Signatures of land use in suspended sediment in Dave Blue Creek, Oklahoma

OMFA Stormwater Quality Workshop

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The UNIVERSITY of OKLAHOMA

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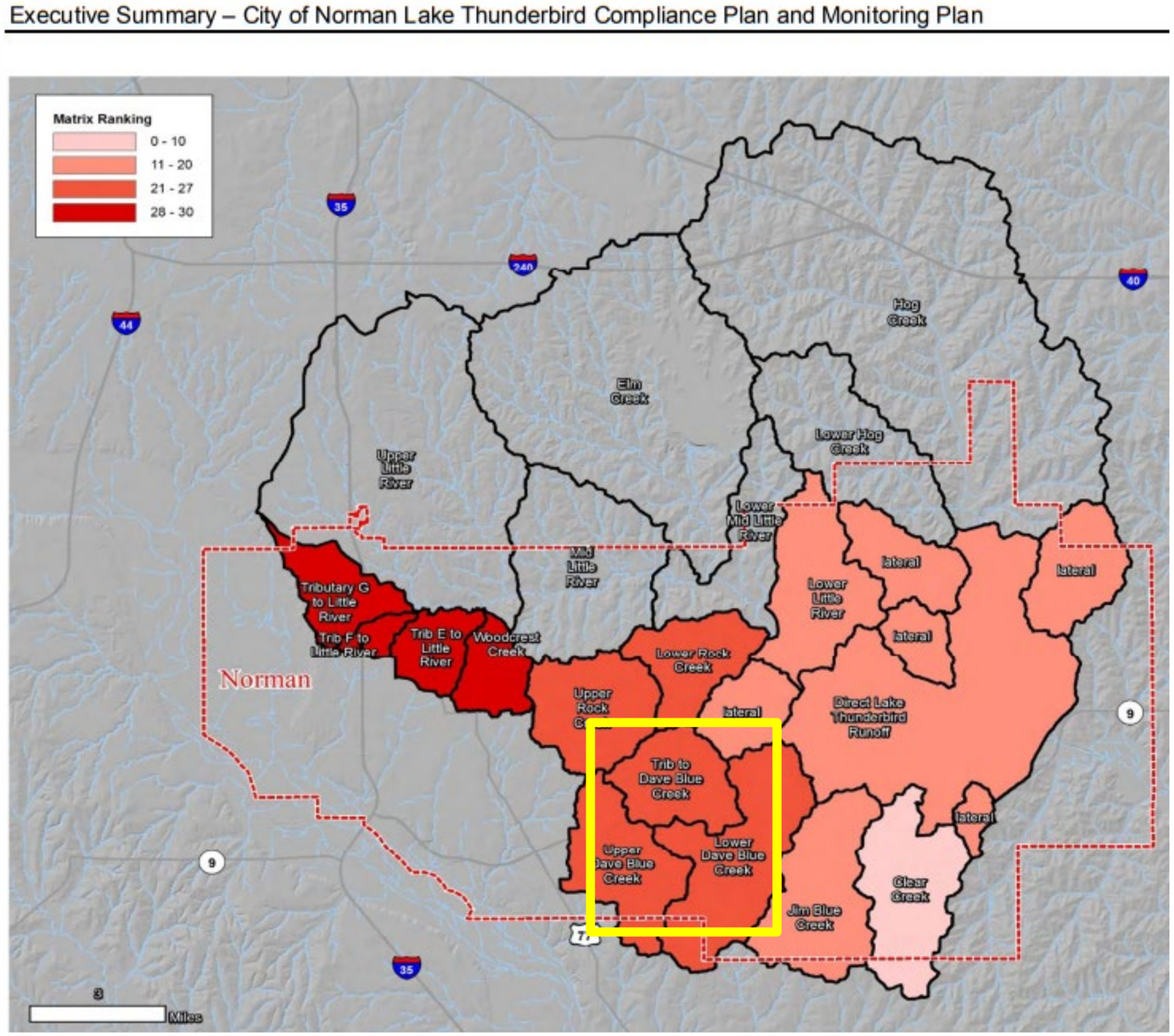
Erosion and suspended sediment:

- Suspended sediment diminished water quality
- Excessive sediment loading occurs via soil erosion
  - Poor land management

(City of Norman, OK Lake Thunderbird Compliance Plan and Monitoring Plan, 2016)

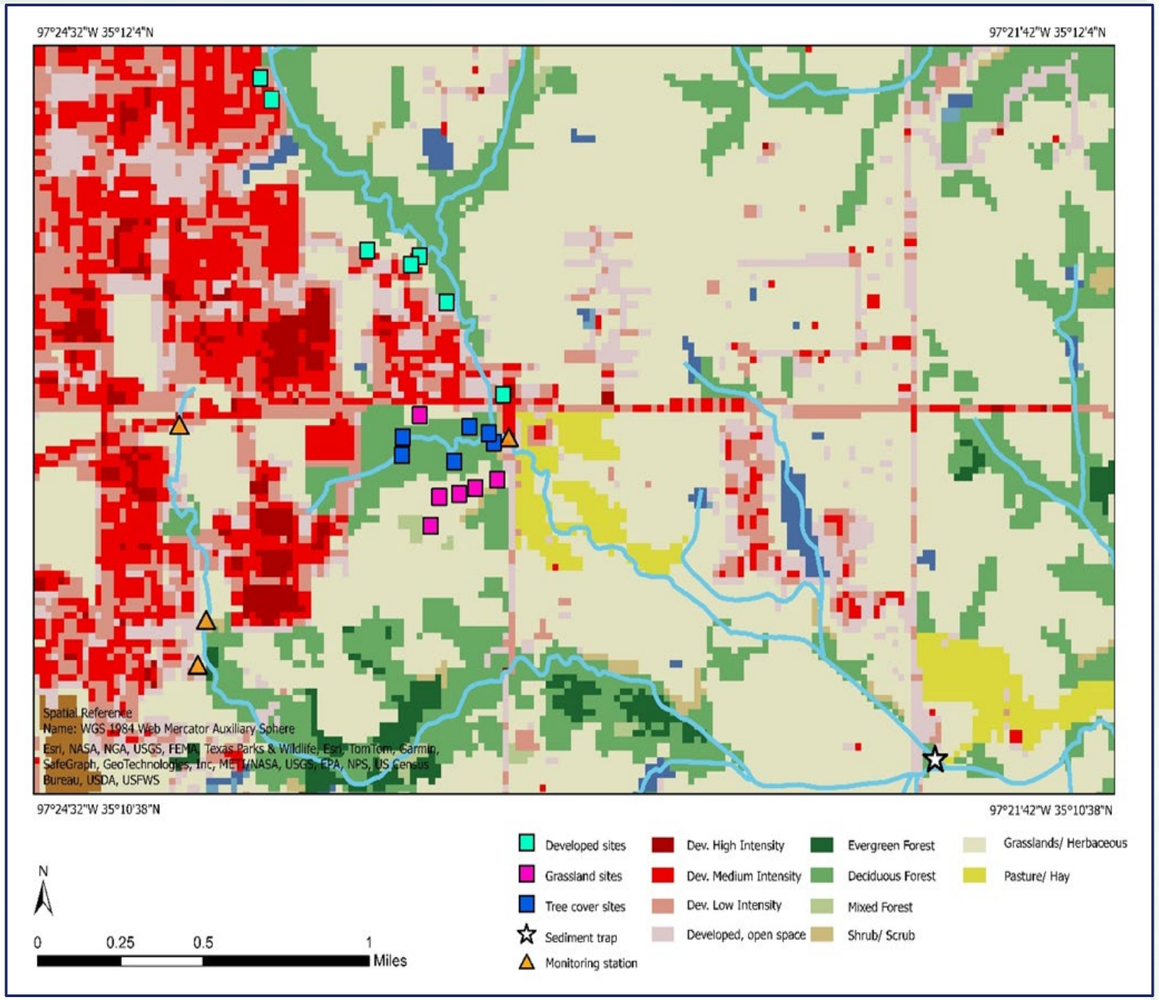


Sediment fingerprinting: land -use and geography

Sediment fingerprinting:

