Terrestrial Riparian Vegetation Monitoring

with links to other ecosystem components

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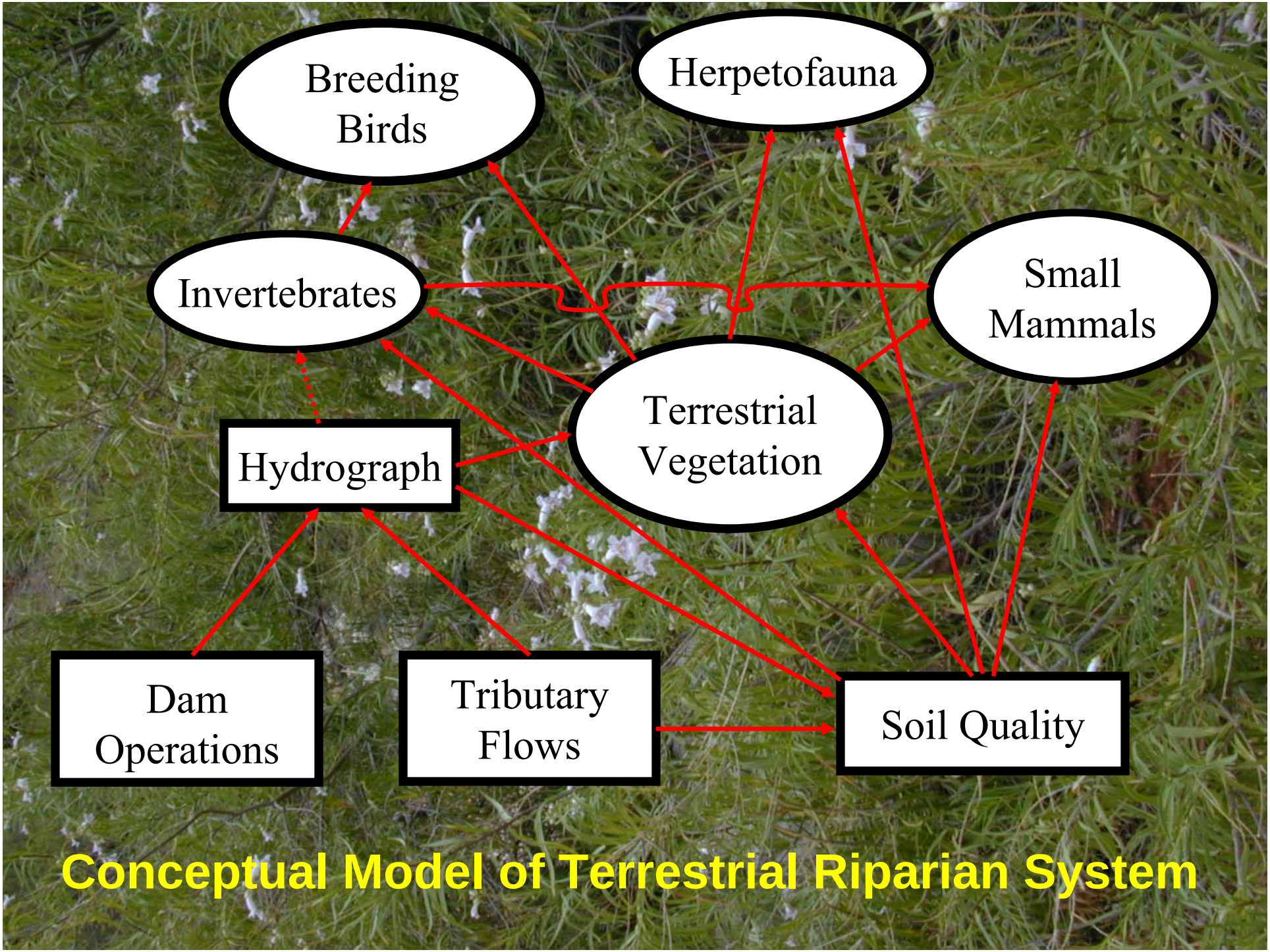


Conceptual Model of Terrestrial Riparian System

Two Types of Data Collected

- "Habitat" Data
  - Integrated Monitoring Sites
  - Bird Survey Sites
- Vegetation Dynamics Data
  - STARS / GUI Model Cross-Sections
  - Transects

Sampling Guidelines

- Use probabilistic sample site selection
  - Minimize effects of “expert” judgement
- Maximize number of sites visited
  - Increase statistical power
- Reduce site impacts
  - Limit frequency of visits to same sites
- Tied to stressors (physical processes)
  - Flows, geomorphology, substrate

Site Selection for “Habitat” Measures

- GIS-based vegetation map
- “Patches” from historical avifauna surveys
  - ~ 110 sites from Carothers, Brown, Sogge, Spence, and others
  - Stratified sample within geomorphic reaches
  - Logistic constraints

Partially Augmented Rotating Panel Sampling Design

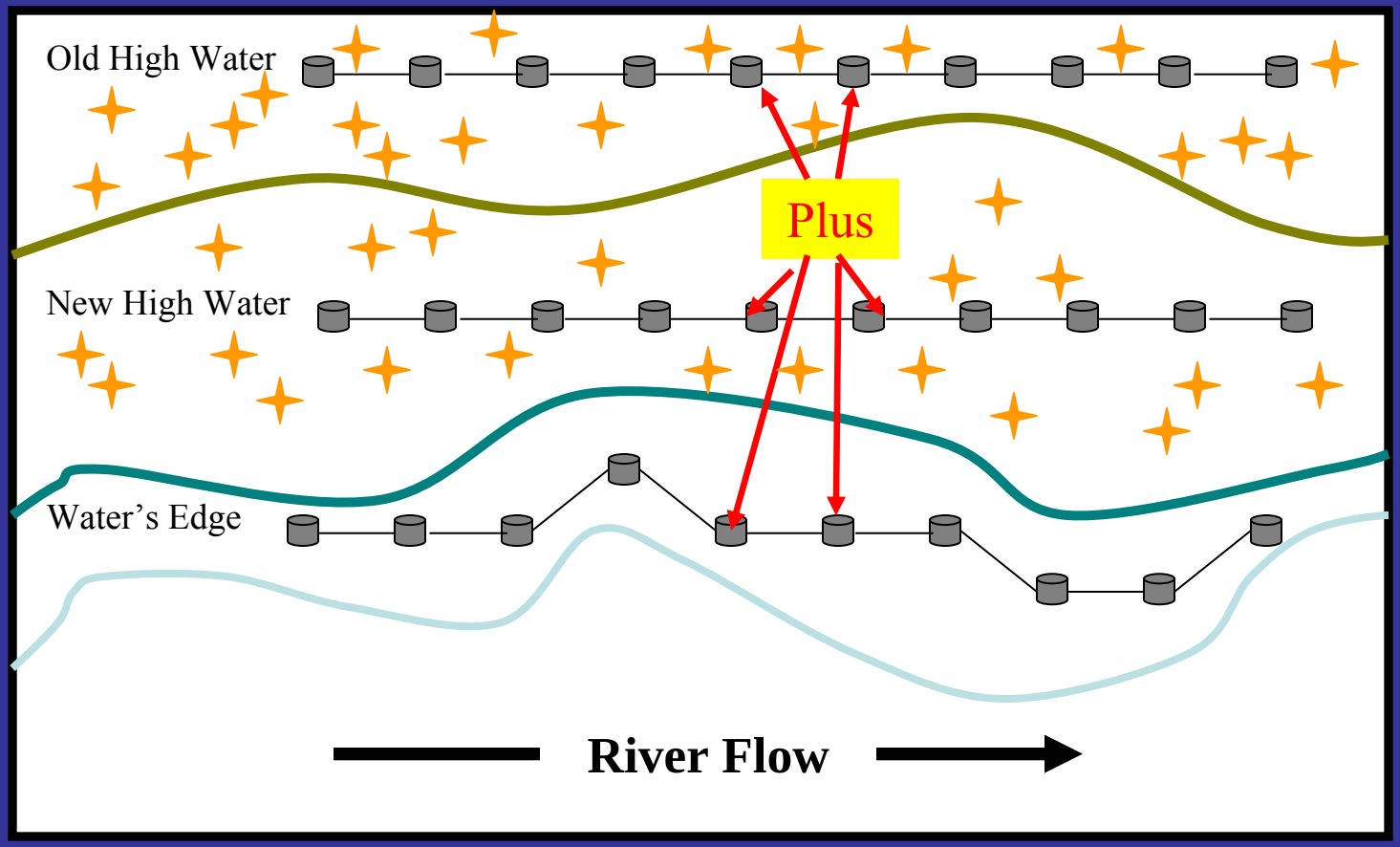
Urquhart et al. (1998) Ecological Applications 8: 246 - 257

	1	2	3	4	5	6	7	8	…	Total
Year 1		X	X		X			X	…	14
Year 2		X				X	X	X	…	14
Year 3	X	X		X				X	…	14
Year 4		X	X		X			X	…	14
Year 5		X				X	X	X	…	14
Year 6	X	X		X				X	…	14

Physical Stressors

- Hydrograph
  - Shoreline
    - Top of fluctuations + 1 meter
  - New High Water Zone
    - Shoreline to Old High Water Zone
  - Old High Water Zone
    - Above ~ 90,000 cfs
- Precipitation Index
  - WRCC database
  - 12 regional sites

Vegetation Structure and Composition Surveys

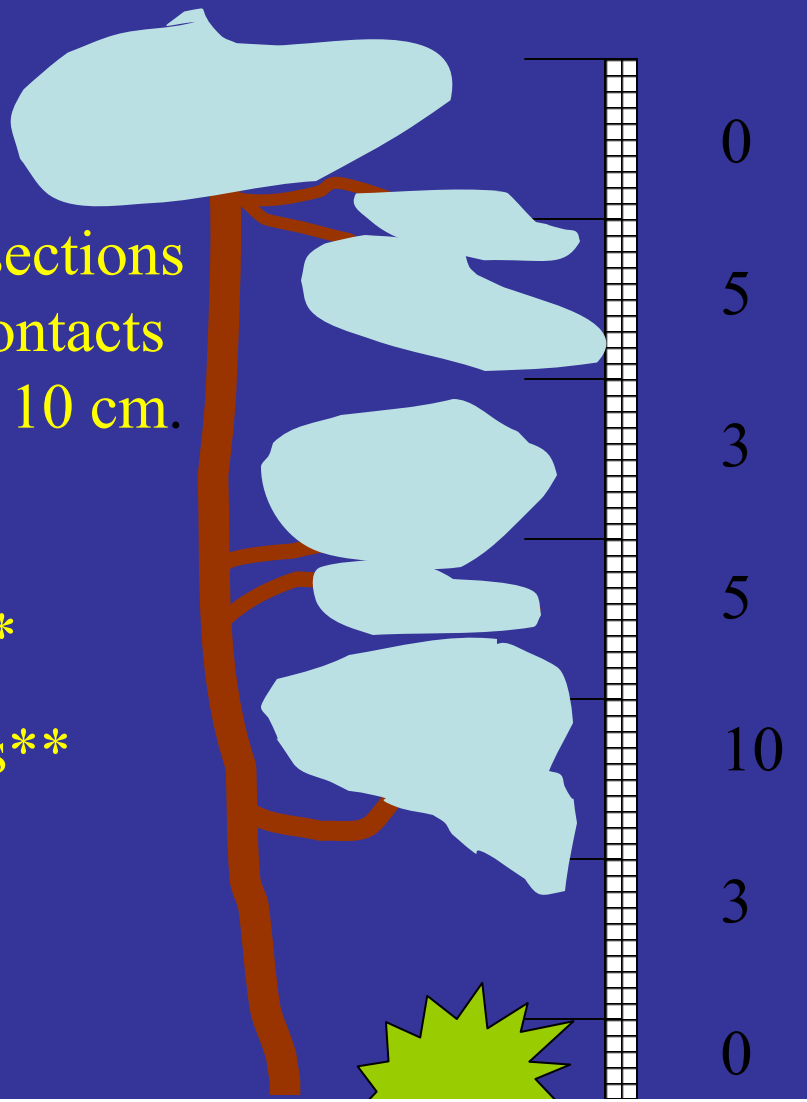


Total Vegetation Volume

The number of 10cm sections of a survey rod with contacts or live material within 10 cm.

