

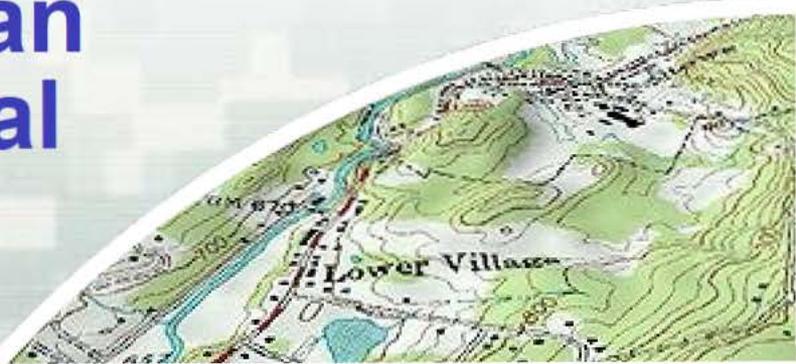
Hydrogeomorphic (HGM) Functions in Appalachian Headwater and Perennial Streams

United States Army Corps of
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Functions in Streams

- 1) Hydrology
- 2) Biogeochemical cycling
- 3) Habitat



Function 1

Hydrology

- Definition: the ability of a stream to dissipate energy associated with flow velocity and transport water downstream



Rationale

- Water transport and energy dissipation are fundamental functions of streams
- Affects the amount of sediment, organic matter and nutrients transported downstream



Effects of Hydrology

- Hydrologic alterations increase runoff and bank erosion, increasing sediment in channel
- Stream energy affects movement of materials downstream
- Excess sediment reduces habitat
 - ▶ Macroinvertebrates
 - ▶ Amphibians
 - ▶ Fish



Influences to Hydrology

- Natural conditions:
 - Climate
 - Geomorphic characteristics
 - Soil

- Anthropogenic alterations to watershed and riparian areas
 - Logging
 - Urban development
 - Agriculture
 - Grazing
 - Filling
 - Road building
 - Removal of large woody debris



Variables for Hydrology Function – Headwater Streams:

- Channel Substrate Embeddedness (V_{EMBED})
 - Channel Substrate Size ($V_{SUBSTRATE}$)
 - Channel Bank Erosion (V_{BERO})
- Indicators of degradation in the channel
- Large Woody Debris (V_{LWD})
 - ▶ Affects flow and dissipation of stream energy
 - Watershed Land-use (V_{WLUSE})
 - ▶ Affect timing and delivery of water to the channel



Hydrology Functional Capacity Index – Headwater Streams

$$FCI = \left\{ \frac{V_{WLUSE} + \left[\frac{V_{LWD} + \min(V_{SUBSTRATE}, V_{EMBED}, V_{BERO})}{2} \right]}{2} \right\}$$

Water inputs from surrounding watershed

Large woody debris in the riparian/buffer zone

Channel indicators of hydrology



Variables for Hydrology Function – Perennial Streams:

- Streambank Stability ($V_{BANKSTAB}$)
 - ▶ If banks are not excessively eroded, channel flow, sediment transport and stream energy are likely appropriate
- Channel Substrate Size ($V_{SUBSTRATE}$)
 - ▶ Indicator of degradation in channel
- Channel Substrate Embeddedness (V_{EMBED})



Hydrology Functional Capacity Index – Perennial Streams

$$FCI = \left\{ \frac{V_{BANKSTAB} + \min(V_{EMBED}, V_{SUBSTRATE})}{2} \right\}$$

Bank conditions

Hydrologic impacts to
channel substrate



Function 2

Biogeochemistry

- Definition: ability of stream to retain and transform inorganic materials into organic forms and oxidize back into elemental forms through respiration and decomposition
- Includes activities of
 - ▶ Producers
 - ▶ Consumers
 - ▶ Decomposers



Rationale

- Supply of organic carbon maintains plant community
 - ▶ Primary productivity
 - ▶ Species composition
- Plant community provides food and structure for animal community
- Decomposers break down these organic materials, which reenter the nutrient cycle



Biogeochemistry: Processes

- 4 components of carbon cycle
 - ▶ Soil
 - ▶ Plants
 - ▶ Consumers (animals, fungi, bacteria)
 - ▶ Detritus
- Primary production sets the stage for all other processes



Influences to Biogeochemical Cycling

- Changes in vegetative cover
 - ▶ Amount of detritus
 - ▶ Temperature
 - ▶ Nutrients in soil
- Hydrologic alterations
 - ▶ Plant community
 - ▶ Nutrient delivery to channel
- Other alterations
 - ▶ Deposition of fill
 - ▶ Excavation
 - ▶ Fire



Variables for Biogeochemical Cycling Function – Headwater Streams:

- Channel Substrate Embeddedness (V_{EMBED})
- Large Woody Debris (V_{LWD})
- Riparian/Buffer Zone Tree Diameter (V_{TDBH})
- Riparian/Buffer Zone Soil Detritus ($V_{DETRITUS}$)
- Watershed Land-use (V_{WLUSE})
- Riparian/Buffer Zone Sapling/Shrub Density (V_{SSD})
- Riparian/Buffer Zone Herbaceous Cover (V_{HERB})

Only for streams with <20% canopy cover



Biogeochemical Cycling Functional Capacity Index – Headwater Streams

Streams with $\geq 20\%$ canopy cover:

$$FCI = \left\{ V_{EMBED} \times \left[\frac{\left(\frac{V_{LWD} + V_{DETRITUS} + V_{TDBH}}{3} \right) + V_{WLUSE}}{2} \right] \right\}^{1/2}$$

