Identifying Sediment Source

ITAT
Sept 10, 2018

Allen Gellis
USGS Maryland WSC
agellis@usgs.gov

Maryland's Final 2016 Integrated Report of Surface Water Quality

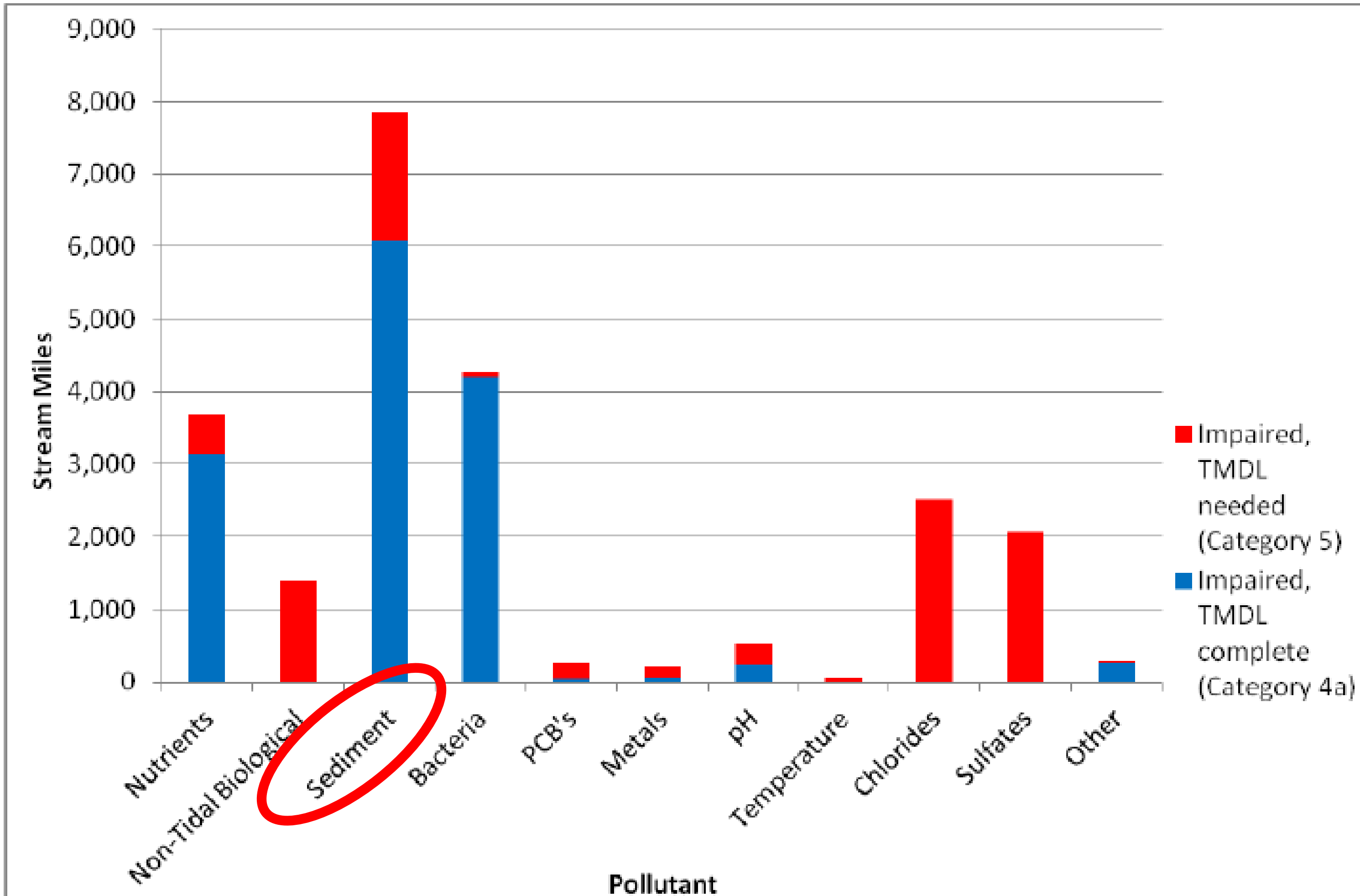
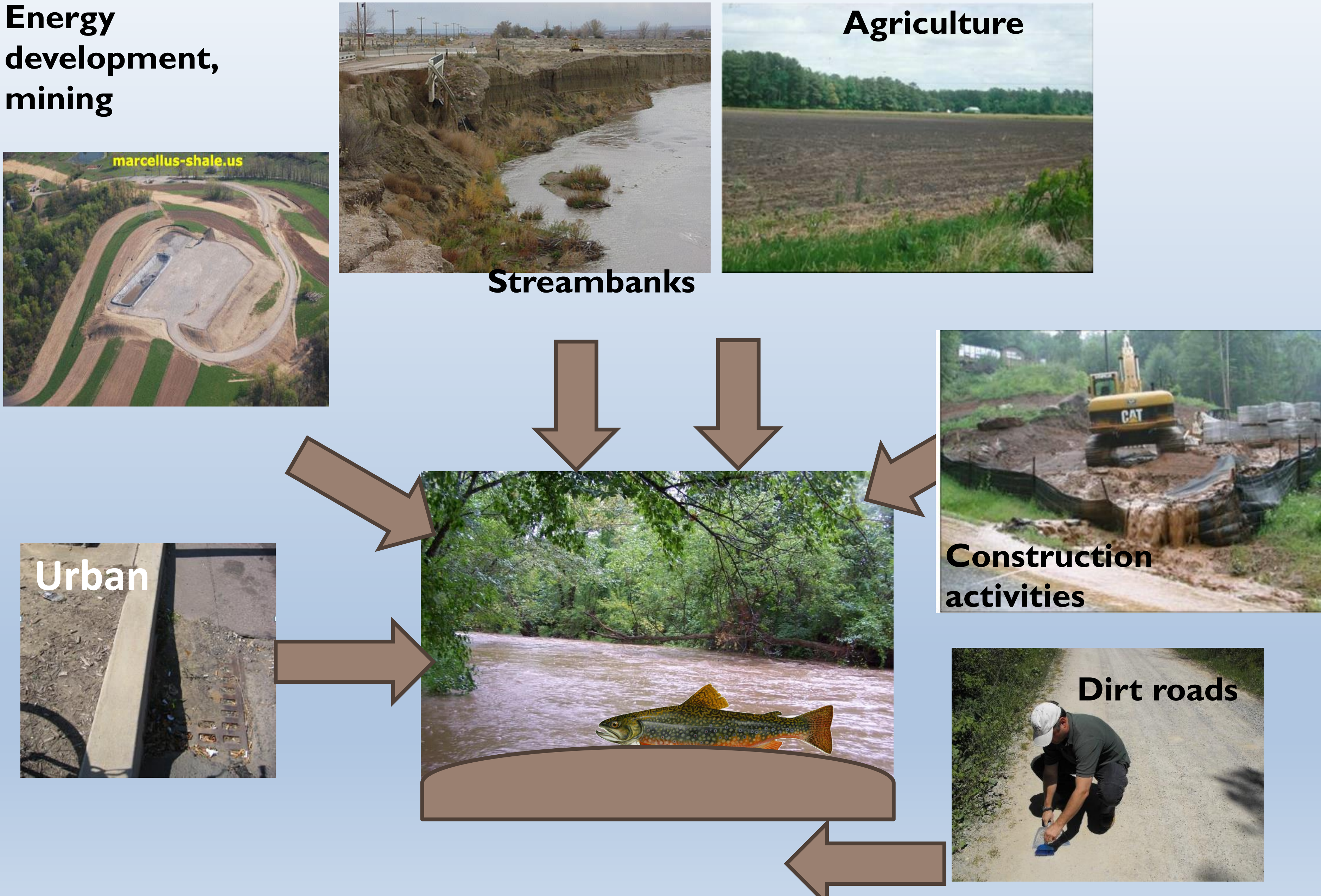


