Synergies of Excess Sediment and Nitrogen: Degraded Hyporheic Dynamics and Compromised River Ecosystem Resilience

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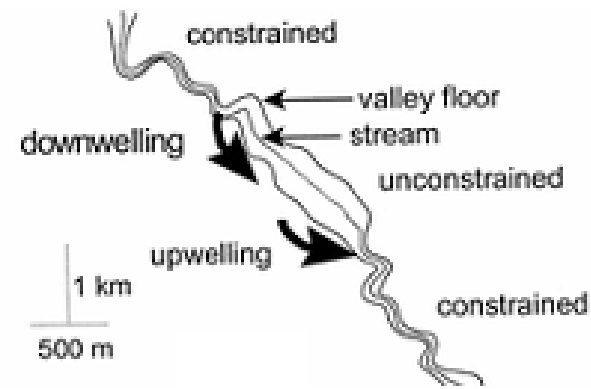
Project Overview

- Question: Are nitrogen and fine sediment synergistic pollutants in streams?
- Hypothesis: Fine sediments restrict hyporheic water flux and reduce the capacity for in-stream N processing.
- Approach: Stream ecosystem simulation modeling integrating geomorphology, hydrology, sediment transport, and biogeochemistry.

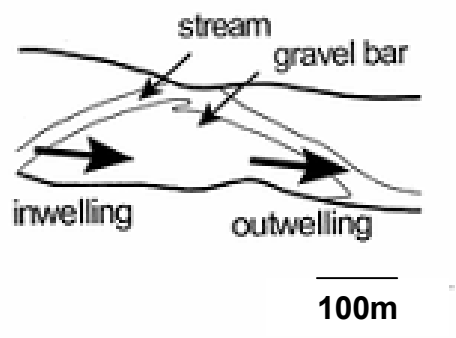
Strategy

- ☑ Assess geomorphic controls on multiple scales of hyporheic exchange
- ☑ Incorporate floodplain geomorphology into modeling system
- ☐ Integrate sediment routing model; assess affects on hyporheic flow patterns
- ☐ Integrate N-C-O biogeochemical model; perform simulation experiments to assess interactions between sediment and N dyanmics