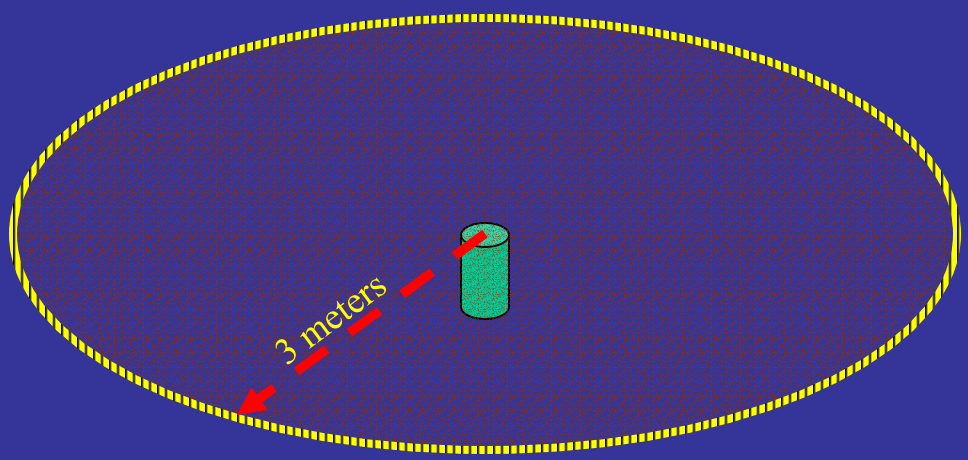
Only live material

Only woody species



TVV = 26

Vegetation species composition at pitfall traps



1. Record All Species
2. Cover Class Estimates for All Species

   1 = < 1%

   2 = 1- 5 %

   3 = 5 – 25%

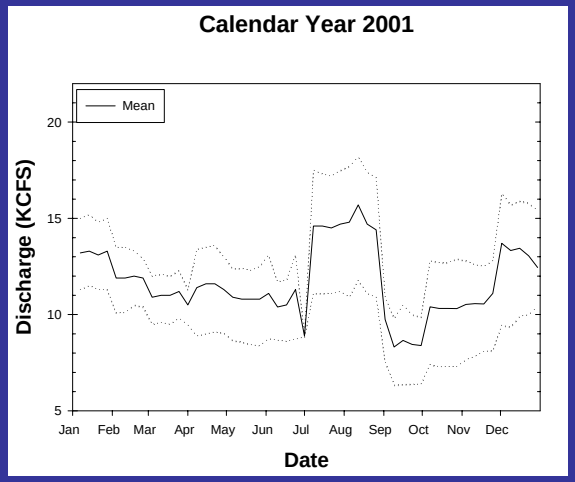
   4 = 25 – 75%

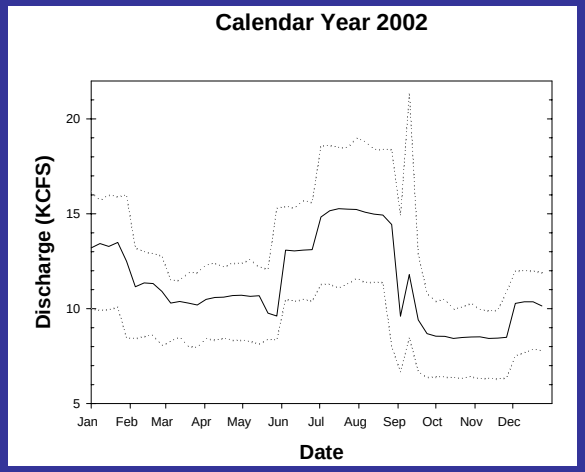
   5 = 75 – 100%

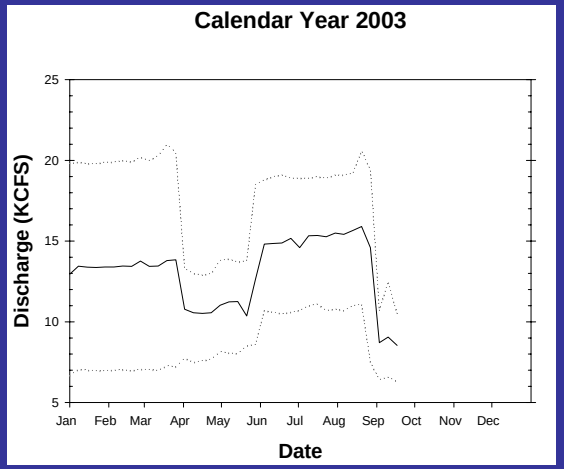
Factors Affecting Vegetation

- **Zone** (Shoreline, New High Water, Old High Water)
- **Canyon Width** (Wide or. Narrow; Schmidt and Graf)
- **Site** (Includes all soil, slope, aspect, rim height, etc.)
- **Year**
  - Hydrograph (Max, min, mean, top of fluctuations)
  - Precipitation (Relative to long term averages)

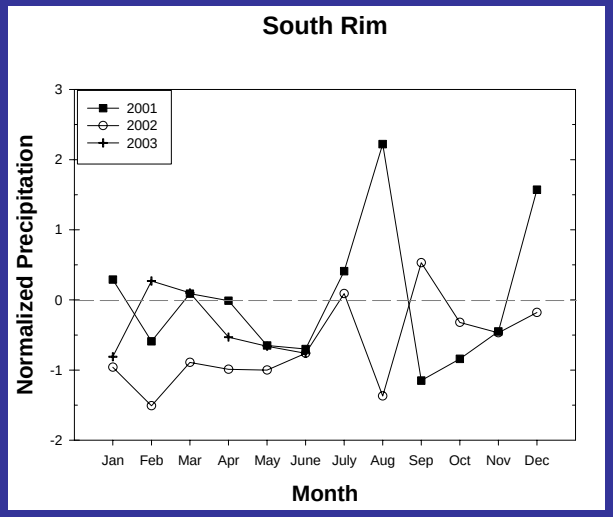
Grand Canyon Gage
2001 - 2003

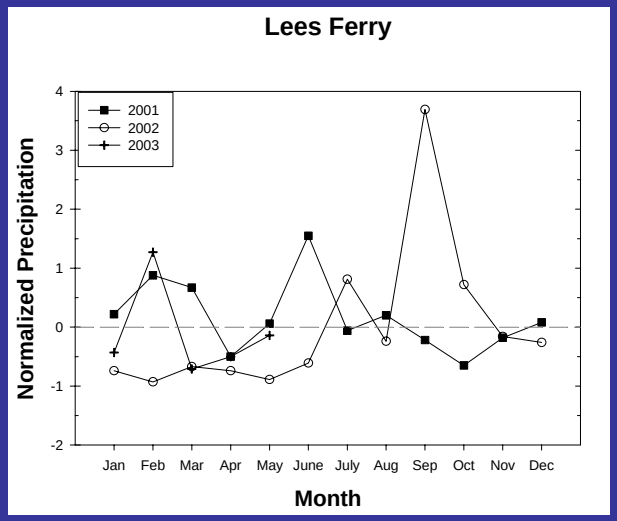


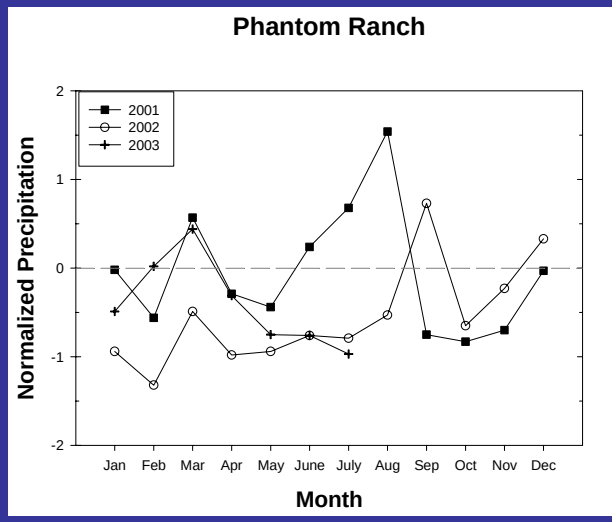




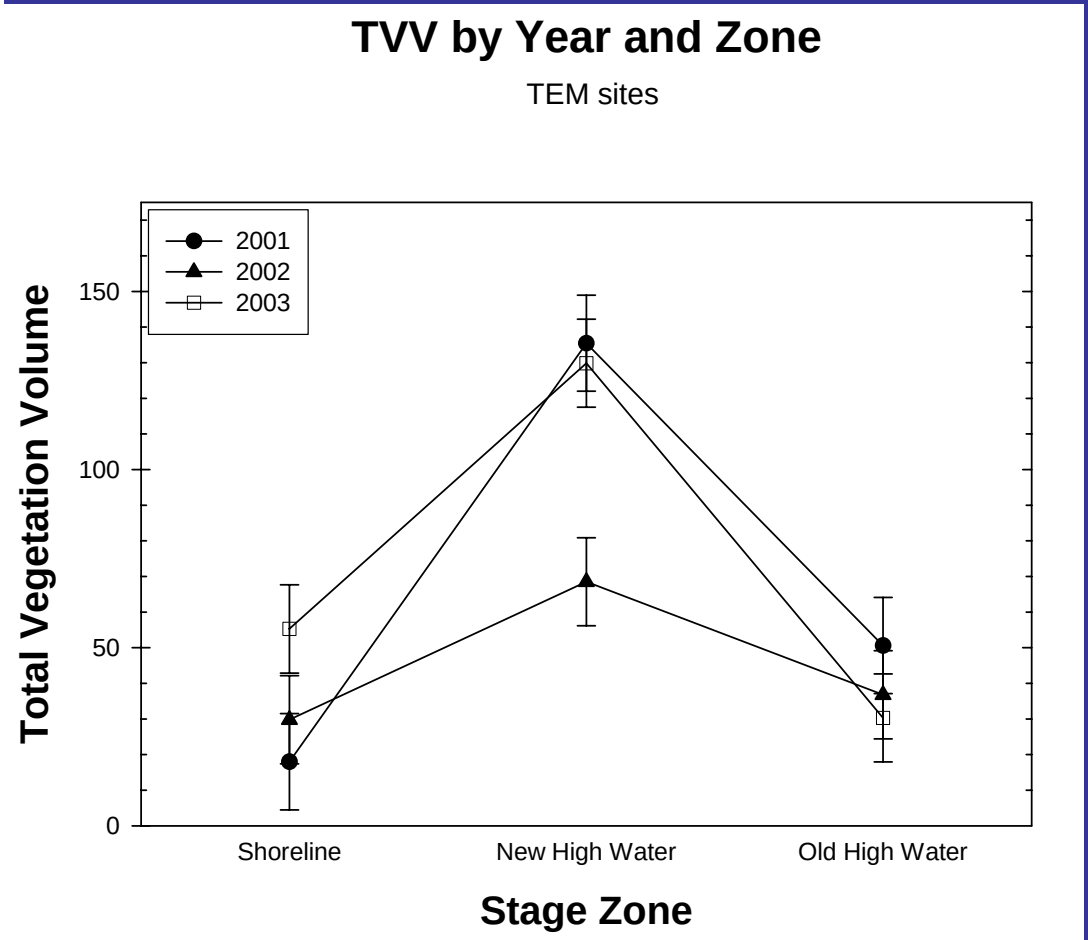
Precipitation Gages







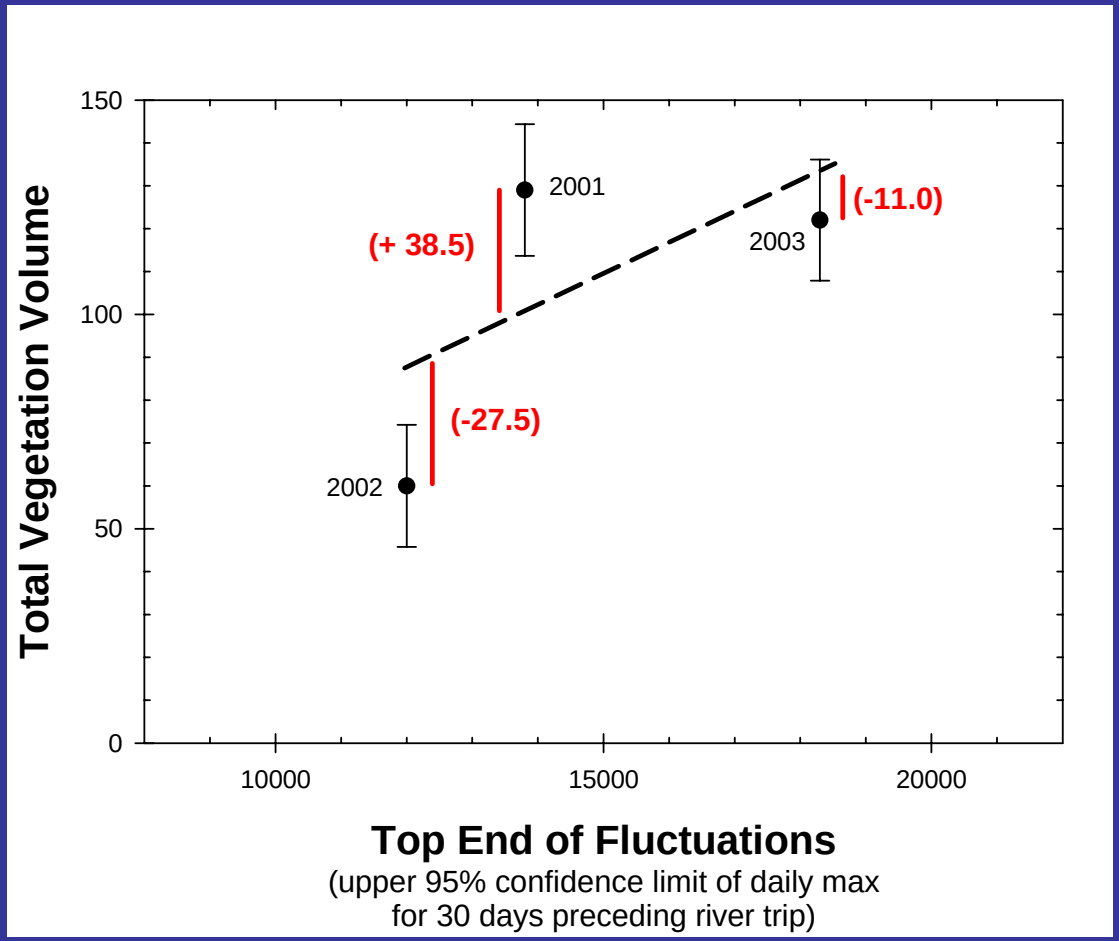
Vegetation Volume Changes



- 2001 = highest
- 2002 = lowest
- 2003 = recovery

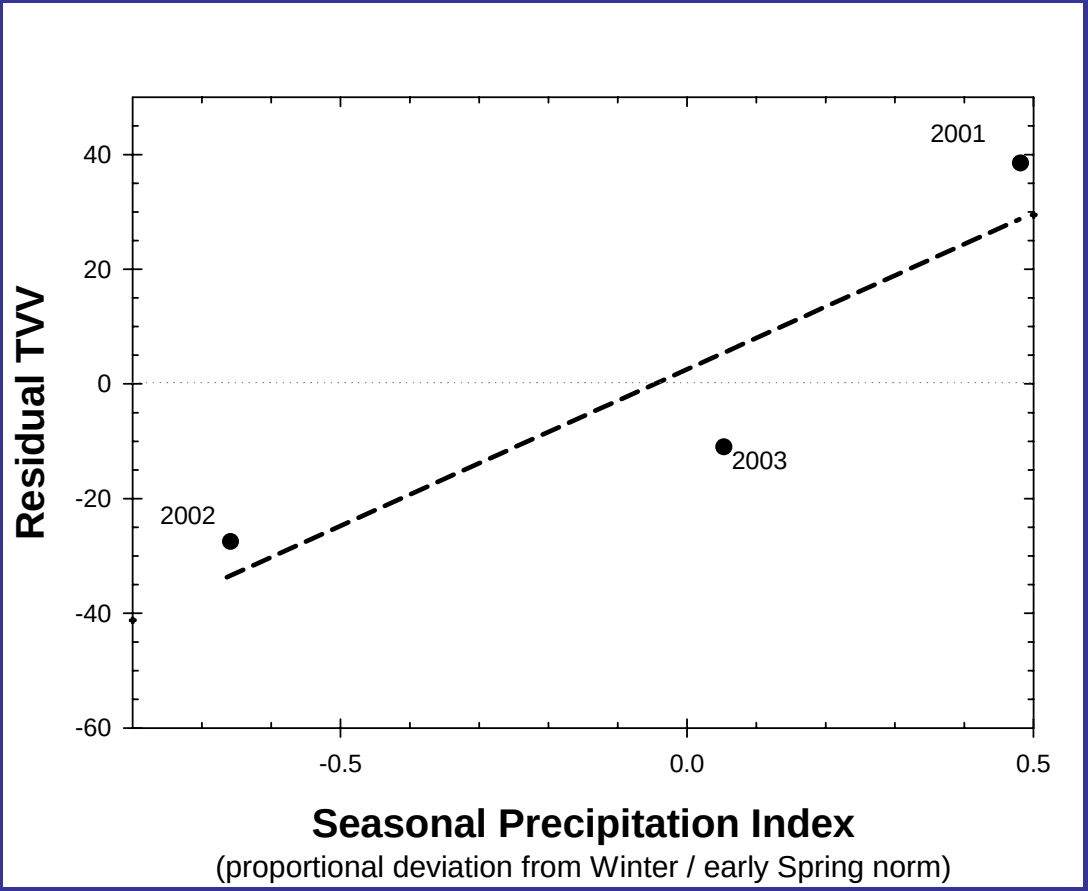
BUT: shoreline and old high water transects behave a little differently than new high water transects

New High Water Zone



- Most vegetation variation by years relates to flow fluctuations
- Unexplained shown in red

New High Water Zone



- Precipitation (relative to long-term averages) explains most of the rest of the between-year differences

WHOA! Big Deal!