Figure 1: Stream miles impaired by various pollutants. Colors denote the stream miles currently addressed by TMDLs (blue) and those that still require TMDLs (red).

Where is all that sediment coming from?

Sediment Sources



Tools to identify sediment sources

- Models – HSPF, GWLF, SWAT, SWMM, SPARROW, etc.
- Field measurements and Assessments
- GIS and Photogrammetry
- Sediment Fingerprinting

PROBLEM: Most of the models cannot estimate streambank erosion or target reaches where management actions should be directed.

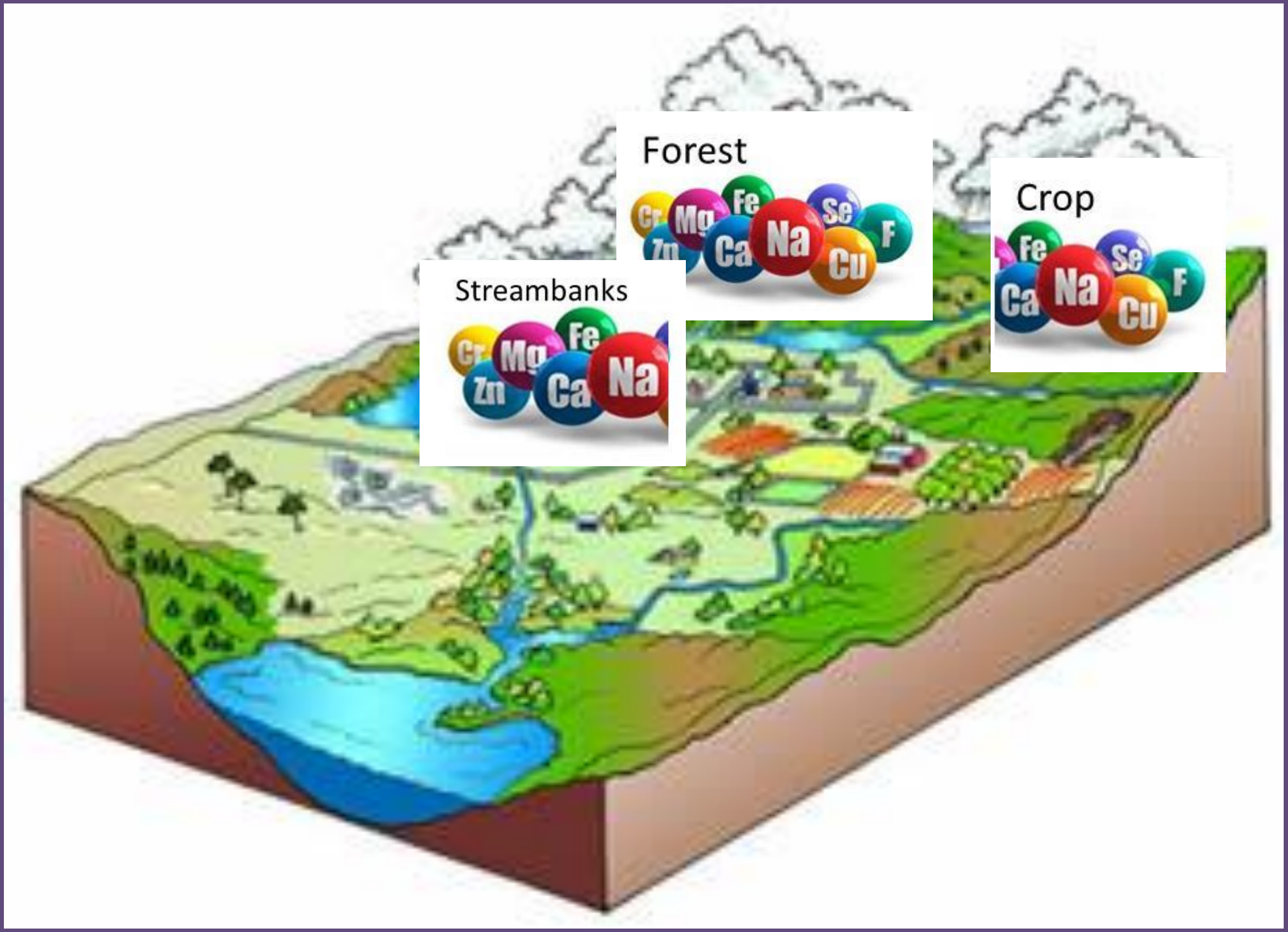
SEDIMENT SOURCING USING SEDIMENT FINGERPRINTS

<u>Underlying principle</u>: potential sediment sources can be characterized using a selected suite of diagnostic physical and chemical properties – the fingerprints