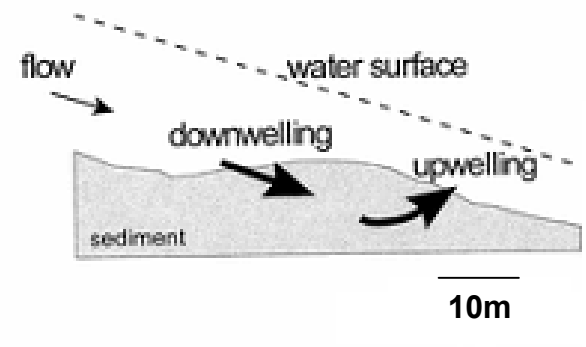
Scales of Hyporheic Flow



Floodplain scale



Meander-bend scale

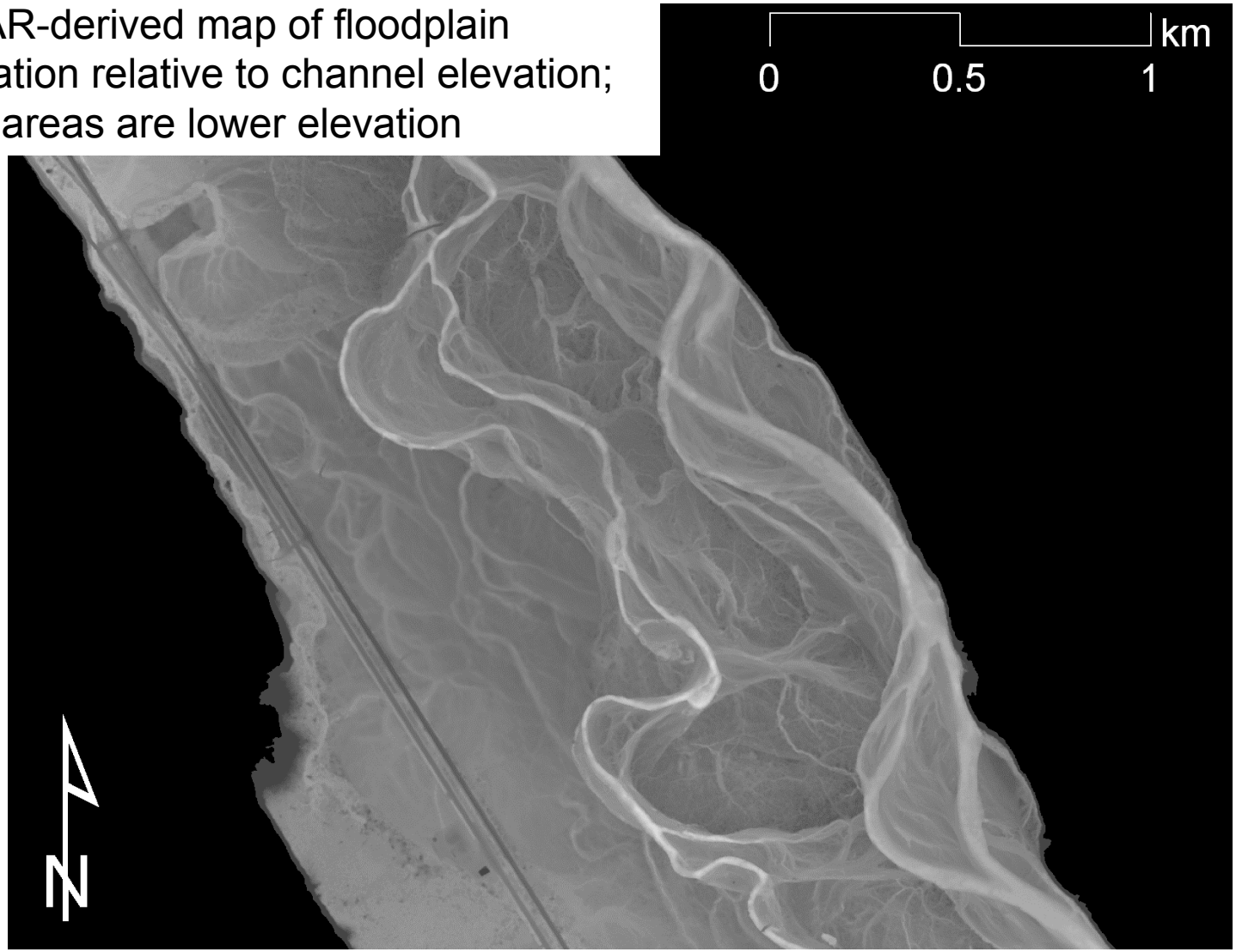


Streambed scale

