Broad-Scale Models

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GOAL

Predict Channel Characteristics in Space and Time

- Assess Potential for Fish Use and Productivity
- Assess Impacts of Land Use and Natural Disturbance

STRATEGY

Use Understanding of Watershed Processes
as a Guide for Empirical Models

- Identify Controls on Habitat Formation
- Determine Appropriate Data Structure – put available information to the best use

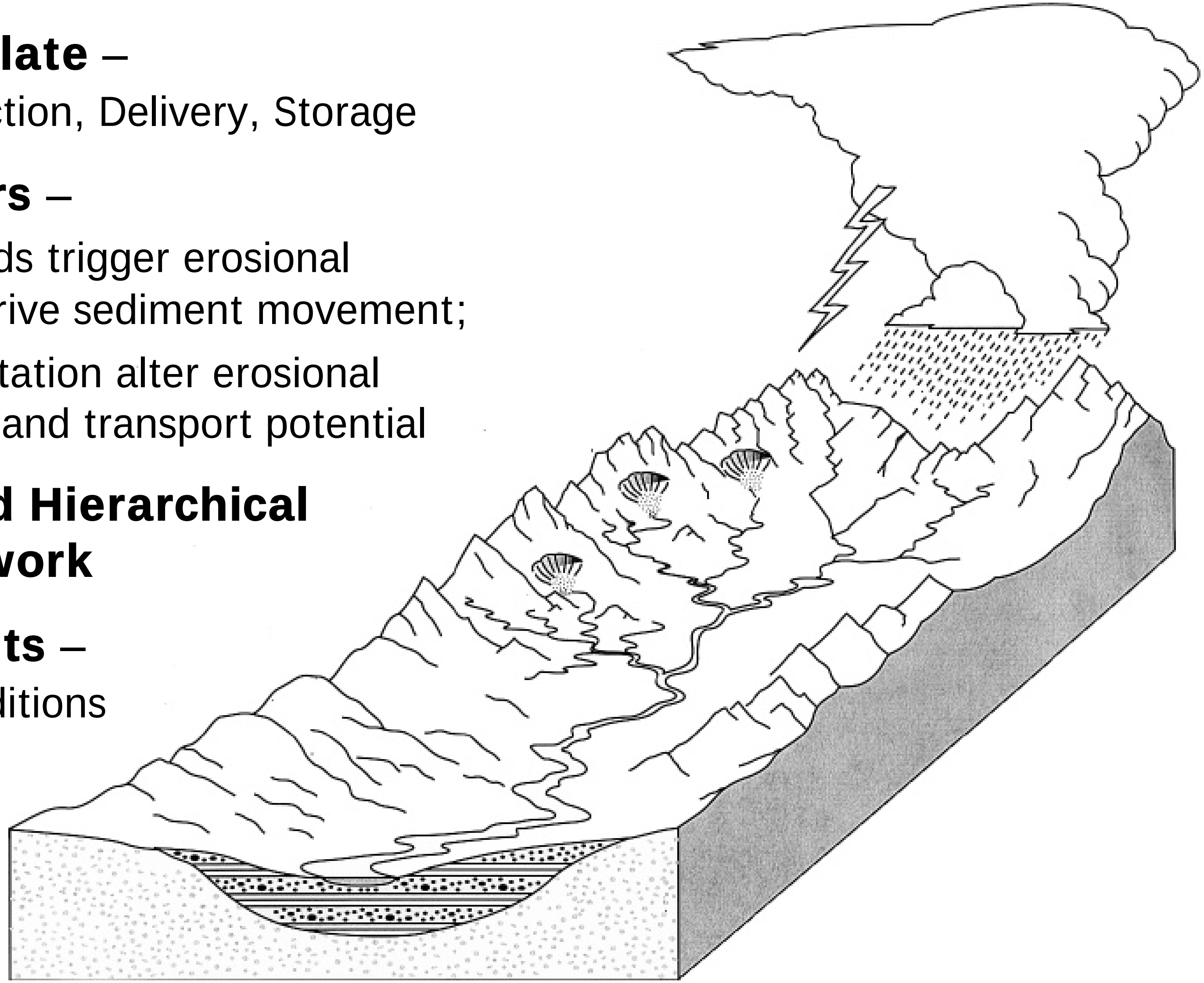
A Conceptual Framework for Process Interactions at the Watershed Scale

A Spatial Template –
Sediment Production, Delivery, Storage

Dynamic Drivers –
Storms and Floods trigger erosional events and drive sediment movement;
Changes in vegetation alter erosional susceptibility and transport potential

A Branched and Hierarchical Channel Network

History of Events –
Antecedent Conditions



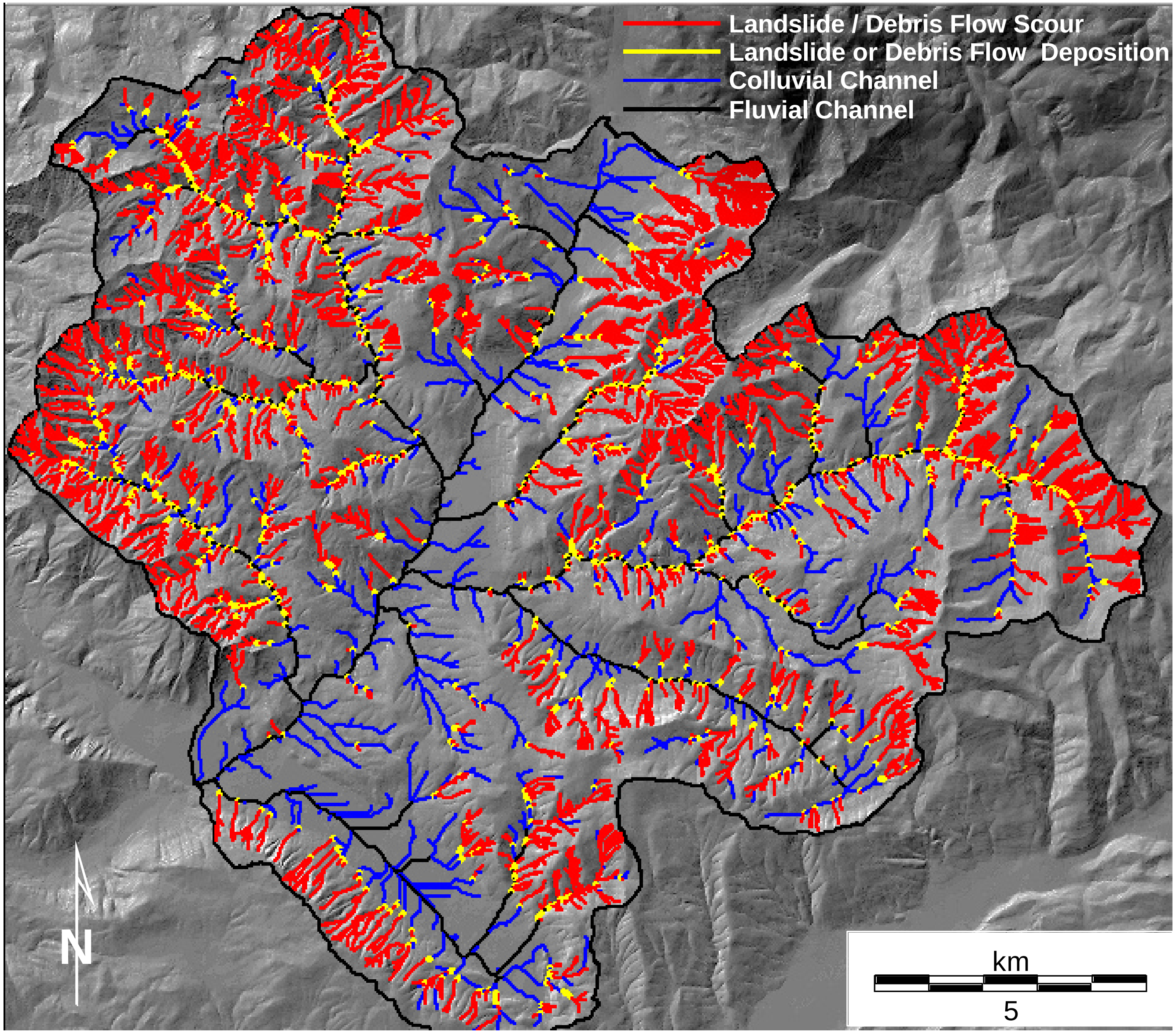
DEM-Derived Attributes: The Spatial Template

