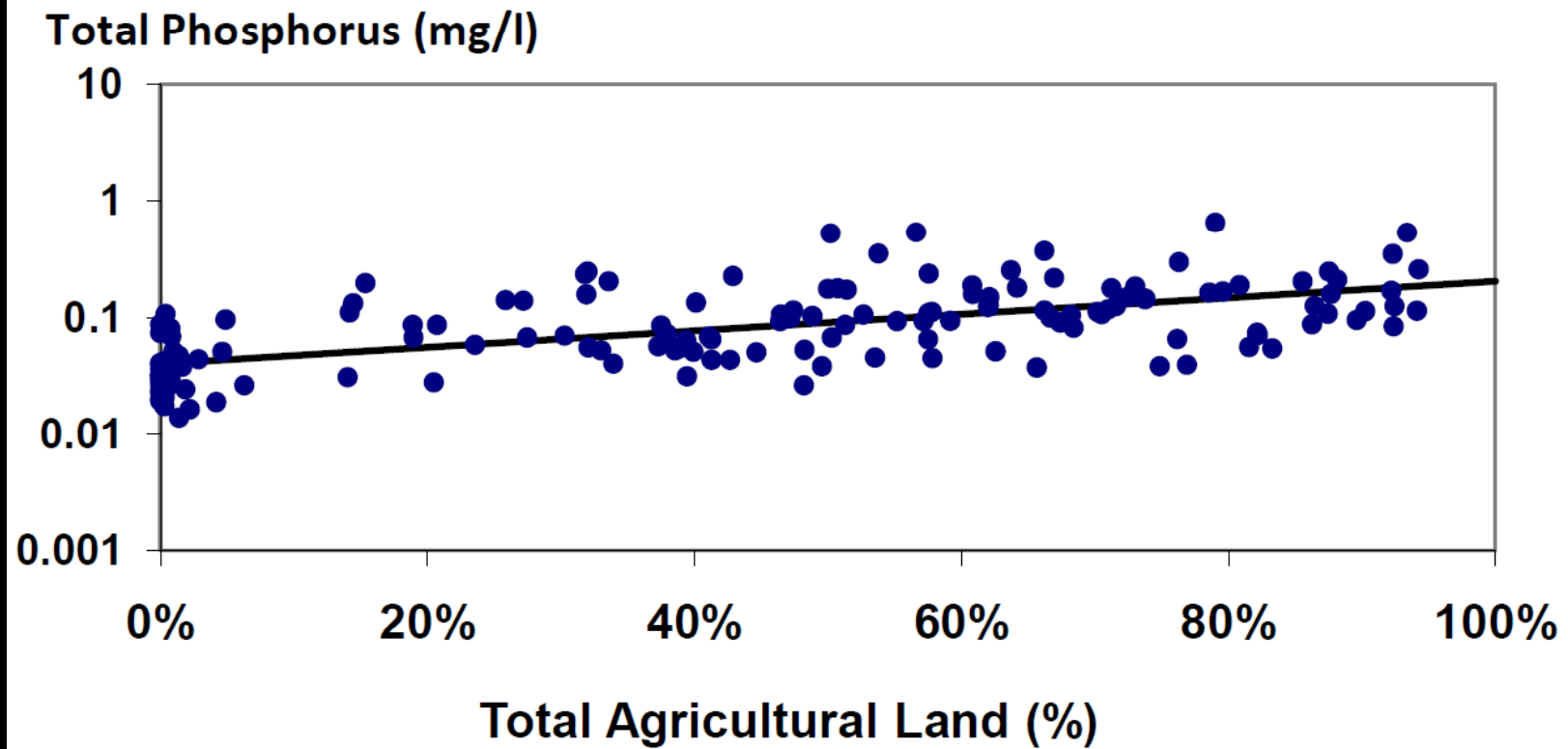
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