Effects of Urban Hydrology on Amphibian Decline in King County

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Watershed and Ecological Assessment Team
Science and Technical Support Section

No Net Loss Of Wetlands

- National Wetlands Policy Forum (1988)
  - "no-net-overall-loss" and "long-term net-gain" in quality and quantity of nation's wetland resources.
- Bush (1988) & Clinton (1993) Administration Support
- Executive Orders by Washington's Governor Booth Gardner (1989, 1990)
- King County's Comprehensive Plan & Sensitive Areas Ordinance (Acreage & Function)
- Providing Amphibian Breeding Habitat is a Critical Wetland Function

Scientific Methods

Two Approaches

- 1) Survey Approach
- 2) Experimental Approach

Survey Approach

Wetland Locations

Map of studied wetlands within King County, Washington State

Egg Mass Surveys

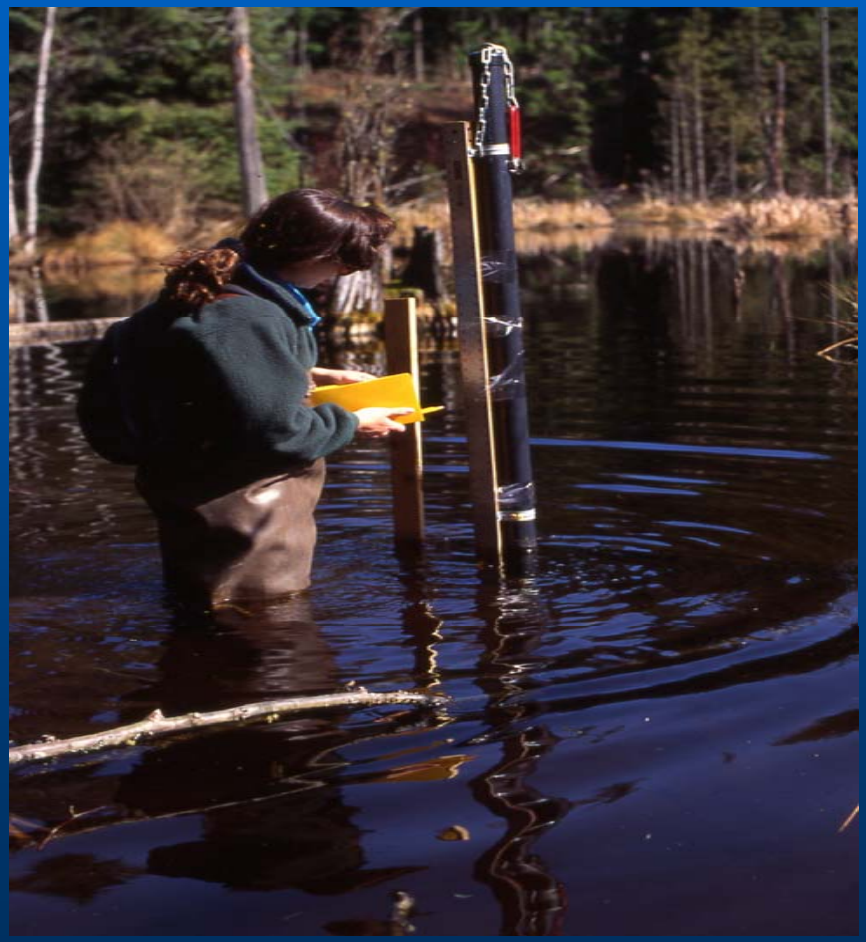
Measured Current Velocity at Egg Mass and Non-Egg Mass Locations

- At inflows, channels and outflow channels of creeks & streams to wetlands I measured current velocity along a gradient where eggs masses were missing and where egg masses first appeared.
- Also measured velocities at egg masses and within wetland channels.

Measuring Water Depths Depths & Depths Below the Surface at Egg Masses of Indicator Species

Identifying Plant Species, Plant Health & Measuring Stem Diameters

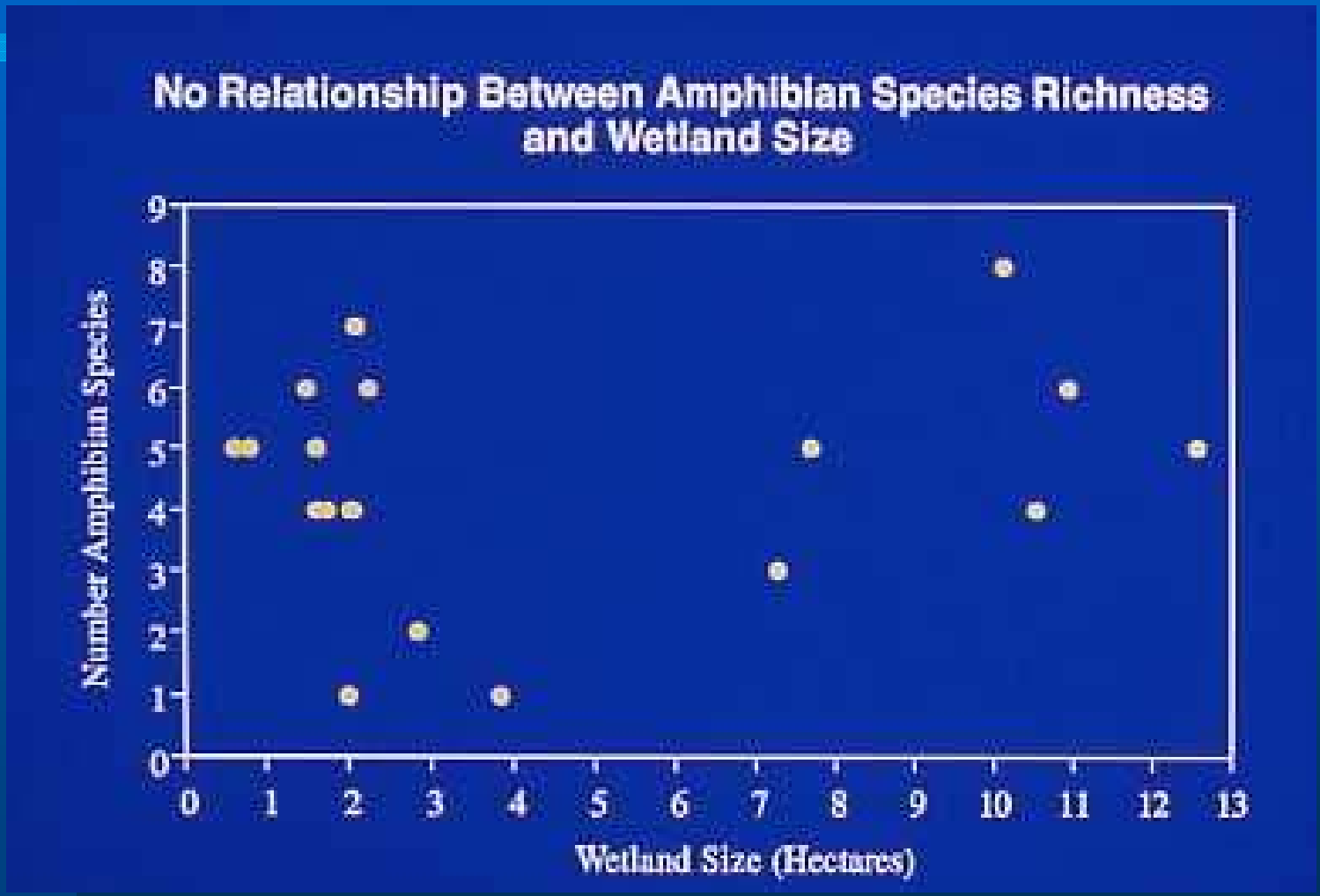
Measuring Instantaneous and Highest Water Levels Since Last Survey