Hillslope

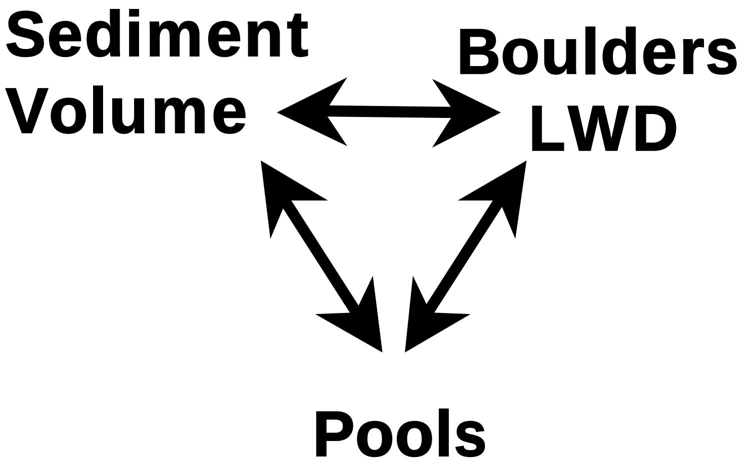
Gradient
Slope Form
Contributing Area
Hydrologic Response
Landslide Susceptibility
Debris Flow Routing

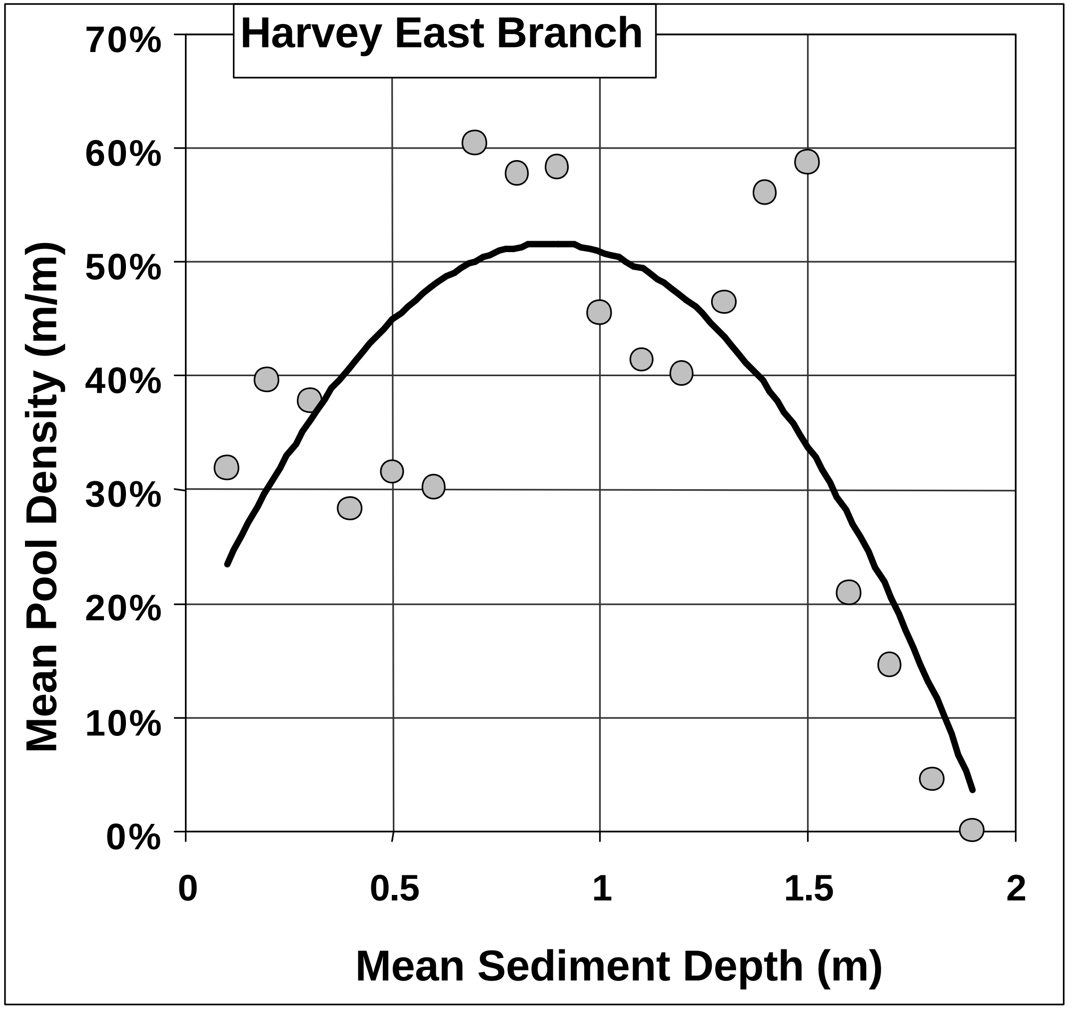
Channel

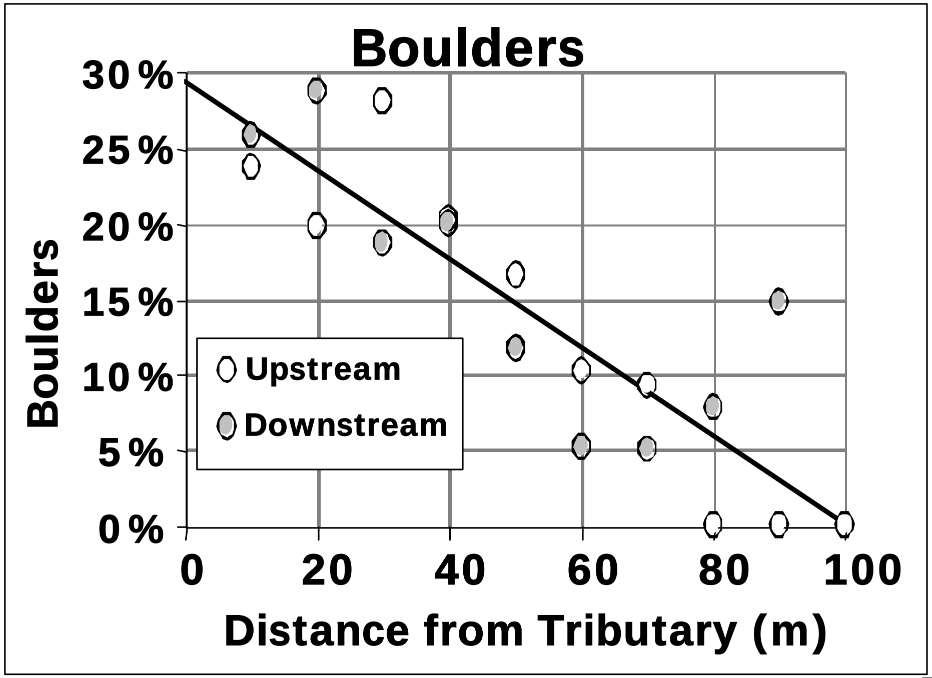
Drainage Area
Gradient
Valley Width
Tributary Junctions
Channel Type / Form
Debris Fan, Terrace