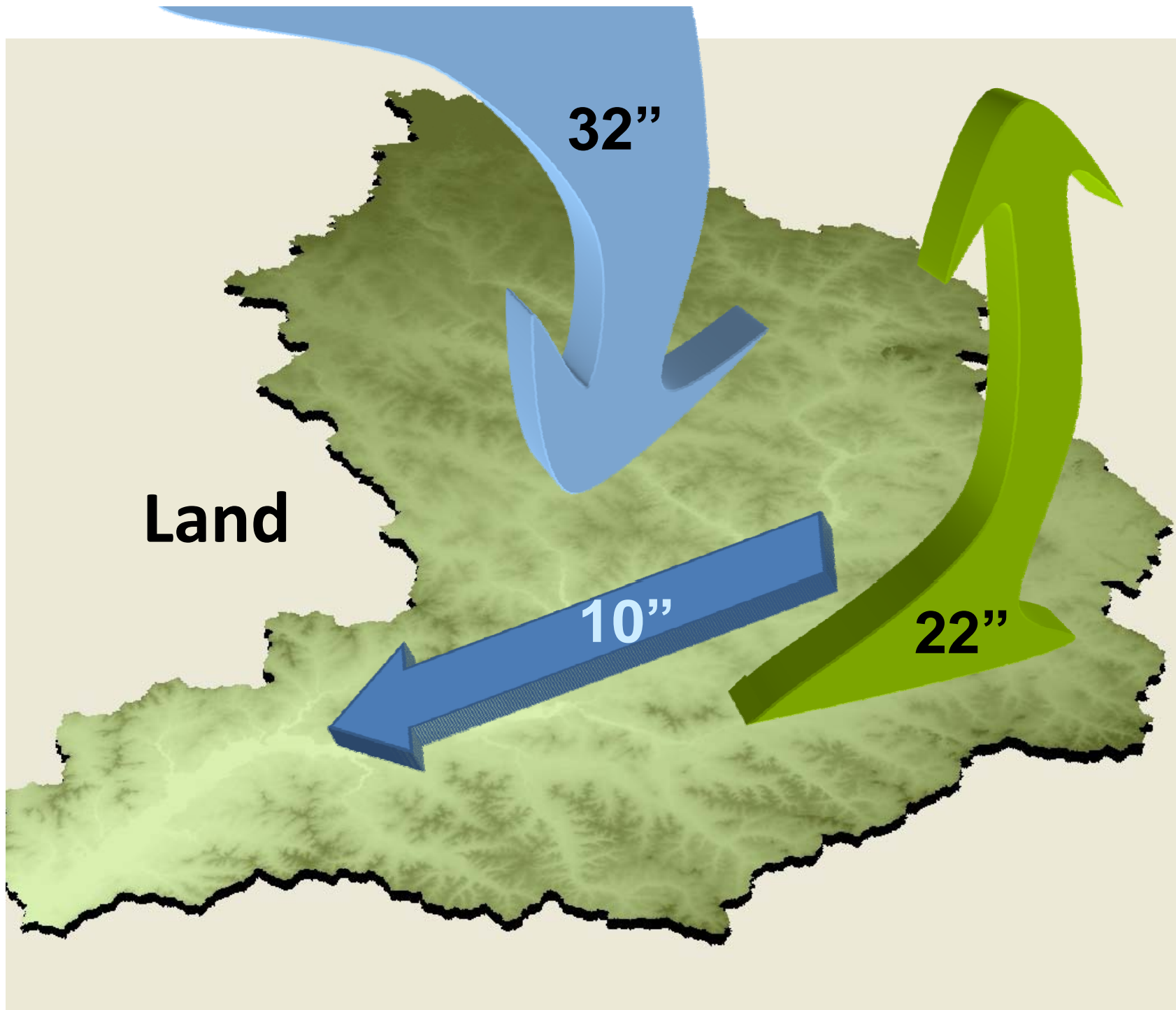
Thank you