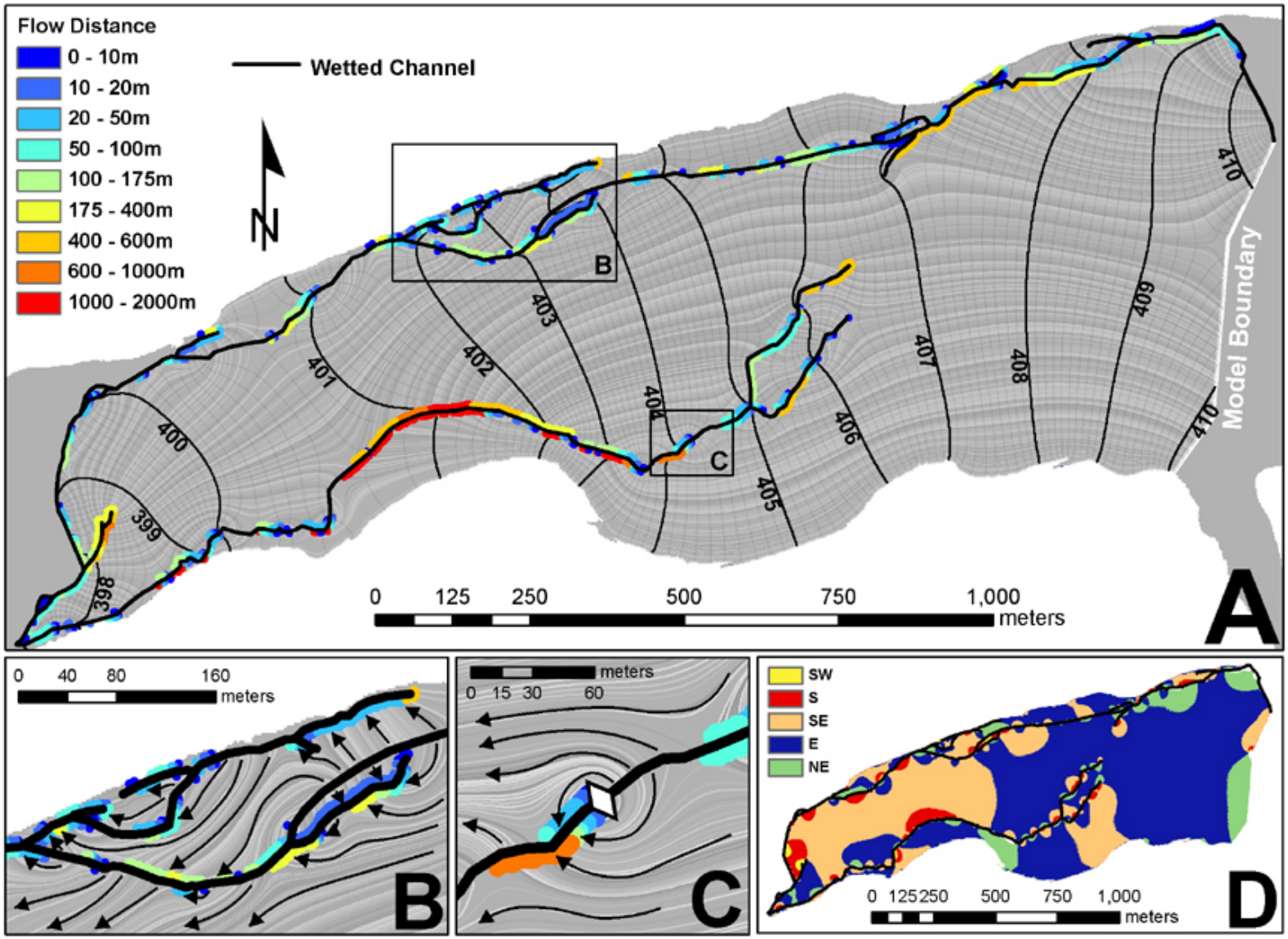
Modified from Dent et al. (2001)

Scales of Hyporheic Flow

LIDAR-derived map of floodplain elevation relative to channel elevation; light areas are lower elevation