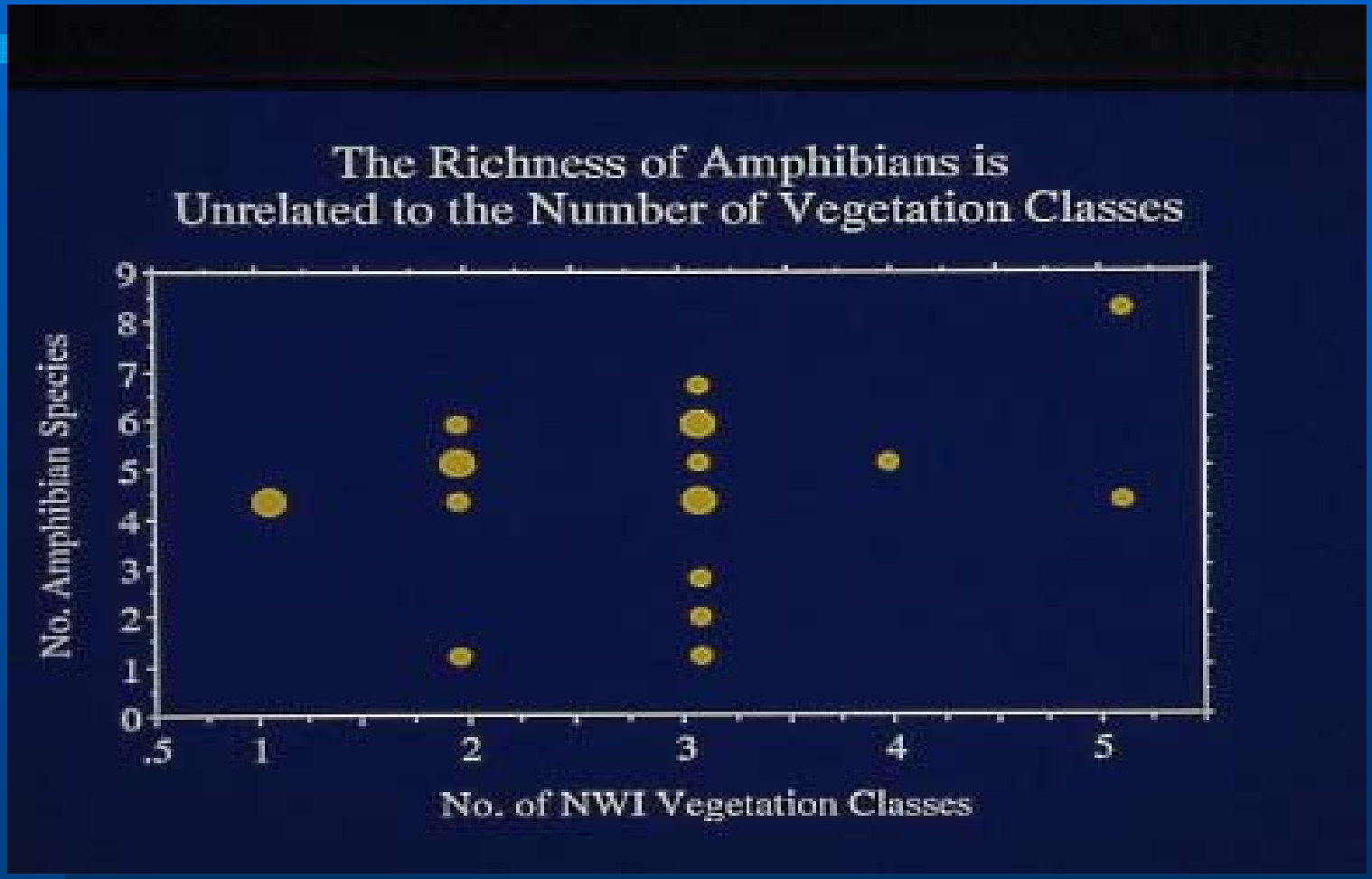


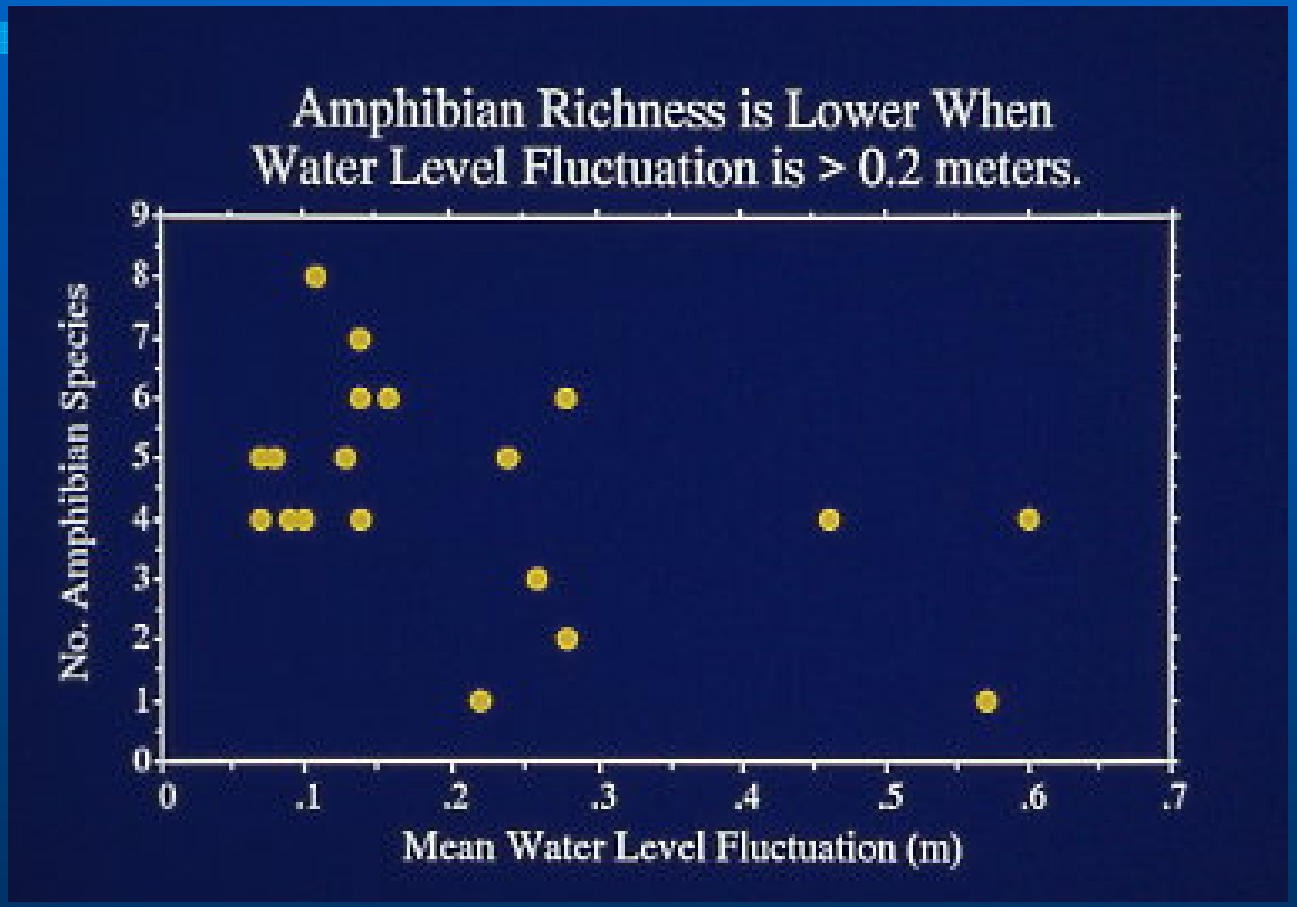
Collecting “Grab” Water Samples

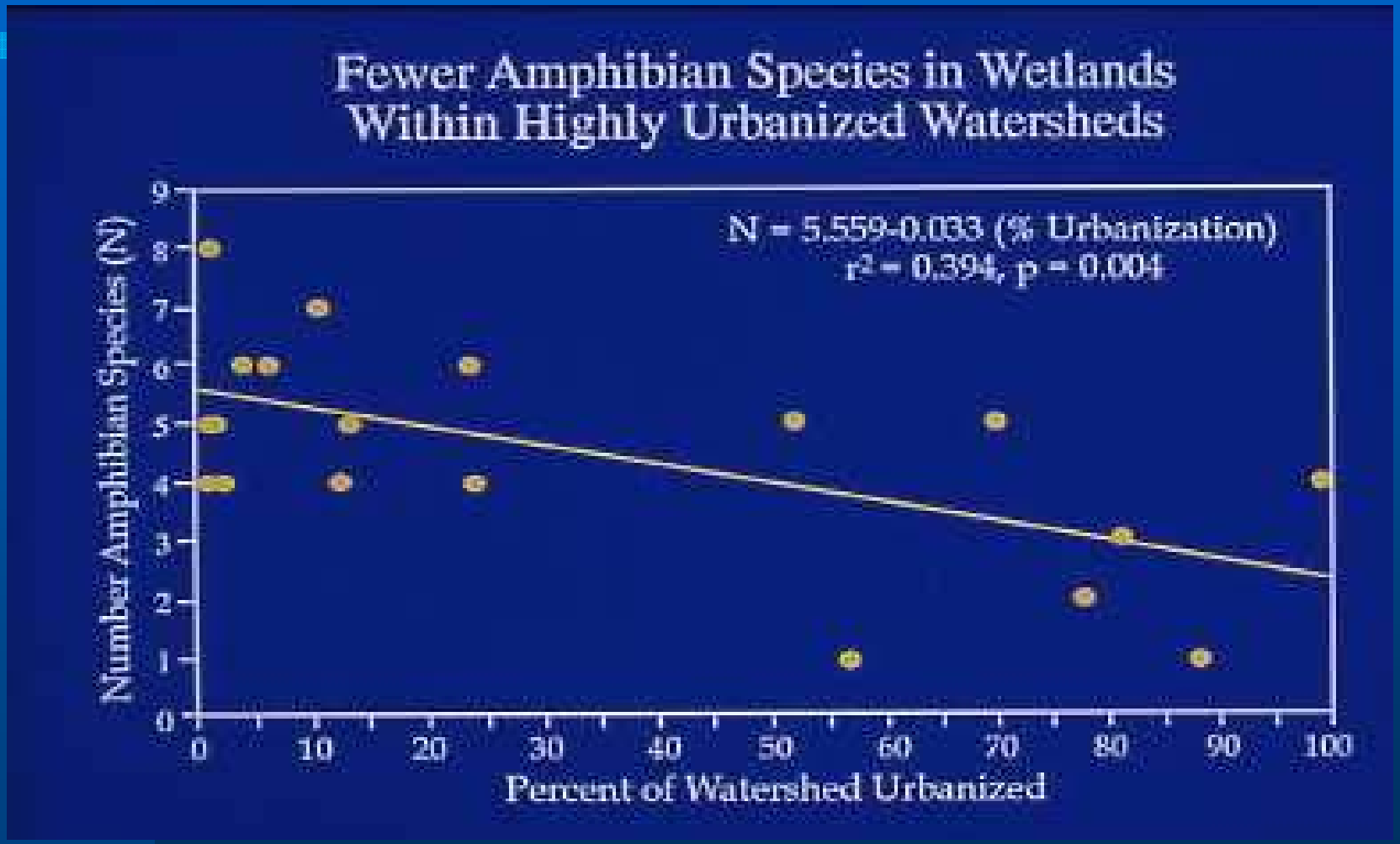
Laboratory Water Quality Analysis