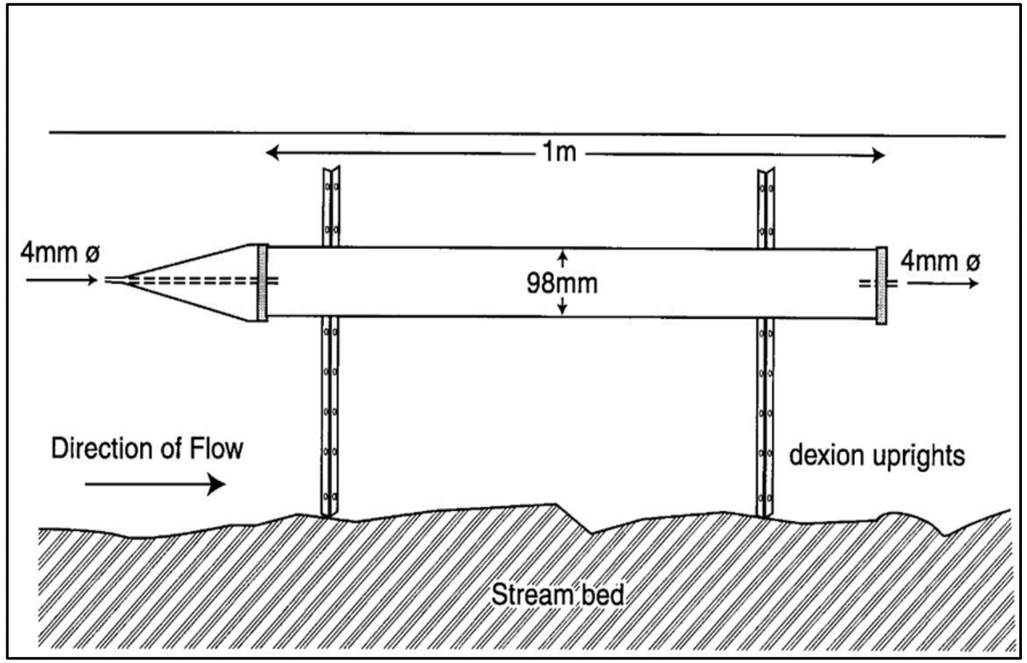
A composite, unique identifier for source group using conservative tracers

- geochemical, mineralogical, isotopic tracers
- depends upon study scale and source group categories
  - sub-watershed scale: trace elements
  - land-use, bank, & upland soils



(NCLD, 2023)

Suspended sediment collection using a passive trap:



(Phillips et al., 2000)

Geochemical fingerprints and Sediment Source Assessment Tool:

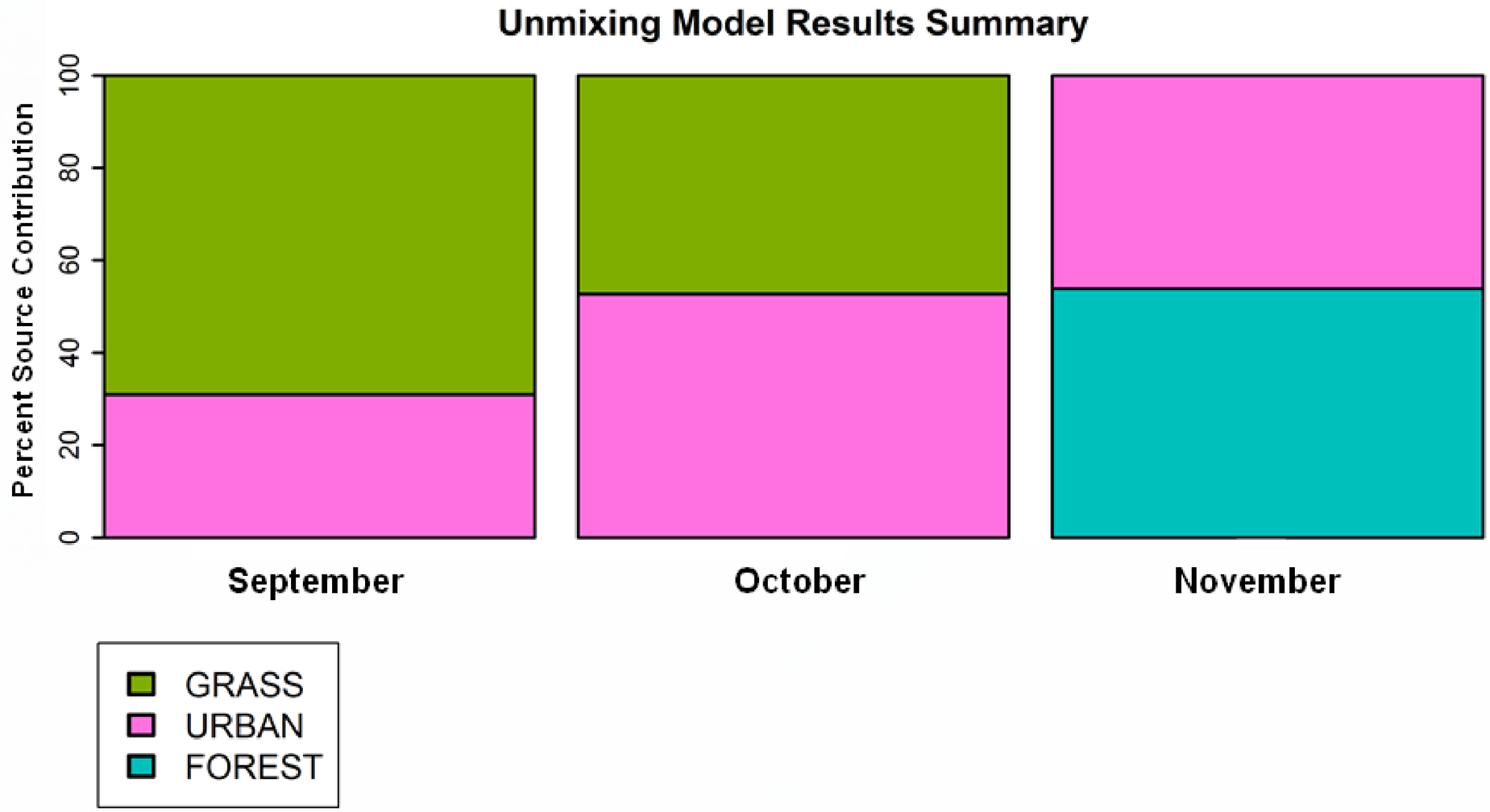
Sediment Source Assessment Tool (Sed_SAT):