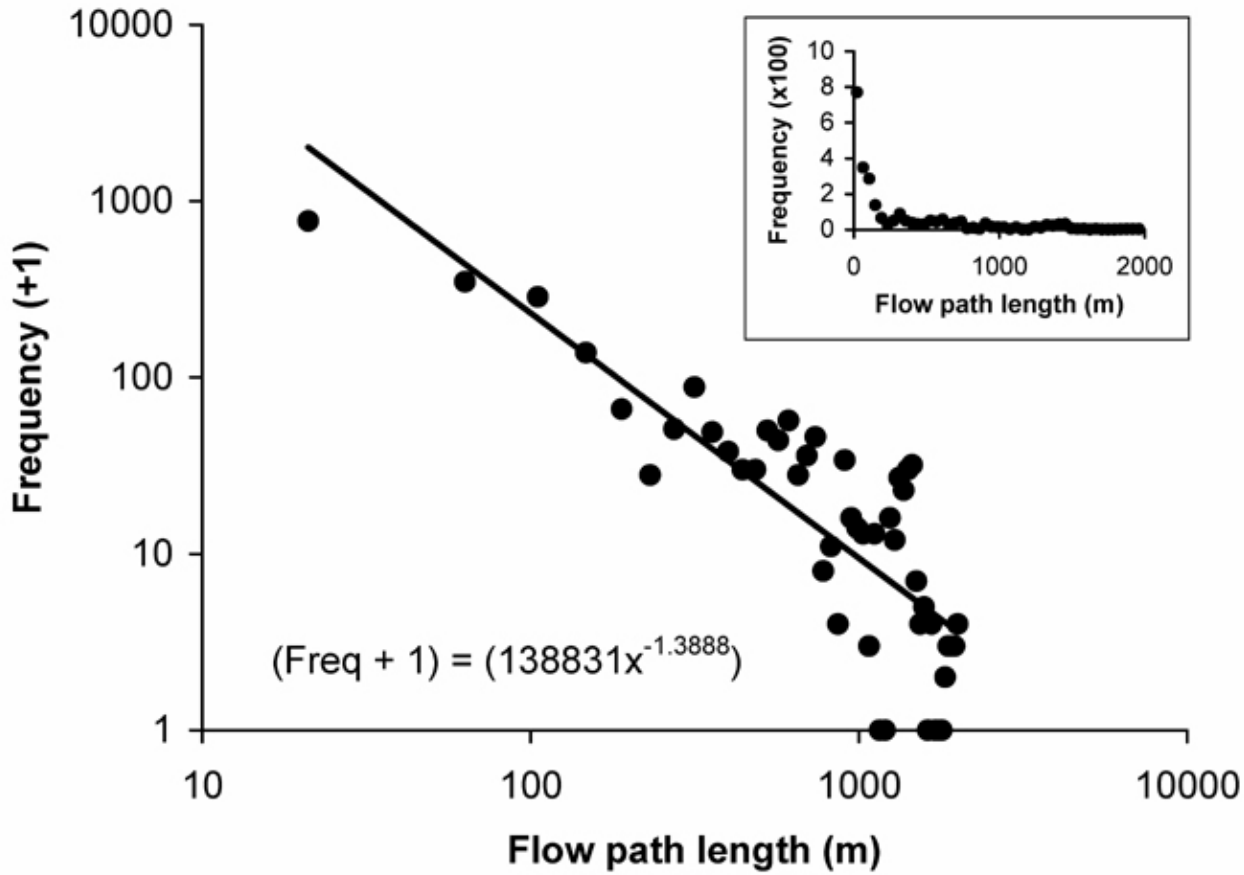
Scales of Hyporheic Flow



Poole et al. (In Prep.)