- Getting water to plants in the desert makes them grow more? WOW!

- This is the first case where year-to-year changes in vegetation abundance has been demonstrated to be linked to Glen Canyon Dam operations (and that *is* a big deal).

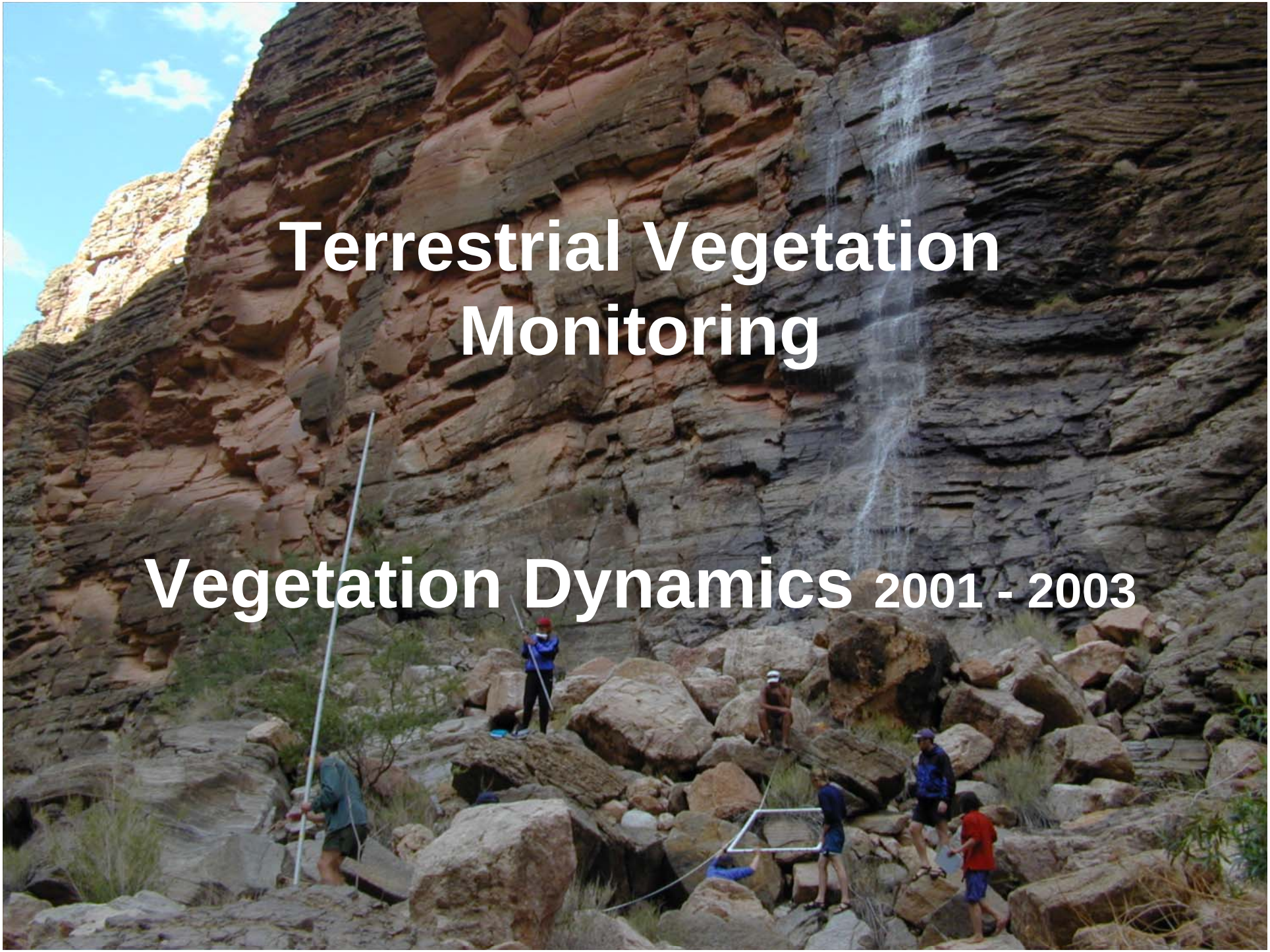
Shoreline and Old High Water Zone

- No statistical difference among years in either zone.
- **BUT:** two-year declines in OHW relate to two years of low winter / spring precipitation.
- **AND:** Two-year increases in Shoreline may be related to increasing top-end of daily fluctuations before spring trips.

Other Vegetation Data

- **Bird Patches**: Show same patterns, though less dramatically

- **Transect composition**: Strong differences between 2002 and 2001 / 2003 (herbs and annuals, mostly)



Terrestrial Vegetation Monitoring

Vegetation Dynamics 2001 - 2003

Vegetation Dynamics

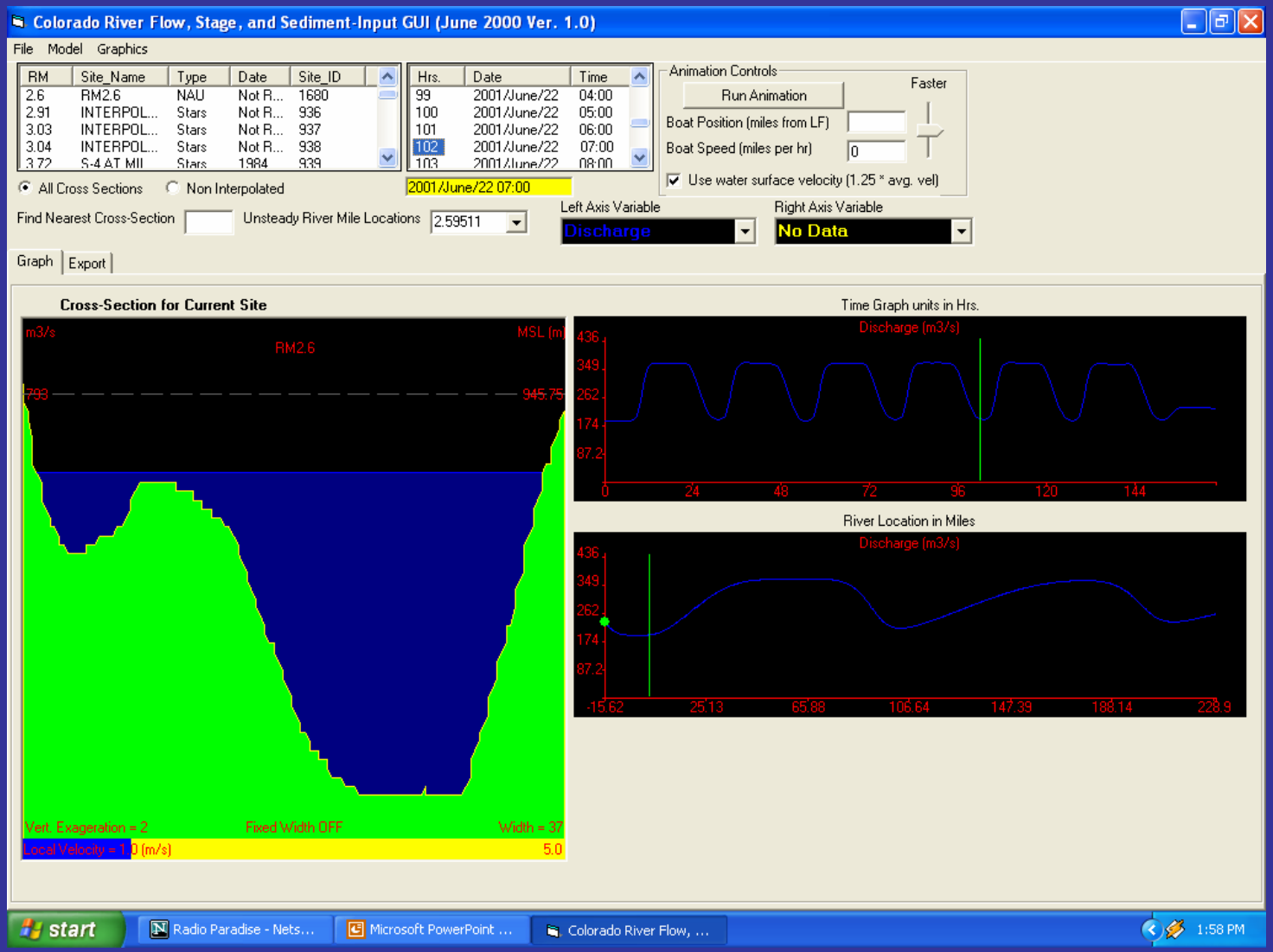
- New High Water Zone only
  - 15 kcfs to 60 kcfs
- Focus on species composition
  - Individual species and functional groups
- Tied to hydrograph
  - Models of elevation vs. discharge

Sampling Guidelines

- Use probabilistic sample site selection
  - Minimize effects of “expert” judgement
- Maximize number of sites visited
  - Increase statistical power
- Reduce site impacts
  - Limit frequency of visits to same sites
- Tied to stressors (physical processes)
  - Flows, geomorphology, substrate

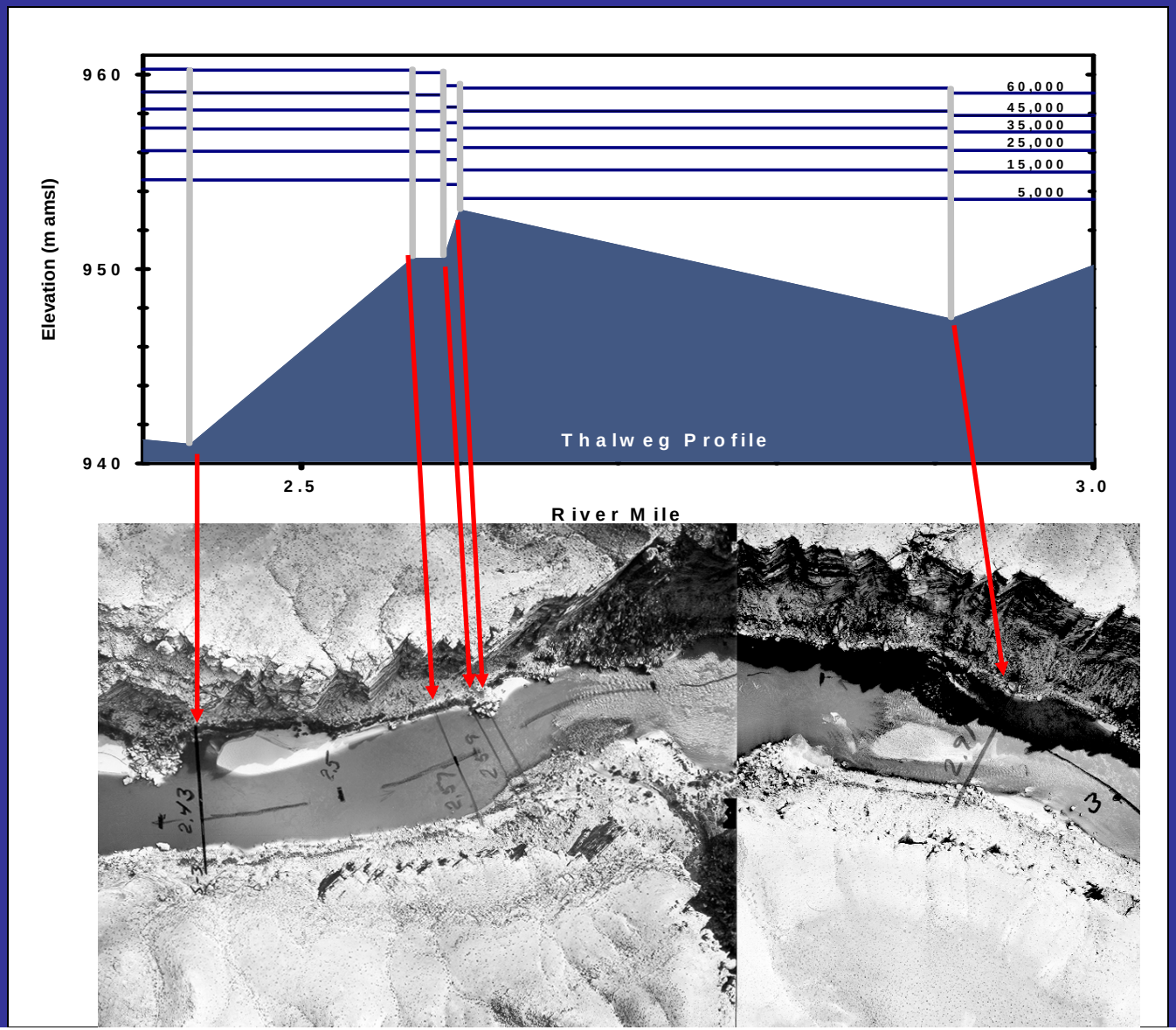
CRFSSGUI Model

(Walters and Korman)



STARS Model

(Randle and Pemberton)