- Identifies source group fingerprints and weighs selected tracers by their predictive power
- Unmixing model to determine relative percent source inputs
- Error analysis: Monte Carlo simulation and Source group assessment

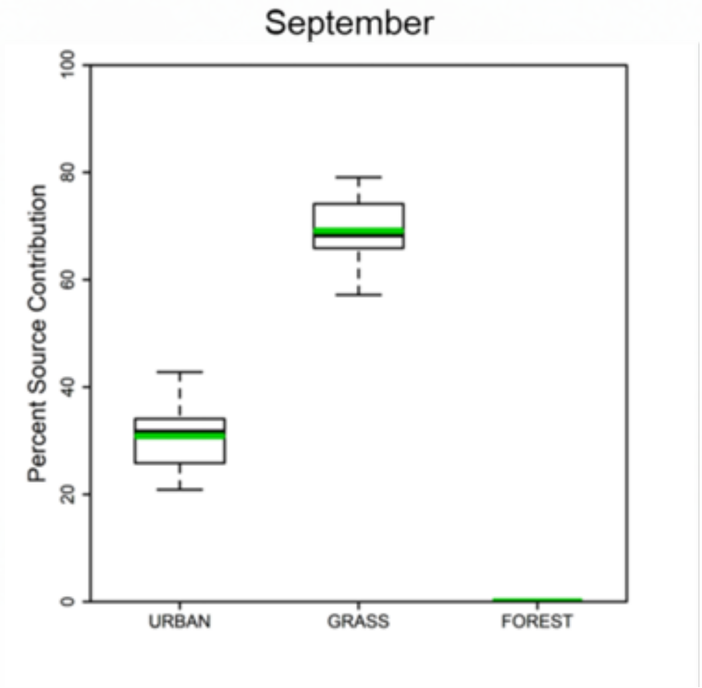
Sample Name	As	Mg	Sc	Nb	Th	U	V	Lu	Sm	Yb
September	4.9	1.53	6.3	0.35	6.7	0.87	46	0.098	4.47	0.776
October	3.6	1.18	4.7	0.29	5.4	0.67	36	0.085	3.69	0.634
November	6	1.47	3.3	0.27	2.5	0.81	31	0.138	5.11	1.145

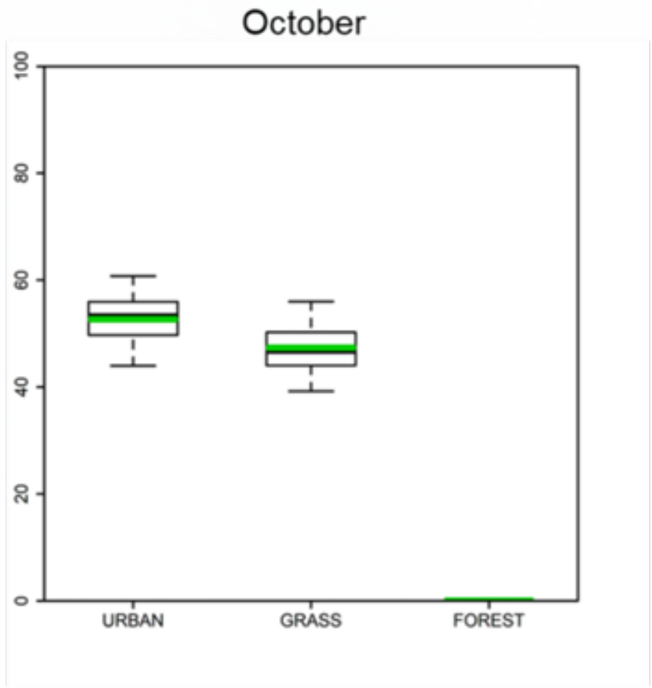
Table 1) Selected tracers and weighing factors