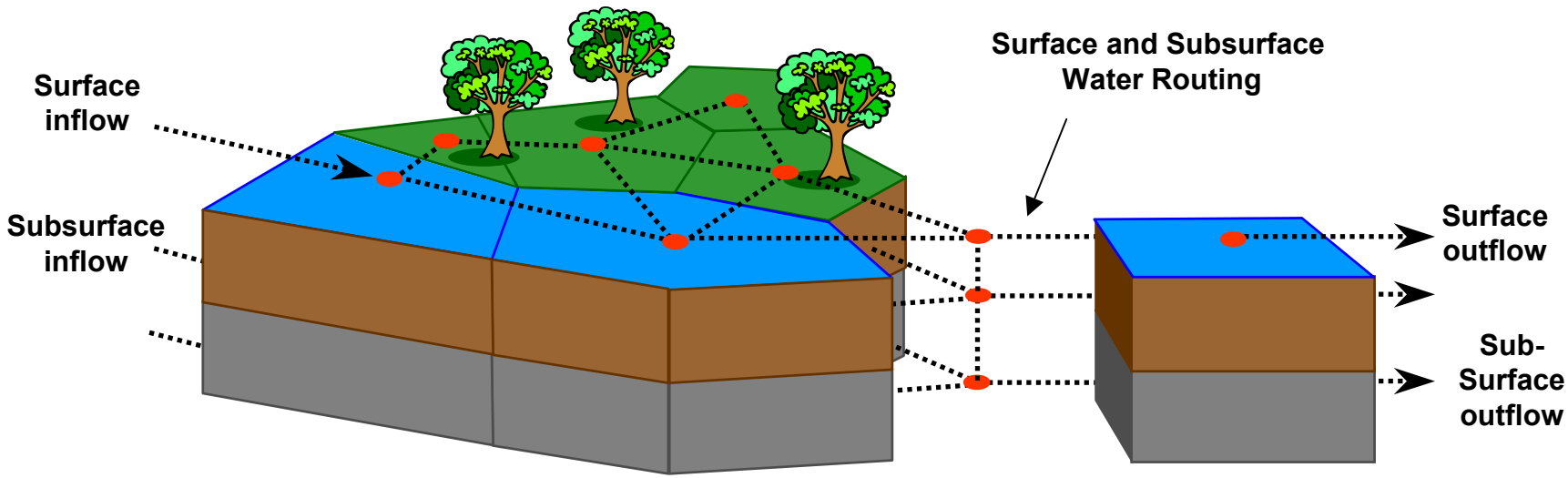
Scales of Hyporheic Flow

Frequency distribution of hyporheic flow path lengths in section of floodplain shown in prior slide



Model Geomorphic Influences on Hydrology

Hydrologic modeling approach: integrated ground- & surface-water flow network. Water flows among nodes (red dots) along links (dashed lines) on the surface and within the alluvial aquifer.

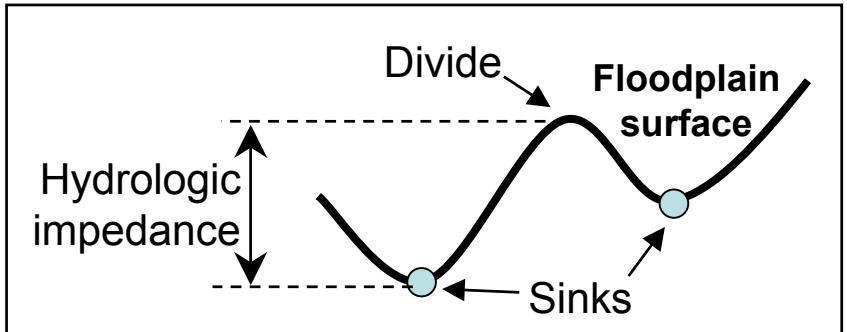


Question: Given a desired node density, how can we use floodplain topography (LIDAR data) to optimize model node locations?

