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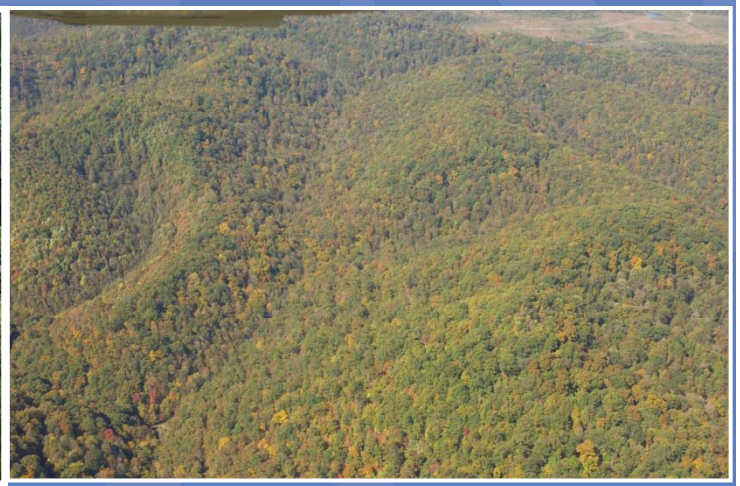
Headwater streams – what are they and what do they do?

Ken Fritz and Brent Johnson



Office of Research and Development
National Exposure Research Laboratory, Ecological Exposure Research Division

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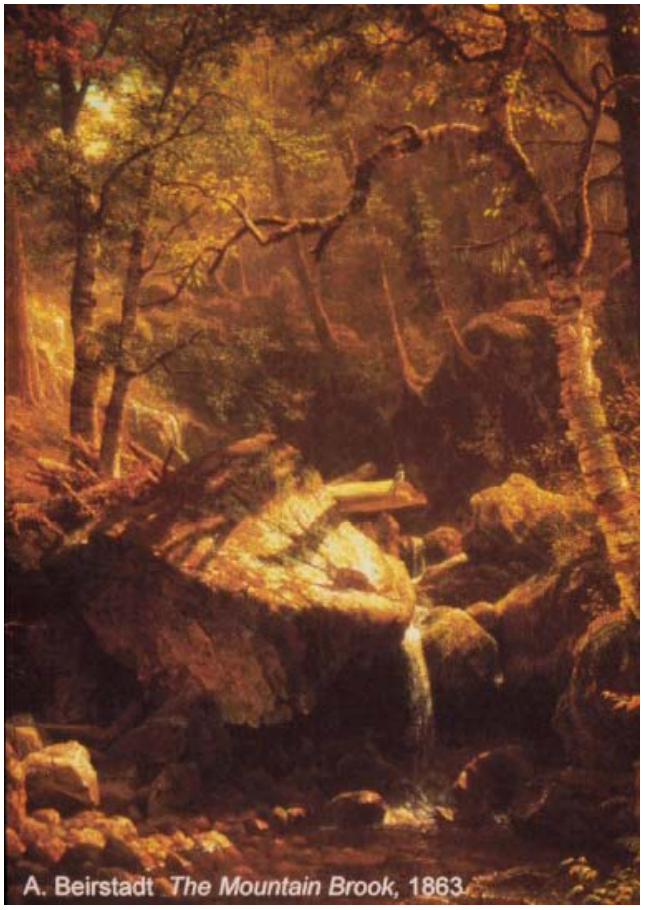
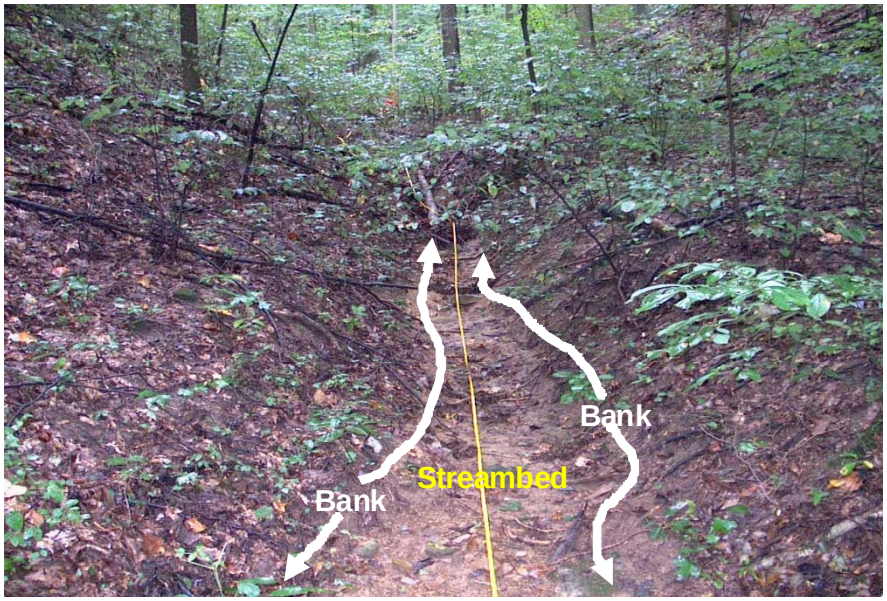
Outline of presentation



- What are headwater streams?
  - Where are they?
  - Components of headwater catchments
  - Longitudinal transitions
- Hydrology of headwater streams
  - Major flowpaths
  - Expansion – contraction
  - How to characterize permanence
- Headwater stream functions
  - Structure and function
  - What are the vitals and how to measure them

What are headwater streams?



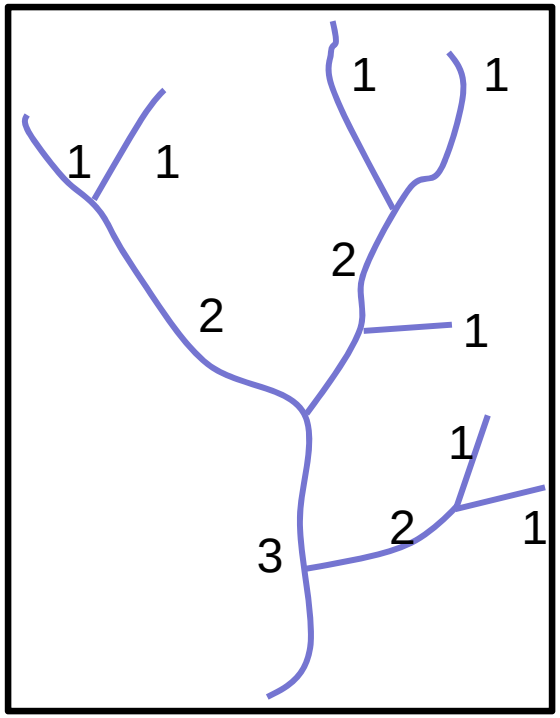
- Subjective term for a small tributary
  – depends on context and scale

- Tributaries are permanent longitudinal features (bed & banks) where water & associated materials from surface runoff and/or ground water are concentrated & mixed at the land-atmosphere interface.

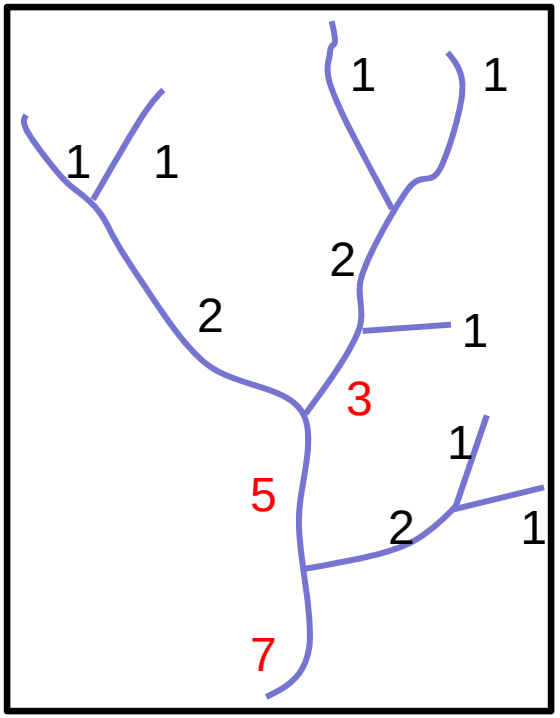
Stream classification

- Exterior or most upland tributaries in river networks
- Typically considered to be 1st & 2nd order streams, but depends on map