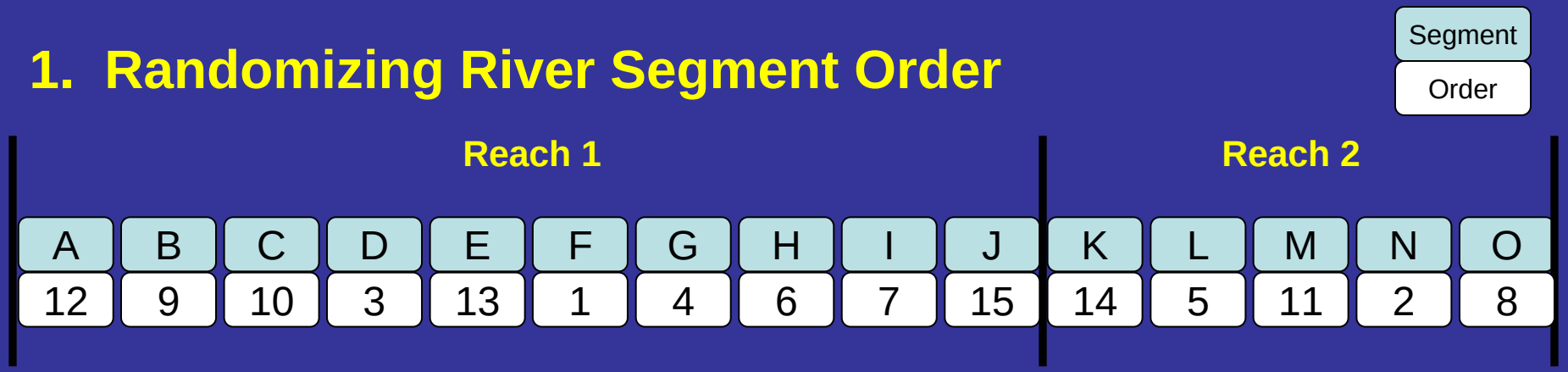
Sample Site Selection

- Stratifed by geomorphic reach
- Randomly selected “segments”
- Random point within segment
- Random side at sample point

- Exclusions:
  - cliffs, administrative, and safety reasons

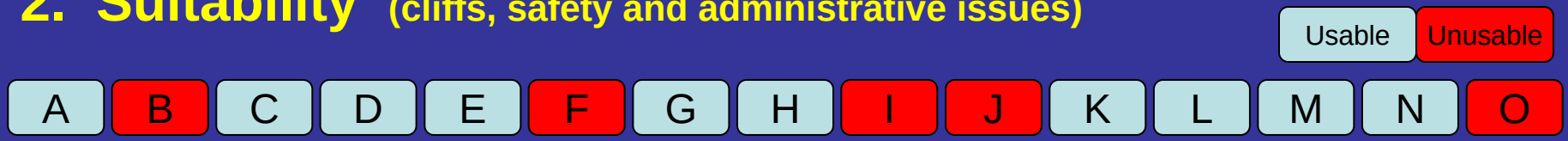
Spatially explicit random samples: A small example

1. Randomizing River Segment Order



Spatially explicit random samples: A small example

2. Suitability (cliffs, safety and administrative issues)



Spatially explicit random samples: A small example

Repeat Panel	D	N
Rotate Panel 1	G	L
Rotate Panel 2	H	C
Rotate Panel 3	A	M

Year 1:	D	G	L	N
Year 2:	C	D	H	N
Year 3:	A	D	M	N

140 Sites, 60 at a time

Augmented Serially Alternating Panel Design							
	Time Period (Years)						
Panel	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Repeat (20)	X	X	X	X	X	X	X
Rotate 1 (40)	X			X			X
Rotate 2 (40)		X			X		
Rotate 3 (40)			X			X	
Total	60	60	60	60	60	60	60

Increases total number of sites (statistical power)

Decreases site impacts of surveys

Vegetation Dynamics Sites

62 Sites per year

Sampling points at:

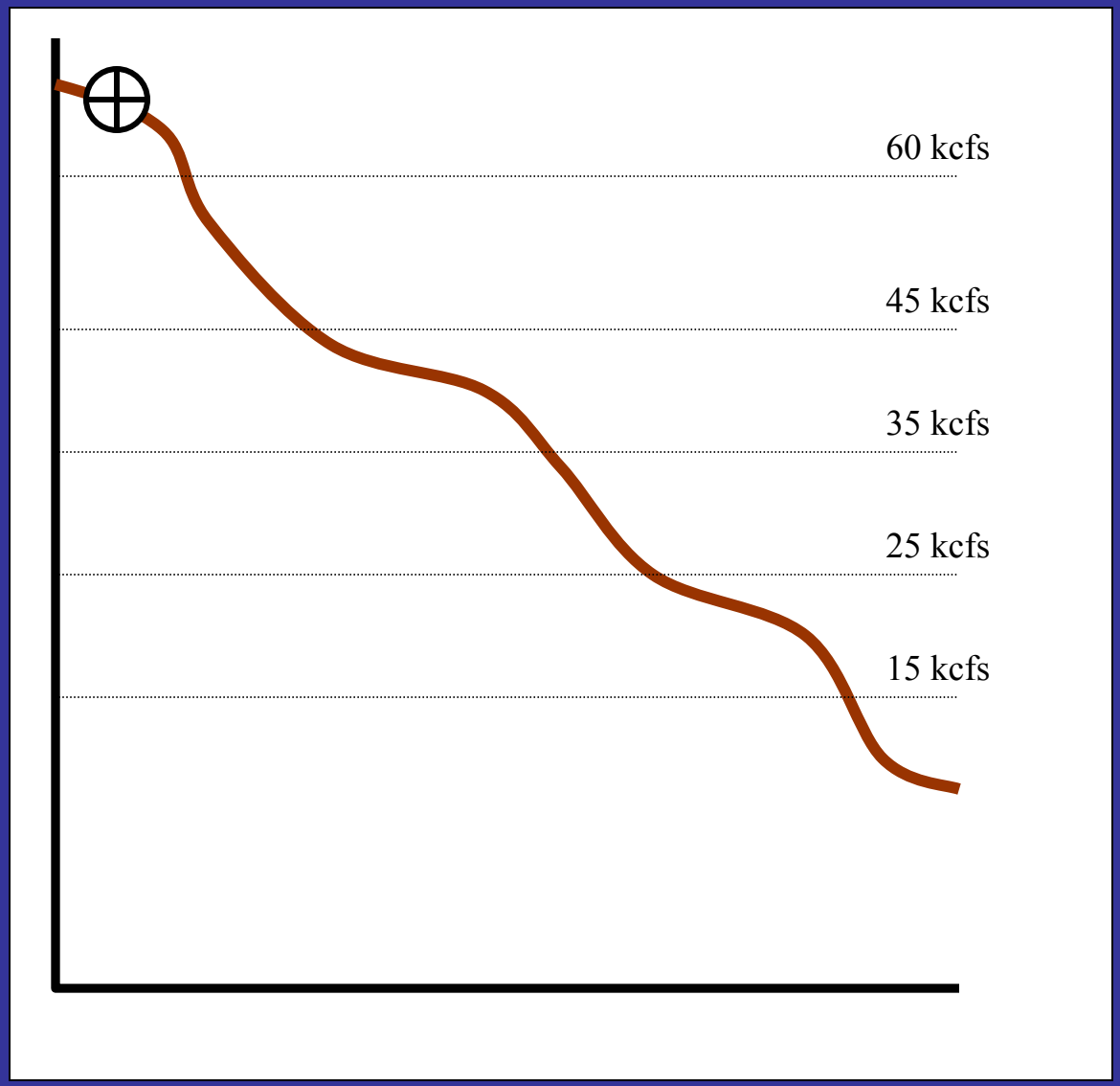
60 kcfs

45 kcfs

35 kcfs

25 kcfs

15kcfs



Vegetation Dynamics Sampling

4 1m plots / zone

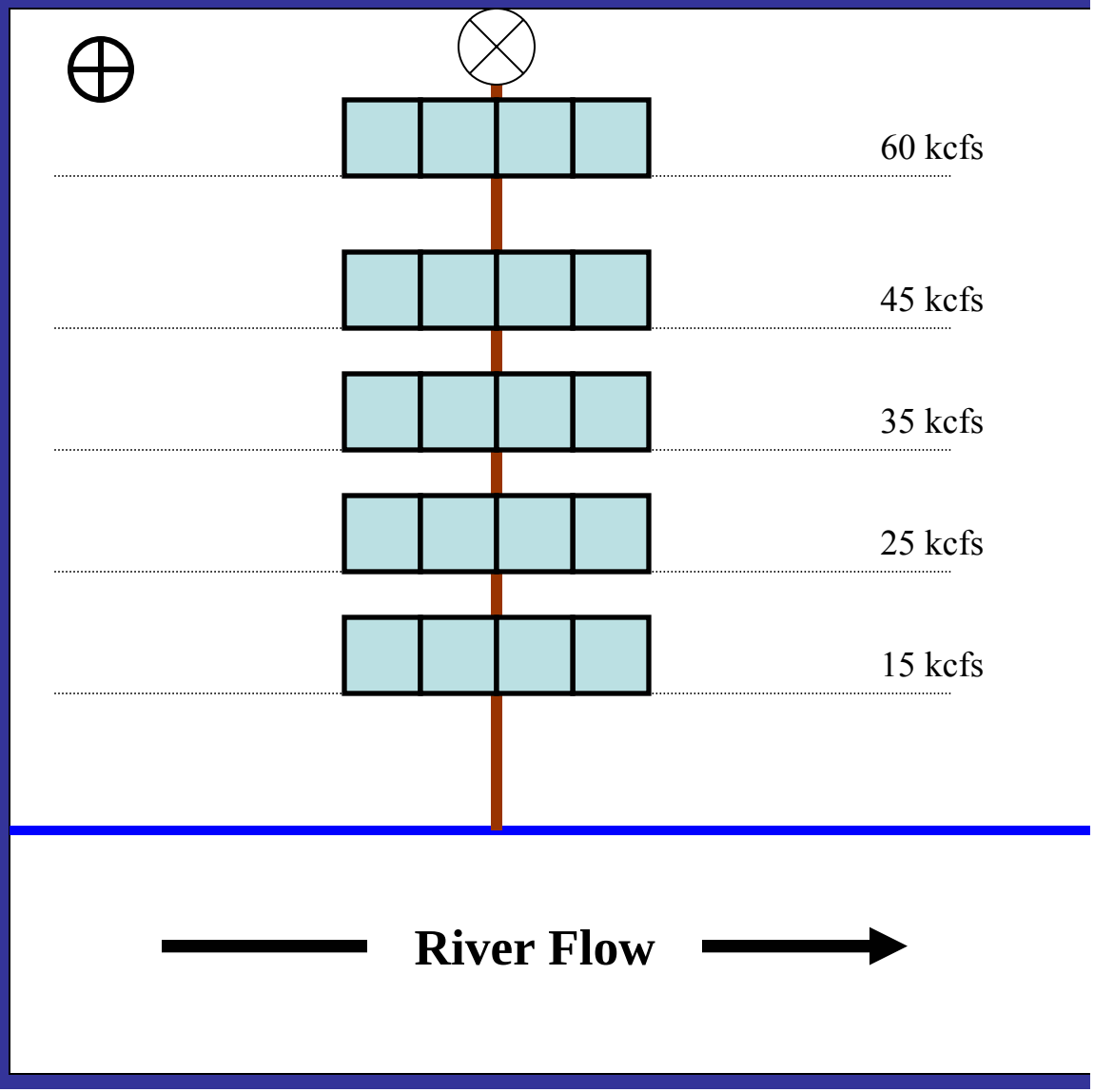
Data recorded:

Species present
Cover by species

Soil texture

Calculate:

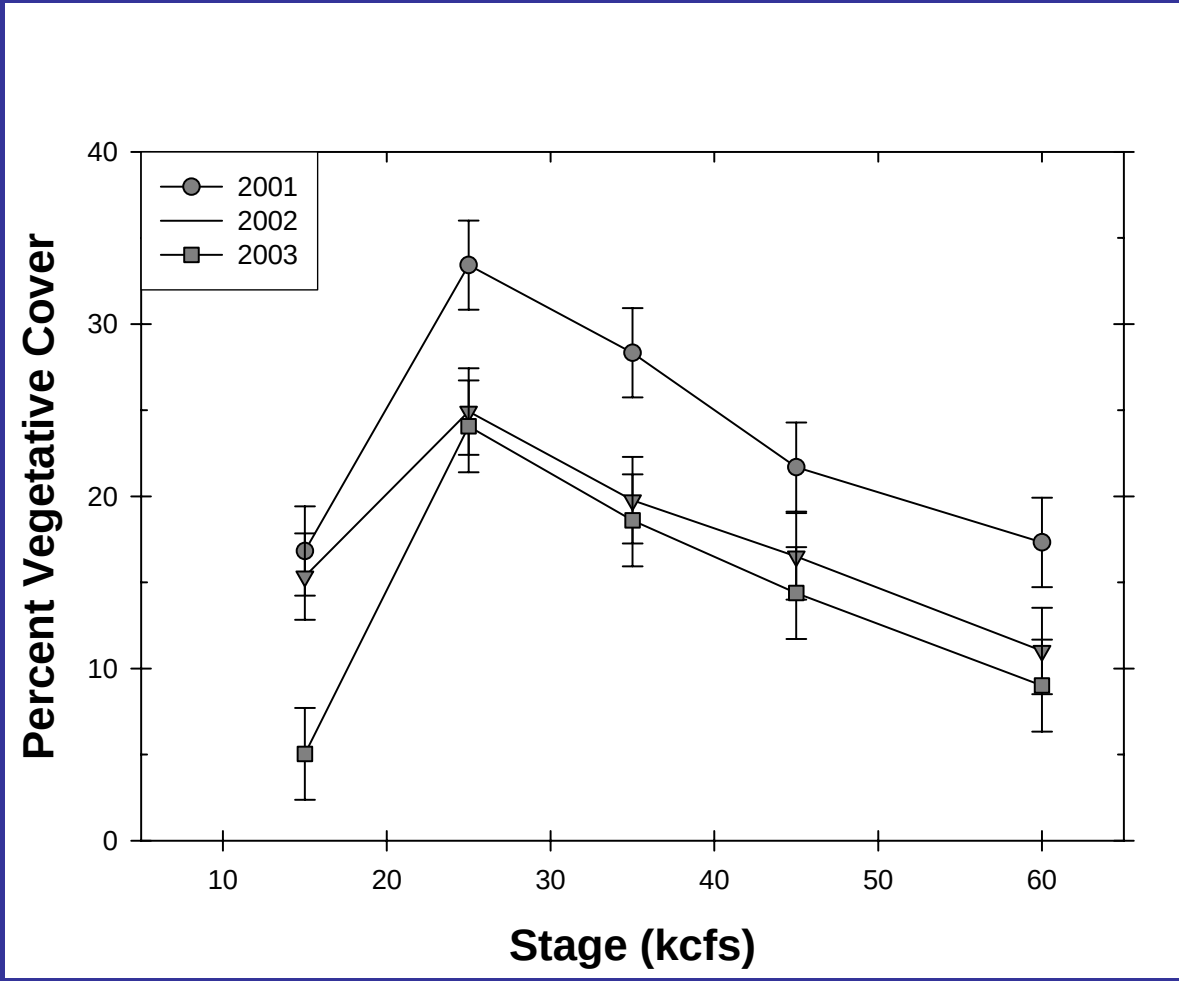
Total Cover, Richness, Diversity, Wetland score