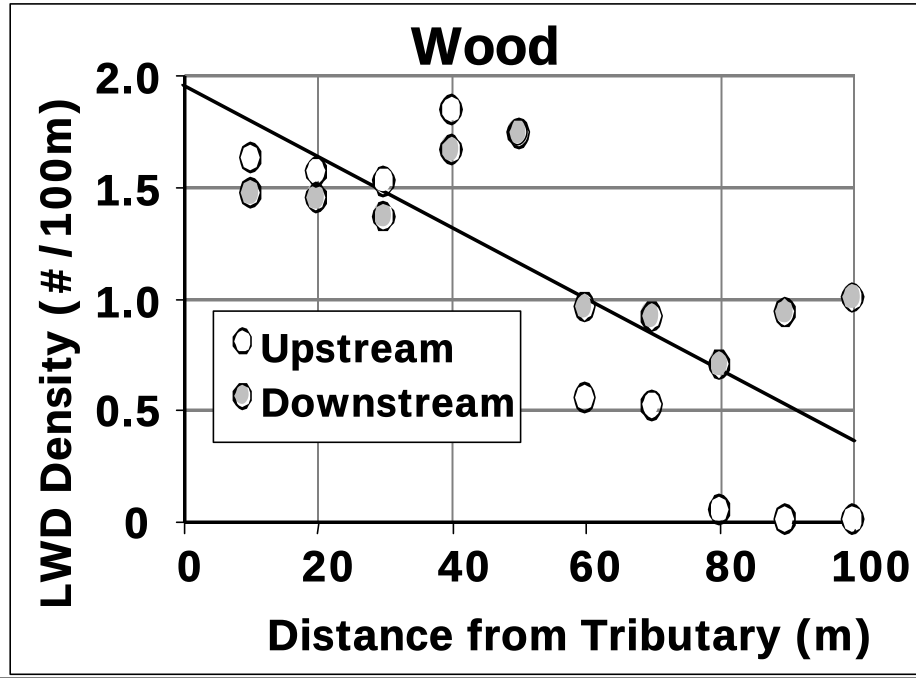


Estimate Habitat Attributes as Functions of Geomorphic Variables



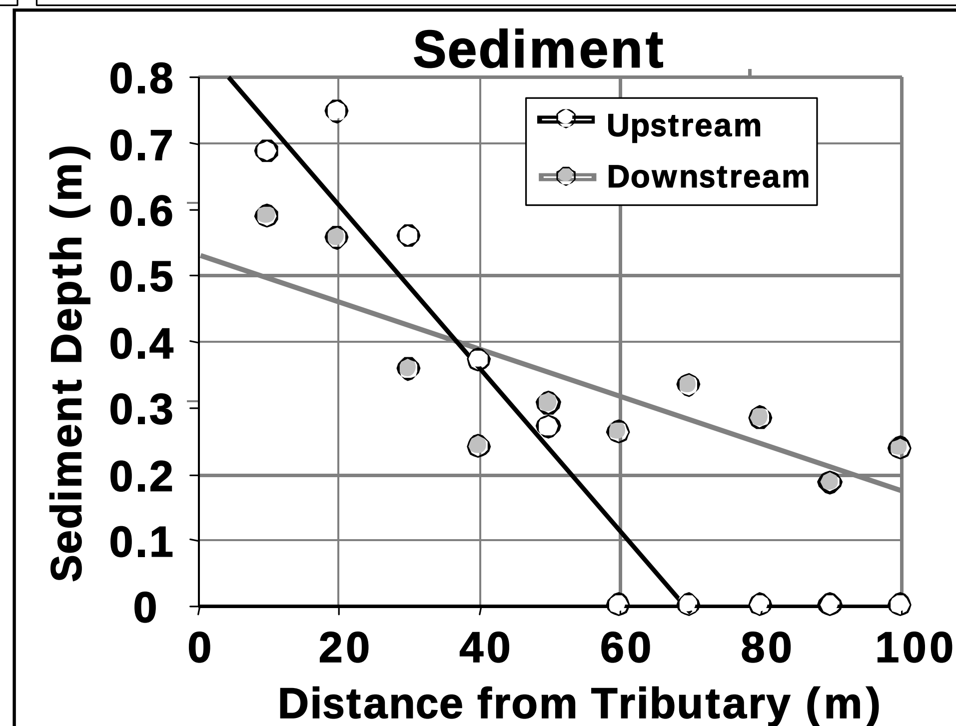




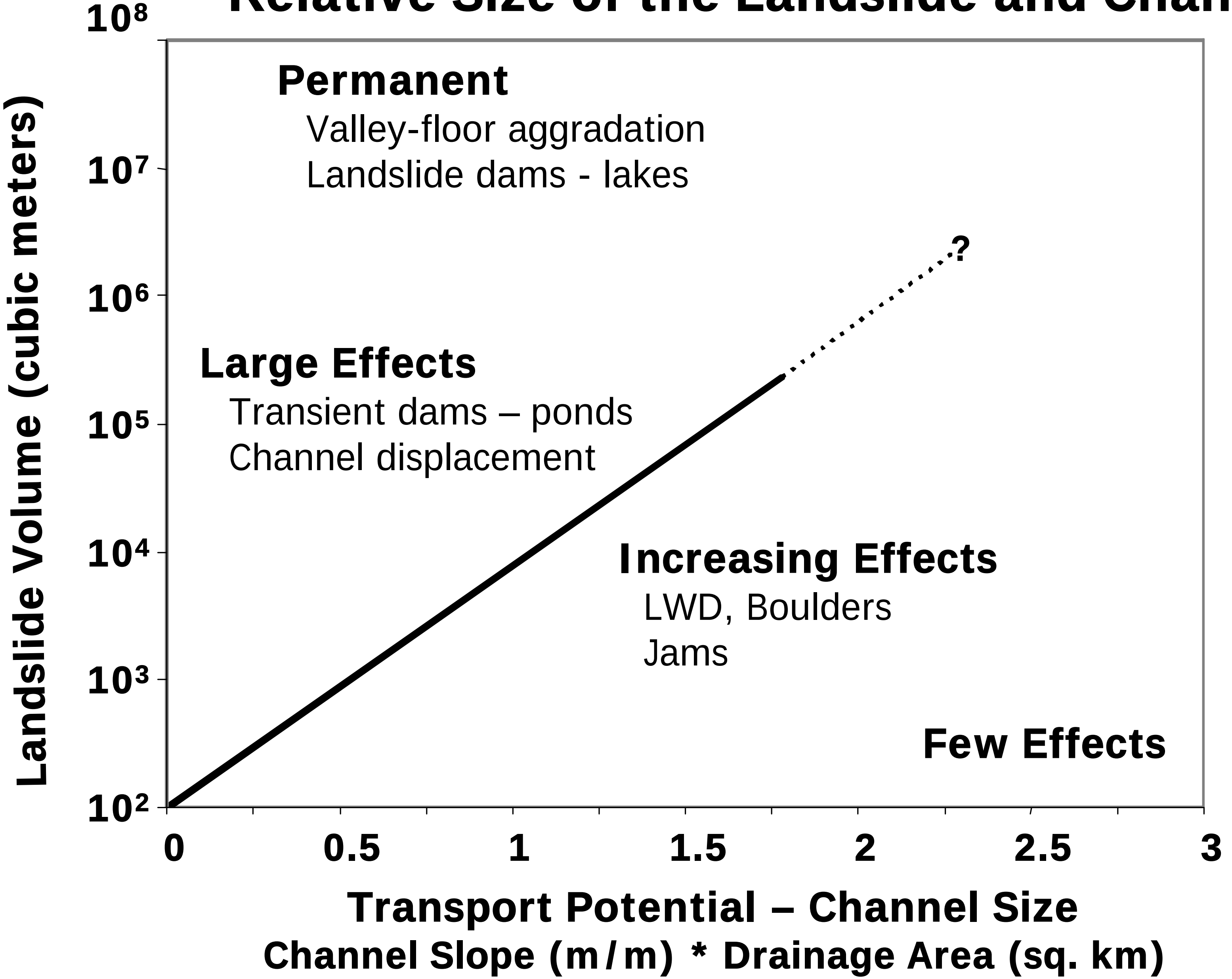


Spatial Controls on Channel Roughness

Boulders and LWD tend to be associated with debris fans at low-order tributary mouths – old debris flow deposits