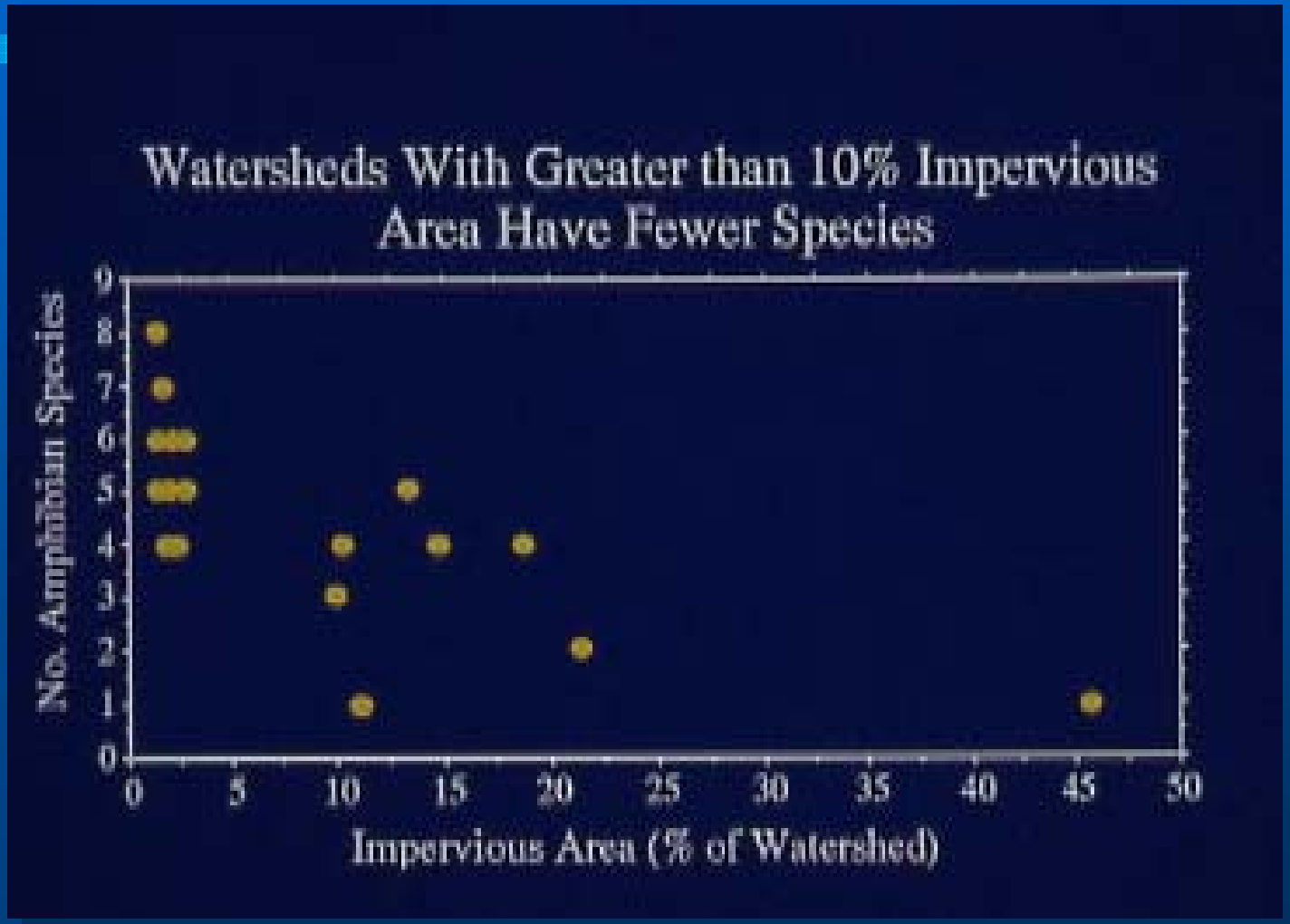
Results


No Relationship Between Amphibian Species Richness and Wetland Size
Number Amphibian Species
0
1
2
3
4
5
6
7
8
9
0
1
2
3
4
5
6
7
8
9
10
11
12
13
Wetland Size (Hectares)