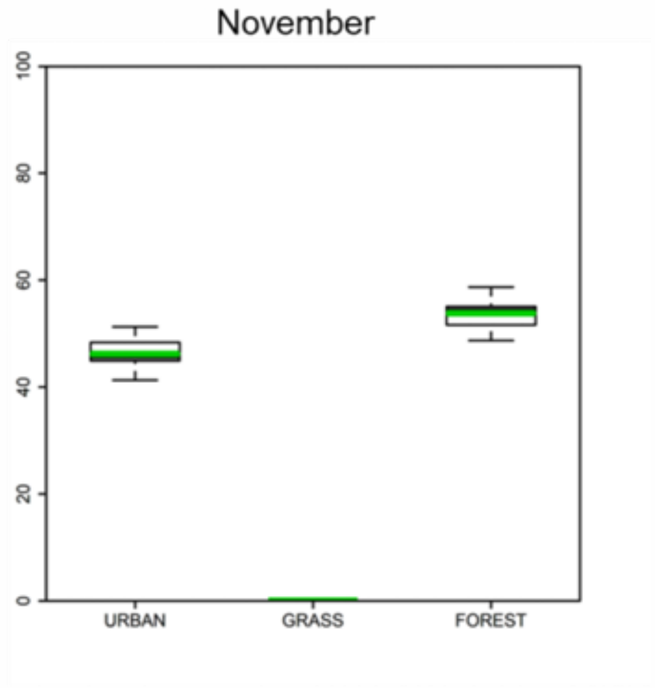
Results: Source group contributions



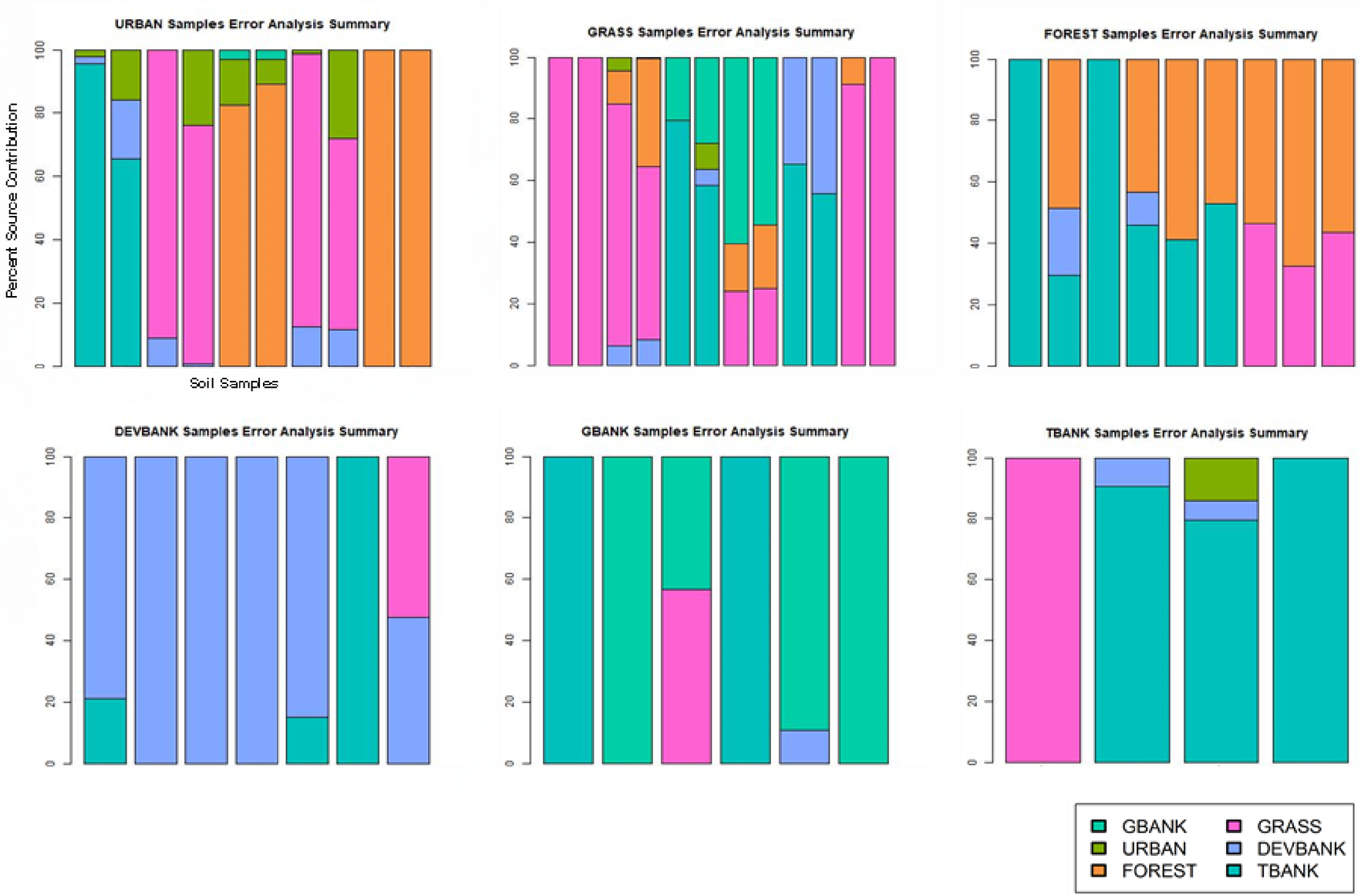
Land use source group Monte Carlo analysis:



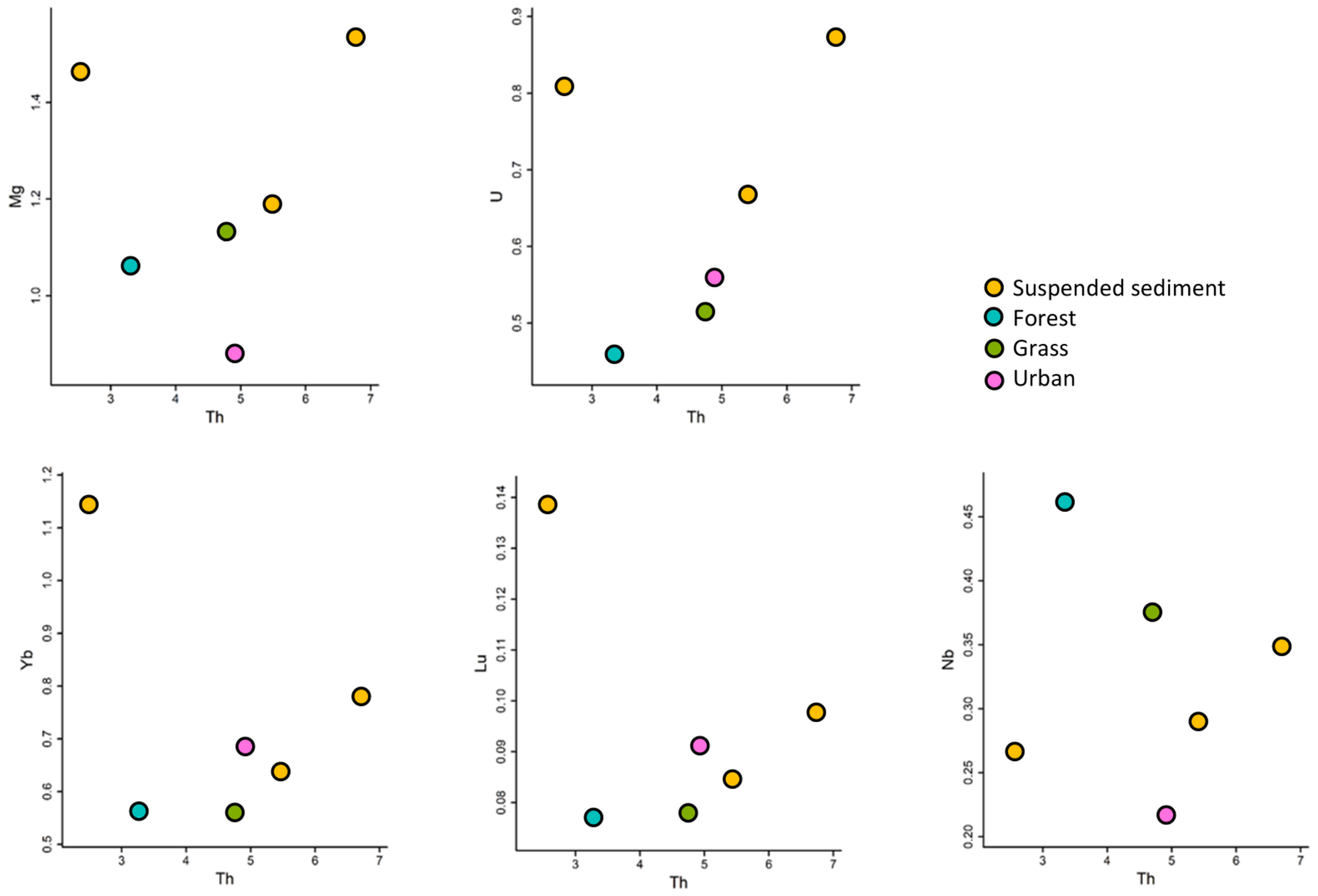




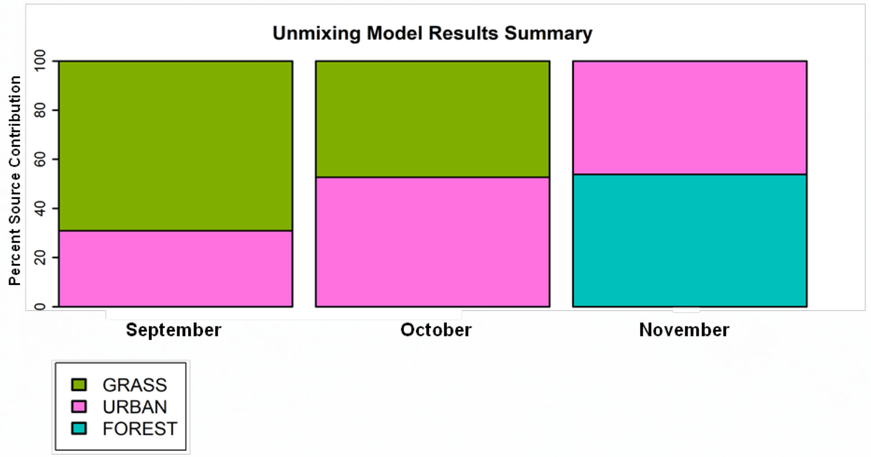
Upland and Bank Error Analysis:

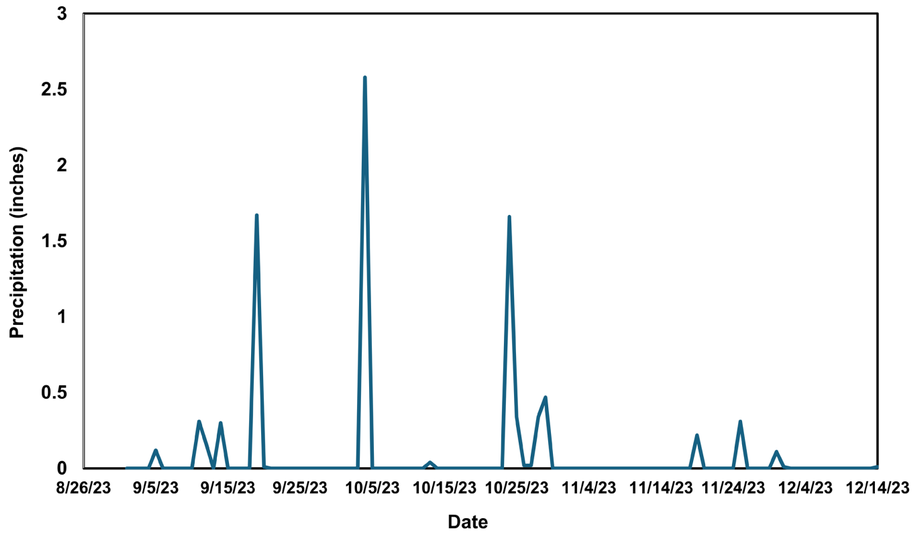


Tracer concentrations in sources versus suspended sediment:

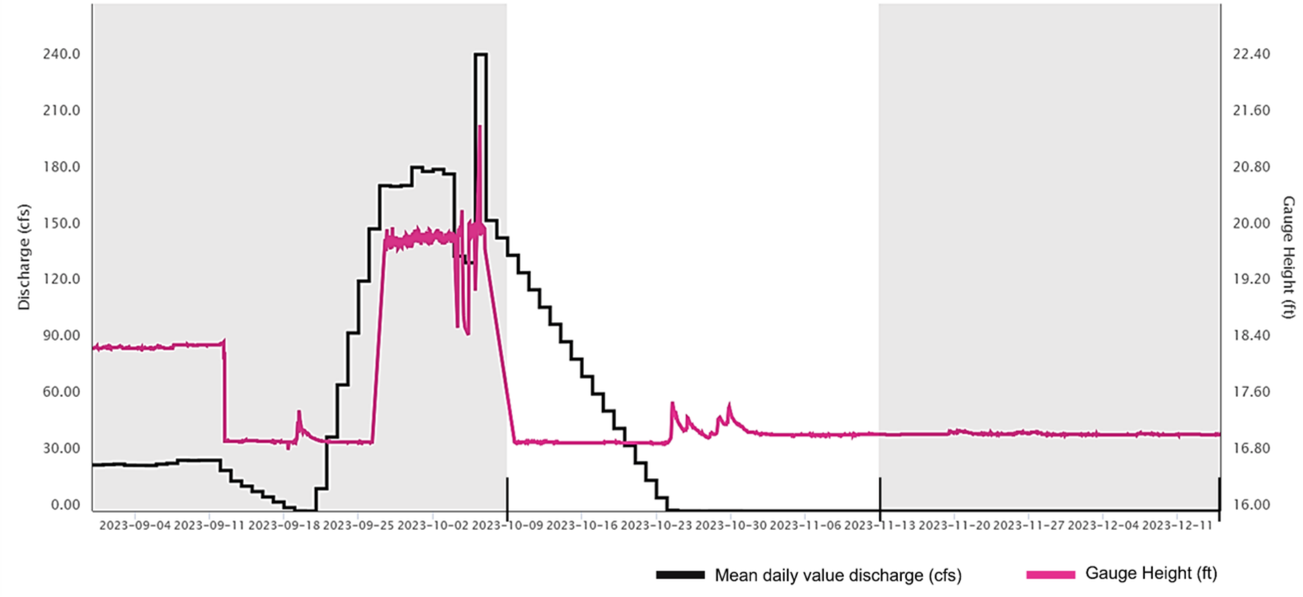


Stream conditions correlate with land use signature shift:



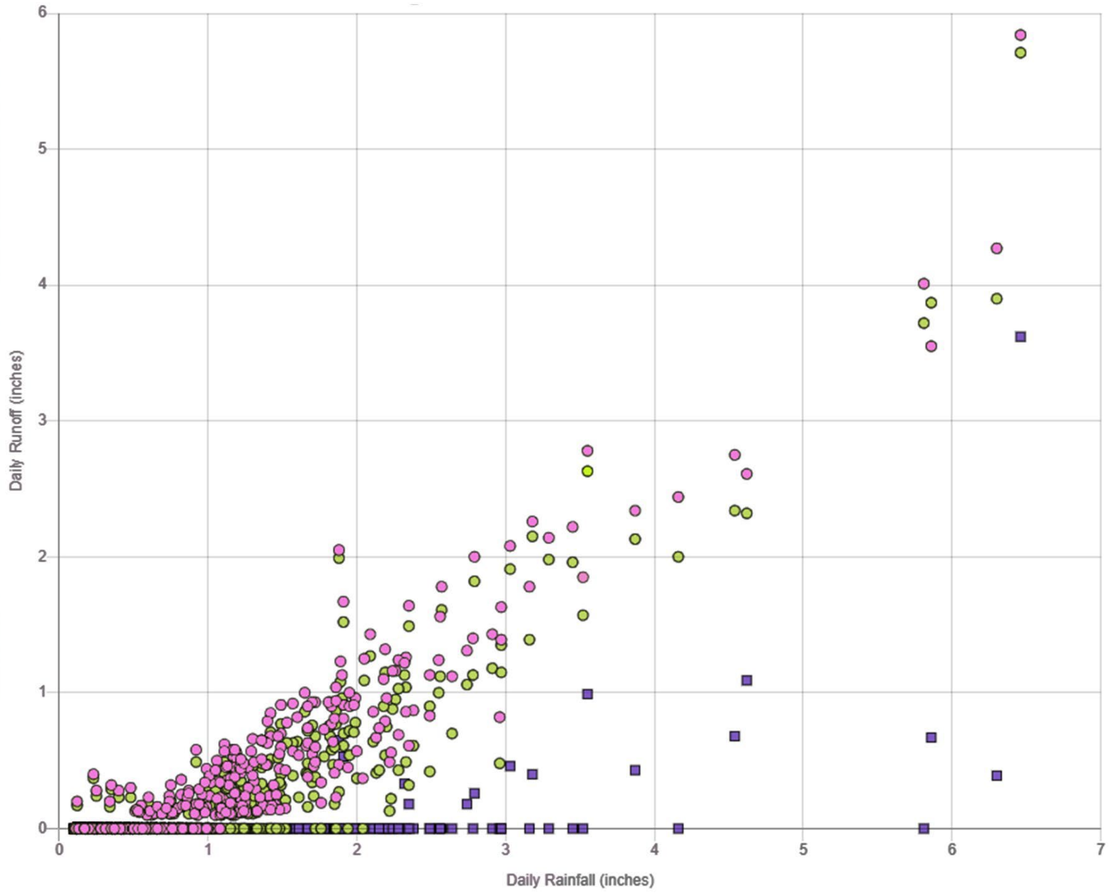


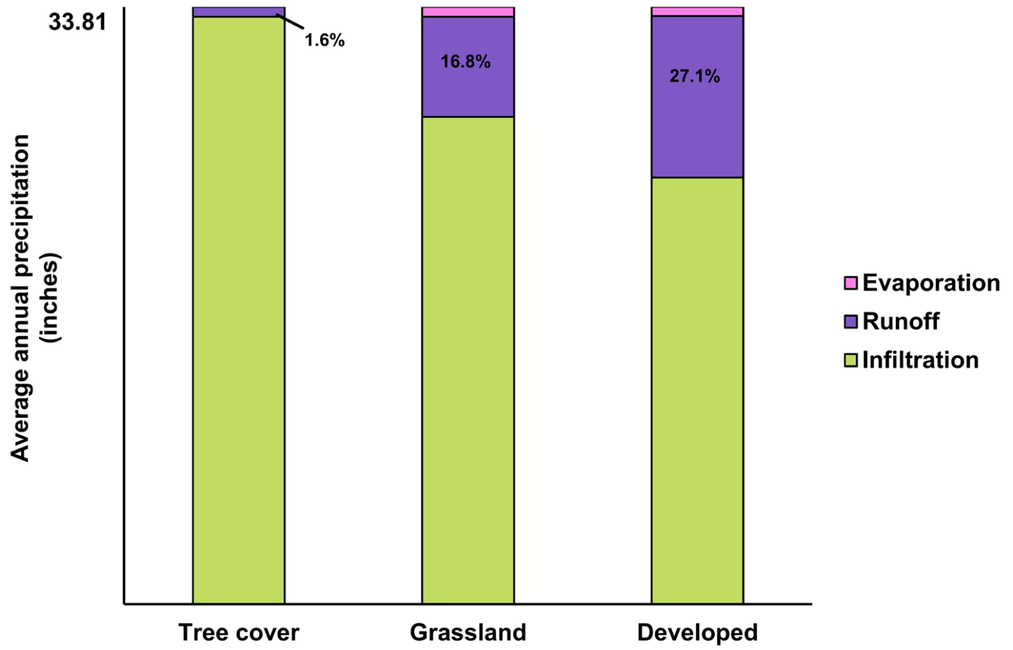
(Norman, Oklahoma Mesonet, 2025)



(Oklahoma Water Resource Board, 2024)

Results: Source group contributions versus estimations





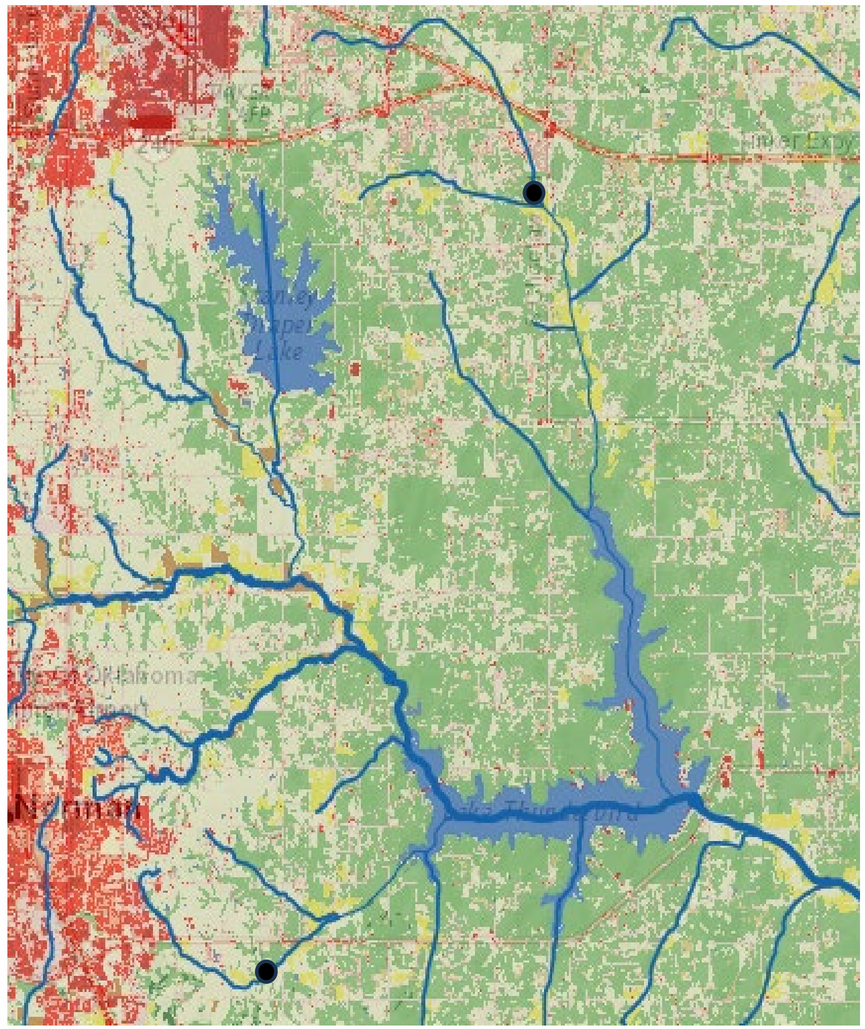
(EPA Stormwater Calculator, 2025)

Results Summary:

- Land-use source contributions were successfully identified over sampling period
- Impacts of anthropogenic activity seen in higher concentrations of trace metals in developed bank source group
- Shift from grassland to tree-cover contributions matched dates for decrease in precipitation and discharge

Implications and Future Directions:

- Future erosion mitigation strategies in Lake Thunderbird watershed should focus on bank stability in developed areas and run-off control in grass-covered areas
- Project expansion to Hog Creek sub-watershed
- Evaluate seasonal effects on land use inputs
- Correlate identified sediment sources and precipitation with soil erosion rates
- Bank sampling in increments to identify signatures at different depths in the soil profile



(https://modelmywatershed.org)

References:

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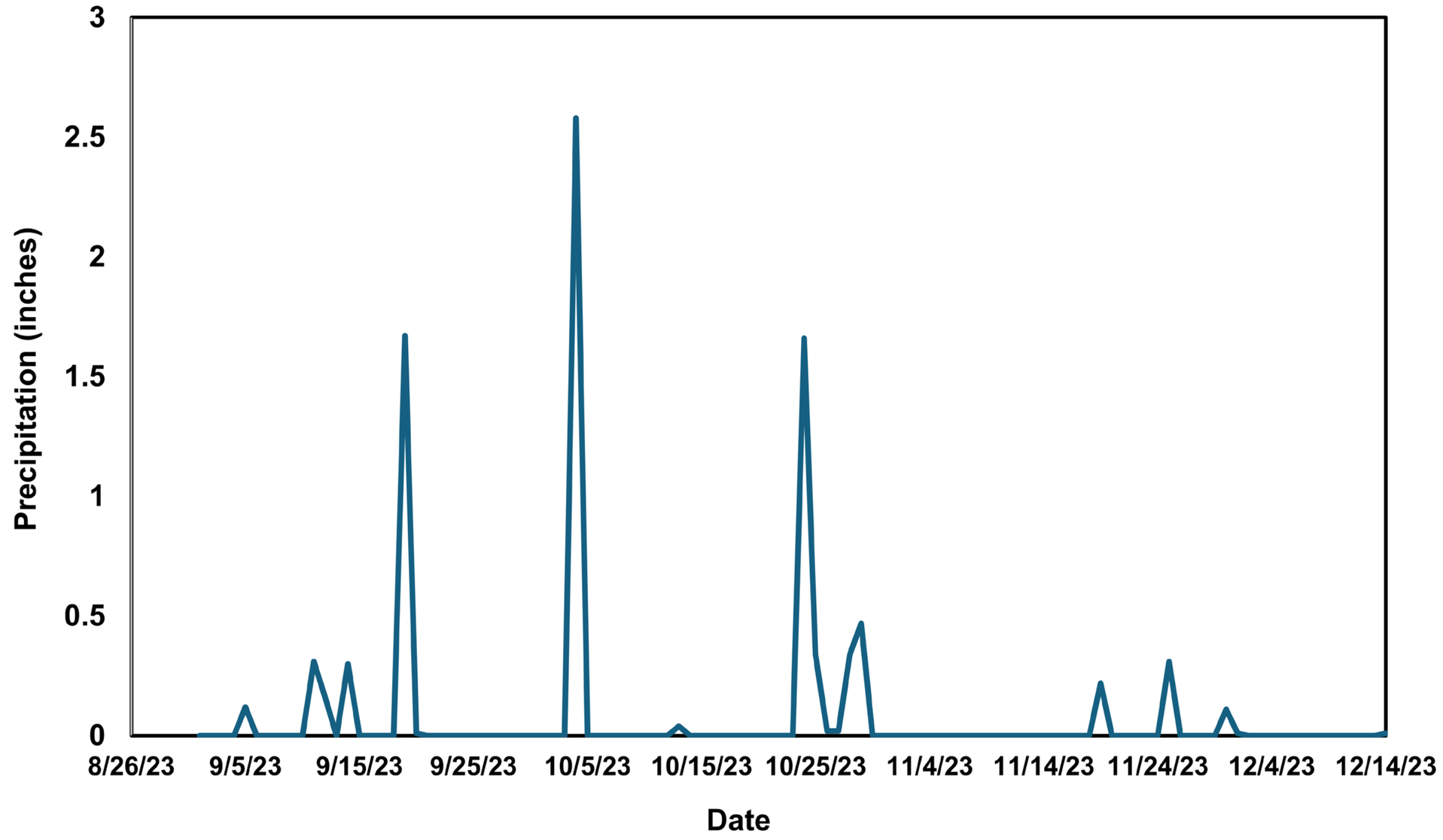
Phillips, J. M., Russell, M. A., & Walling, D. E. (2000). Time -integrated sampling of fluvial suspended sediment: A simple methodology for small catchments. Hydrological Processes, 14(14), 2589–2602. https://doi.org/10.1002/1099-1085(20001015)14:14<2589::aid- hyp94>3.0.co;2-d

Walkinshaw, Mike, A.T. O'Geen, D.E. Beaudette. "Soil Properties." *California Soil Resource Lab*, 1 Oct. 2023, casoilresource.lawr.ucdavis.edu/soil-properties/.

Extras:


Precipitation (inches)
3
2.5
2
1.5
1
0.5
0
8/26/23
9/5/23
9/15/23
9/25/23
10/5/23
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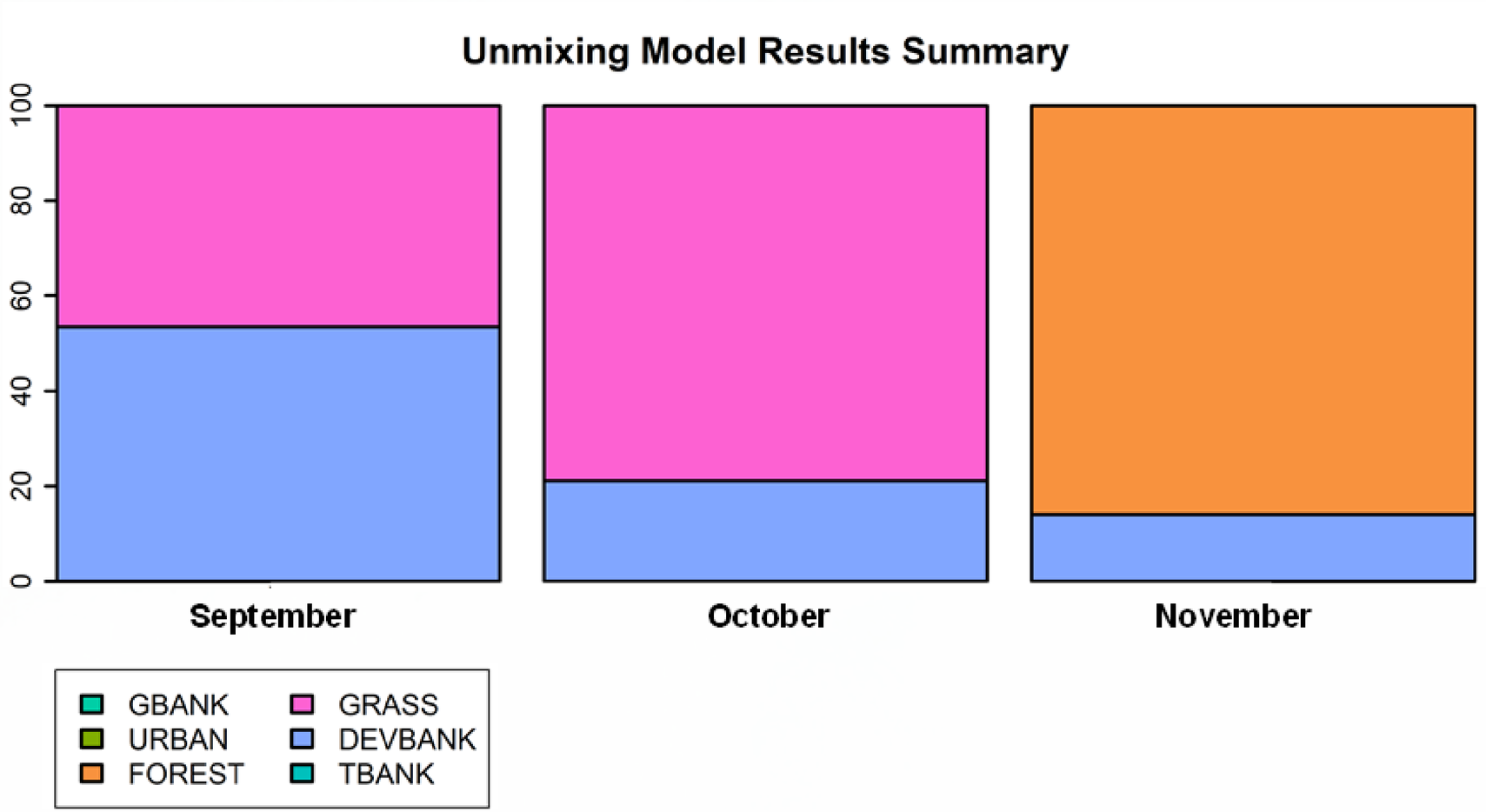
11/14/23
11/24/23
12/4/23
12/14/23
Date

Results: Source group contributions



Evaluating the signatures of land use in suspended sediment in Dave Blue Creek, Oklahoma

Brittany L. Moehnke[1], Tim Filley[1], Jason Vogel[1], Dr. Caitlin A. Hodges[1]

[1]University of Oklahoma, School of Geosciences

Background

Surface soil and stream bank erosion detrimentally impact both soil and water quality.