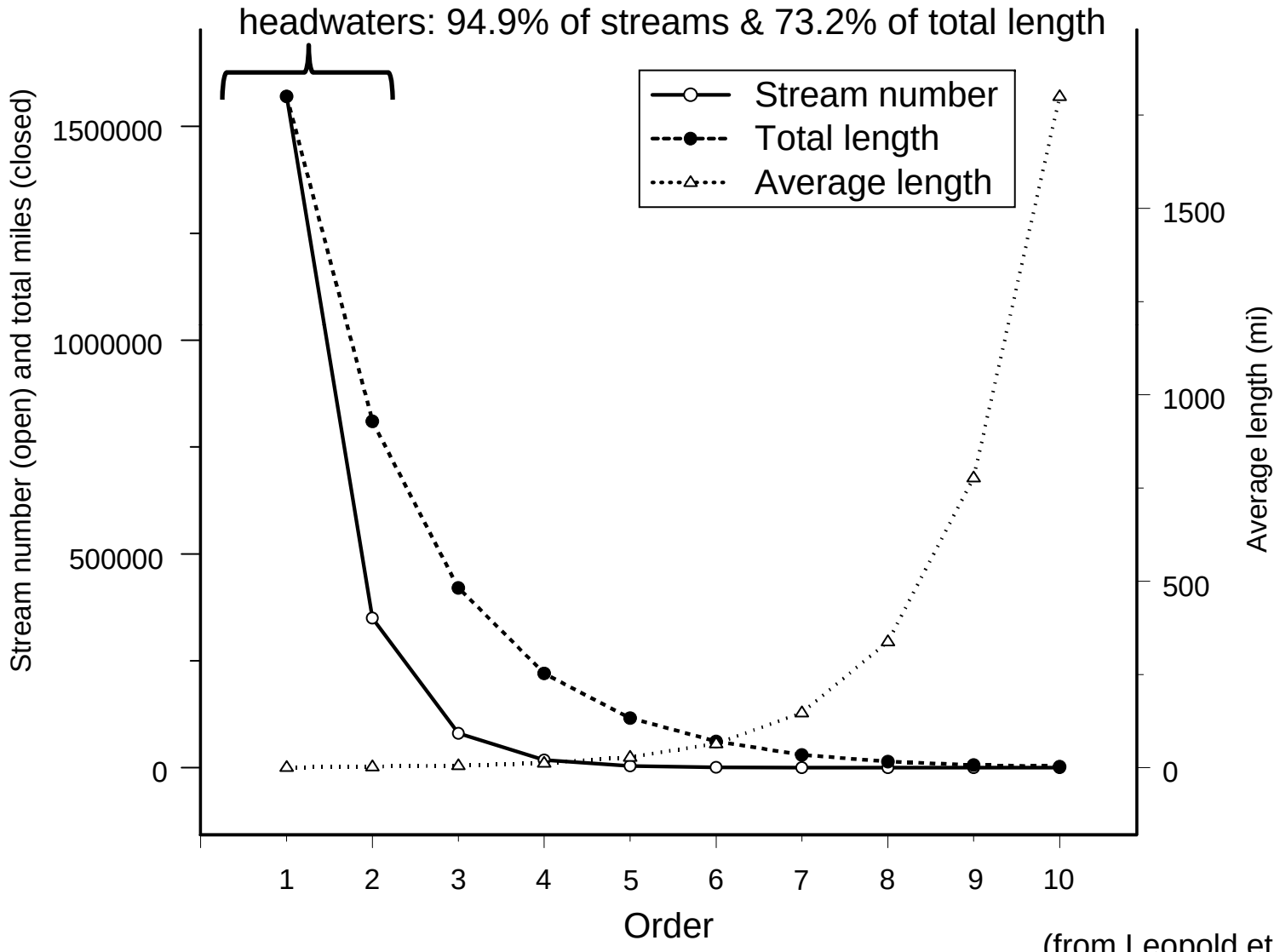
stream order



link magnitude

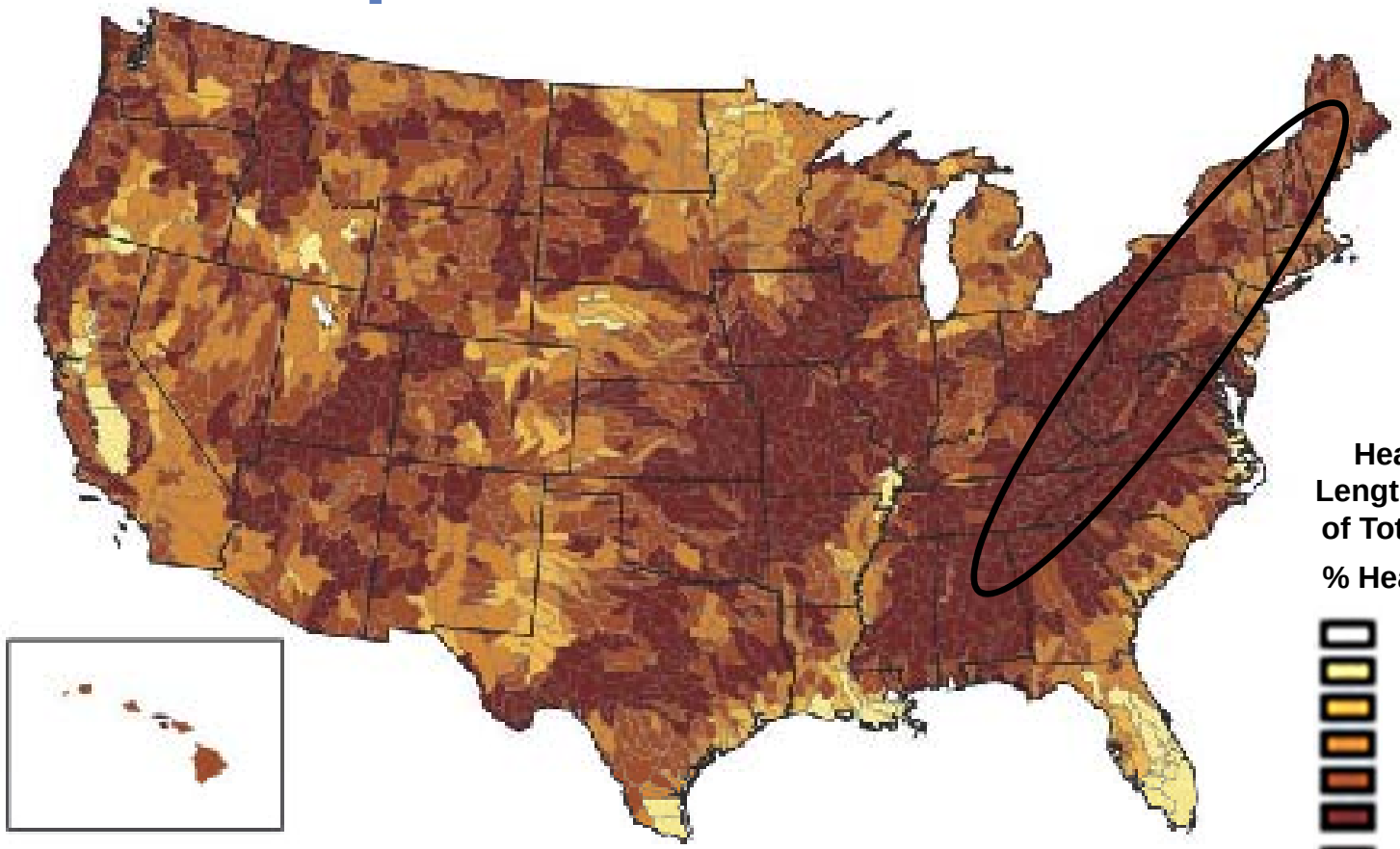


Extent of headwater streams



(from Leopold et al. 1964)

Headwater streams: a national picture



Headwater Stream Length as a Percentage of Total Stream Length

% Headwater Streams

- **0**
- **1-19**
- **20 -36**
- **37-48**
- **49-57**
- **58-100**
- **State boundary**

FIGURE 1. Headwater Stream Length, as a Proportion of Total Stream Length Within Each 8 Digit HUC Watershed, in the U.S., Excluding Alaska, as Computed Querying the NHD RAD v2.0 for Reaches That Have No Other Inflowing Streams at the 1:100,000 Scale. The NHD RAD v2.0 Does not Capture Streams Under 1 mile (i.e., 1.61 km) in Length.