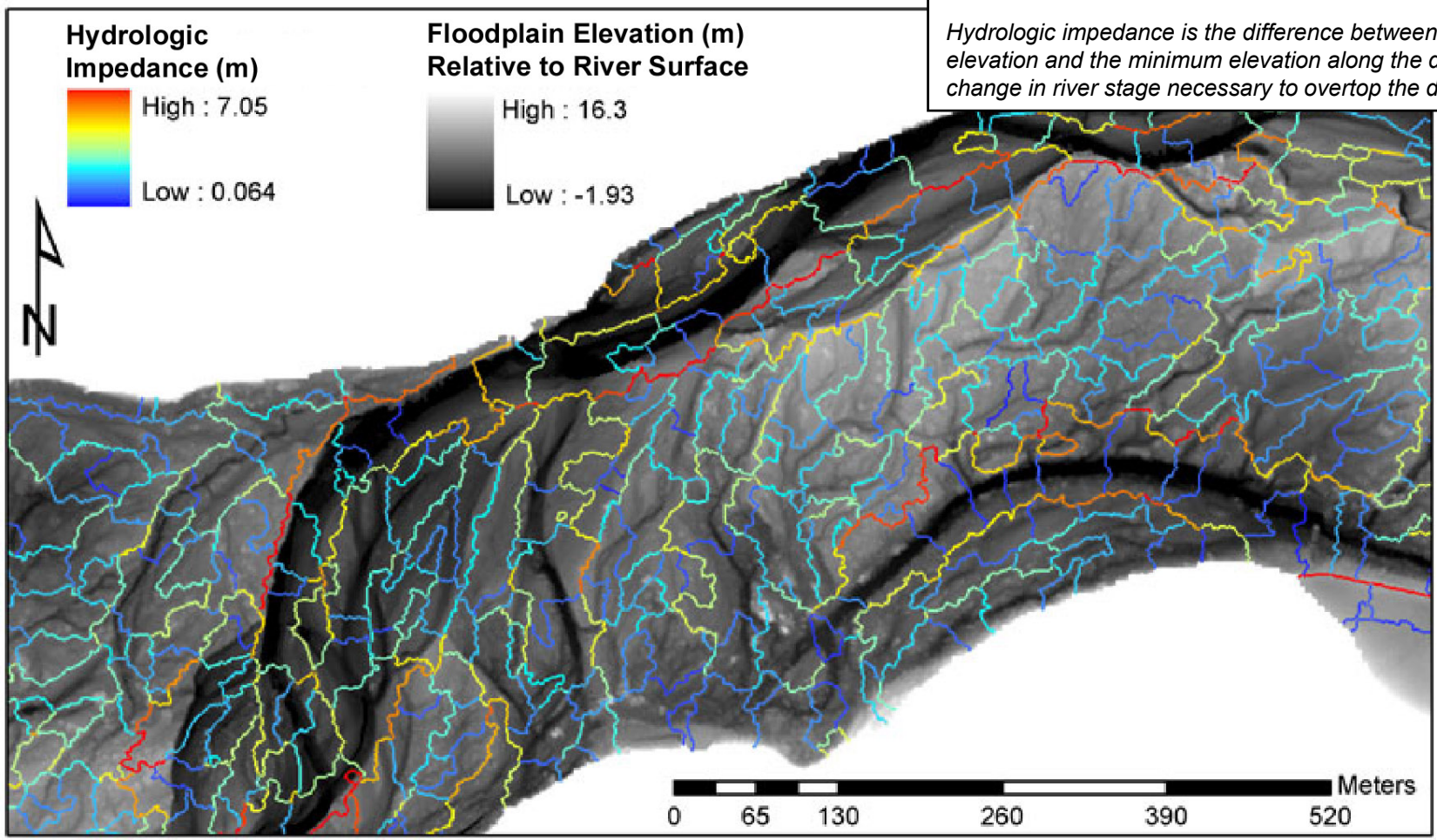
(See also Poole et al. 2002; 2004; 2006)

Model Geomorphic Influences on Hydrology

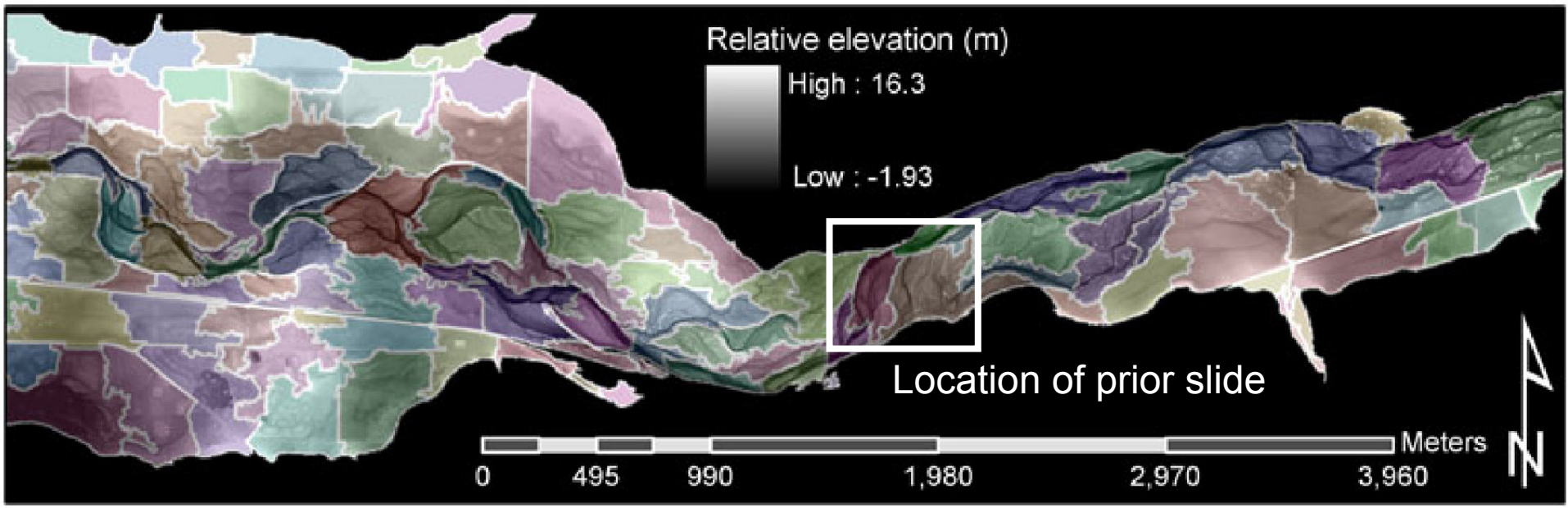
Floodplains can be conceptualized as mosaics of hydrologic sinks and divides. Surface water flow impedance of divides between floodplain sinks can be mapped from LIDAR data (Jones at al. In Prep).