Nutrient retention
in channel

Nutrient inputs and
long-term retention

Inputs from
watershed

Streams with $< 20\%$ canopy cover:

$$FCI = \left\{ V_{EMBED} \times \left[\frac{\left(\frac{V_{LWD} + V_{DETRITUS} + V_{SSD} + V_{HERB}}{4} \right) + V_{WLUSE}}{4} \right] \right\}^{1/2}$$



Variables for Biogeochemical Cycling Function – Perennial Streams:

- Channel Substrate Embeddedness (V_{EMBED})
- Channel Substrate Size ($V_{SUBSTRATE}$)
- Channel Canopy Cover ($V_{CCANOPY}$)
- Riparian/Buffer Zone Tree Density (V_{TDEN})



Biogeochemical Cycling Functional Capacity Index – Perennial Streams

$$FCI = \left\{ \frac{\min(V_{EMBED}, V_{SUBSTRATE}) + \min(V_{CCANOPY}, V_{TDEN})}{2} \right\}$$

Nutrient retention
in channel

Nutrient inputs and
retention



Function 3: Habitat

Definition:

- The capacity of a stream ecosystem to provide critical life requisites to selected components of the vertebrate and invertebrate wildlife communities



Rationale:

- Species found in and around streams often are unique and not found in other ecosystems
- Responsible for secondary productivity and energy flows among trophic levels



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Impacts to the Wildlife Community Influence:

- Secondary productivity
- Carbon and nutrient export/transport
- Biological diversity including richness and evenness of the animal community itself and of the plant community
 - ▶ Patch level
 - ▶ Landscape level
- Trophic level processes



Impacts to Wildlife

- Hydrologic alteration
 - ▶ Scouring decreases habitat availability
 - ▶ Increases in fine sediment inhibit respiration
 - ▶ Turbidity slows primary production
 - ▶ Increased flows wash away fish eggs and young



Impacts to Wildlife (cont.)

- Channel vegetative cover
 - ▶ Water temperature and light levels
 - ▶ Detritus inputs to channel
 - Food availability
 - Breeding sites
 - Refugia

- Riparian and watershed vegetation
 - ▶ Amphibian habitat and dispersal
 - ▶ Erosion and sedimentation reduction



Variables for Habitat Function – Headwater Streams:

- Channel Canopy Cover ($V_{CCANOPY}$)
- Channel Substrate Embeddedness (V_{EMBED})
- Channel Substrate Size ($V_{SUBSTRATE}$)
- Channel Bank Erosion (V_{BERO})
- Large Woody Debris (V_{LWD})
- Riparian/Buffer Zone Tree Diameter (V_{TDBH})



Variables for Habitat Function – Headwater Streams (cont.):

- Riparian/Buffer Zone Snag Density (V_{SNAG})
- Riparian/Buffer Zone Vegetation Species Richness (V_{SRICH})
- Riparian/Buffer Zone Soil Detritus ($V_{DETRITUS}$)
- Watershed Land-use (V_{WLUSE})
- Riparian/Buffer Zone Herbaceous Cover (V_{HERB})
- Riparian/Buffer Zone Sapling/Shrub Density (V_{SSD})

Only for
streams with
<20% canopy
cover



Habitat Functional Capacity Index – Headwater Streams

Streams with $\geq 20\%$ canopy cover:

$$FCI = \left\{ \left[\frac{V_{CCANOPY} + \min(V_{EMBED}, V_{SUBSTRATE})}{2} \right] \times \left\{ \frac{\left(\frac{V_{LWD} + V_{DETRITUS}}{2} \right) + \left[\frac{(V_{SNAG} + V_{TDBH} + V_{SRICH})}{3} + V_{WLUSE} \right]}{2} \right\} \right\}^{1/2}$$

Channel characteristics

Riparian condition and seral stage

Watershed condition



Habitat Functional Capacity Index – Headwater Streams (cont.)

Streams with <20%
canopy cover:

$$FCI = \left\{ \min(V_{EMBED}, V_{SUBSTRATE}) \times \left[\frac{\left(\frac{V_{LWD} + V_{DETRITUS}}{2} \right) + \left[\frac{V_{SNAG} + V_{SSD} + V_{HERB} + V_{SRICH}}{6} \right] + V_{WLUSE}}{4} \right] \right\}^{1/2}$$

Channel
characteristics

Riparian condition
and seral stage

Watershed
condition



Variables for Habitat Function – Perennial Streams:

- Channel Canopy Cover ($V_{CCANOPY}$)
- Channel Substrate Embeddedness (V_{EMBED})
- Channel Substrate Size ($V_{SUBSTRATE}$)
- Large Woody Debris (V_{LWD})
- Percent Forest (V_{FOREST})
- Riparian/Buffer Zone Tree Diameter (V_{TDBH})
- Coefficient of Conservatism (V_{CVALUE})



Habitat Functional Capacity Index – Headwater Streams

$$FCI = \left\{ \frac{V_{CANOPY} + \min(V_{EMBED}, V_{SUBSTRATE})}{2} \right\} \times \left\{ \frac{V_{LWD} + V_{FOREST} + \left(\frac{V_{DBH} + V_{CVALUE}}{2} \right)}{3} \right\}^{1/2}$$

Channel characteristics

Riparian and channel woody debris

Watershed condition

Riparian/buffer zone

- Species composition
- Seral stage



Questions?