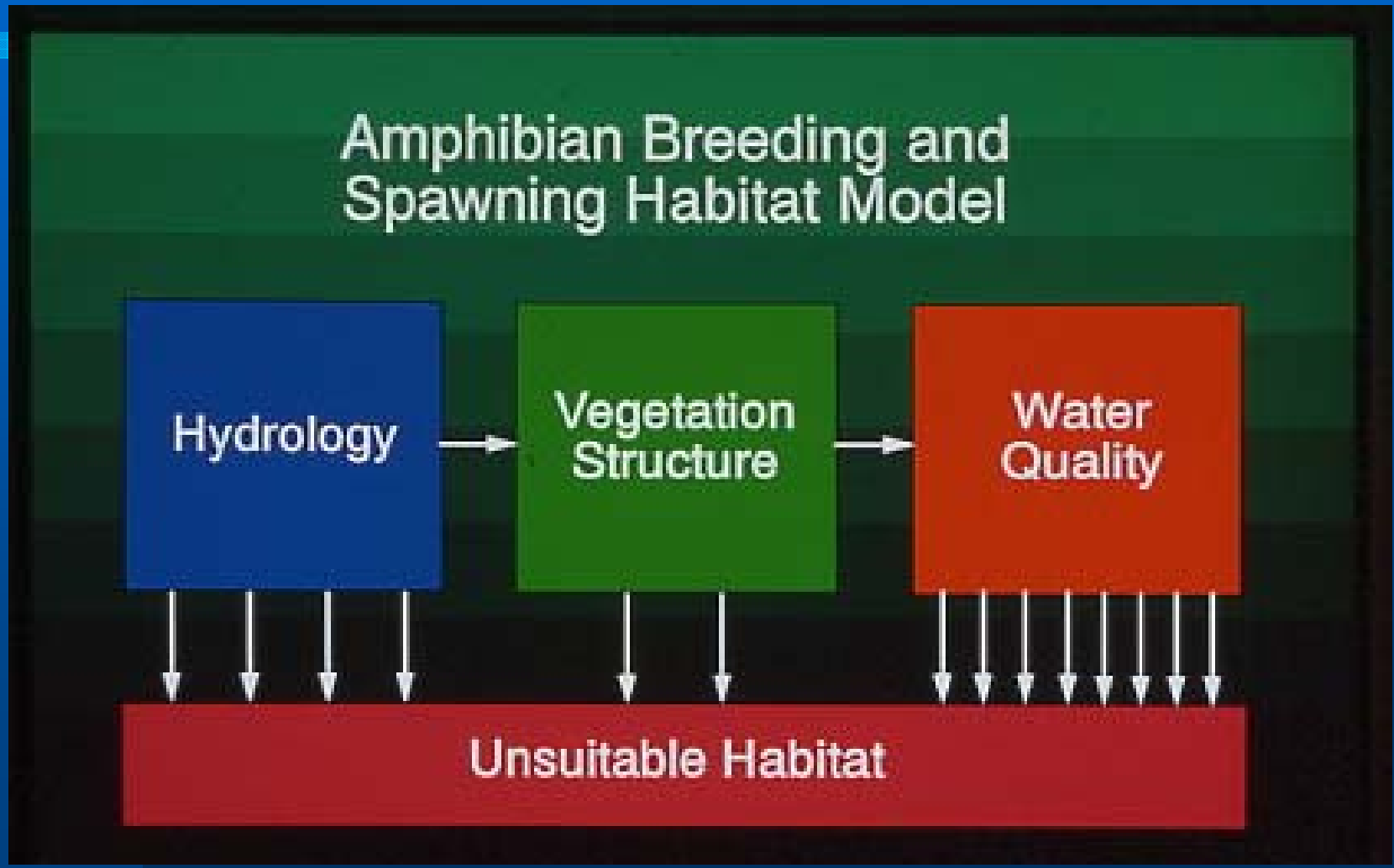

The Richness of Amphibians is
Unrelated to the Number of Vegetation Classes
No. Amphibian Species
0
1
2
3
4
5
6
7
8
9
.5
1
2
3
4
5
No. of NWI Vegetation Classes

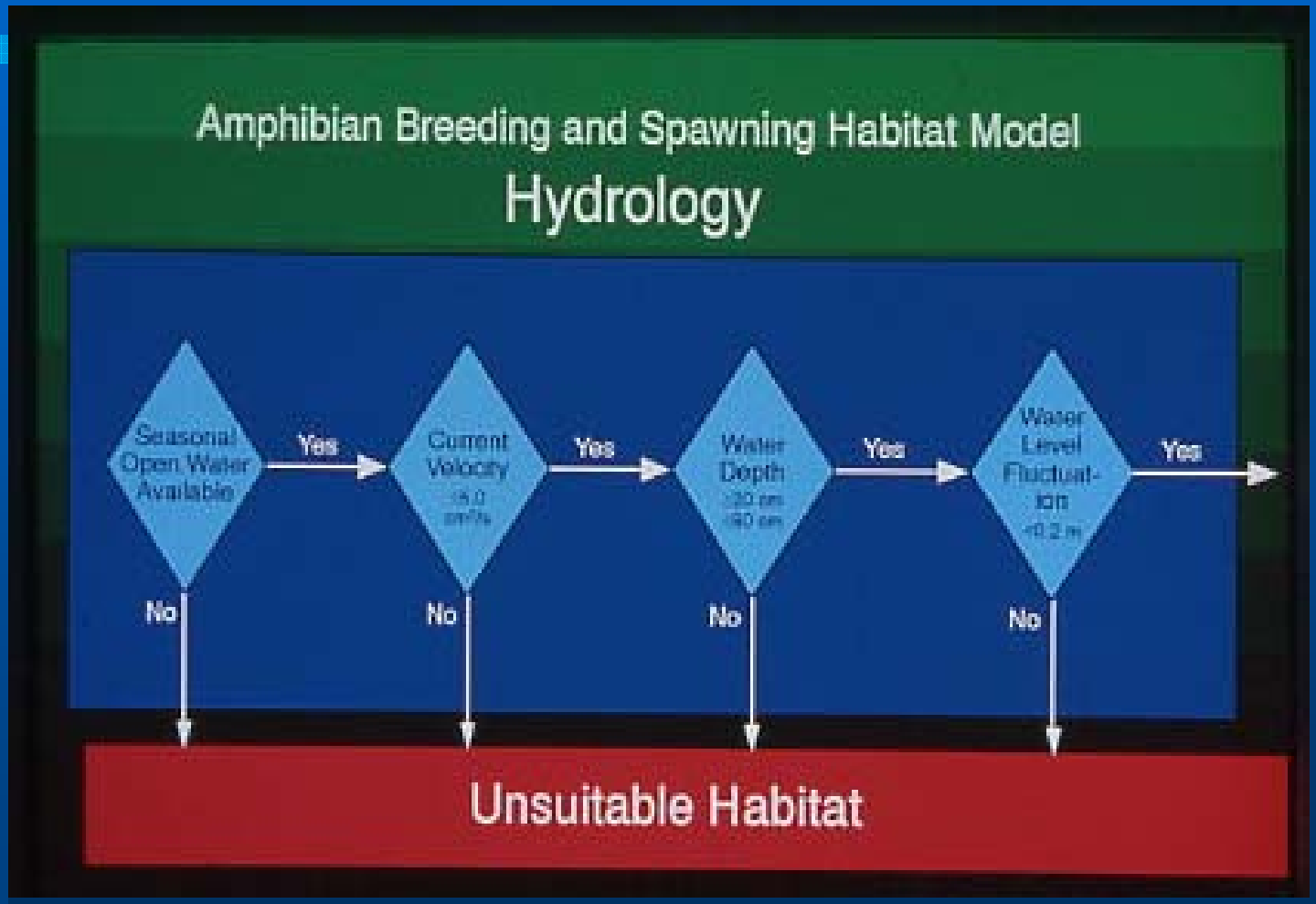

Amphibian Richness is Lower When
Water Level Fluctuation is > 0.2 meters.
No. Amphibian Species
0
1
2
3
4
5
6
7
8
9
0
.1
.2
.3
.4
.5
.6
.7
Mean Water Level Fluctuation (m)