Hydrologic impedance is the difference between the lower sink elevation and the minimum elevation along the divide (i.e., the change in river stage necessary to overtop the divide).

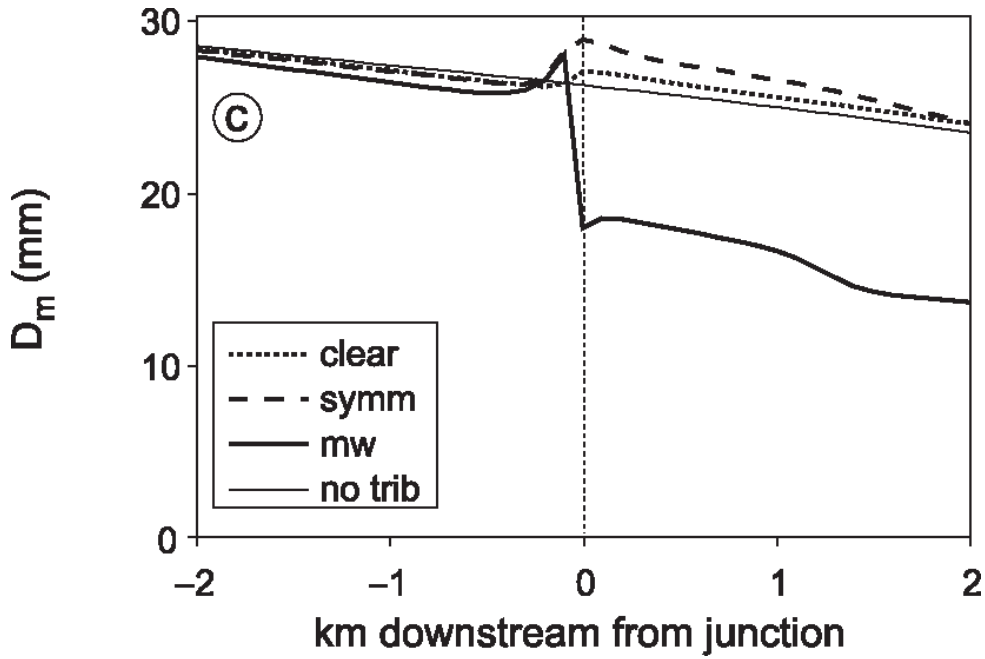


Model Geomorphic Influences on Hydrology



- Sink areas are aggregated into larger patches (colored randomly, above) by merging sink areas across divides with low hydrologic impedance.
- Remaining boundaries of aggregated patches represent divides with highest impedance, and therefore represent dominant controls on surface water flux.
- To model system hydrology, one model node is associated with each aggregated floodplain patch, and each boundary is represented by a model link.