Factors affecting vegetation

- **Zone** (15, 25, 35, 45, and 60 kcfs)
- **Canyon Width** (Wide or Narrow; Schmidt and Graf)
- **Site** (Includes all soil, slope, aspect, rim height, etc.)
- **Year**
  - Hydrograph (Max, min, mean, top of fluctuations)
  - Precipitation (Relative to long term averages)

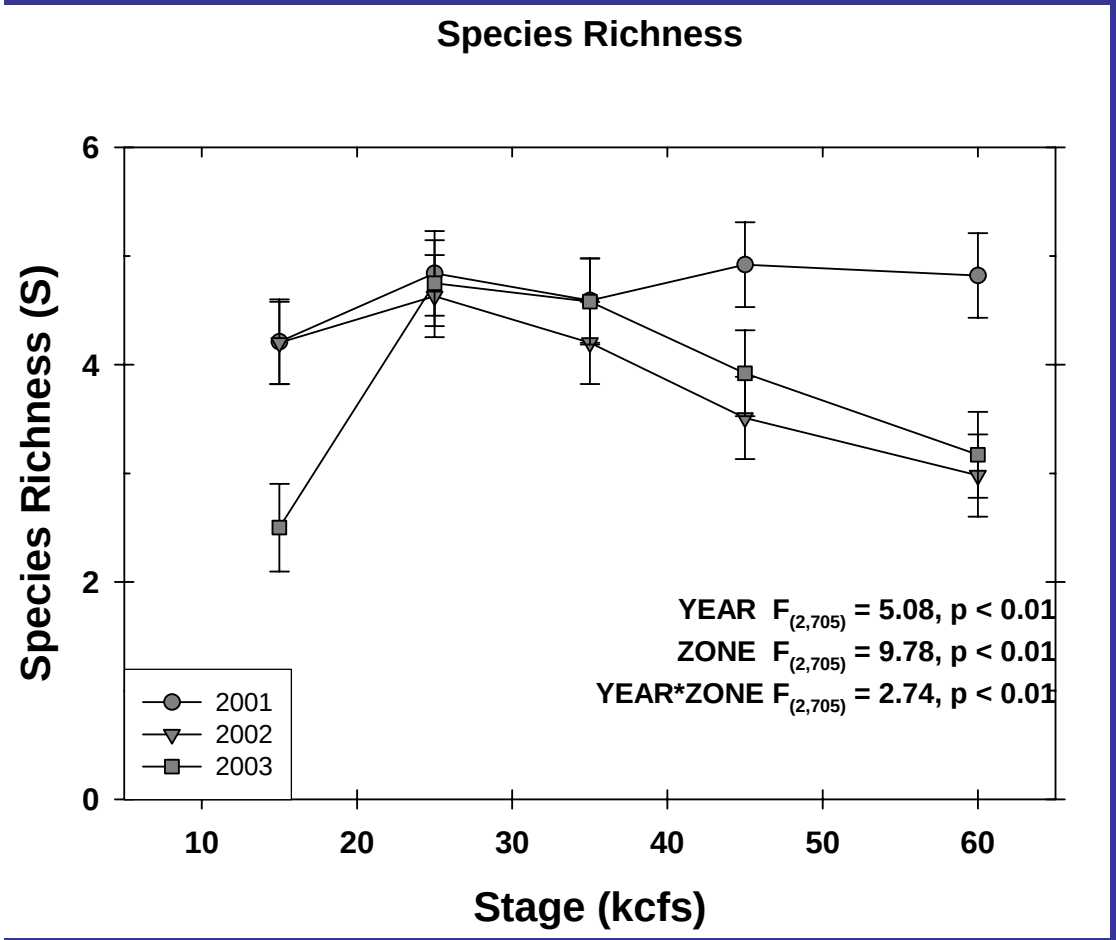
Vegetation Cover: 2001 - 2003



Cover Summary

- **All Zones:**
  - **Site is extremely important**
  - **Wider reaches have more cover**
- **Individual Zones**
  - **15, 25 kcfs: Cover decreased by increasing flow**
  - **35 kcfs: Cover increased by increasing flow**
  - **45, 60kcfs: Reductions in cover by flows – lagged responses?**

Species Richness Patterns



- Years are different (2001 > 2002/2003)
- Zones are different (15 / 25 / 35 > 45 / 60)
- Zones behave differently between 2001 - 2003

Species Richness Patterns Within Zones

- Site is the strongest factor (40 – 55% of all)
- Width is important
  - Wider reaches have more cover, change more
- Years differ in most cases:
  - 15 kcfs: Flow minimum decreases richness
  - 25 kcfs: Flow mean increases richness
  - 35 kcfs: Relative precipitation increases richness
  - 45 kcfs: Relative precipitation increases richness
  - 60 kcfs: Relative precipitation increases richness

Compositional Measures

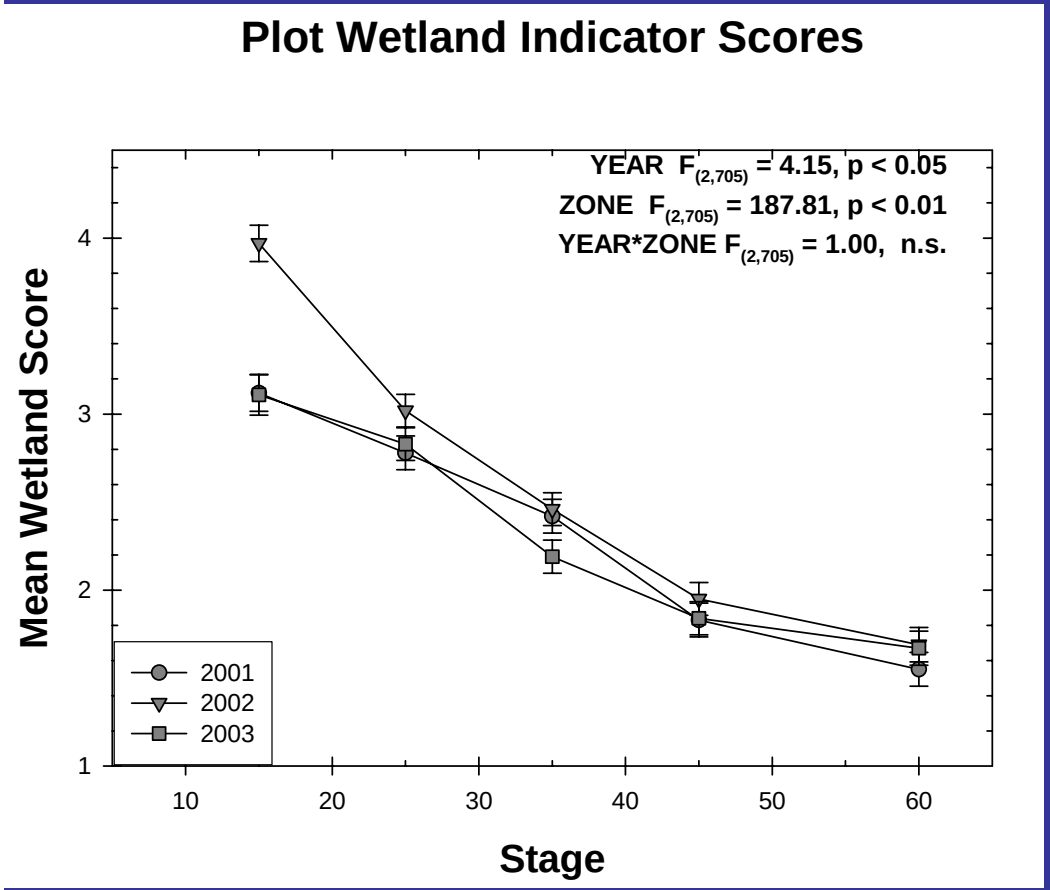
- Wetland Indicator Score (Stromberg et al 1996)
  - Plot Score = {Σ (Species Scores) / Total # spp.}

- Indicator Species Analysis (Dufresne and Legendre 1997)

Transect Compositional Analysis

- Wetland indicator score changes
  - Species have scores (0 = upland, 5 = wetland)
  - Plot scores are means of species scores
- Species present in plots differs…
  - …by zone (no big deal)
  - …by year within zones (a bigger deal)

Wetland Indicator Scores



- **Years are different (2002 > 2001 / 2003)**
- **Zones are different (15 > 25 / 35 > 45 / 60)**
- **Zones behave differently**
- **Not as expected…**

Wetland Score Changes

- **Driest year has “wettest” wetland score.**
- **Opportunistic species (annual herbs and grasses) arrive with increased precipitation.**
- **These species rate as more facultative or upland, and so drive the “wetlandishness” score down.**

Indicator Species Analysis

	2001	2002
15 kcfs	**Ripgut grass** **Red brome**	***N/A***
25 kcfs	**Ripgut grass** **Red brome**	***N/A***
35 kcfs	**Ripgut grass** **Red brome** **Scratchgrass**	***N/A***

Indicator Species Analysis

	2001	2002
45 kcfs	Spiny aster Ripgut grass Red brome Sand dropseed Mesa dropseed	*N/A*
60 kcfs	Threeawn grass Cane bluestem grass Red brome Western tansymustard Slender poreleaf Desert pepperweed Sixweeks fescue	*N/A*

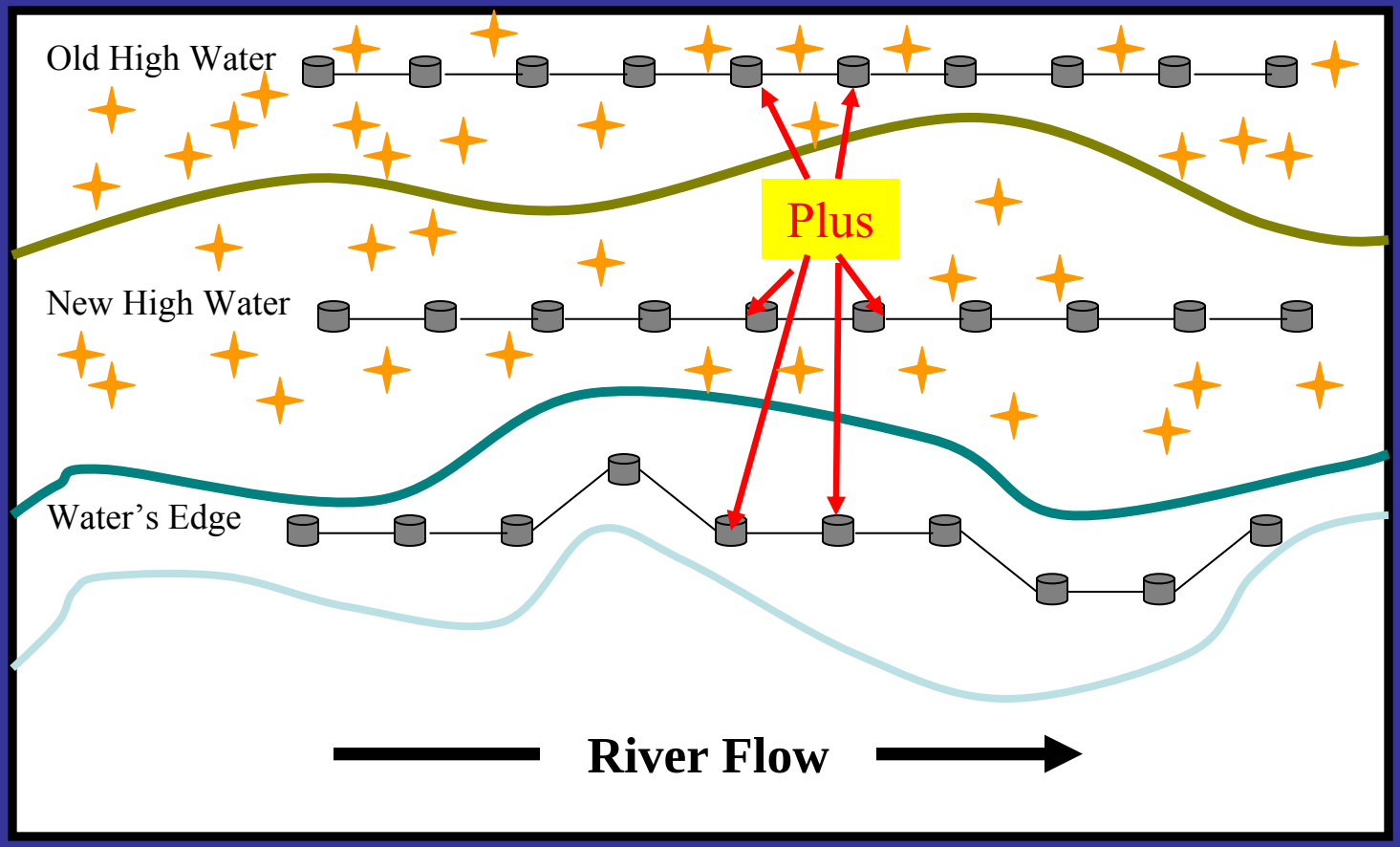
Summary

- **Richness, and to a lesser extent, total cover, are affected by flows and precipitation (big deal).**
- **Lower elevation plots are more strongly affected by flows, higher elevation plots by precipitation.**
- **Loss of cover at higher elevations due to death of perennial herbs and grasses little recovery in 2003.**