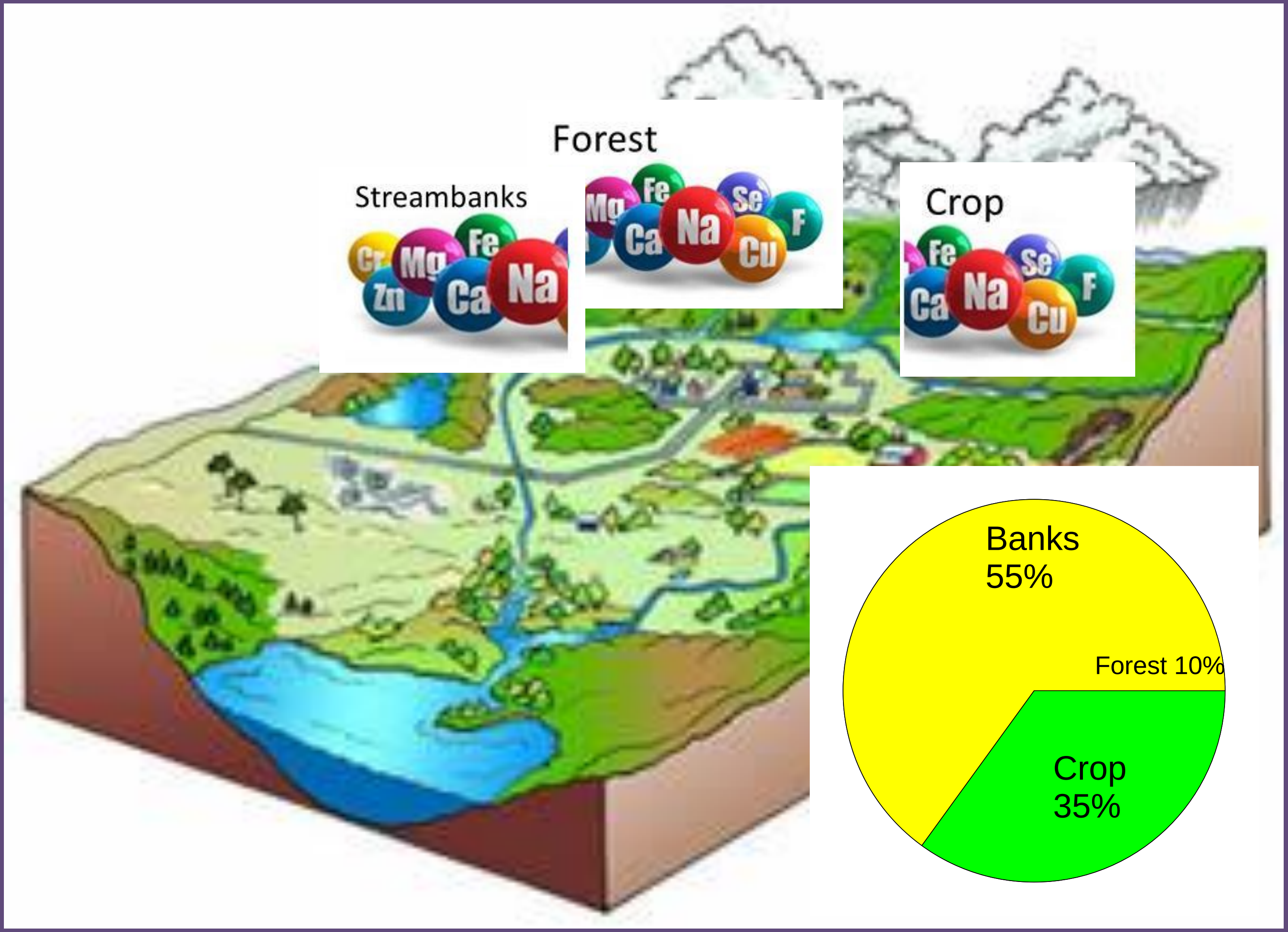
Comparison of these fingerprints with equivalent information for fluvial (target) samples permits the relative importance of the potential sources