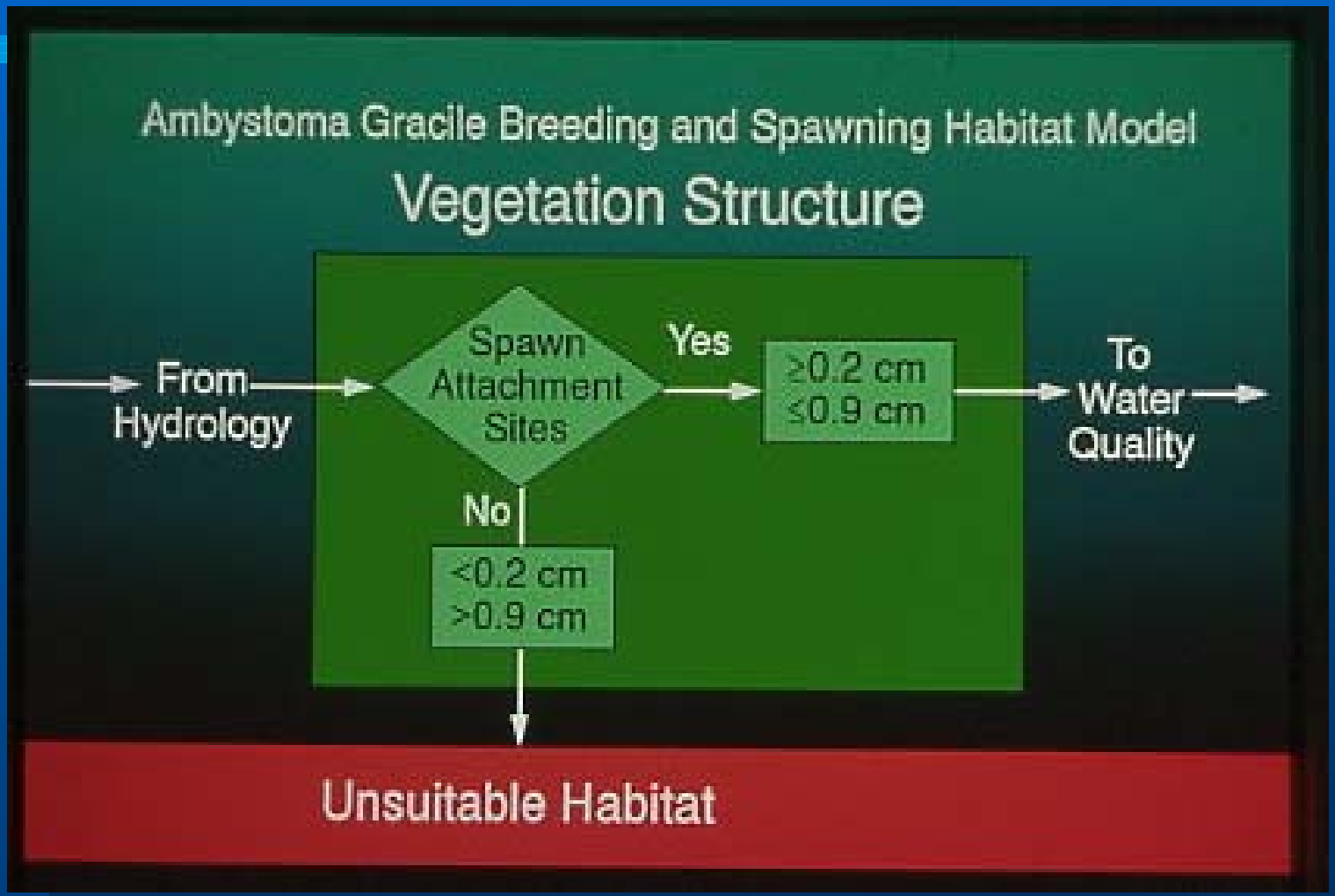

Fewer Amphibian Species in Wetlands
Within Highly Urbanized Watersheds
N = 5.559-0.033 (% Urbanization)
r² = 0.394, p = 0.004
Number Amphibian Species (N)
0
1
2
3
4
5
6
7
8
9
0
10
20
30
40
50
60
70
80
90
100
Percent of Watershed Urbanized


Watersheds With Greater than 10% Impervious Area Have Fewer Species
No. Amphibian Species
0
1
2
3
4
5
6
7
8
9
0
5
10
15
20
25
30
35
40
45
50
Impervious Area (% of Watershed)

Developed an Oviposition Hypothesis for Northwestern Salamander as a Hierarchical Model


Amphibian Breeding and Spawning Habitat Model
Hydrology
Vegetation Structure
Water Quality
Unsuitable Habitat


Amphibian Breeding and Spawning Habitat Model
Hydrology
Seasonal Open Water Available
Yes
Current Velocity
Yes
Water Depth
Yes
Water Level Fluctuat-ion
Yes
No
No
No
No
Unsuitable Habitat


Ambystoma Gracile Breeding and Spawning Habitat Model
Vegetation Structure
From Hydrology
Spawn Attachment Sites
Yes
≥0.2 cm
≤0.9 cm
To Water Quality
No
<0.2 cm
>0.9 cm
Unsuitable Habitat


Ambystoma Gracile Breeding and Spawning Habitat Model
Water Quality
Suspended Sediment
No
Nutrients
No
Acidity
No
Metals
No
Pesticides
No
No
Other
Conductivity
No
Turbidity
Petroleum Hydrocarbons
No
No
Yes
Unsuitable Habitat

Experimental Approach

Instillation of Surrogate Plants

Measuring Water Level Fluctuation with the Richter “3000”

Measuring Depth to Egg Masses

Results

Aspect as a Determinant of Spawning in *Ambystoma gracile* : North - South Transition

Aspect	Total Number of Dowels	Number of Spawn	Percent of Total Spawn	Mean Spawn per 100 Dowels
North	120	45	98	37
South	84	1	2	1
Total	204	46	100	

Results:

- 98 % of Total Spawn along North Shore
- 2 % of Total Spawn Along South Shore

- 37 Spawn per 100 Dowels Along West Shore
- 1 Spawn per 100 Dowels Along East Shore

Aspect as Determinant of Spawning in *Ambystoma gracile* : East - West Transition

Aspect	Total Number of Dowels	Number of Spawn	Percent of Total Spawn	Mean Spawn per 100 Dowels
East	60	13	29	22
West	60	32	71	53
Total	120	45	100	

* Total Dowels Deletes Southern Exposure Replicates.