(from Nadeau and Rains 2007)

Map scale & headwater streams

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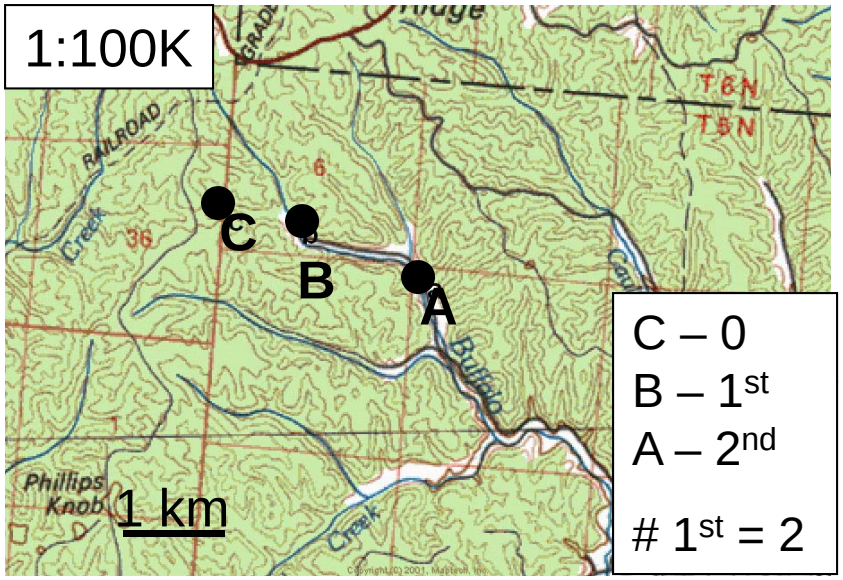

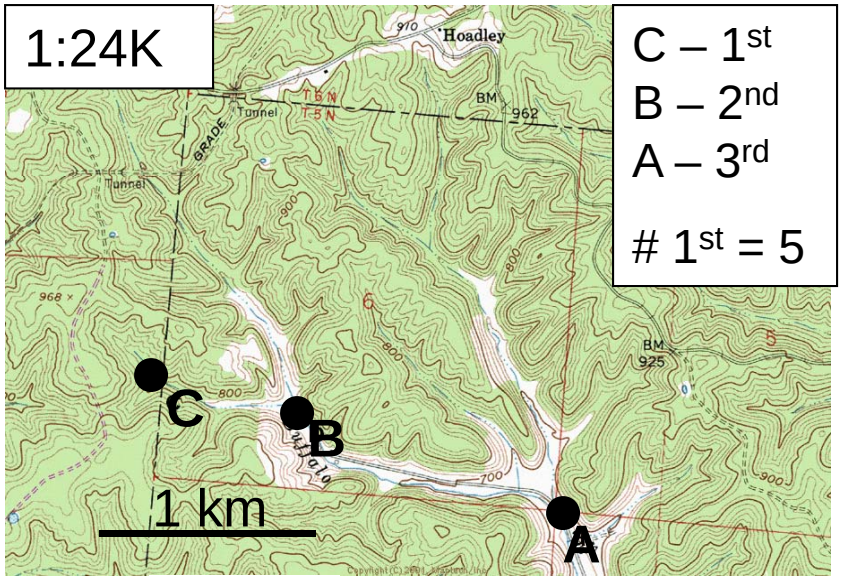

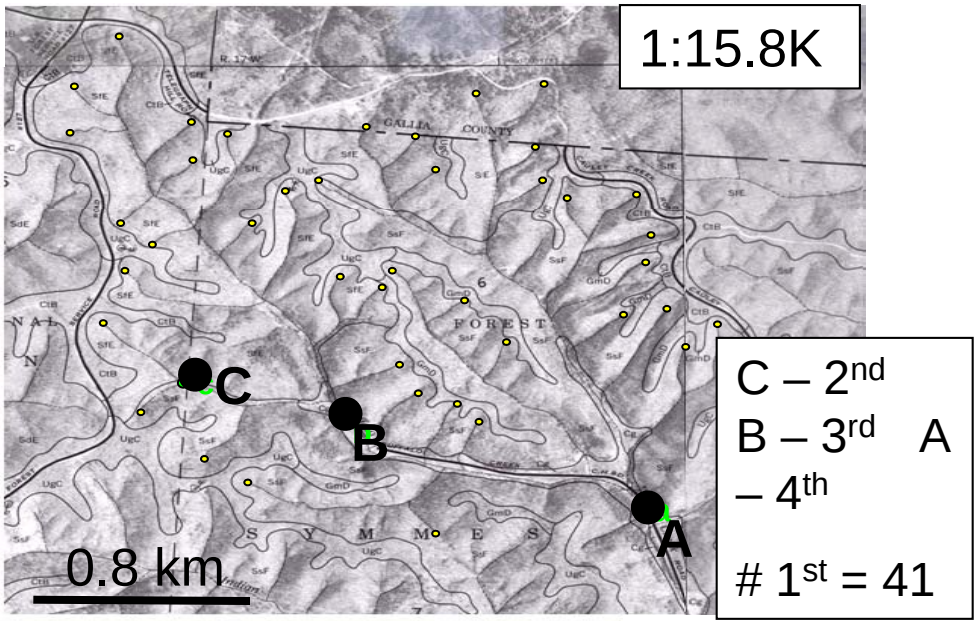

Extent of headwater streams

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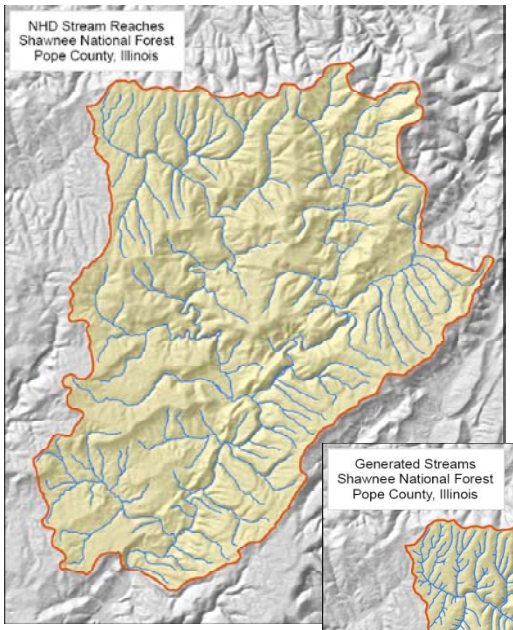
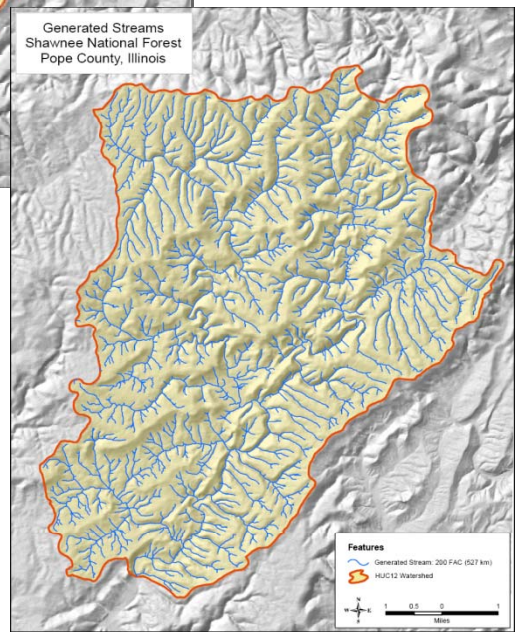


National Hydrographic Database (NHD) total stream length : 233 km



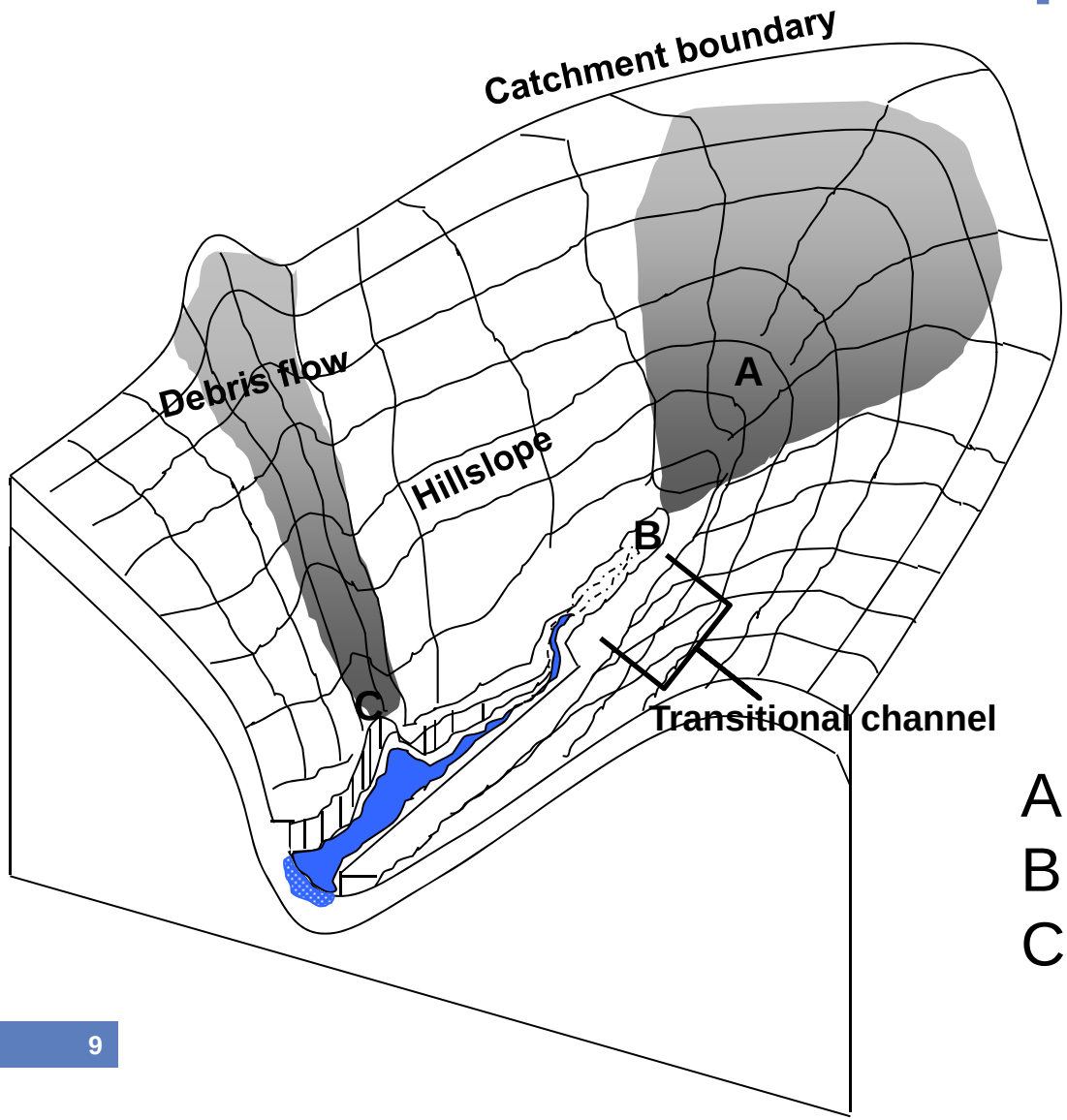
Generated prediction total stream length: 527 km