Walling et al., 1999

Sediment Fingerprinting <0.063 mm



Sediment Fingerprinting <0.063 mm



Steps in Sediment Fingerprinting Fines (Silts & Clays) (<0.063 mm)

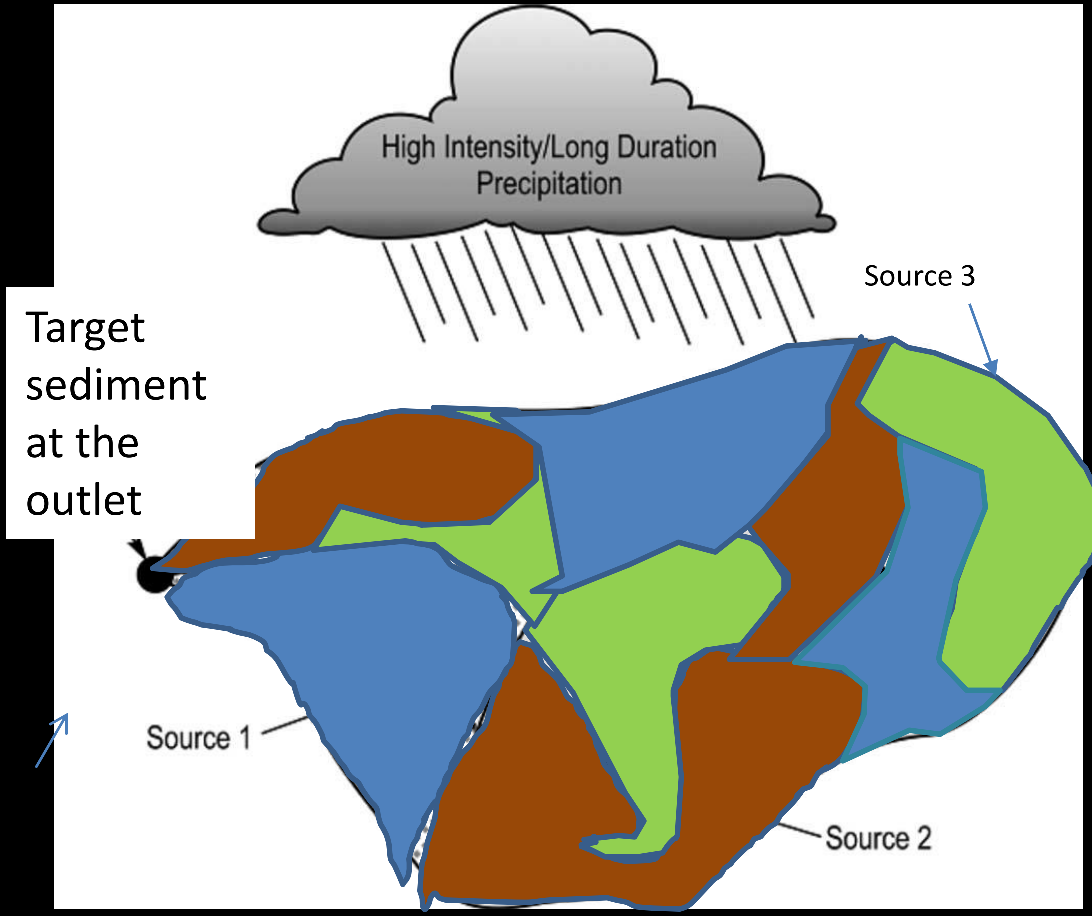
1) Identify sources

2) Sample sources

3) Sample Target–(fluvial sediment)

