Quantitative Assessment of Floodplain Functionality Using an Index of Integrity

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Background

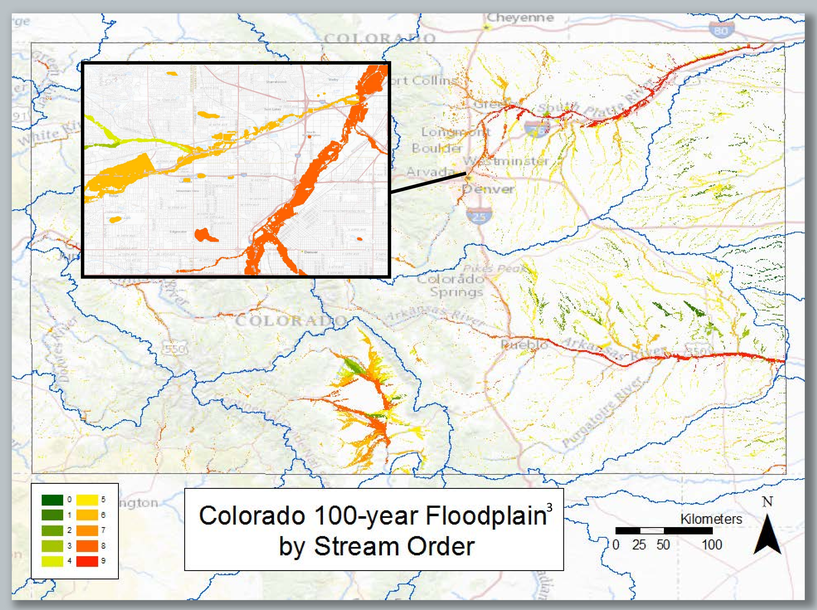
Floodplains provide important ecosystem services including attenuating floods, regulating sediment and solutes, and creating habitat[1].

Human development on floodplains and alteration of river hydrology has affected floodplain functionality.

Assessing floodplain integrity provides a measure of how well the floodplain functions are maintained. However, it is difficult to identify an "unaltered" floodplain to serve as a basis for comparison.

Instead of comparing a floodplain to an unaltered reference, this integrity assessment identifies stressors that limit floodplain functions for which data is readily available. Quantifying the abundance of each stressor in the floodplain allows for a floodplain assessment that can be applied at broad spatial scales. Similar methods have been used to asses the integrity of entire watersheds[2].

Using available data to produce a quantifiable integrity metric allows for comparison of Colorado's floodplain integrity across space and time.



Colorado 100-year Floodplain[3] by Stream Order

Floodplain Integrity

Hydrologic Alteration

- Dams reduce peak flows
- Wells lower groundwater table
- Diversions change flow timing and volume

Landscape Modification

- Roads, levees, etc. limit connectivity
- Changes in roughness with landcover
- Development obstructs flow

Index Calculation

1. Identify stressors for each floodplain function
2. Spatially divide floodplain into areas of similar geographic and climatic characteristics
3. Quantify level of stressor in floodplain relative to theoretical maximum
4. Combine weighted stressor values to create "Index of Integrity" for each floodplain function
5. Calculate overall floodplain integrity as product of indices for each floodplain function

$$I_{Floodplain} = I_{Floods} \times I_{GW} \times I_{Sed} \times I_{Org} \times I_{Habitat}$$

Floodplain Functions

Flood Reduction

- Increased with flow obstruction
- Increased with rougher land cover
  - Forest vs. grassland
- More attenuation in heterogeneous areas

Groundwater Storage

- More bank storage when flow is obstructed
- Depends on soil permeability
- Impervious surfaces reduce infiltration
- Water table changed by wells and pumping

Sediment Regulation

- Retention increased with peak flood reduction
- Dependent on soil erodibilty
- Increased sediment with upstream logging
- Wildfires increase sediment supply

Organics/Solutes Regulation

- Mobilization decreased with peak flow reduction
- Large wood important for organic matter

Habitat Provision

- Dependent on hydrologic connectivity
- Decreased by development in floodplain
- Land cover change alters habitat

Future Work

- Determine floodplain unit scale for computing and analyzing integrity
- Specify numerical relationships between quantity of stressor and integrity of floodplain function
- Perform data analysis of stressor datasets for floodplain in GIS
- Analyze spatial trends in floodplain integrity for Colorado

Desired Outcome: Development of a method to analyze floodplain integrity for large spatial scales and an evaluation of floodplains in Colorado.

References

1. Wohl, E. E. (2018). *A review of floodplains and flood-induced changes*. Manuscript in preparation.
2. Thornbrugh, D. J., Leibowitz, S. G., Hill, R. A., Weber, M. H., Johnson, Z. C., Olsen, A. R., ... & Peck, D. V. (2018). Mapping watershed integrity for the conterminous United States. *Ecological indicators*, *85*, 1133-1148.
3. Wing, O. E., Bates, P. D., Sampson, C. C., Smith, A. M., Johnson, K. A., & Erickson, T. A. (2017). Validation of a 30 m resolution flood hazard model of the conterminous United States. *Water Resources Research*, *53*(9), 7968-7986.

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