Landslide Effects Determined by the Relative Size of the Landslide and Channel



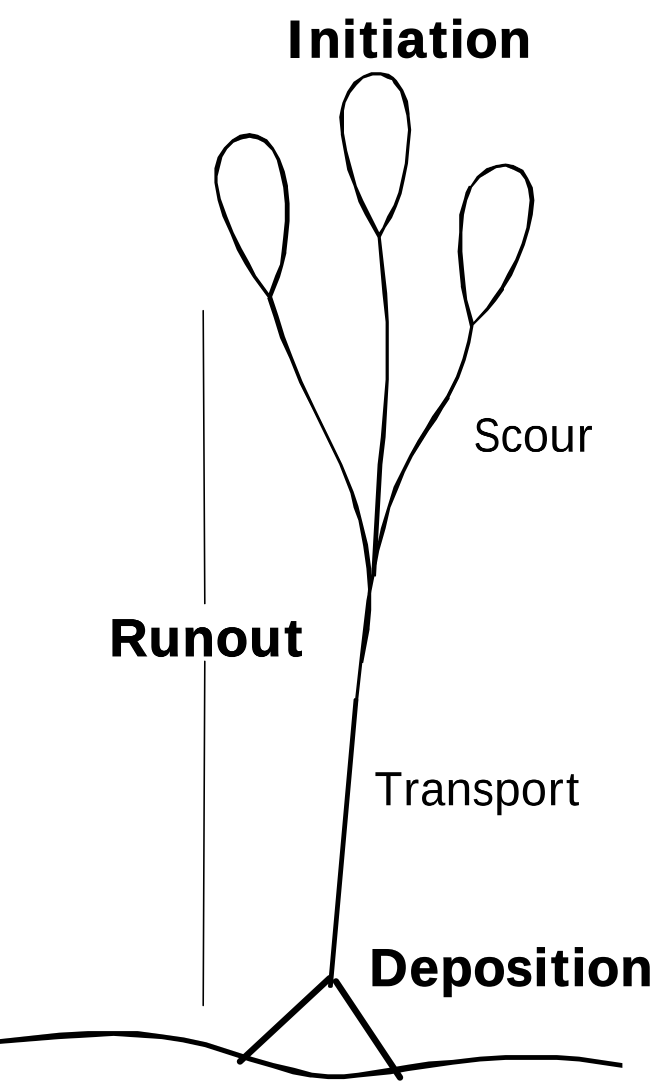
Channel Characteristics

- Sediment / LWD Inputs $\longrightarrow$ Landslides, Debris Flows
- Transport Potential $\longrightarrow$ Discharge $\propto$ Drainage Area
  Channel Gradient
- Storage Potential $\longrightarrow$ Valley Width

Basin Characteristics

- Assembly of channel and valley types (size, gradient, width)
- Size, network location, and spacing of debris-flow-prone tributaries

Debris Flows: Addressed in terms of Initiation, Runout, and Deposition



Landslide Occurrence

What factors affect landslide susceptibility?

- Balance of Forces
- Pore-Pressure Gradients
- Effective Soil Strength

Estimate probability of soil failure as a function of:

- Surface Gradient
- Specific Contributing Area

DEM

- Stand Type
- Forest Roads

Empirically calibrate against mapped landslide locations
(ODF 1996 storm study, Siuslaw National Forest 1996 landslide inventory)

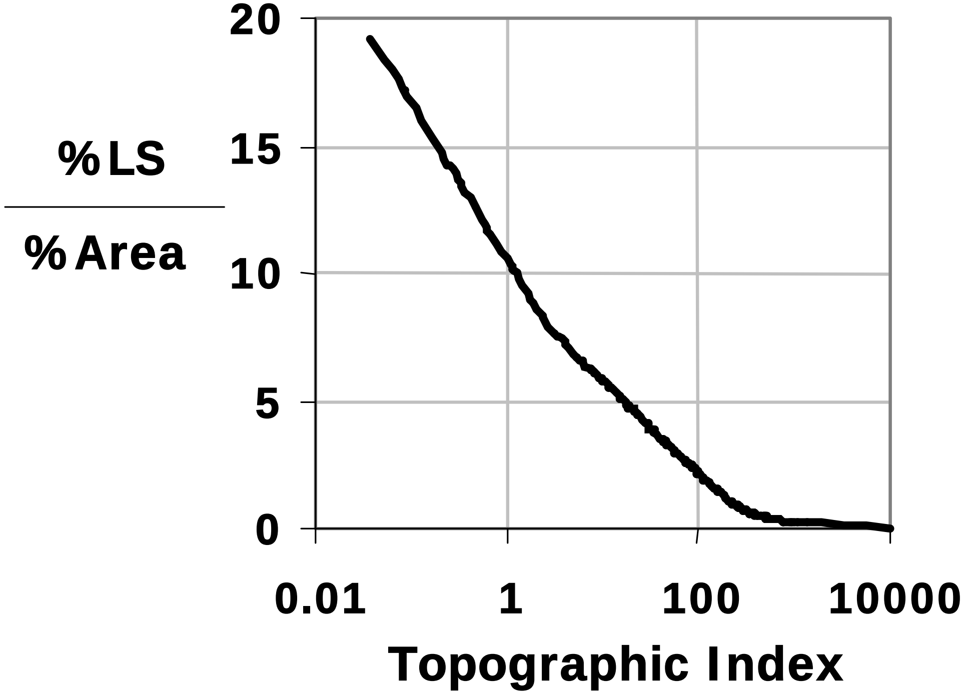
Landslide Susceptibility as a function of topography and vegetation cover

Define a Topographic Index of Landslide Susceptibility $= A^{-1}\sin(q)(1-\tan(q))$