Results:

- 71 % of Total Spawn along West Shore
- 29 % of Total Spawn Along East Shore

- 53 Spawn per 100 Dowels Along West Shore
- 22 Spawn per 100 Dowels Along East Shore

Water Depth as a Determinant of *Ambystoma gracile* Spawning

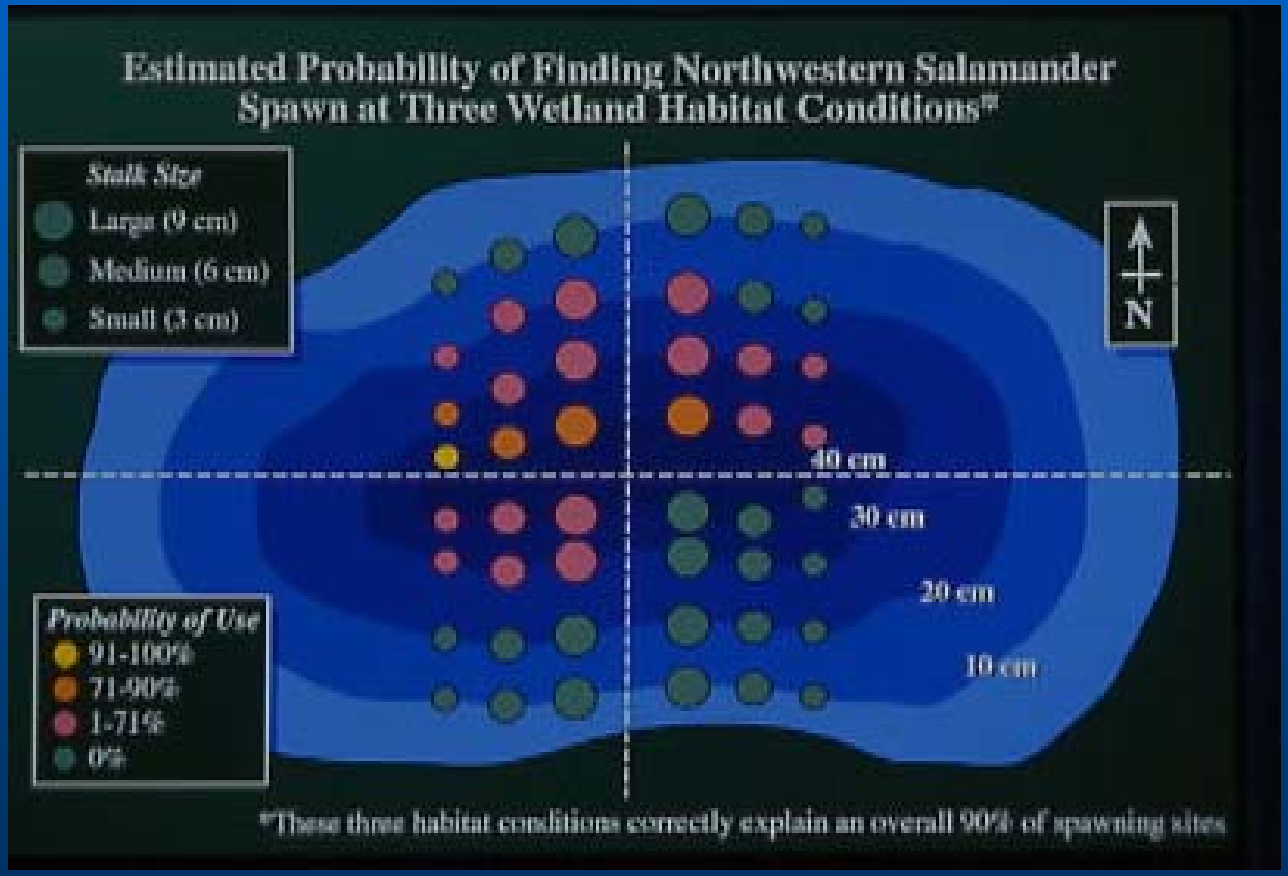
Depth Category (cm)	Total Number of Dowels	Number of Spawn	Percent of Total Spawn	Mean Spawn per 100 Dowels at Depth
10	30	0	0	0
20	30	1	2	3
30	30	13	29	43
40	30	31	69	103
Total	120	45	100	

- Total Dowels = 3 Dowels/Replicate, 10 Replicates on North Shore Only. Deleted 1 clutch on LPS9 South Shore.

Dowel Diameter as a Determinant of *Ambystoma gracile* Spawning

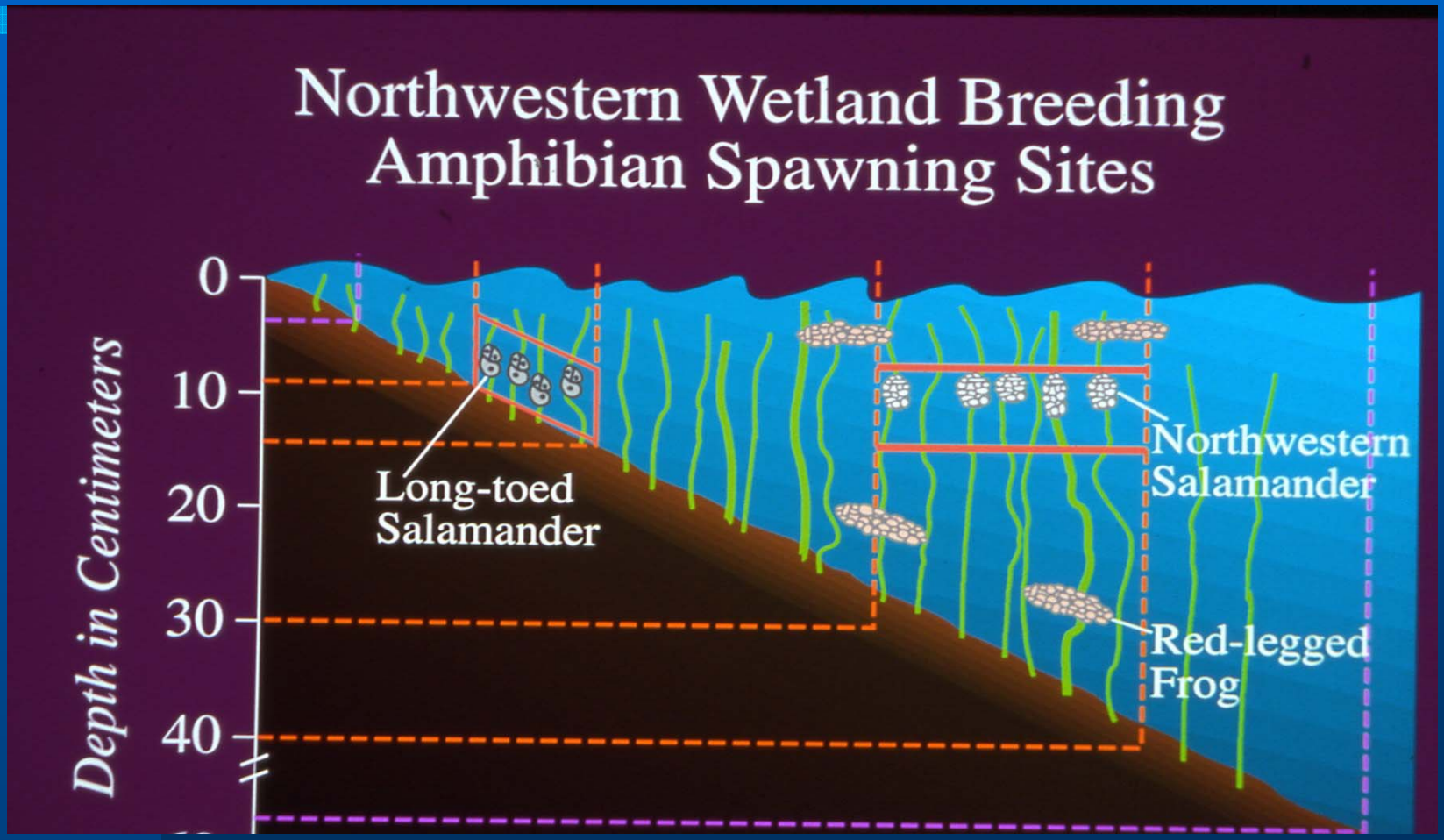
Dowel Diameter (mm)	Total Number of Dowels	Number of Spawn	Percent of Total Spawn	Mean Spawn per 100 Dowels at Diameter Class
3	40	30	67	75
6	40	11	24	27
9	40	4	9	10
Total	120	45	100	