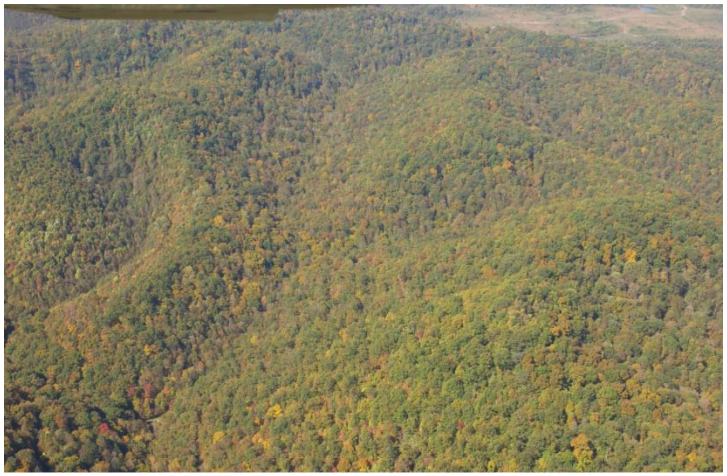
- Field surveying the position of channel origins & hydrologic transition zones
- Estimate extent of headwater streams within surrounding HUC based on field determined Flow Accumulation Coefficients.
- Comparisons to existing resource databases.

NHD coming up short?

Location	HUC drainage area (km^2)	Total stream length (km)		Percent additional length
		NHD 1:24 K	Generated	
Robinson Forest, KY	7.5	12	28	+133.3
Wayne N.F., OH	45.4	17	49	+188.2
Dodge Brook, NH	76.3	151	317	+109.9
Edge of Appalachia, OH	77.5	2	28	+1300.0
Hoosier N.F., IN	91.4	39	49	+25.6
Lower Big Sandy, WV	104.3	114	299	+162.3
Shawnee N.F., IL	128.7	233	527	+125.9
Silver Creek, WA	131.4	242	511	+111.4
Cheat River, WV	158.4	179	454	+153.6
Huntington River, VT	172.3	276	508	+84.1
Beaverkill, NY	251.3	255	481	+88.8
Fir Brook, NY	342.8	438	701	+60.0
n = 12				$\bar{X}$ = +114.4

Headwater catchment components

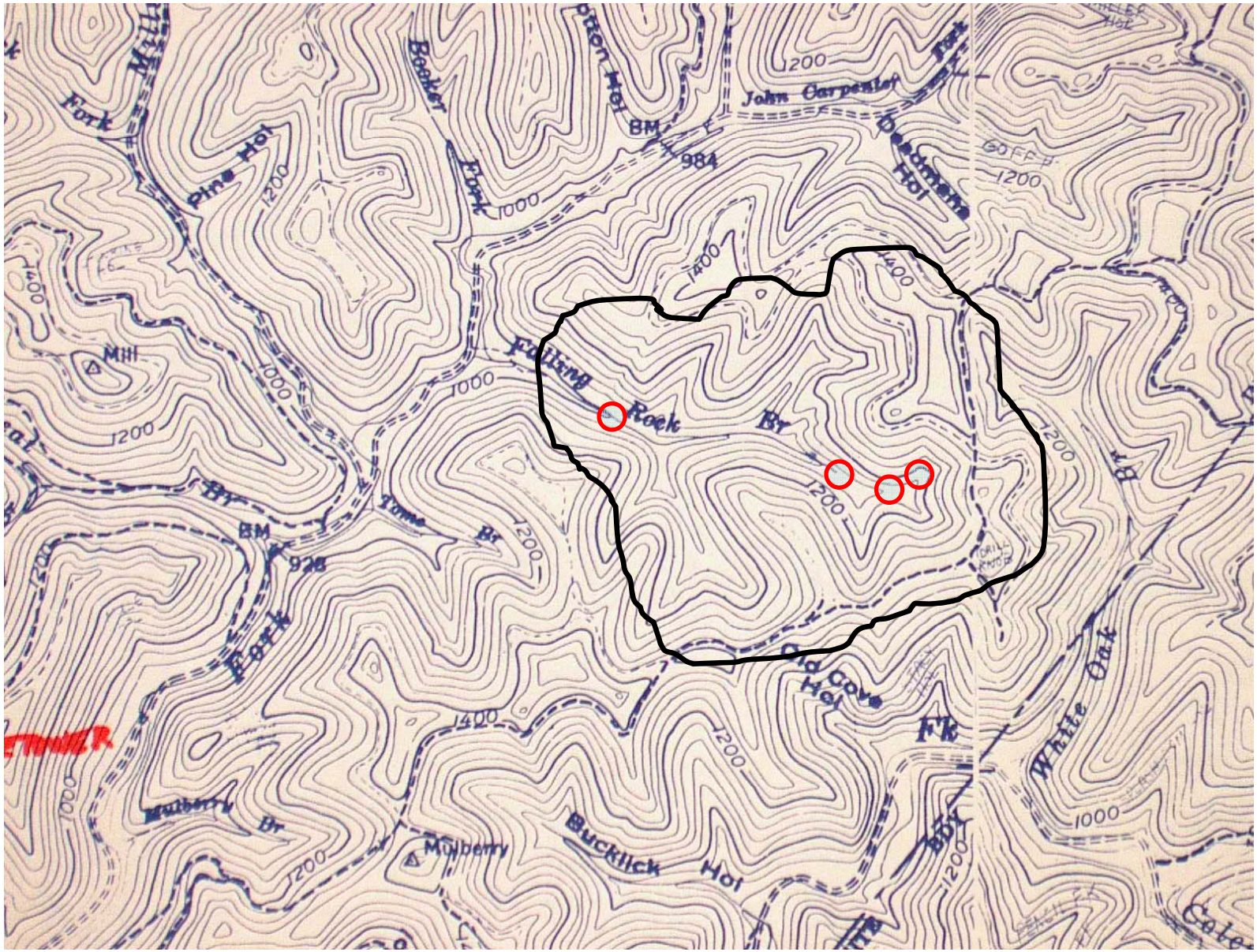




A – valley head or swale
B – gradual channel head
C – abrupt channel head

(based on Dietrich & Dunne 1993)