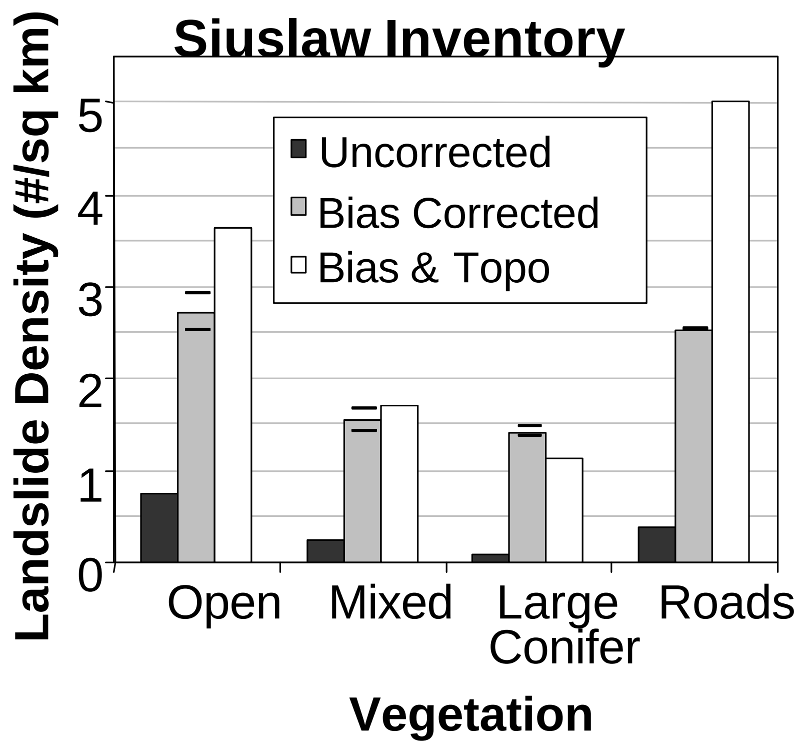
A^{-1} = specific contributing area

q = surface gradient

Normalized Landslide Density as a Function of the Index



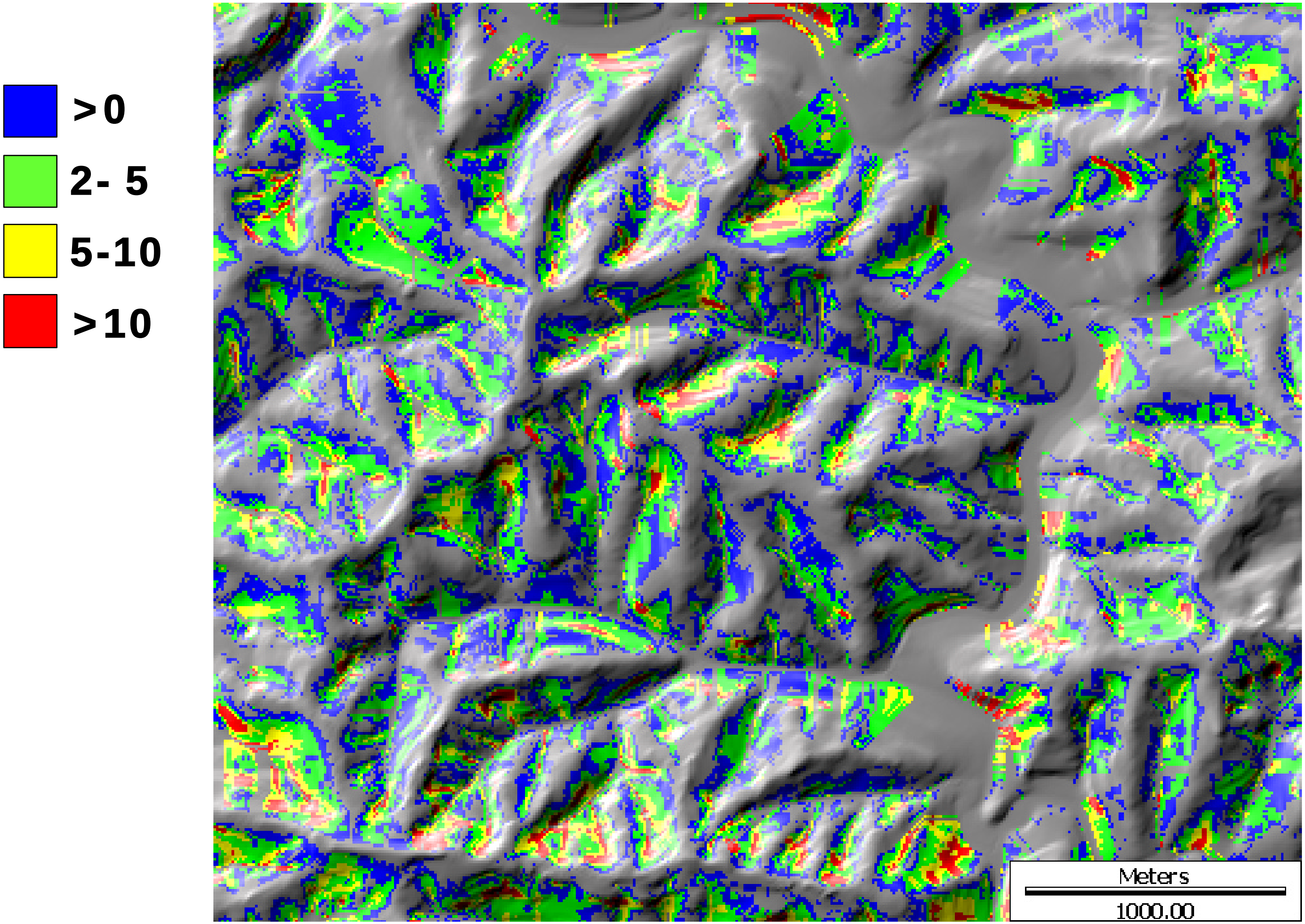
Mean Landslide Density as a Function of Vegetation Cover



Probable Landslide Density (# / km^2)

based on topography and stand-type

Calibrated to February, 1996 Storm; Knowles Creek Basin, OR



Debris Flow Runout

What factors affect runout distance?

- Gravitational acceleration
- Changes in mass
- Frictional deceleration and deposition

Estimate probability of runout to any point as a function of:

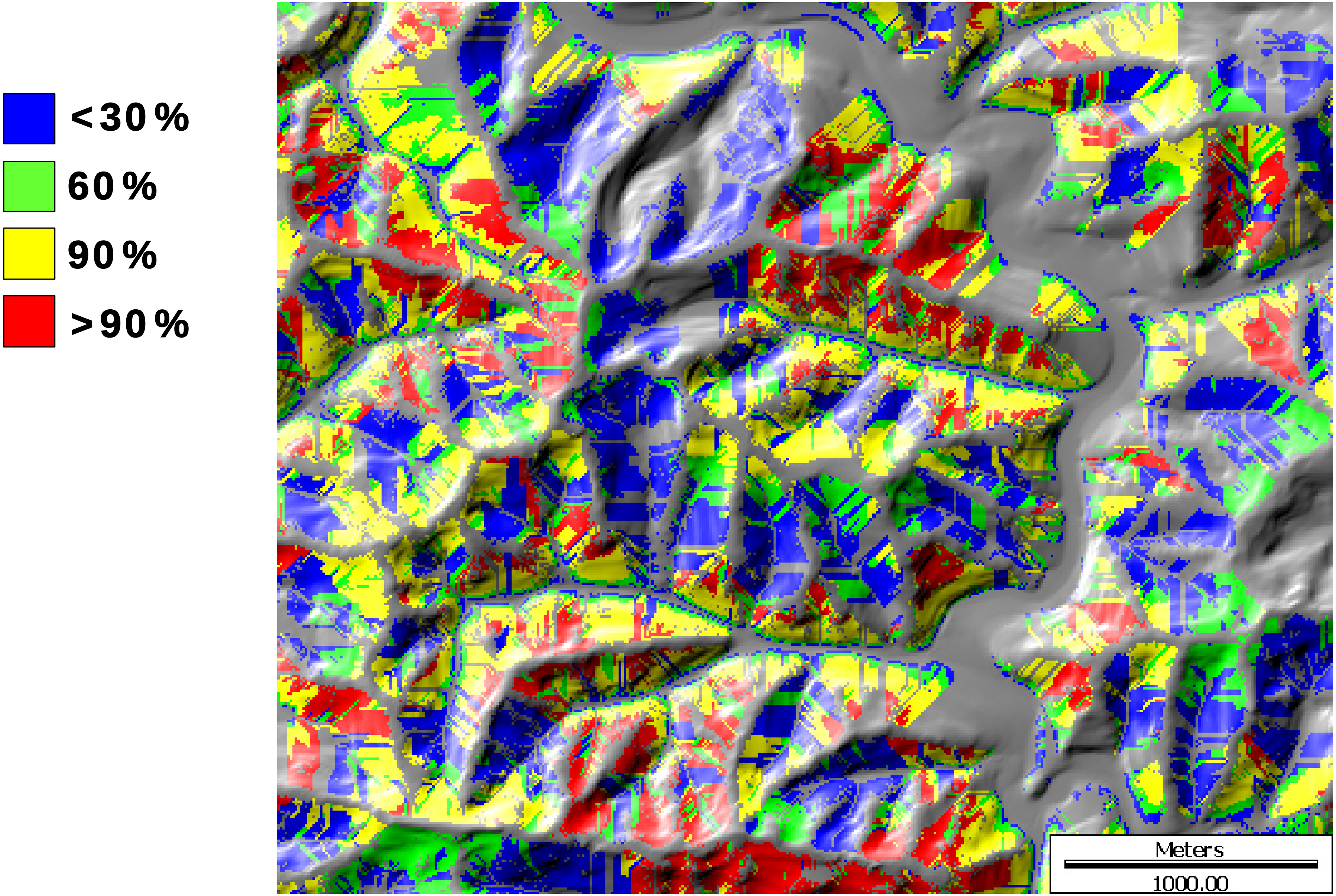
- Channel gradient
- Tributary junction angles
- Probable volume –
  using cumulative scour length as a proxy
- Riparian stand type

DEM

Empirically calibrate against mapped debris flow impacts
(ODF 1996 storm study)