- Loss of organic matter, nutrients, and structural components of the soil.
- Overloading of streams with nutrients and heavy metals bound to sediment.

The state of Oklahoma has a long history of poor land-management practices that have resulted in excessive rates of soil erosion.

- Combined with a drought, this led to the Dust Bowl of the 1930s which was followed by severe flooding.

Today, human activities such as farming and urban development still contribute to soil erosion and result in high sediment inputs into local

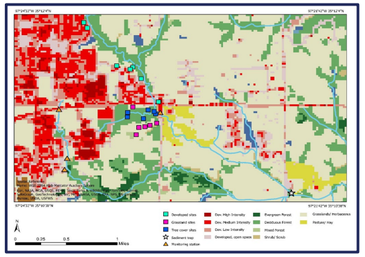


Figure 1) Sampling sites along Dave Blue Creek, Norman, OK. Land cover layer from the National Landcover Database (NLCD) 2023.

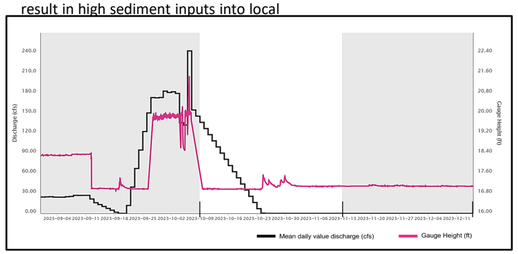


Figure 2) Hydrograph depicting stream conditions over sampling period and indication of sediment collection dates: 10-09-2023, 11-13-2023, and 12-14-2023 (Oklahoma Water Resource Board, 2023).

Research Questions

- What land uses are responsible for the excessive sediment load in Dave Blue Creek, a stream which drains into Lake Thunderbird as contributes to its water quality issues?
- Which trace elements may be used as a composite fingerprint to individually characterize each land use?

Experimental Design

- Surface soils for each land use were sampled by collecting scrapes of the top 2 cm of soil taken in a transect at each site then pooled together to account for site variability. Bank samples were taken from bottom to top on both sides of the channel at each site then composited.
- A passive sampler using the design of Phillips (2000), was installed on 08-31-2023 downstream of all field sites. The contents of the sediment trap were collected in once a month over three months on the dates of 10-09-2023, 11-12-2023, and 12-14-2023.
- Samples were dried and sieved to <63 µm and analyzed for elemental composition by an outside laboratory.
- Sediment and soil geochemistry were used to identify relative source contributions using the USGS Sediment Source Assessment Tool (Sed_SAT).

Figure 4) Photograph of submerged sediment trap in Dave Blue Creek, Norman, OK.

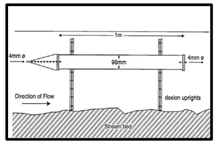


Figure 3) Passive sediment trap schematic (Phillips et al., 200).

Results

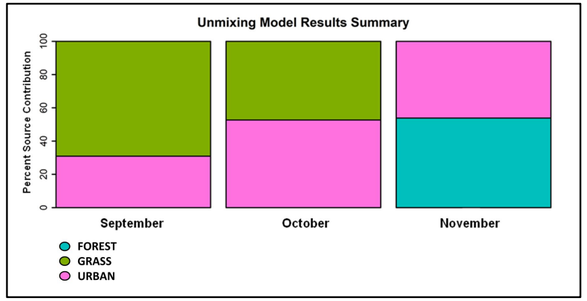


Figure 5) Unmixing model results show a consistent input from urban land uses and grassland signatures and corresponded with sampling periods which had higher stream discharge and monthly precipitation totals.

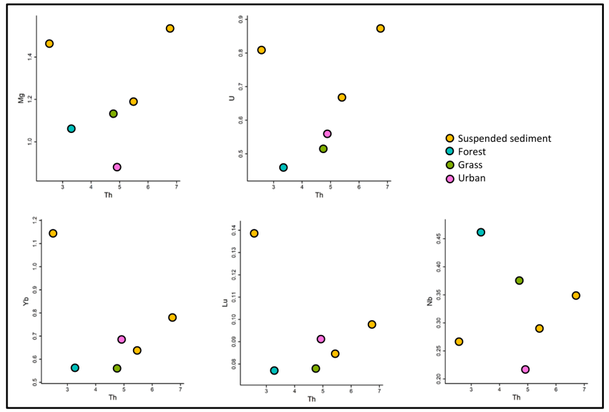


Figure 6) Plots of conservative tracer concentrations for each source group and suspended sediment sample plotted against thorium concentrations.

Error Analysis

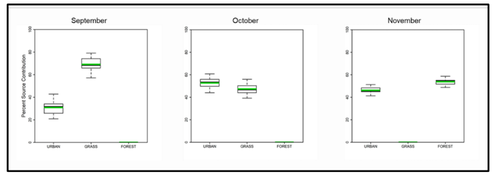


Figure 7) Monte Carlo analysis of source groups evaluating confidence in source group apportionment.

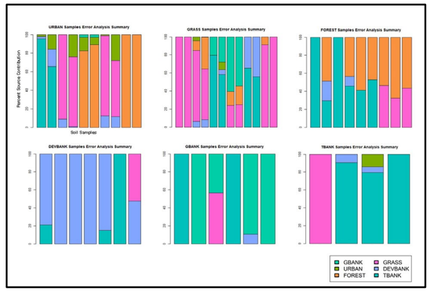


Figure 8) Evaluation of individual source sample compositions when evaluated in the unmixing model as a target sediment samples of unknown compositions.

Sample Name	As	Mg	Sc	Nb	Th	U	V	Lu	Sm	Yb
September	4.9	1.53	6.3	0.35	6.7	0.87	46	0.098	4.47	0.776
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Table 1) Average tracer concentrations (ppm) in suspended sediment collected over each month.

Conclusions and Implications

- Contributions from developed land were identified across all suspend sediment samples.
- The geochemical tracers identified could not discriminate between upland and stream bank sources of the same land use.
- A shift in grass cover inputs to tree cover inputs corresponded with a decrease in precipitation events and discharge.
- Erosion mitigation strategies in this watershed should target surface runoff in grassland systems and bank stabilization in developed areas.

Future Directions

- Expansion to other streams within the Lake Thunderbird watershed.
- Continue sample collection over longer period to evaluate seasonal effects on land use inputs.
- Correlate identified sediment sources and precipitation with soil erosion rates.
- Incorporate other tracers and sampling methods to better discriminate between bank and upland sources:
  - Stable isotope analysis: δ15N.
  - Bank sampling in increments to identify signatures at different depths in the soil profile.