Logistic Regression Results



Desiccating Egg Masses as Storm Water Levels Drop

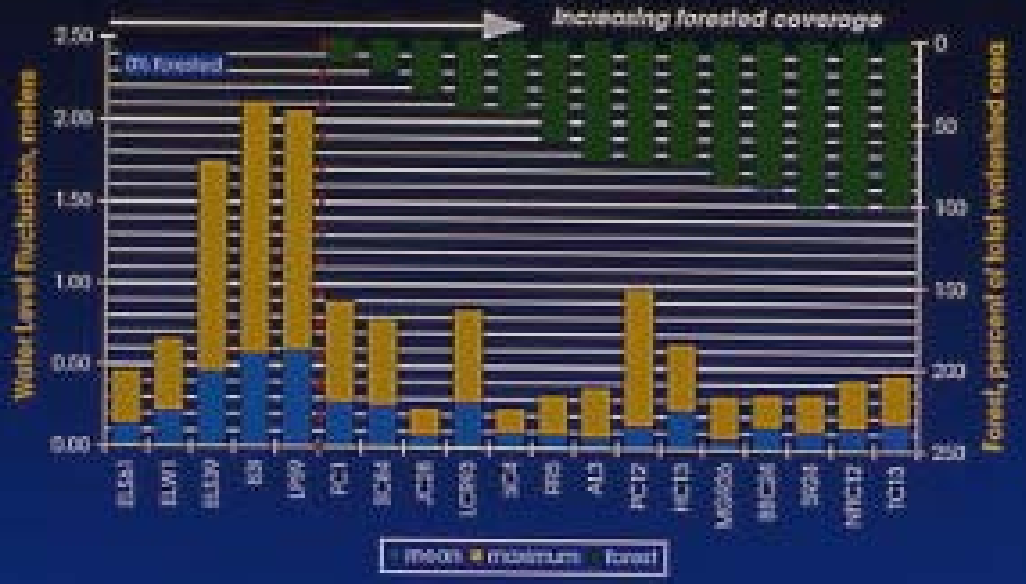
Frozen Egg Mass

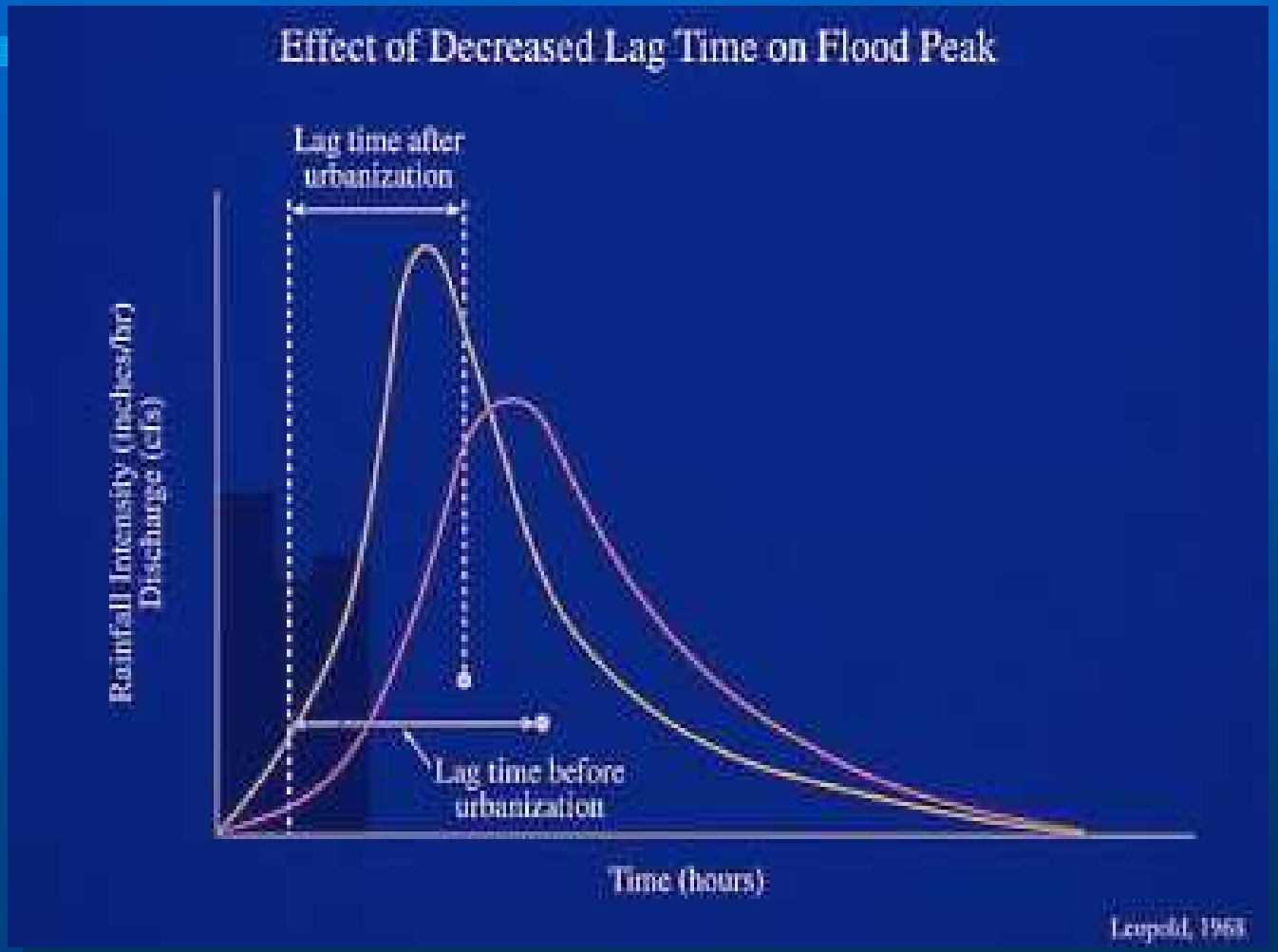

Northwestern Wetland Breeding
Amphibian Spawning Sites
Depth in Centimeters
0
10
20
30
40
Long-toed
Salamander
Northwestern
Salamander
Red-legged
Frog

Northern Red Legged Frog Eggs at Northwest Quadrant Stranded at Identical Water Depths & Retreating Shoreline

Probable Hydrologic Mechanism for Amphibian Declines in Urbanizing Areas

Significance of Watershed Forests




Effect of Decreased Lag Time on Flood Peak
Lag time after urbanization
Rainfall Intensity (inches/hr)
Discharge (cfs)
Lag time before urbanization
Time (hours)
Leopold, 1968