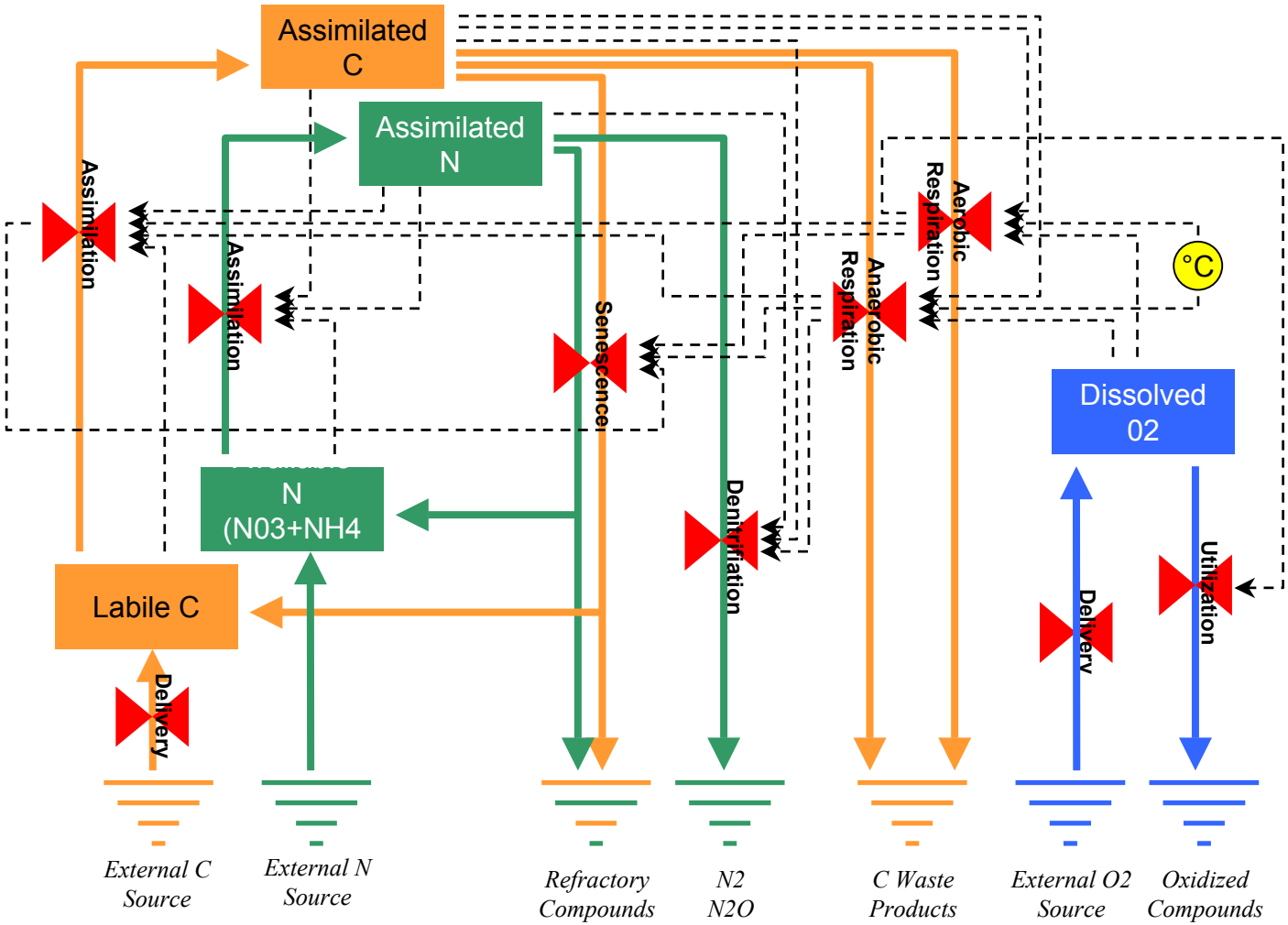
Sediment model



(Ferguson et al. 2006)

We have identified an existing sediment routing model, compatible with out hydrologic model, that predicts change in bed sediment sizes (D_m) as a function of flow velocity and sediment supply.

Biogeochemical Model



Preliminary structure of in-stream biogeochemical cycling model, incorporating interactions among Nitrogen (green), Carbon (Orange), Oxygen (Blue), and Temperature (Yellow)

References

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