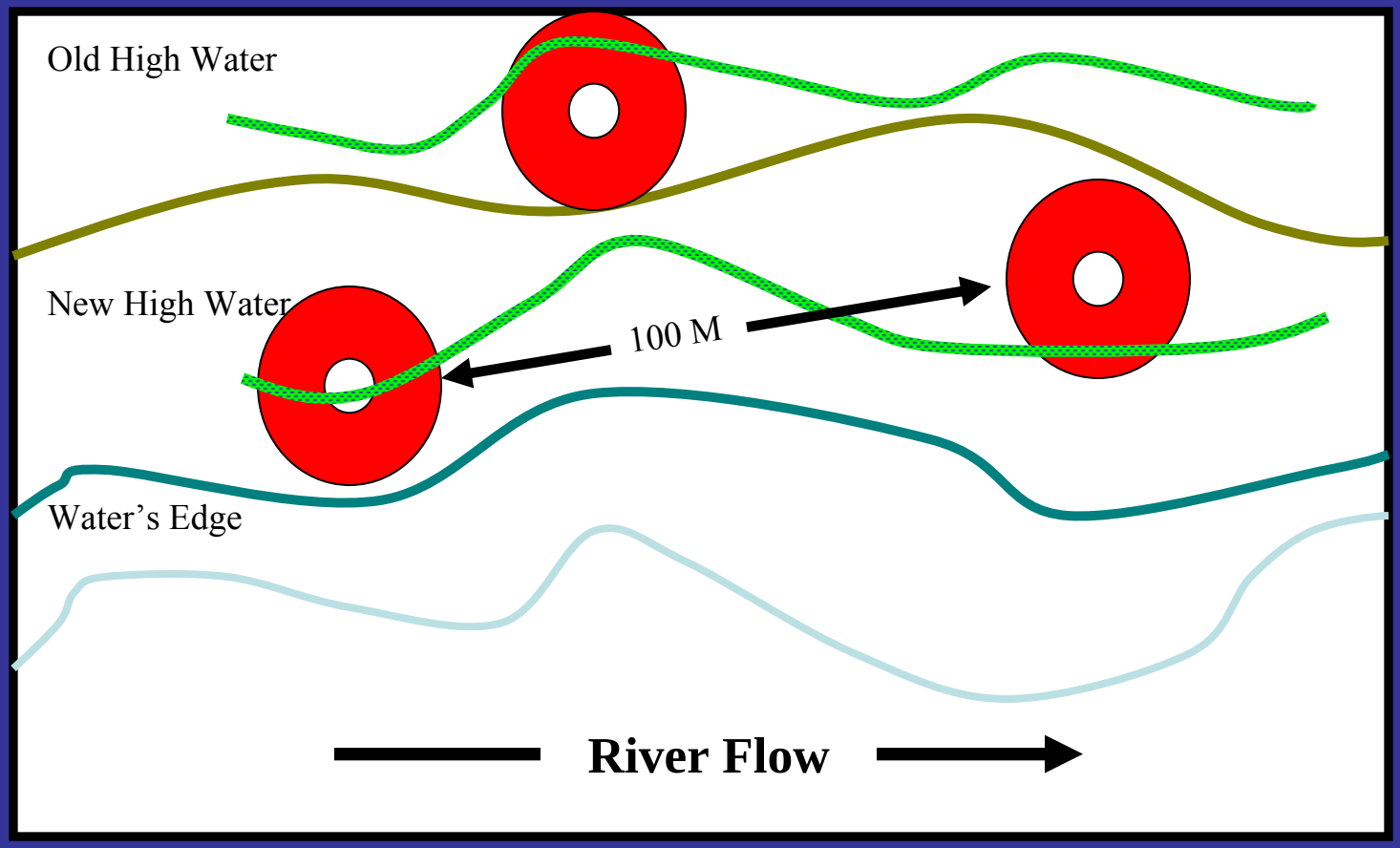
Connections to Fauna

- Breeding Birds
  - Helen Yard
- Invertebrates
  - Dave Lightfoot, Sandy Brantley, Neil Cobb
- Herpetofauna
  - Geoff Carpenter
- Small Mammals
  - Jennifer Frey

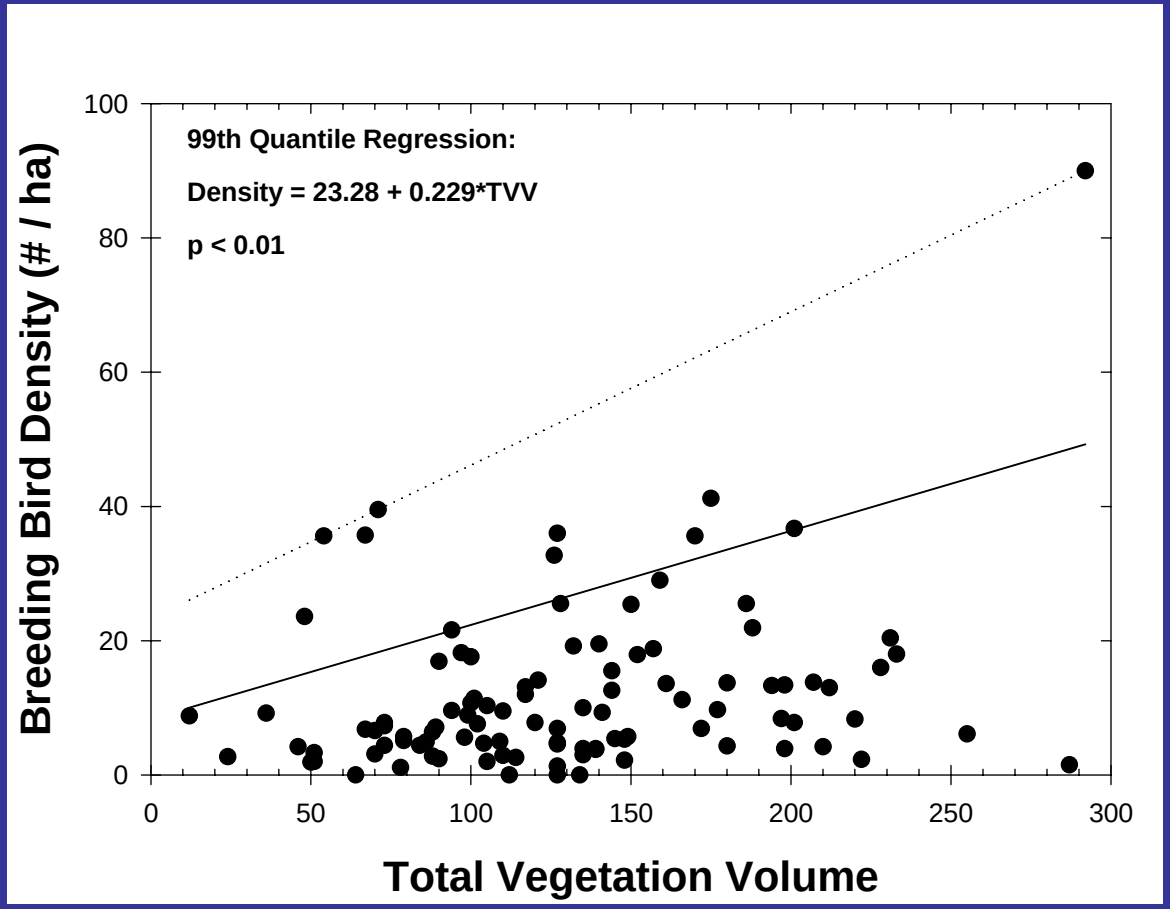
Vegetation Structure Surveys



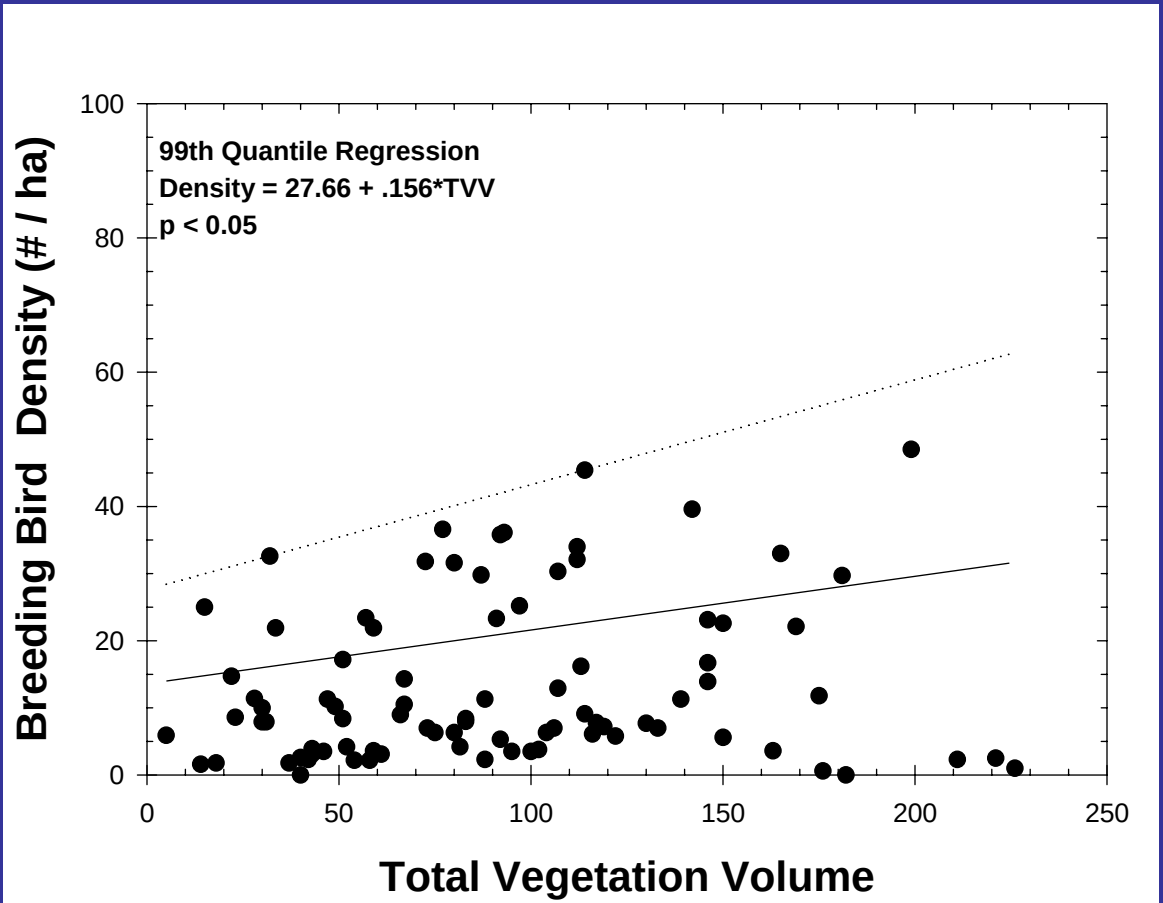
Breeding Bird Surveys



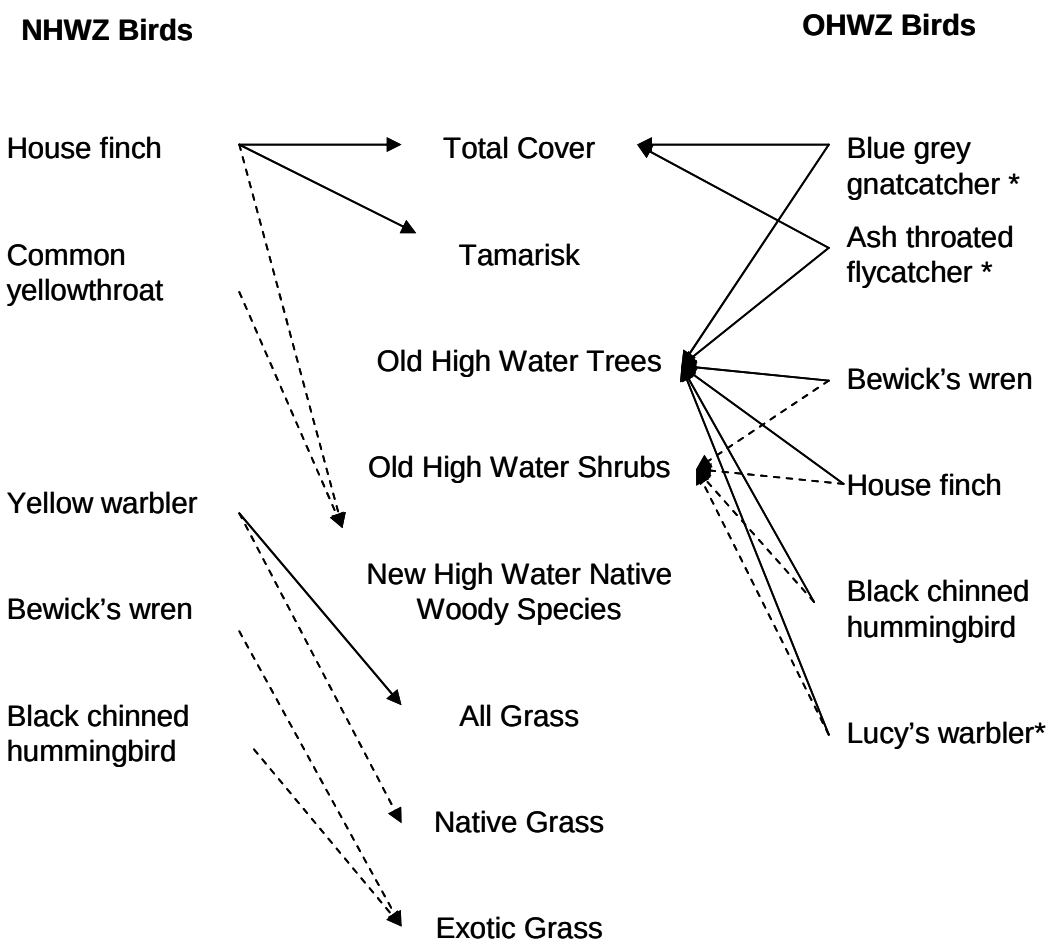
New High Water Zone Breeding Birds



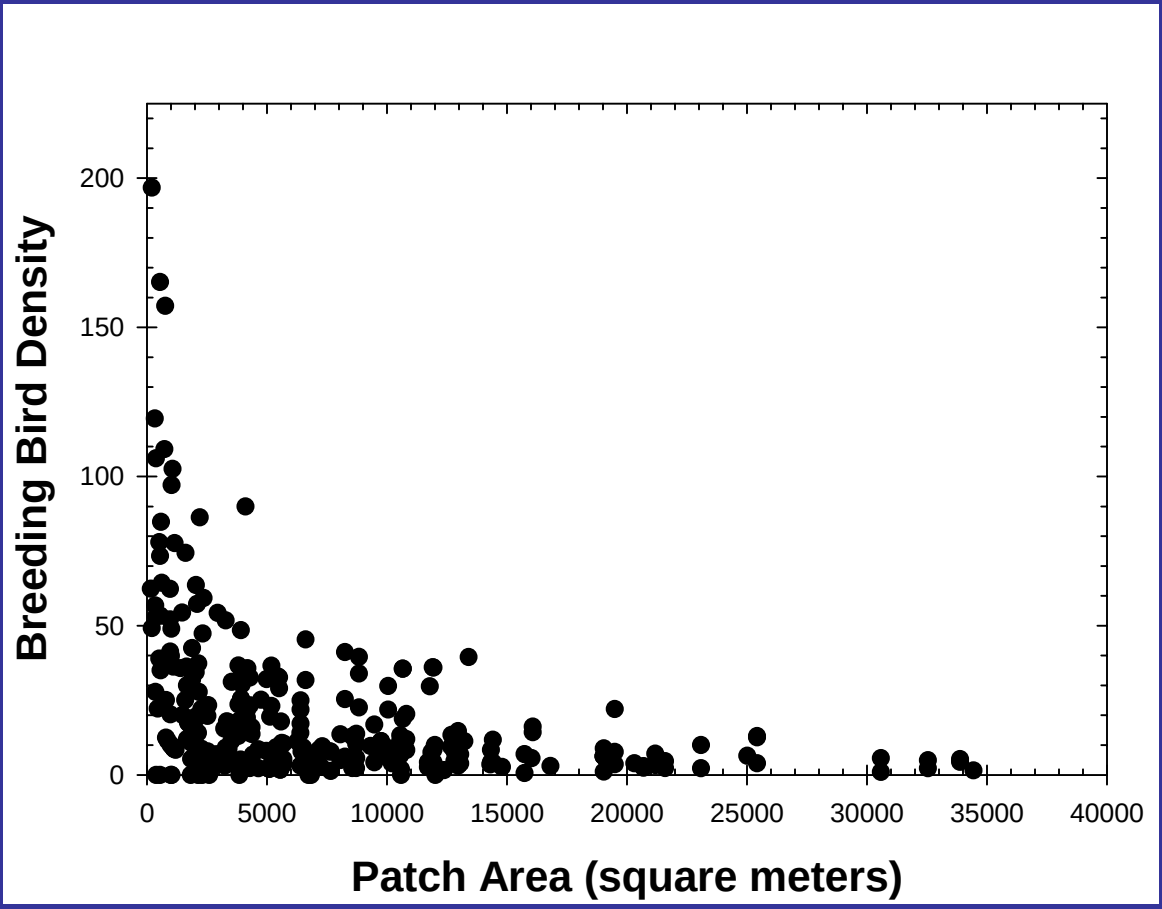
Old High Water Zone Breeding Birds



Birds and Vegetation



Breeding Bird Density vs. Patch Area



Small patches are far more variable

Small patches have higher densities?