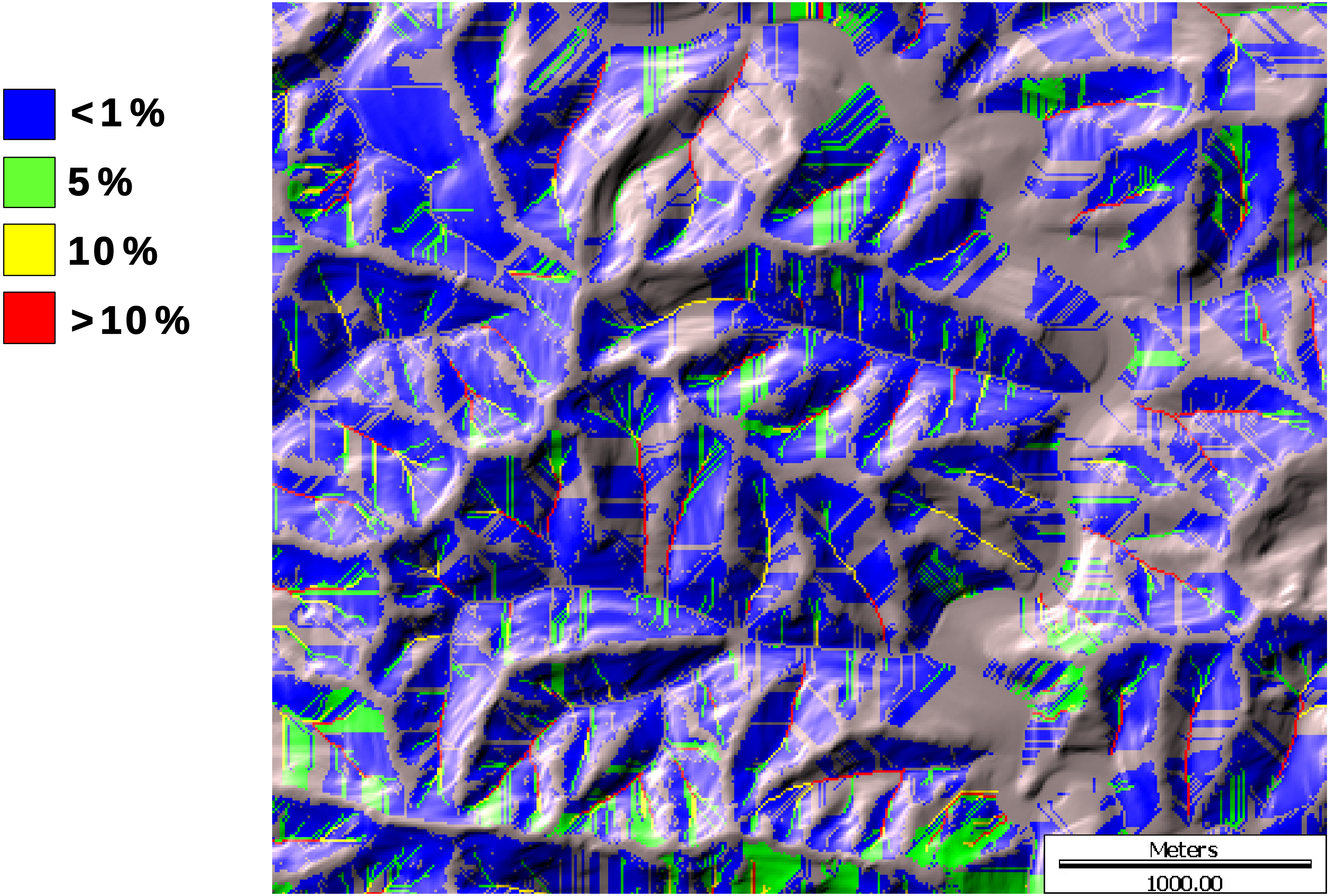
Probability of Delivery to a Fish-Bearing Channel based on gradient, scour length, tributary junction angles, and stand type

Calibrated to February, 1996 Storm; Knowles Creek Basin, OR



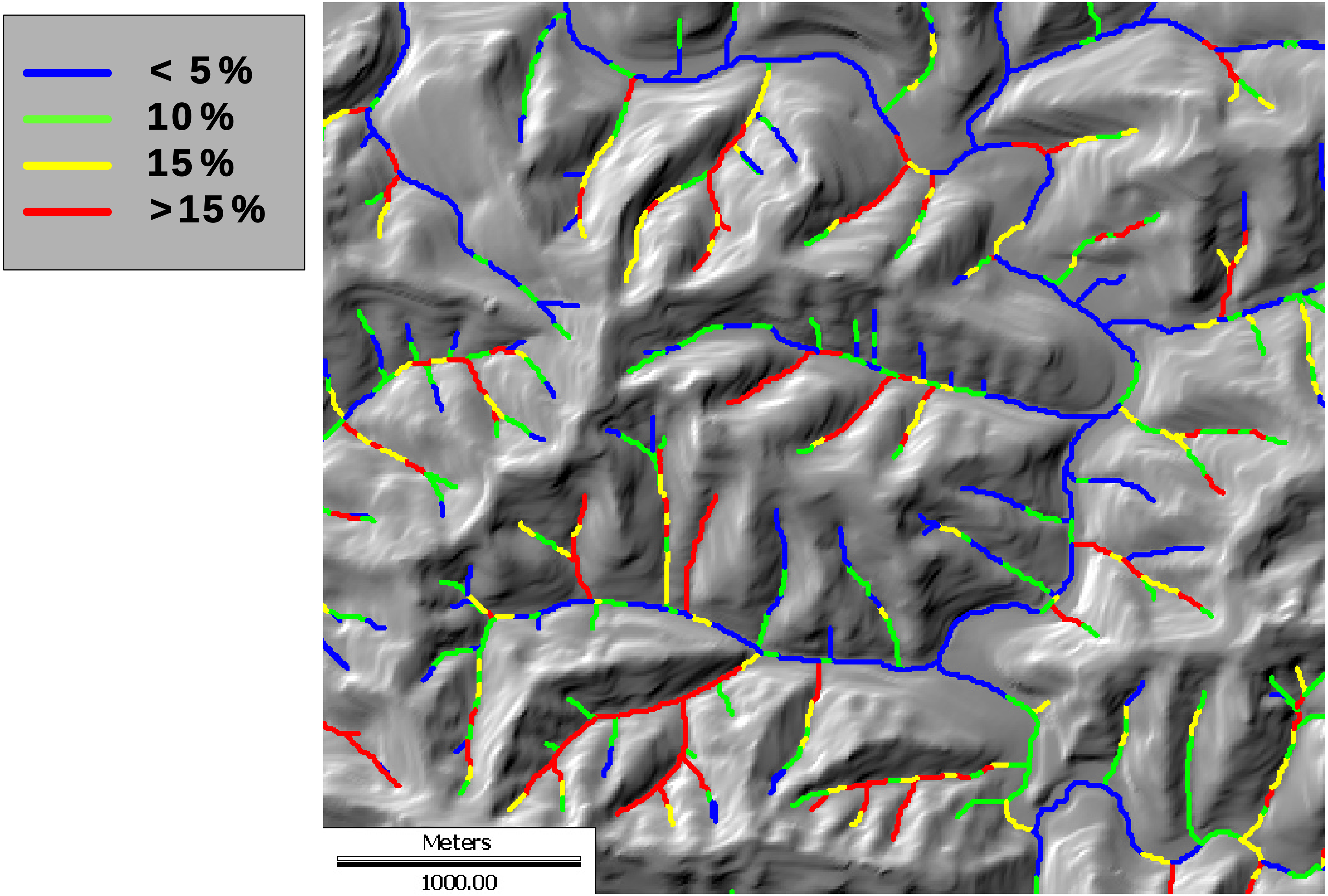
Probability of LWD Recruitment based on probability of upslope landsliding and delivery to a fish-bearing channel