A longitudinal tour



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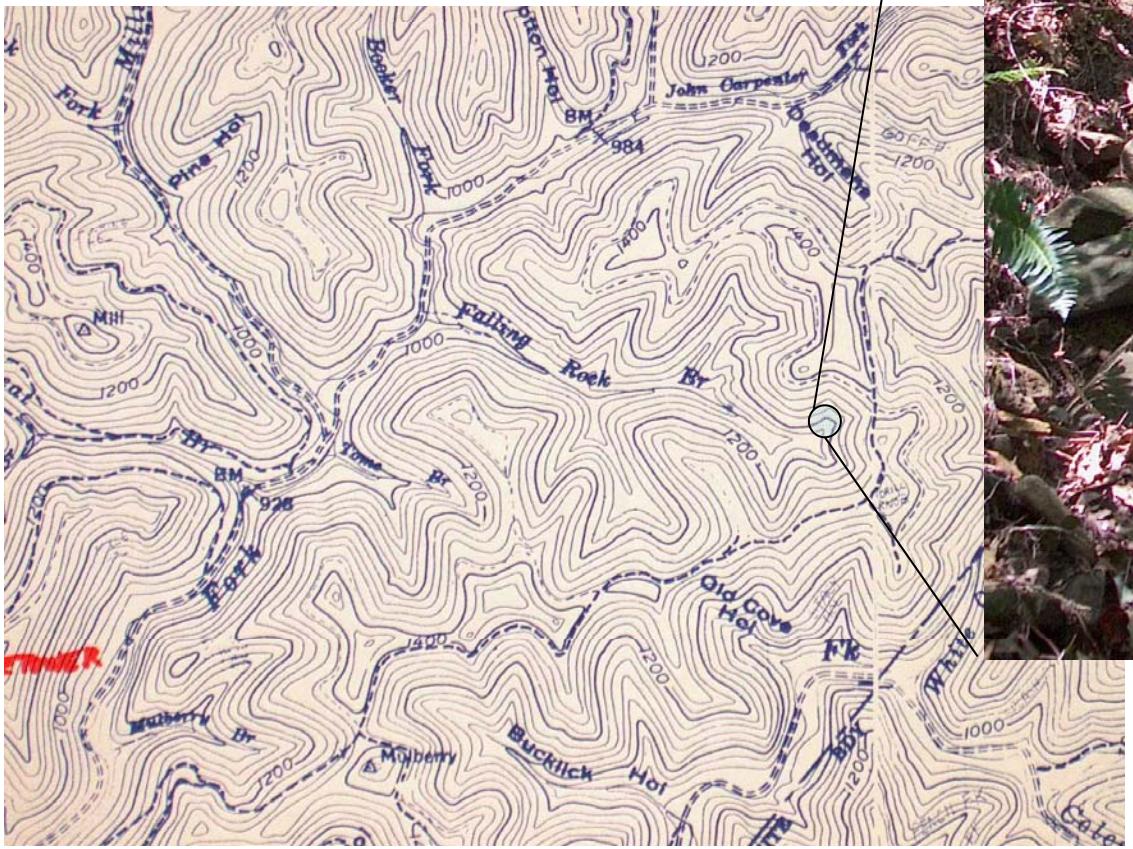
Drainage area: 1.9 ha
Slope: 46.3%
D_{50}: 128 mm (cobble-boulder)
Steep sideslopes
Colluvial/cascade



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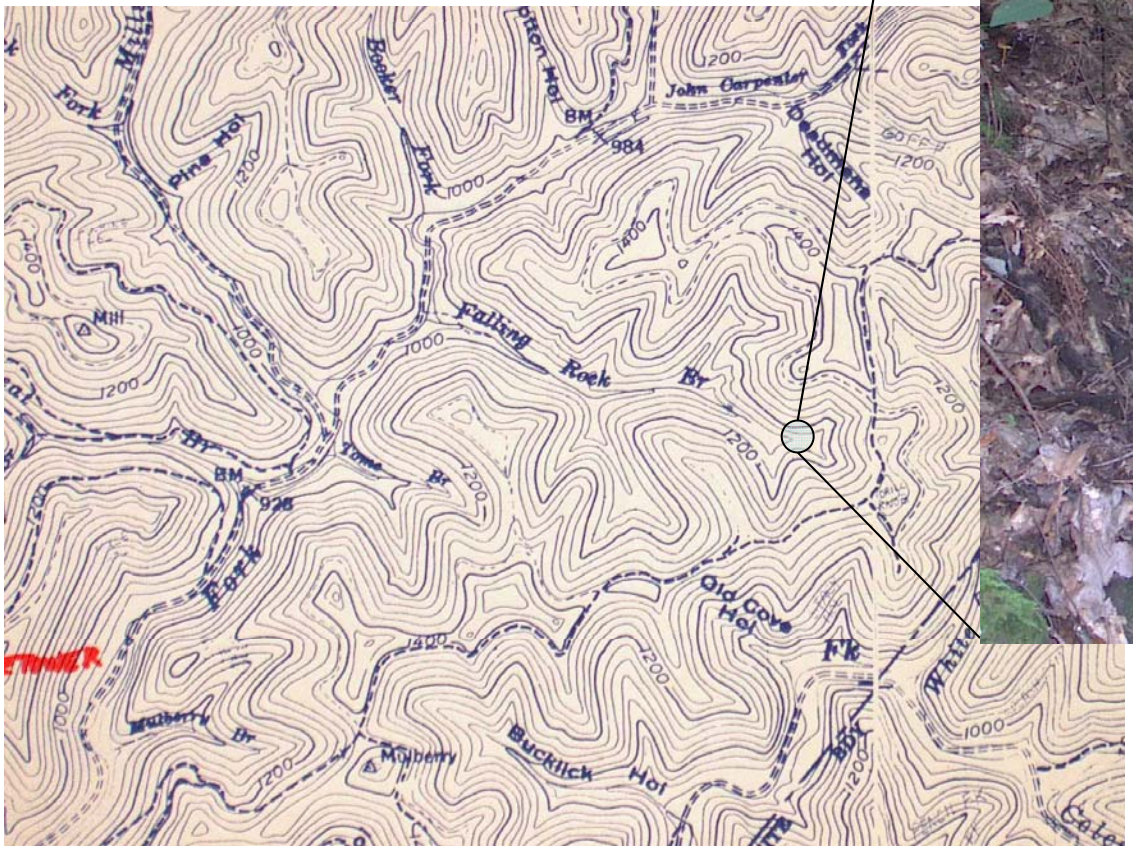
Drainage area: 9.6 ha
Slope: 9%
D_{50}: 64 mm (pebble-cobble)
Steep sideslopes
Cascade/step-pool



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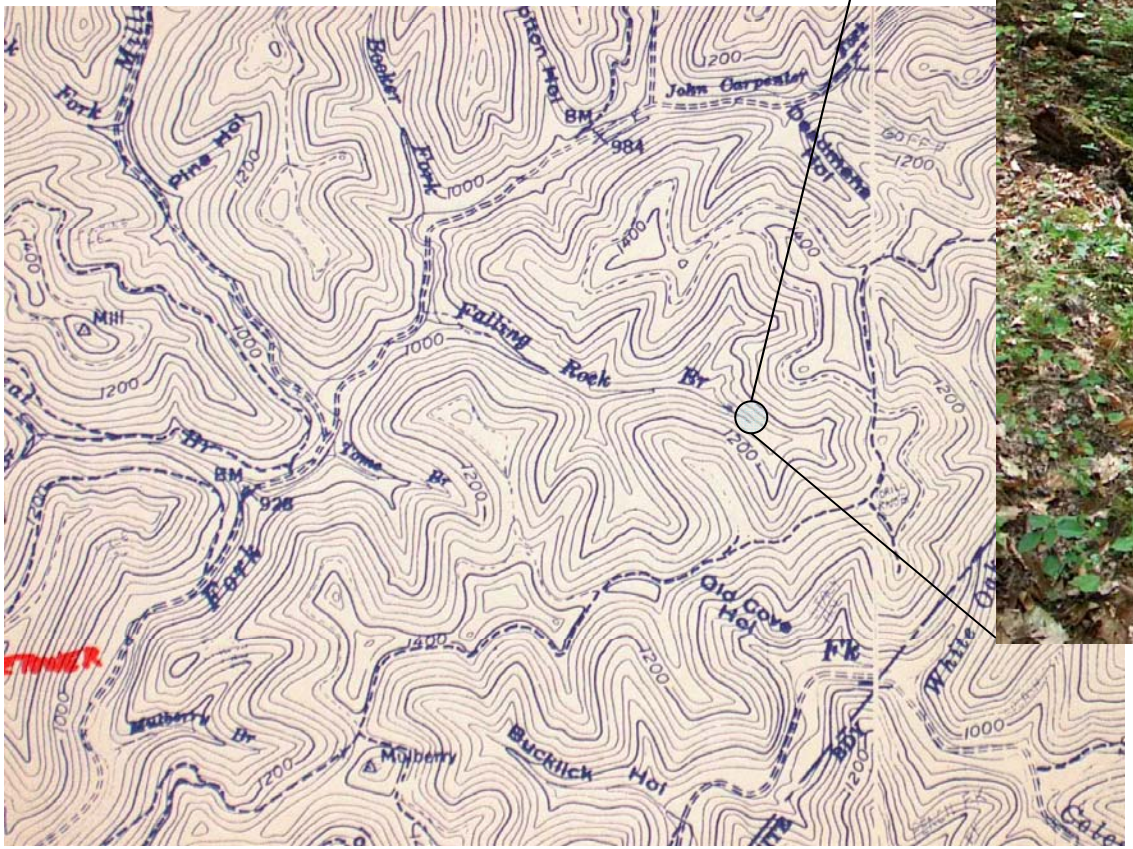
Drainage area: 18.5 ha
Slope: 3.3%
D_{50}: 64 mm (pebble-cobble)
Less constrained
Riffle-pool