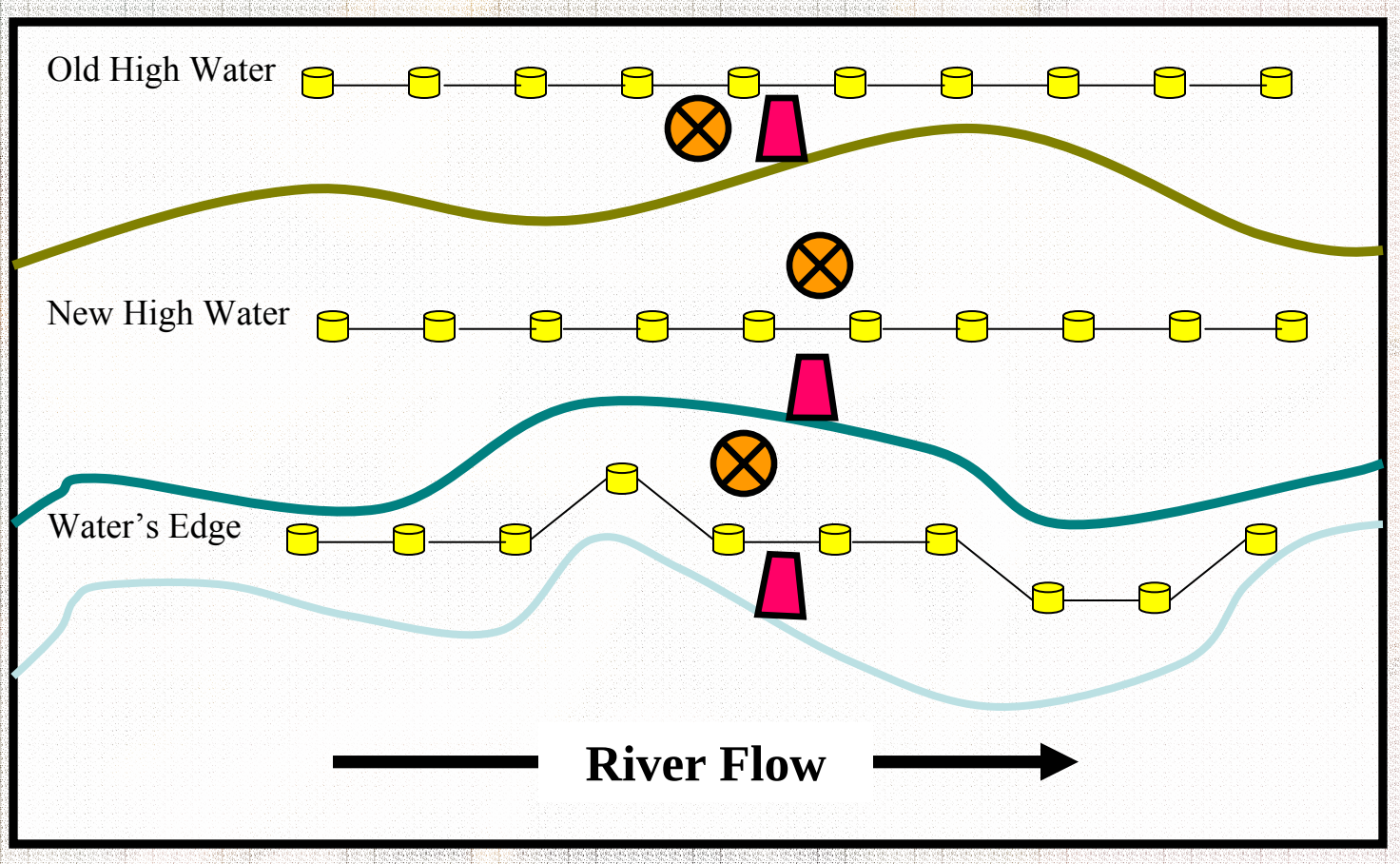
Patterns:

a) Edge Species?

b) Forage vs. Nest?

c) Survey methods?

Invertebrate Sampling



Plus transect sweeps, collecting by plant species and general collecting

Arthropod Surveys:

- Primarily inventory
- Reference collection
- Some connections are obvious

Arthropod Results to Date

923 Taxa delineated

90,000^{+} specimens processed

8 undescribed species (>100 expected)

Variation in abundance and composition of arthropods for all four sampling methods across zones, sites, and seasons.

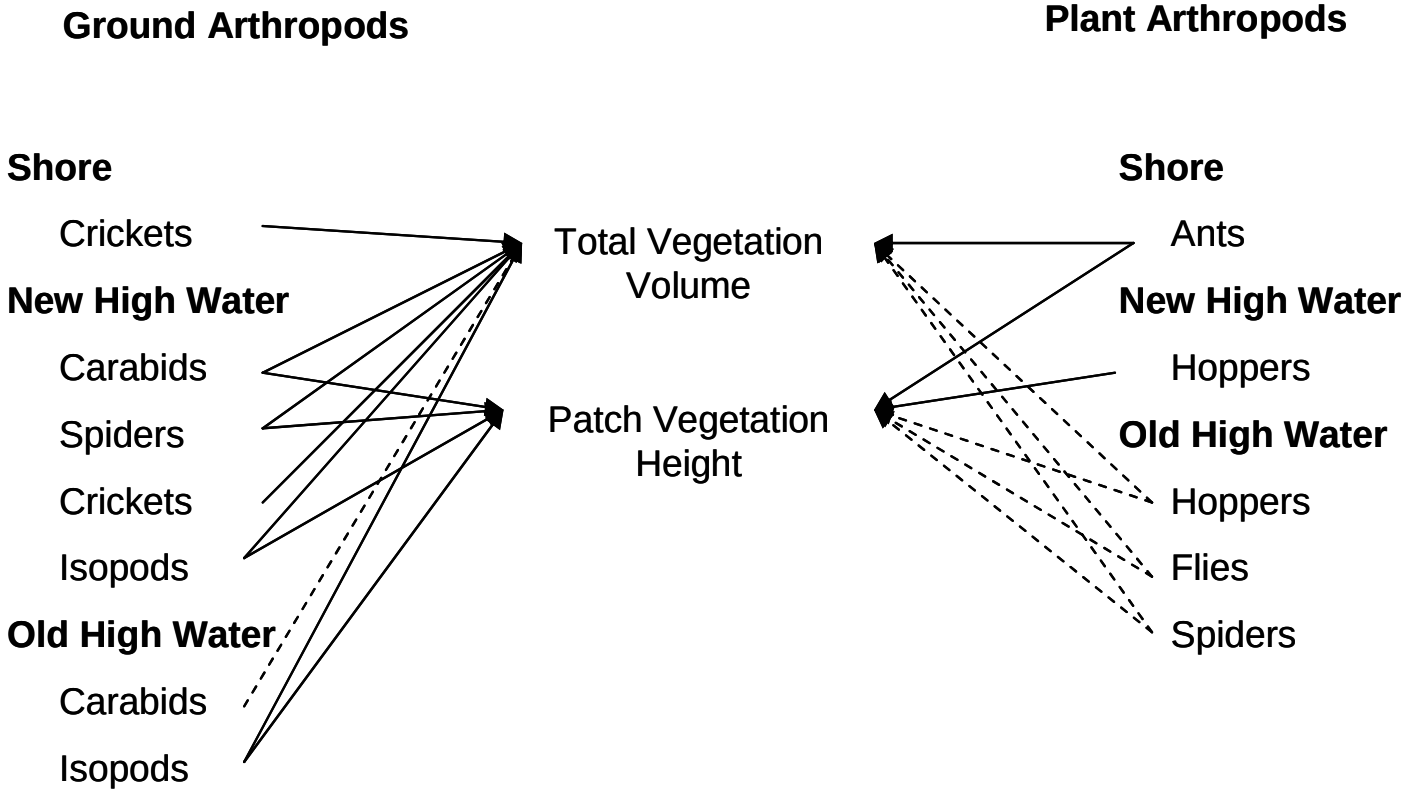
↓

Over 120 arthropod taxa show zonal affiliations (Shore, NHW, & OHW).

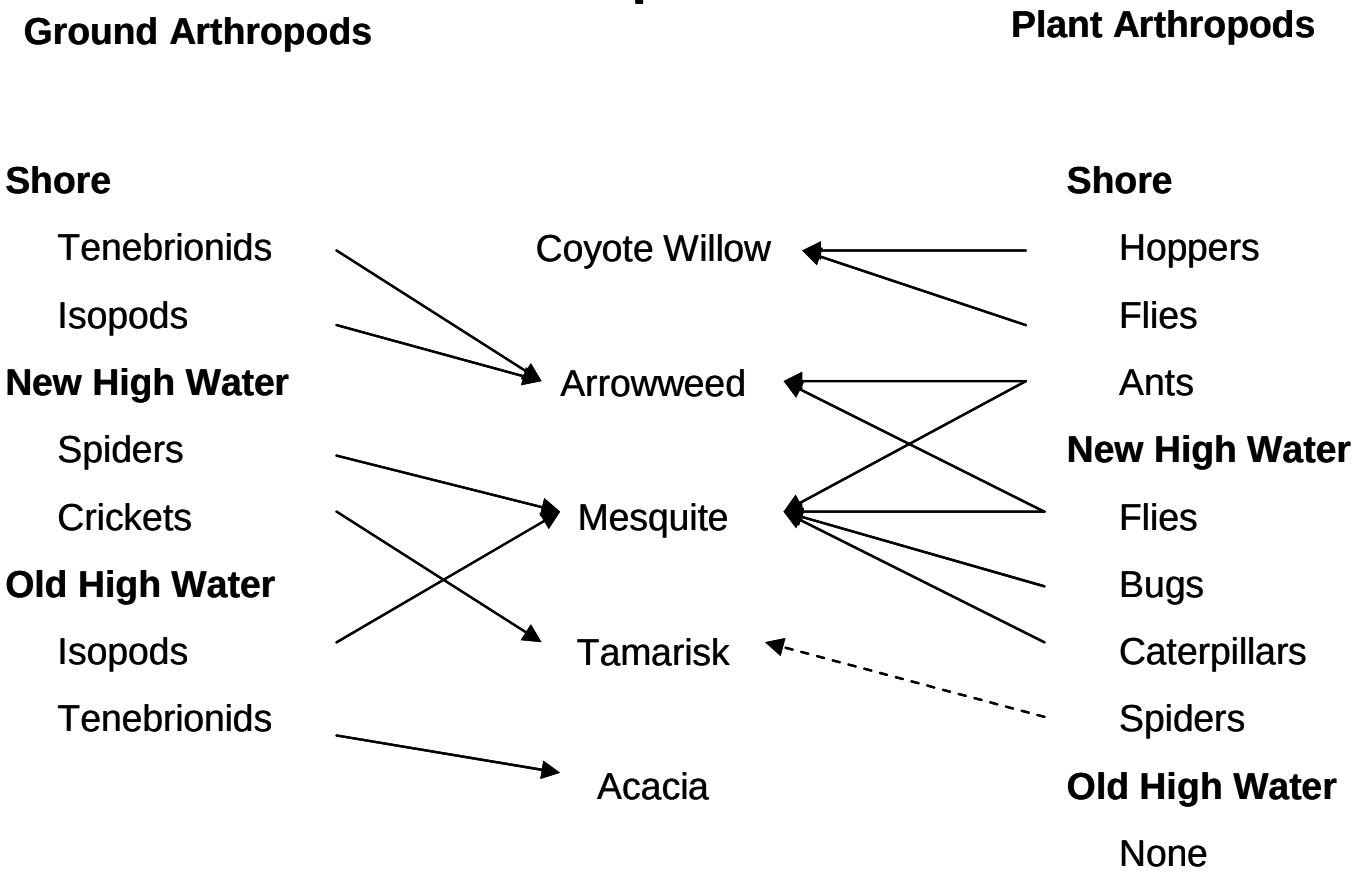
↓

Potential for indicator taxa in future monitoring programs is high.