Calibrated to February, 1996 Storm; Knowles Creek Basin, OR

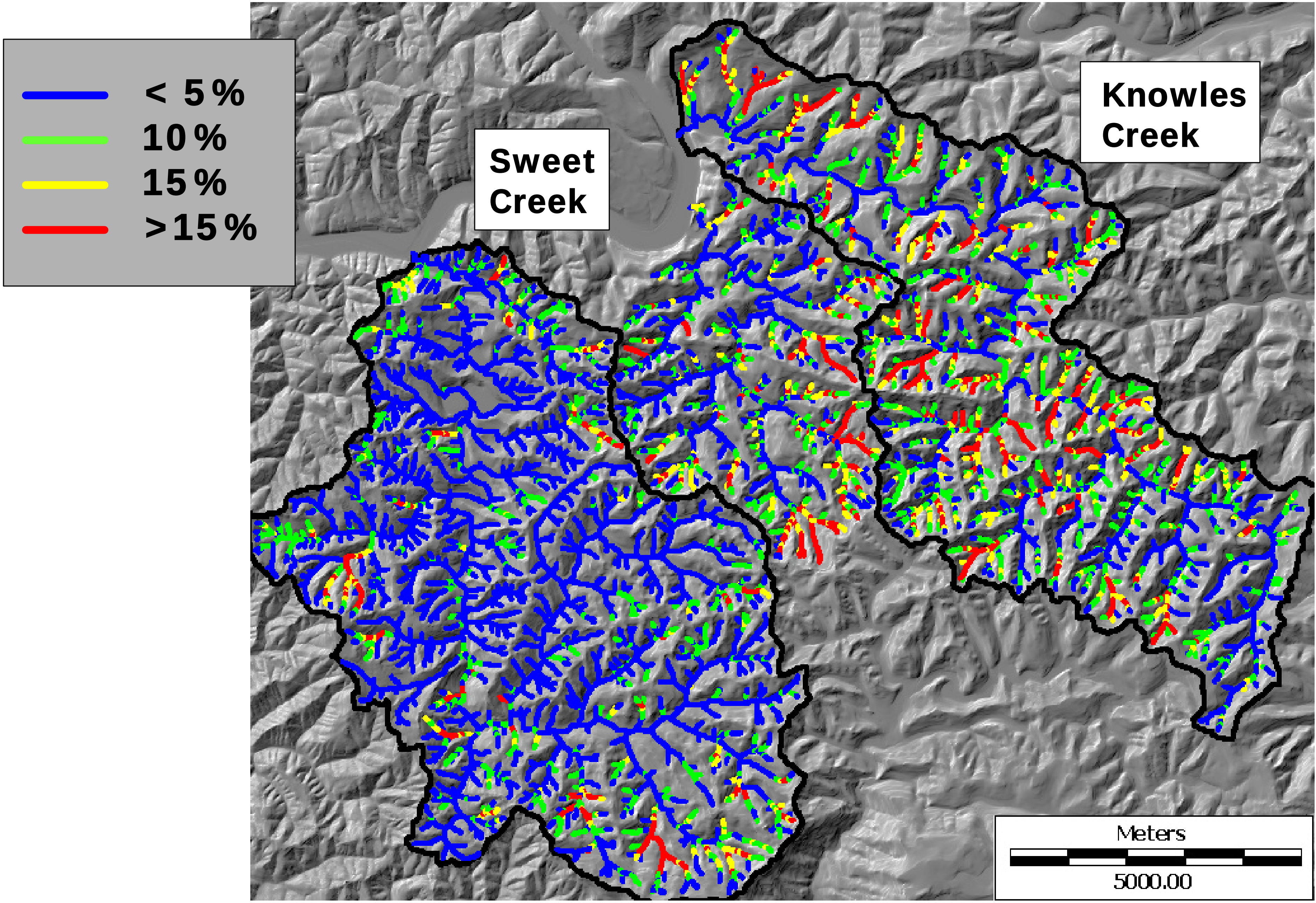


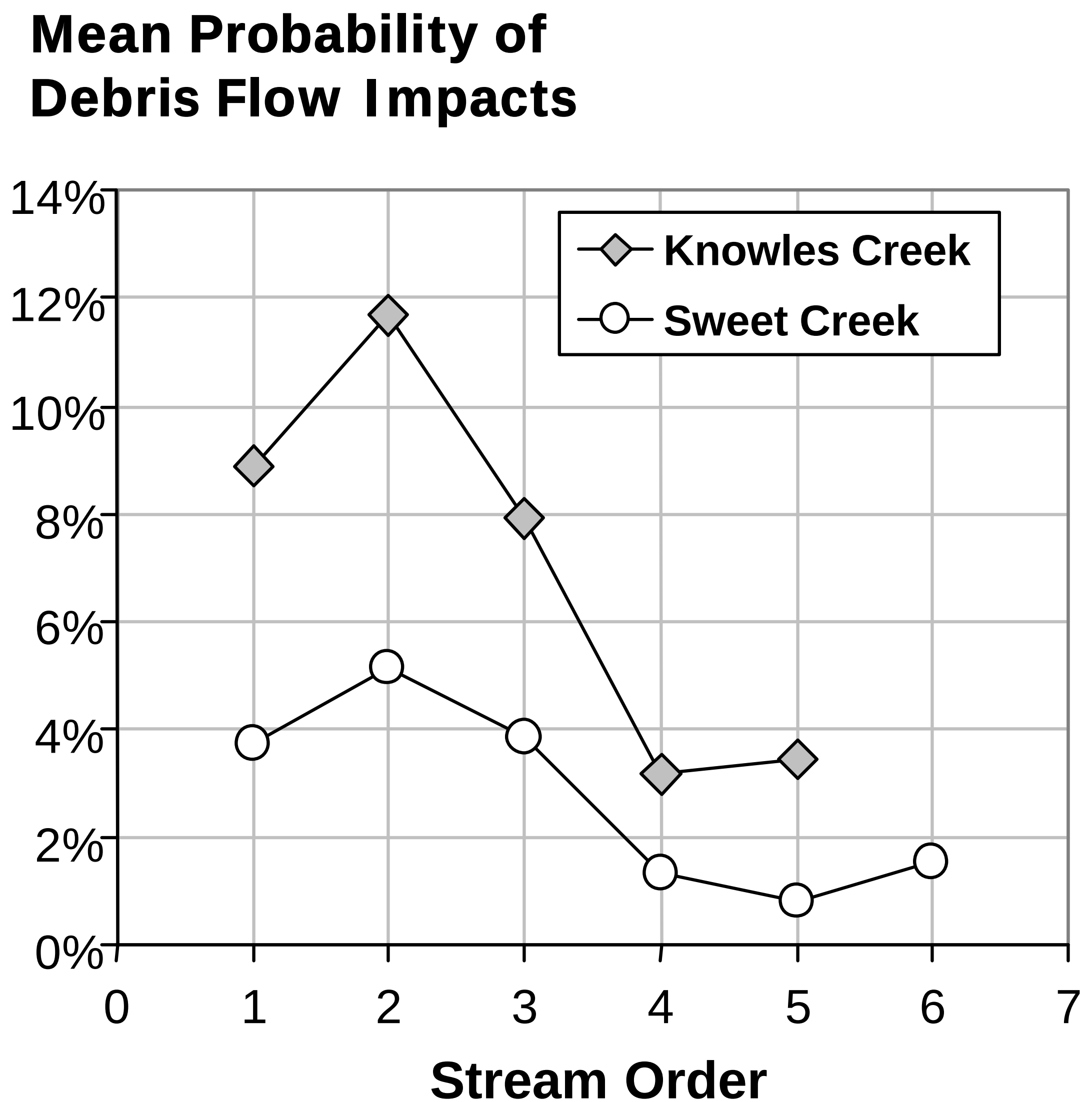
Probability of Direct in-channel Debris Flow Impacts