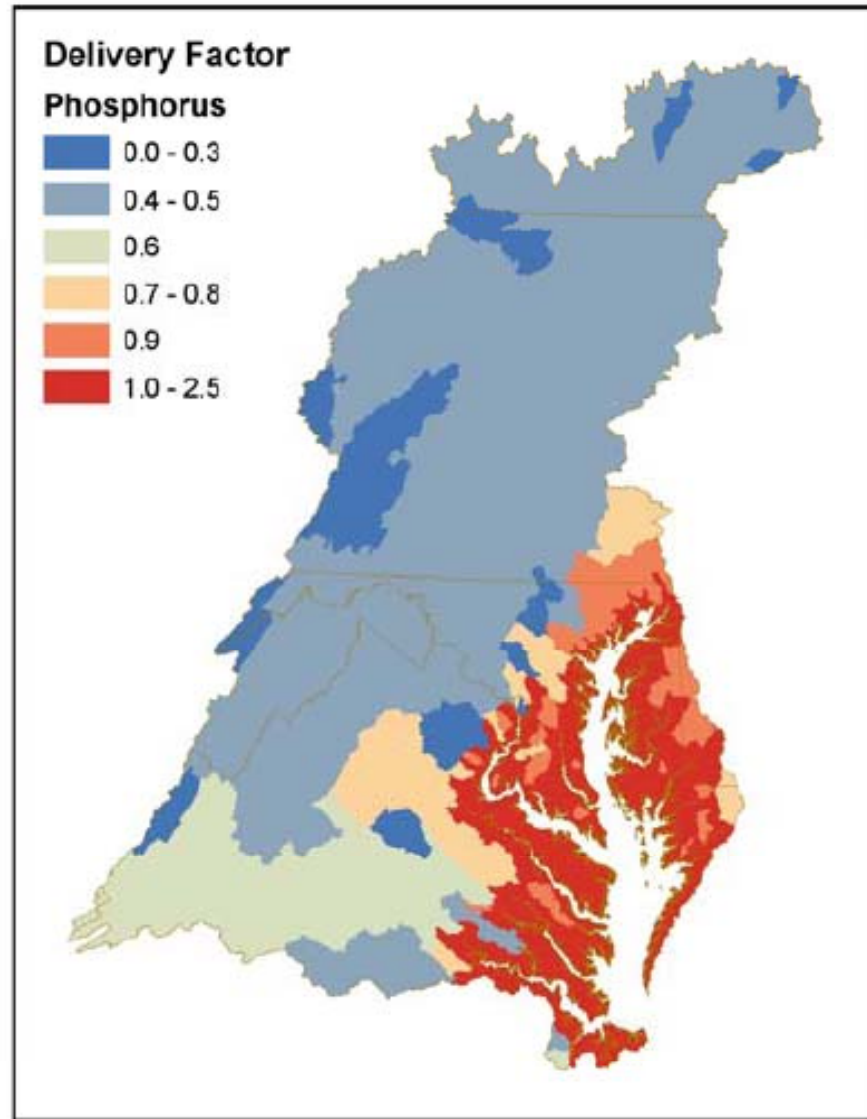
Questions...