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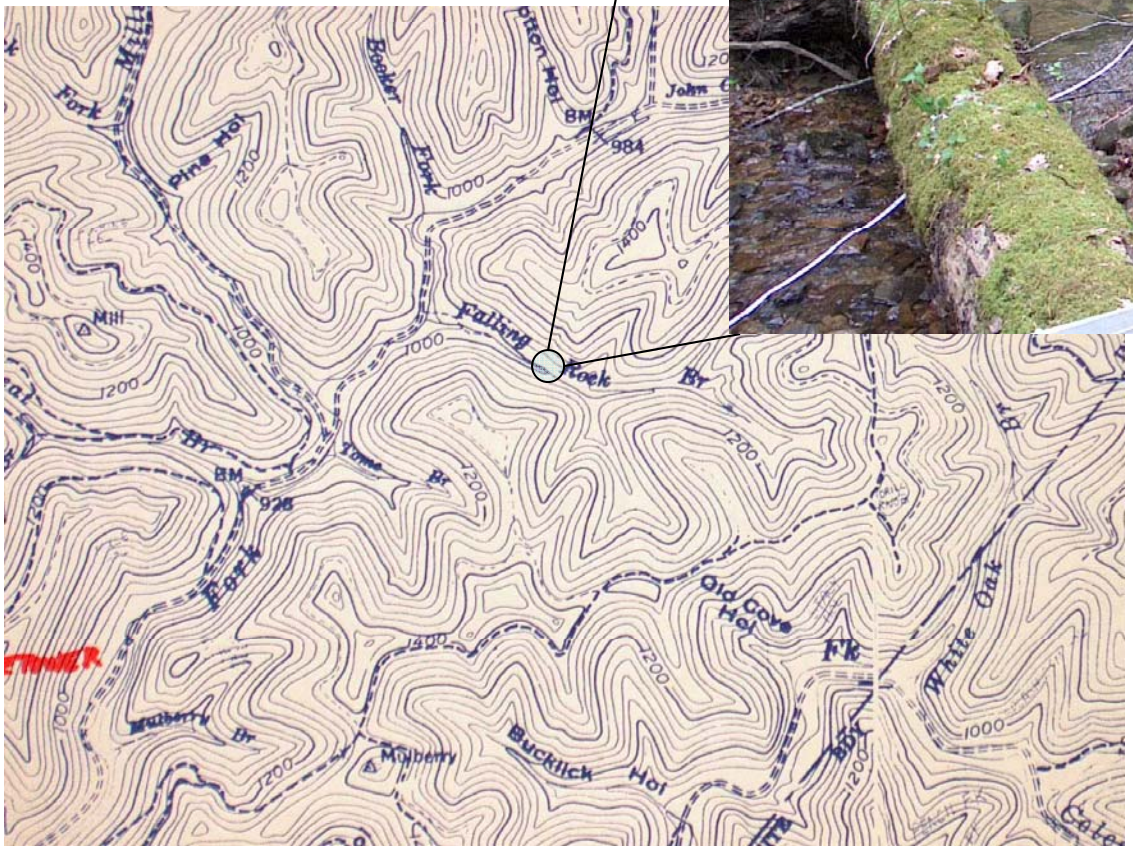
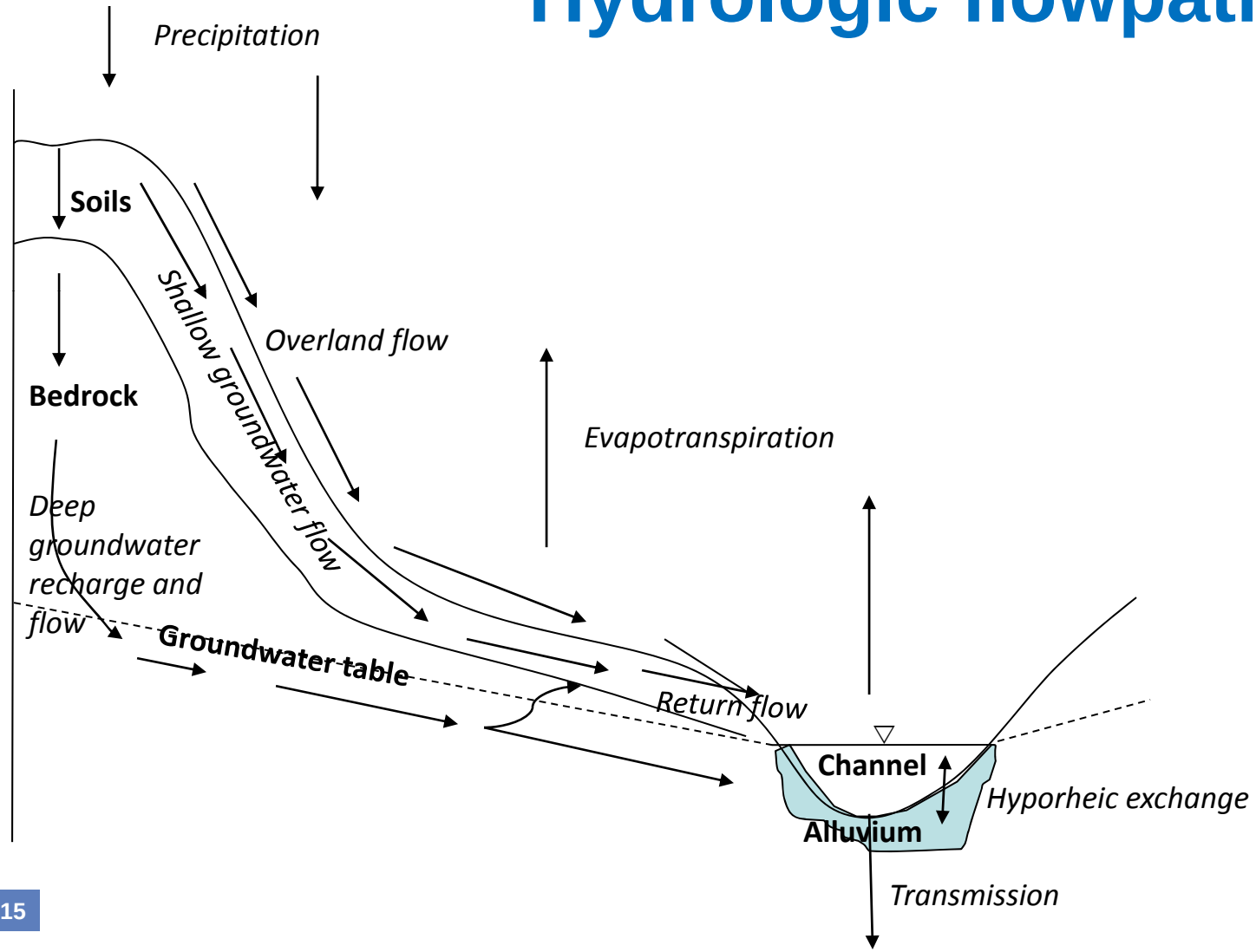
Drainage area: 89.4 ha
Slope: 2.3%
D_{50}: 64 mm (pebble-cobble)
Unconstrained
Riffle-pool



Hydrologic flowpaths



Expansion-contraction

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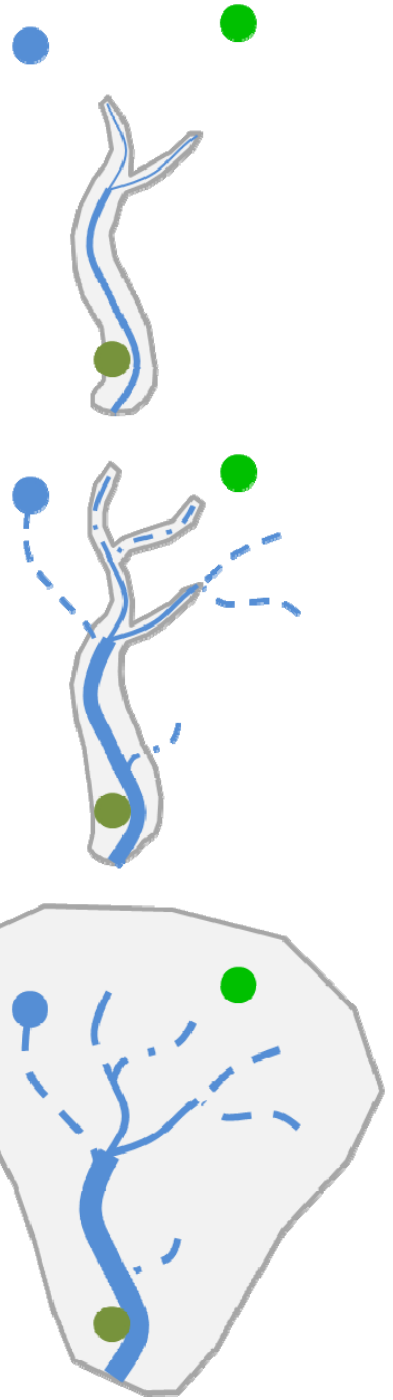
Gray = ground water contributing zone