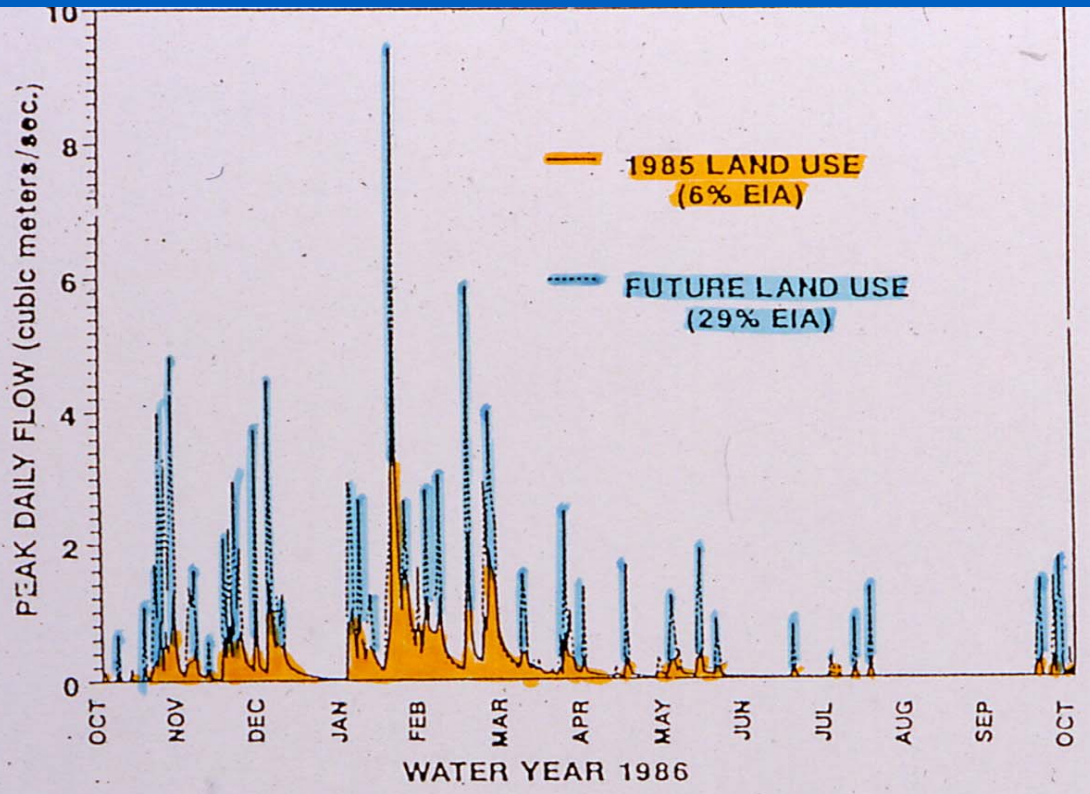
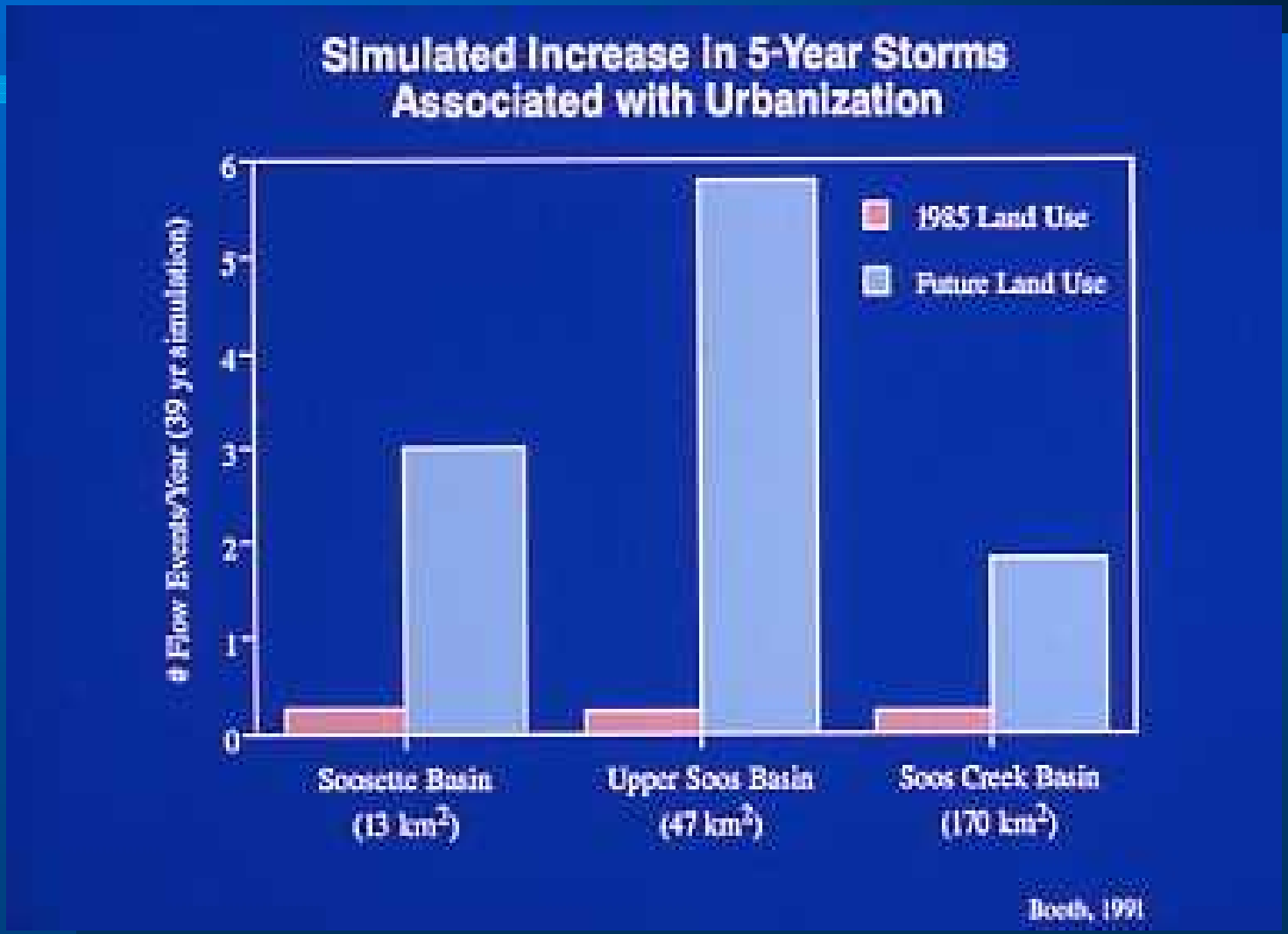
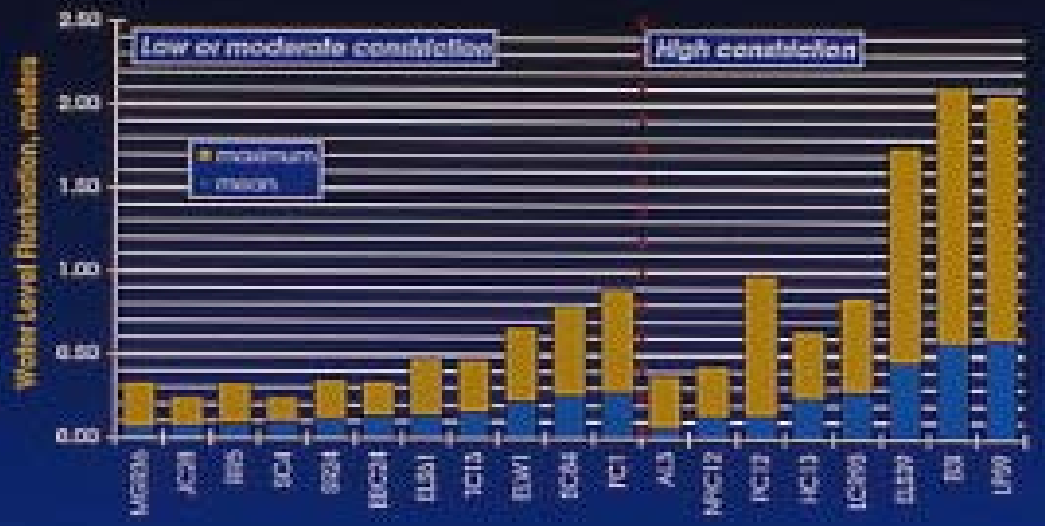


Fig. 1. One year of simulated streamflow for a 13-km² drainage basin under differing land uses, simulated with the Hydrologic Simulation Program Fortran (HSPF). Parameters characterize existing (1985) land cover (6 percent effective impervious area [EIA]) and projected future land cover (29 percent EIA).


Simulated Increase in 5-Year Storms
Associated with Urbanization
Flow Events/Year (39 yr simulation)
0
1
2
3
4
5
6
1985 Land Use
Future Land Use
Soosette Basin
(13 km²)
Upper Soos Basin
(47 km²)
Soos Creek Basin
(170 km²)
Booth, 1991

Cause-and-Effect Relationship between Watershed Urbanization and Decreasing Amphibian Richness in King County Wetlands

Significance of Wetland Outlet Configuration



Significance of Watershed Area Relative to Wetland Area