How much variation in streamflow P concentration can we explain?
(data from the USGS 248 Wadeable Stream Study, Robertson et al)





Chesapeake Bay Model

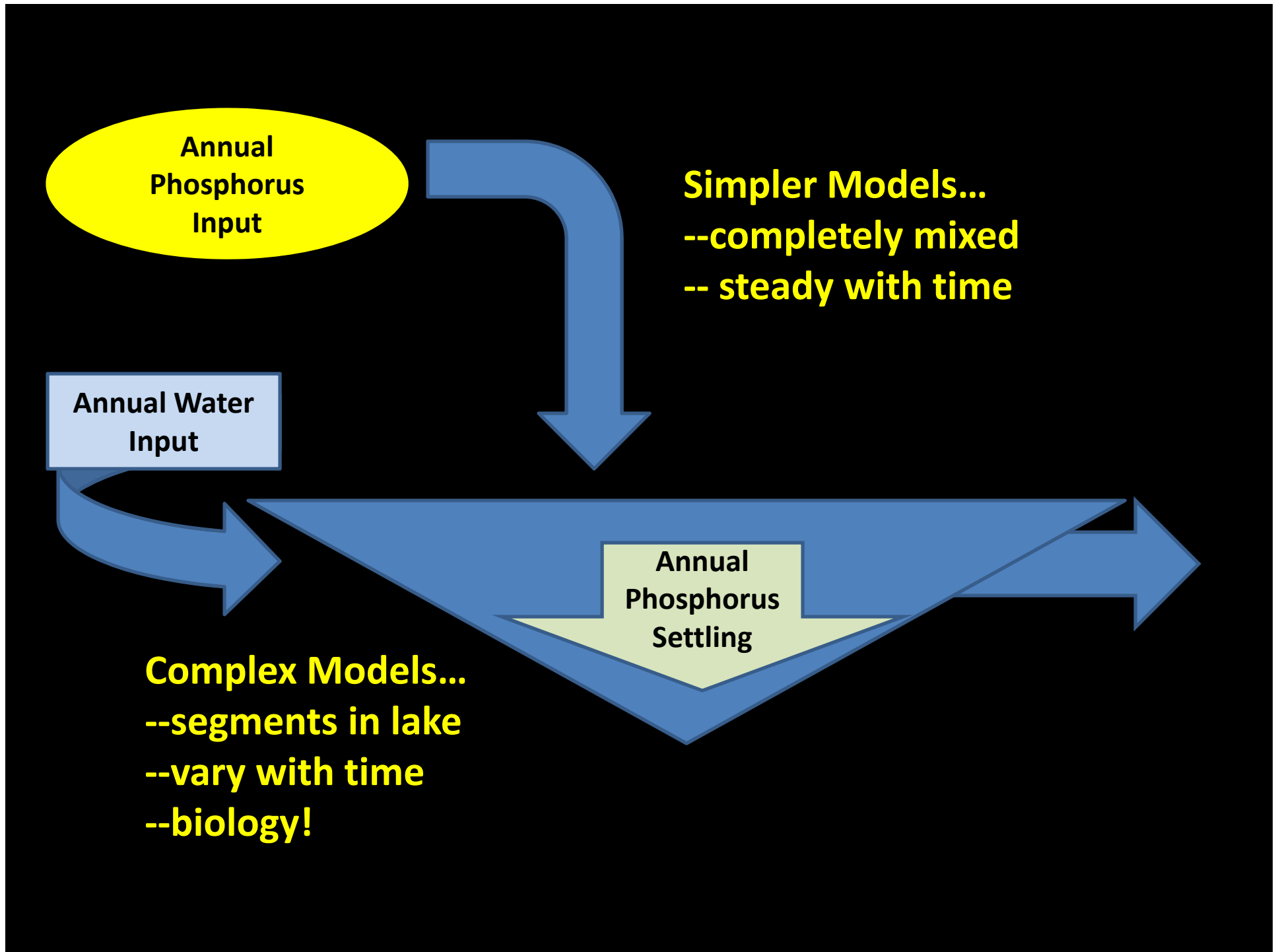
**Annual
Phosphorus
Input**

**Annual Water
Input**

Simpler Models...
--completely mixed
-- steady with time

**Annual
Phosphorus
Settling**

Complex Models...
--segments in lake
--vary with time
--biology!



Compare SWAT and WI-PI

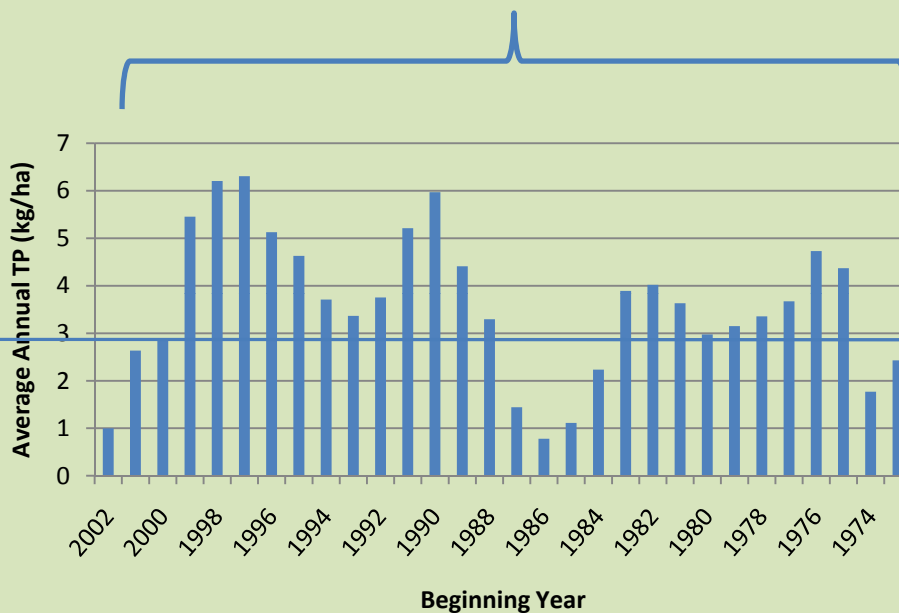
(Pioneer Farm S3)

8 Year Simulation
Last Six: AACCCA

Calibration Period
All Events: TP -28%
Non-Winter Events: TP
+16.2%
(based on total TP)

30 6 year simulations
Average TP 3.6 kg/ha/yr

PI Rotation Average 2.8



What's a model

One definition: A mathematical description to help visualize something