incorporating probability of initiation, transport, and deposition



Basin-Scale Heterogeneity in Debris Flow Probability



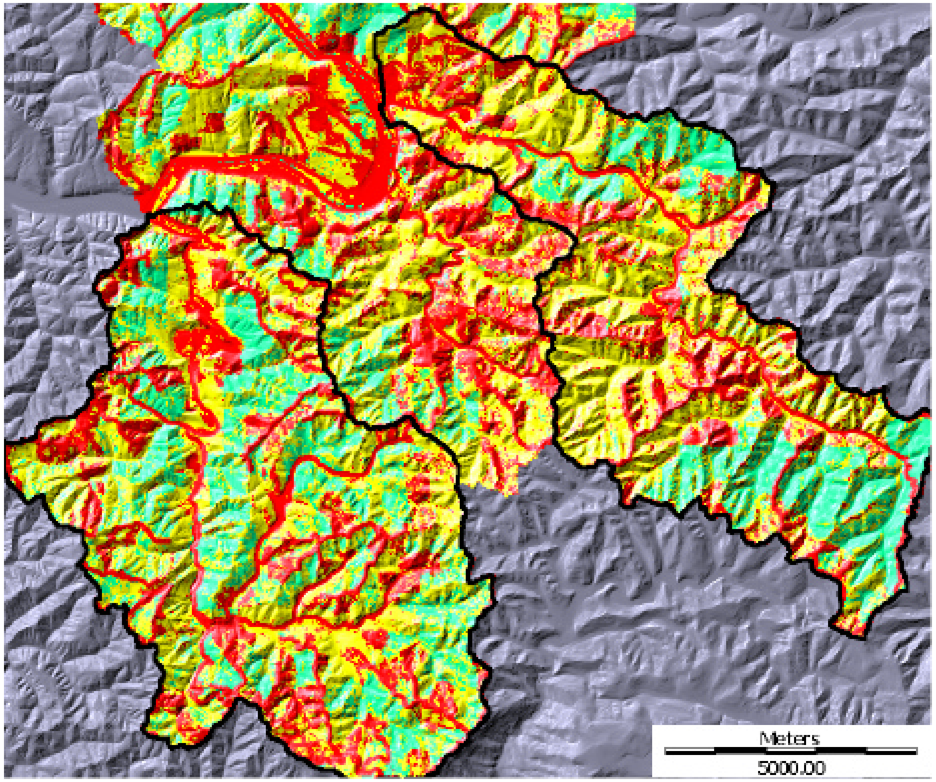


Greater probability of debris flow impacts at Knowles Creek

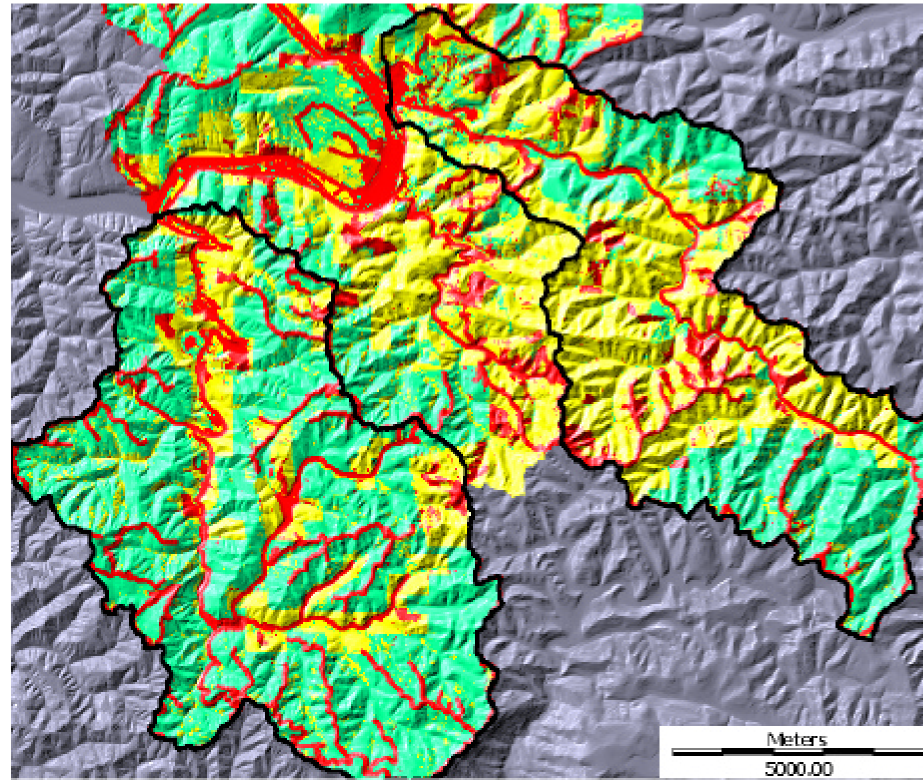
Low-order channels more prone to impacts than high-order channels

Vegetation Changes over Time

Current



100 years



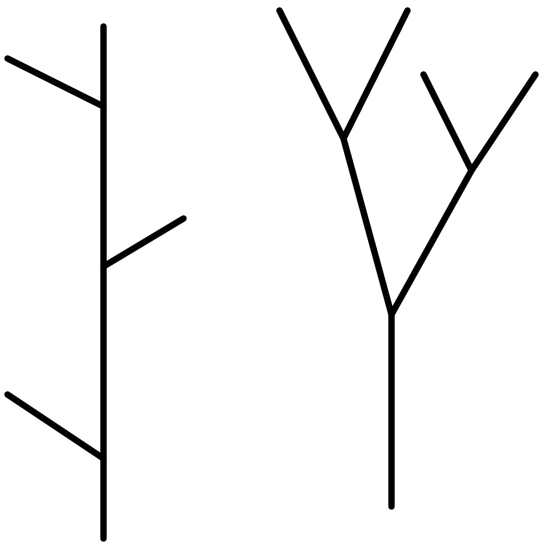
Vegetation affects:

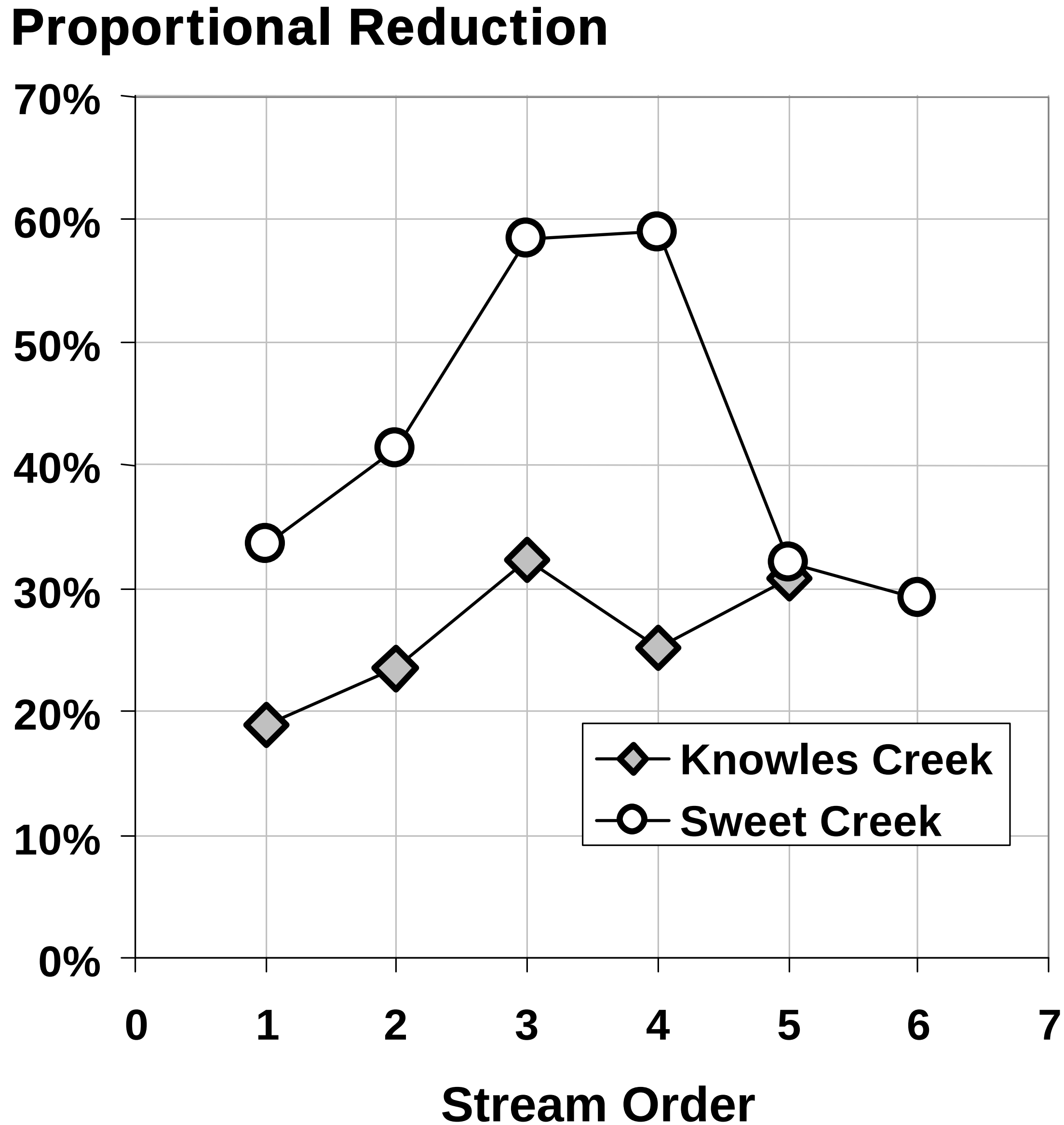
- Landslide susceptibility
- Probable debris flow runout distance

Open, Roads
Mixed
Large Conifer

Changes in vegetation cover alter the probability of debris flow impacts

These alterations vary as a function of stream order and network structure





Goal: Topographic, vegetation cover, and landslide/debris flow mapping at coarse scales to infer channel/habitat characteristics at finer scales

Accomplishments:

Landslide susceptibility and debris-flow-runout probability as functions of topography and vegetation cover

Landslide initiation hazard
Potential for landslide delivery
Probability of debris flow traversal – LWD recruitment, road crossings

Reach- and basin-scale estimates of channel characteristics

Topographic controls on spatial heterogeneity:
number, location, and spacing of debris-flow prone tributaries
Effects of vegetation change modulated by network structure