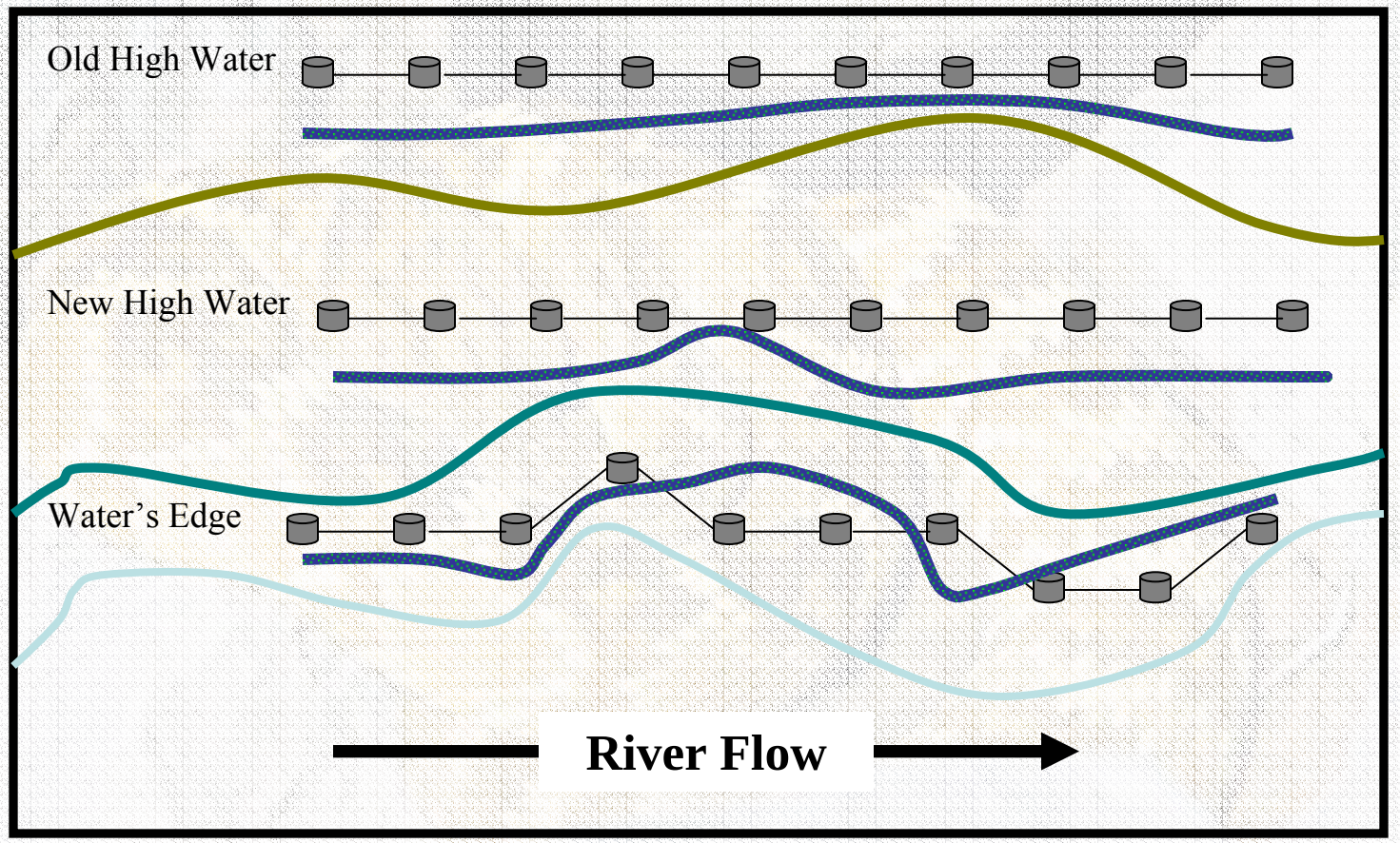
Arthropods and Vegetation Volume



Arthropods and Plant Species



Herpetofaunal Sampling

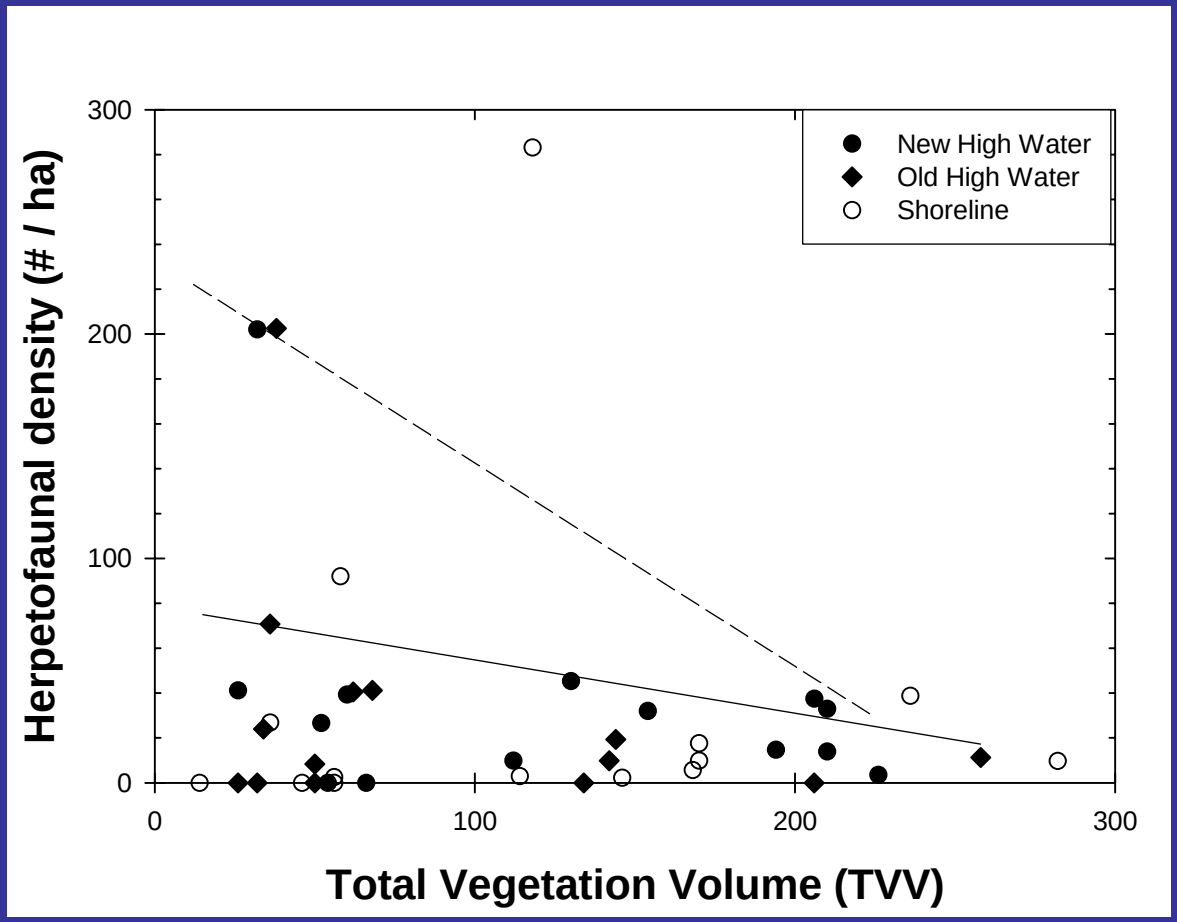


Plus general visual searching of TEM sites and bird sites and nocturnal surveys

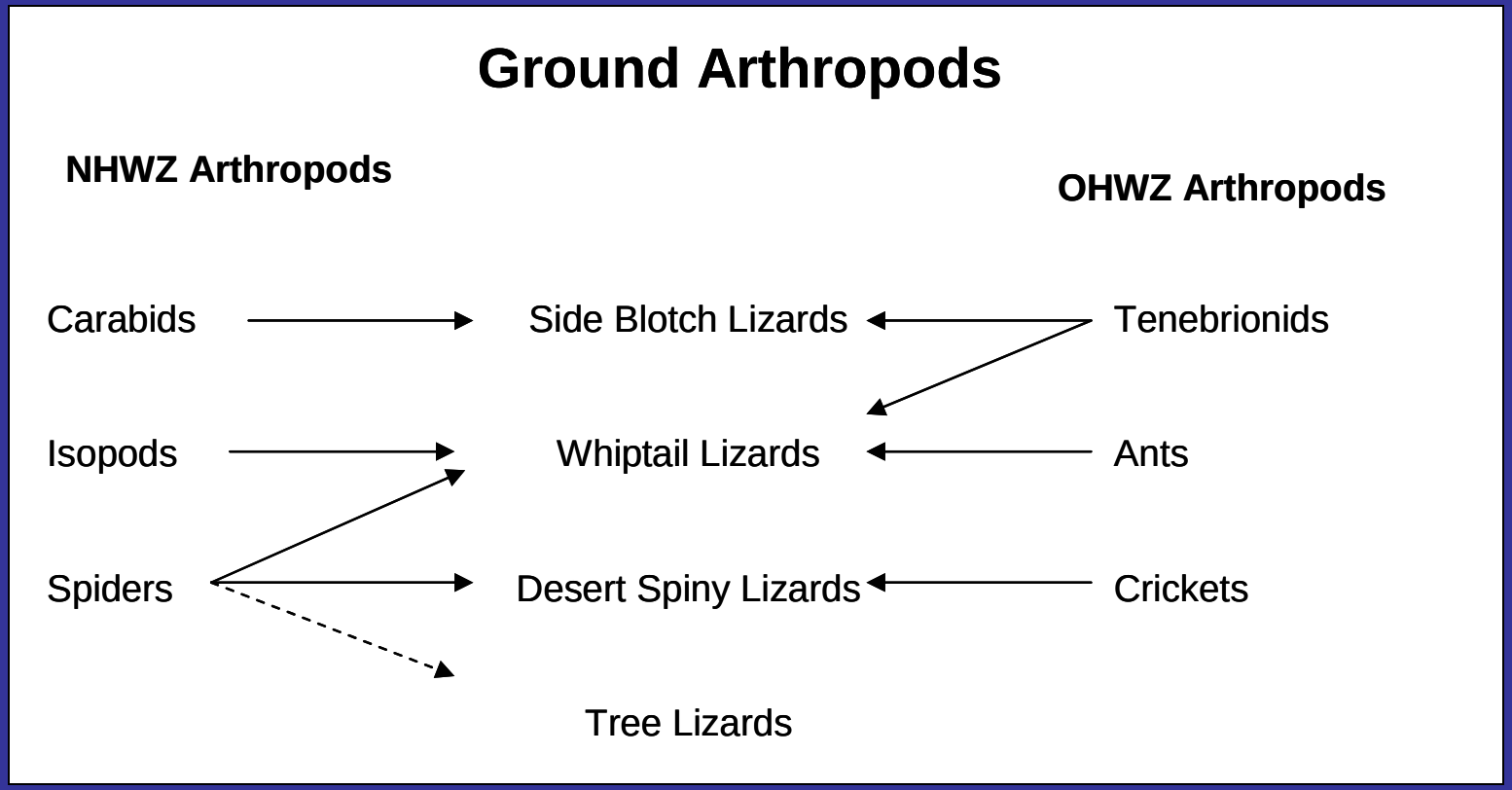
Herpetofaunal Surveys:

- Primarily inventory
- Distribution and relative abundance
- Some connections are obvious

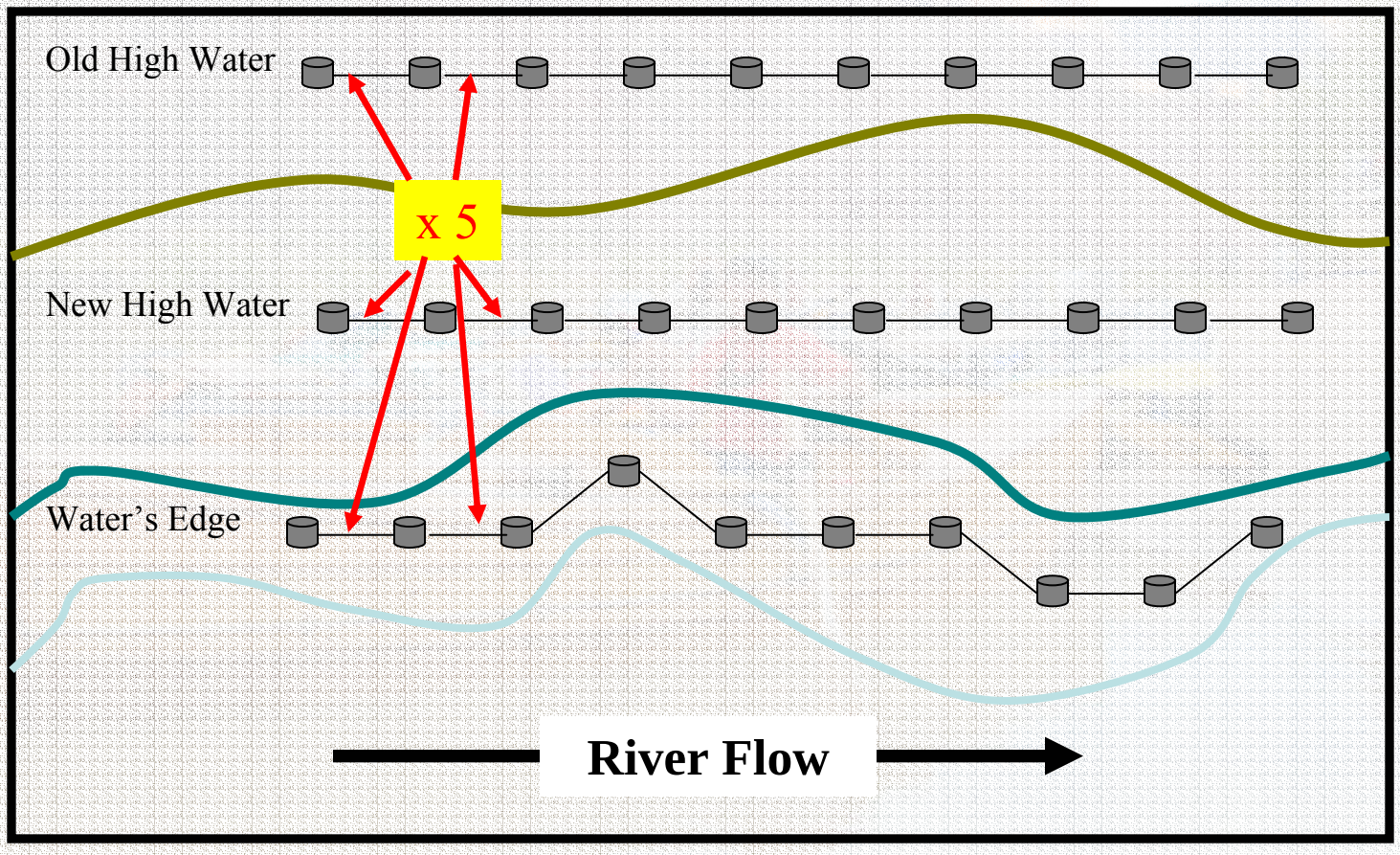
Herpetofauna and vegetation



Herpetofauna and ground arthropods



Small Mammal Sampling



Plus general visual searching of TEM sites

Small Mammal Surveys:

- Primarily inventory
- Distribution and relative abundance
- Some connections are obvious
  - No correlation with Vegetation Volume
  - Individual correlations with arthropods

Ground Arthropods