- Perennial
- Intermittent
- Ephemeral
- Seep spring
- Isolated wetland
- Adjacent wetland



Expansion-contraction

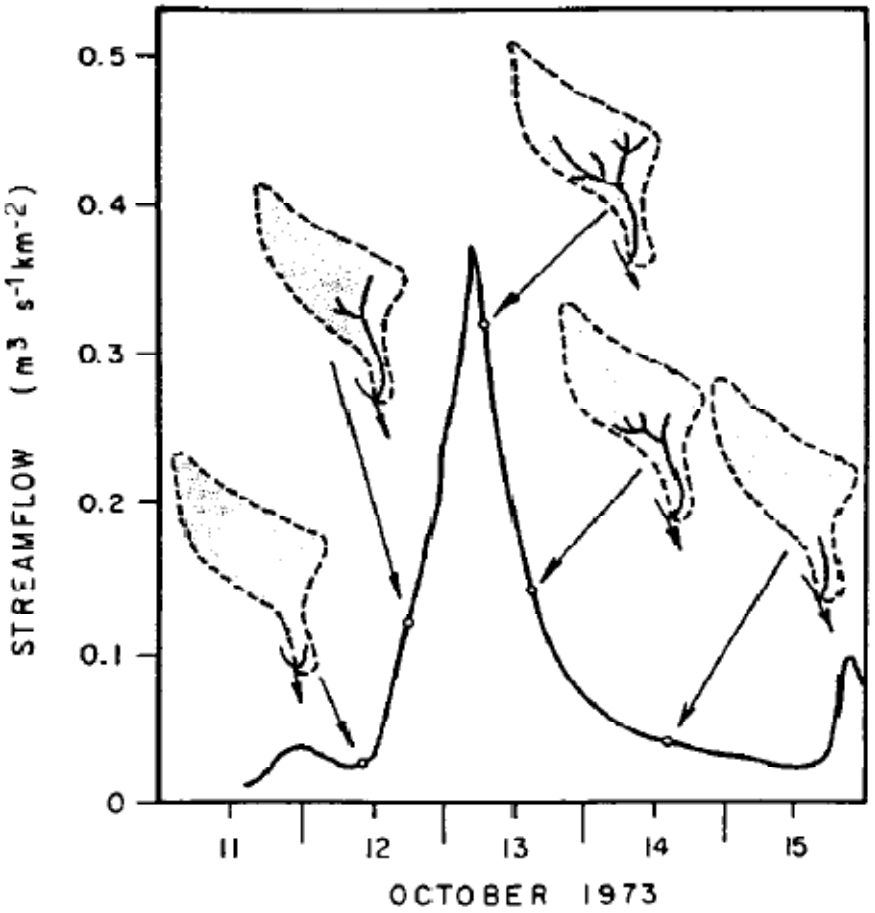


Fig. 4. A stormflow hydrograph of Jamieson Creek and the measured changes in the stream channel network of a subwatershed during a rainfall runoff event in October, 1973.

Hydrograph mapped w/ extent of flowing channel.

Southwestern British Columbia, drainage area : 300 ha (~1 mi^2)

(from Cheng 1988)

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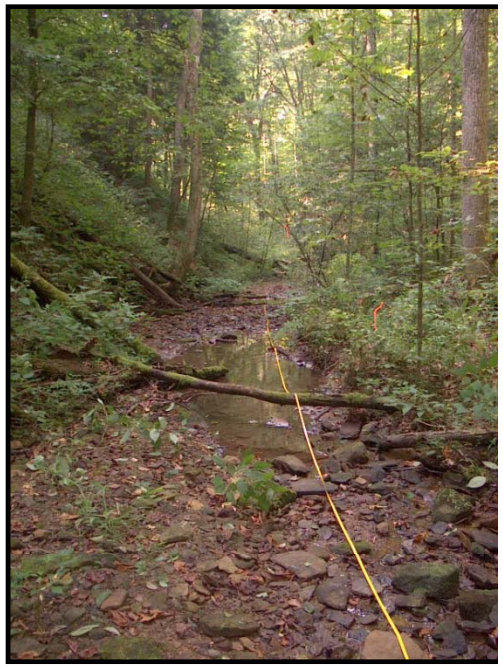
Hydrologic Permanence

- Ephemeral, intermittent & perennial
- But permanence varies continuously (rather than categorically) in frequency, duration & timing
- Interannual variation
- Longitudinal gradient, but can be discontinuous over space
- Surface and subsurface
- Direct and indirect methods to characterize



Electrical resistance data

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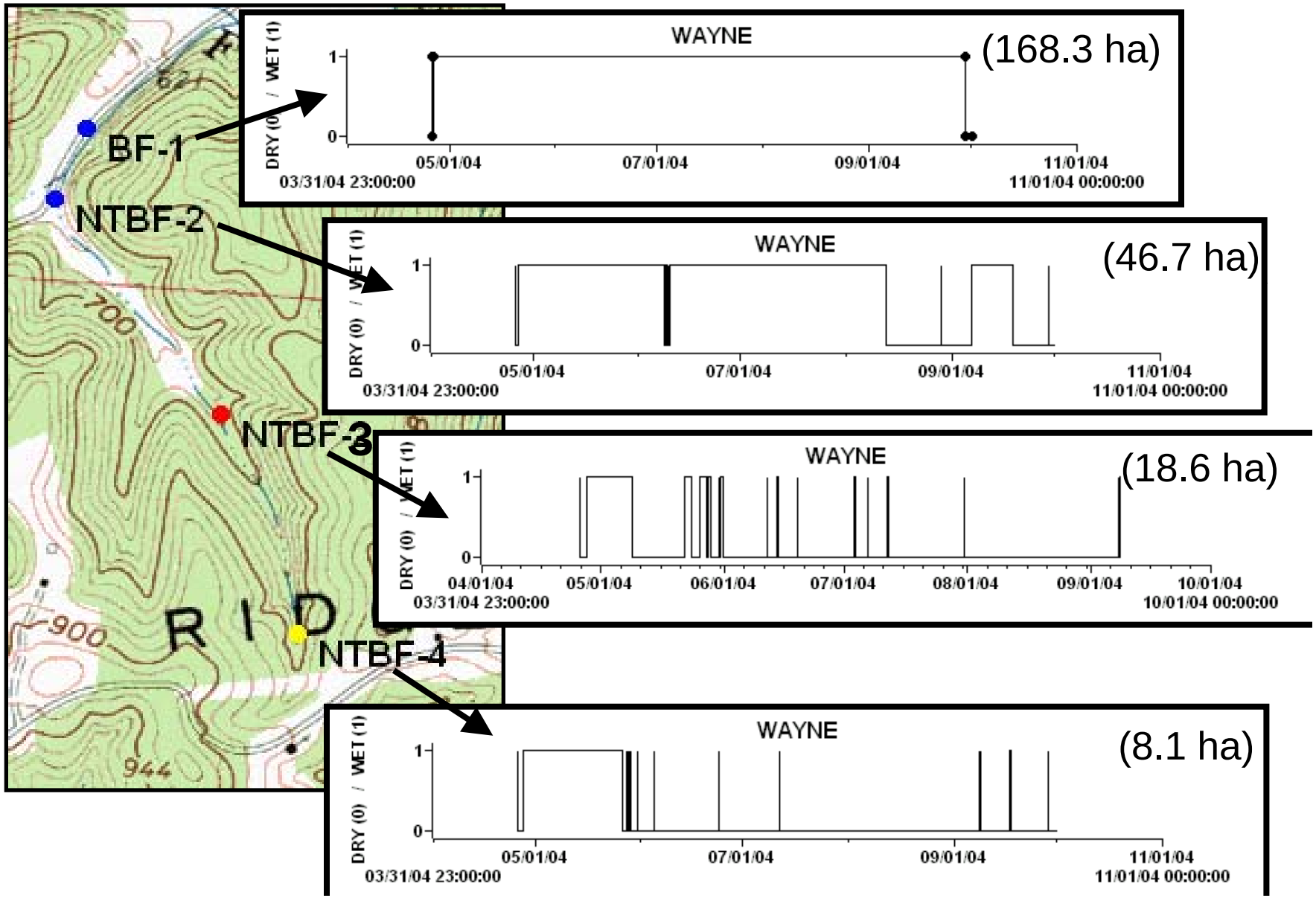
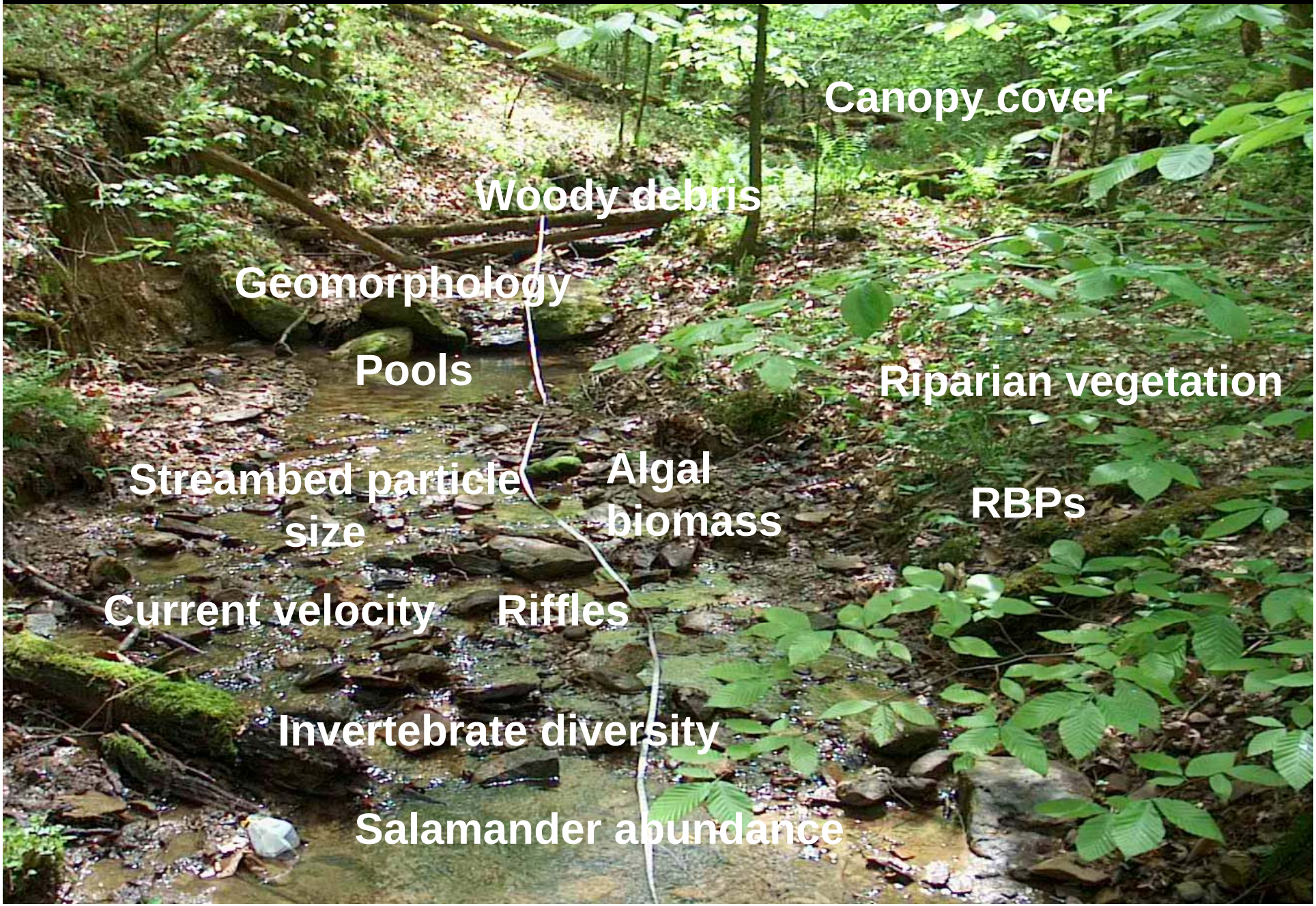
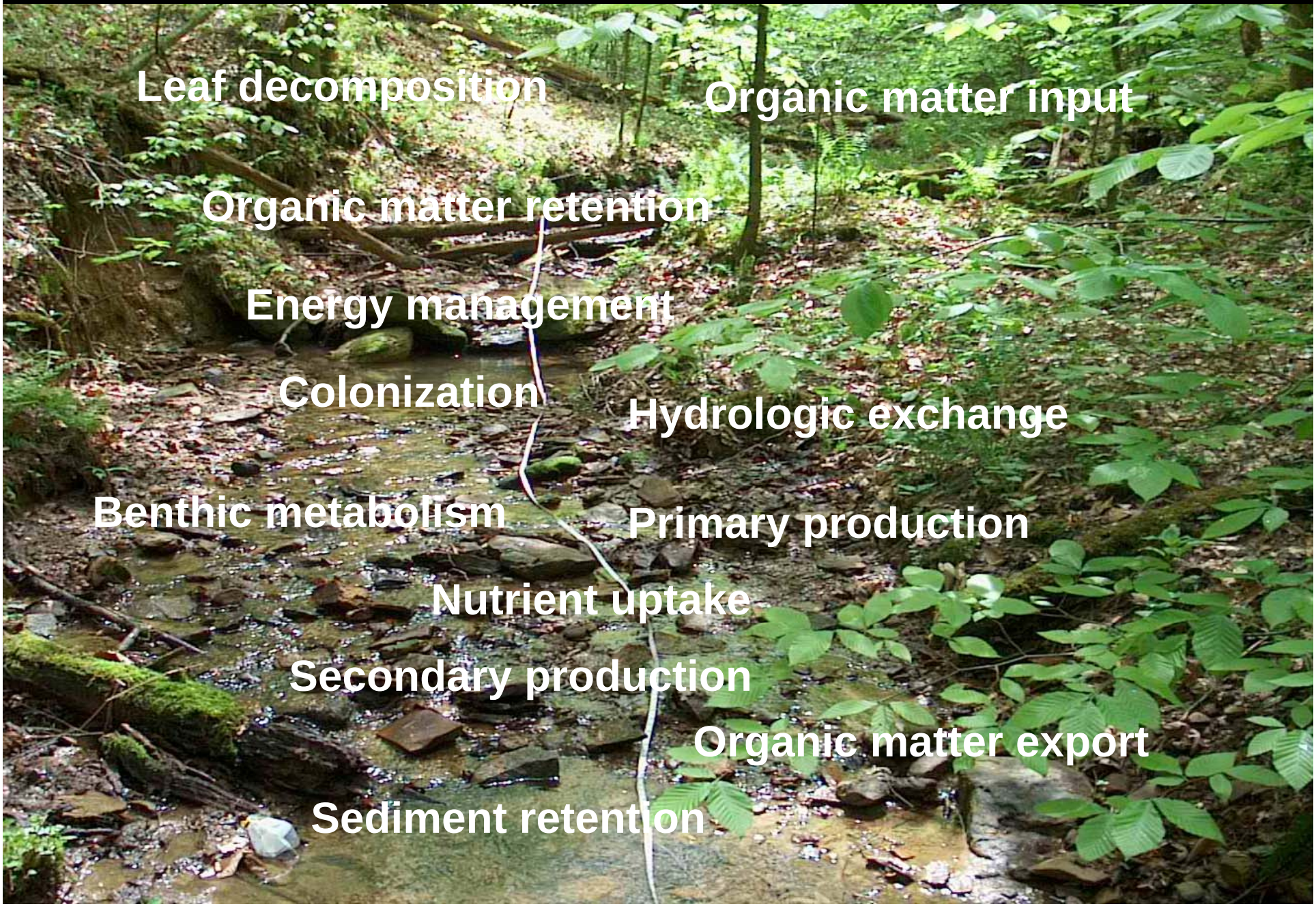


Structural Measures of Stream Condition



Functional Measures of Stream Condition



What do Appalachian headwater streams do?

Intimately linked to hillslopes
Represent sources to the network

- Supply water
- Store, transform and transport organic matter/energy (metabolism & production)
- Store and transport sediment
- Store, transform & transport nutrients
- Buffer water temperature

Not necessarily continuously
Cumulatively over time & space

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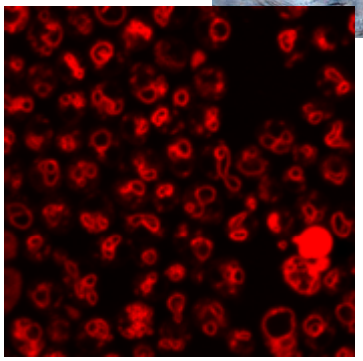
How to measure the vitals?



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