4) Lab Prep

5) Determine the proportion coming from each source

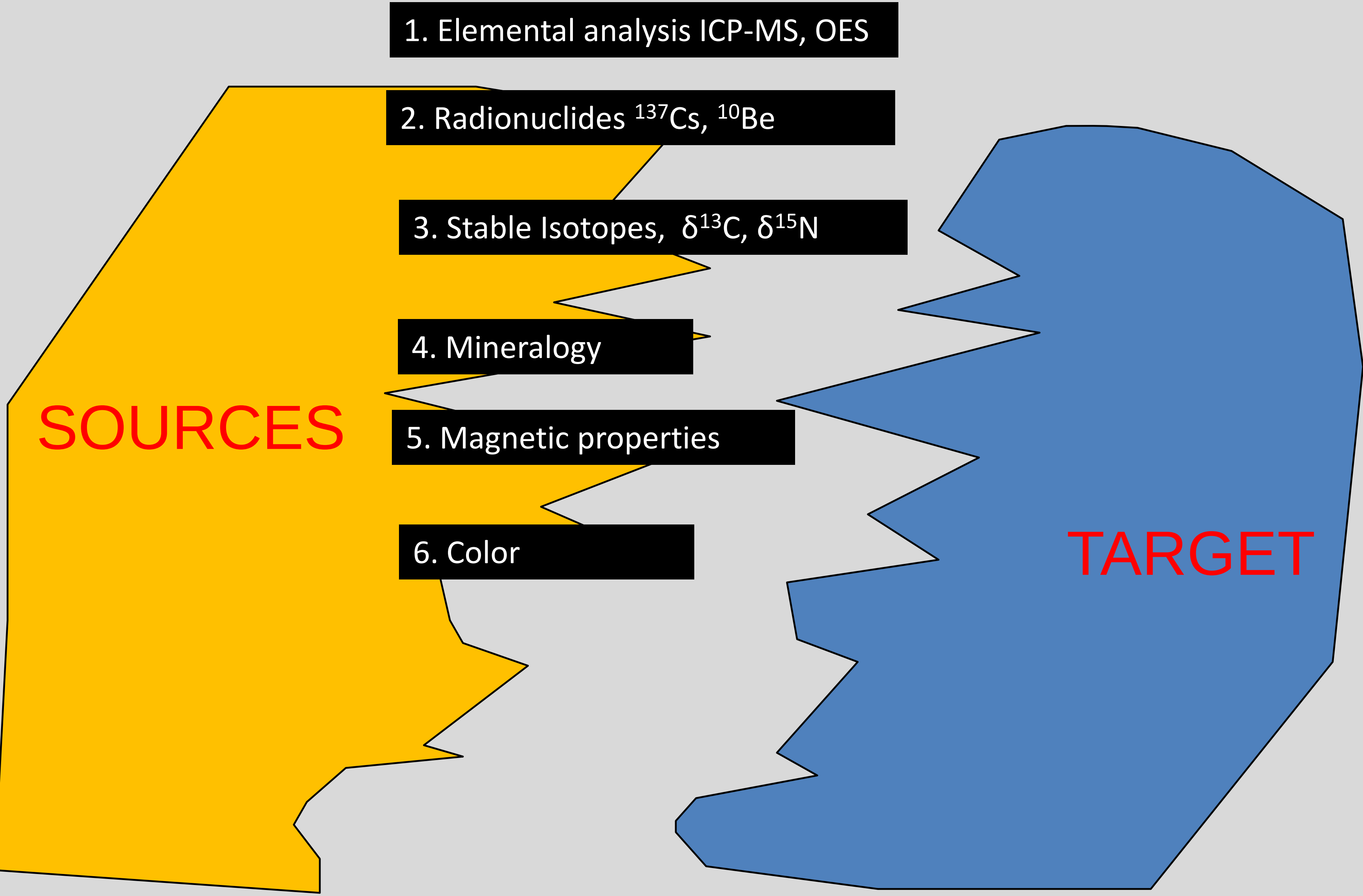


Fluvial or Target Samples

- Suspended sediment – ISCO, Passive Samplers (Walling Tubes), Isokinetic samplers, centrifuge
- Bed material – fine grained sediment deposits Recently deposited floodplain sediment –
- Lake/reservoir/pond/impoundment

Passive Sampler (after Phillips, et al,. 2000)

TRACERS OR FINGERPRINTS USED



Statistical Steps in Sediment Fingerprinting

Imputing non-detects

↓

Outlier removal

↓

Size and organic corrections

↓

Bracket test

↓

Stepwise Discriminant Function Analysis

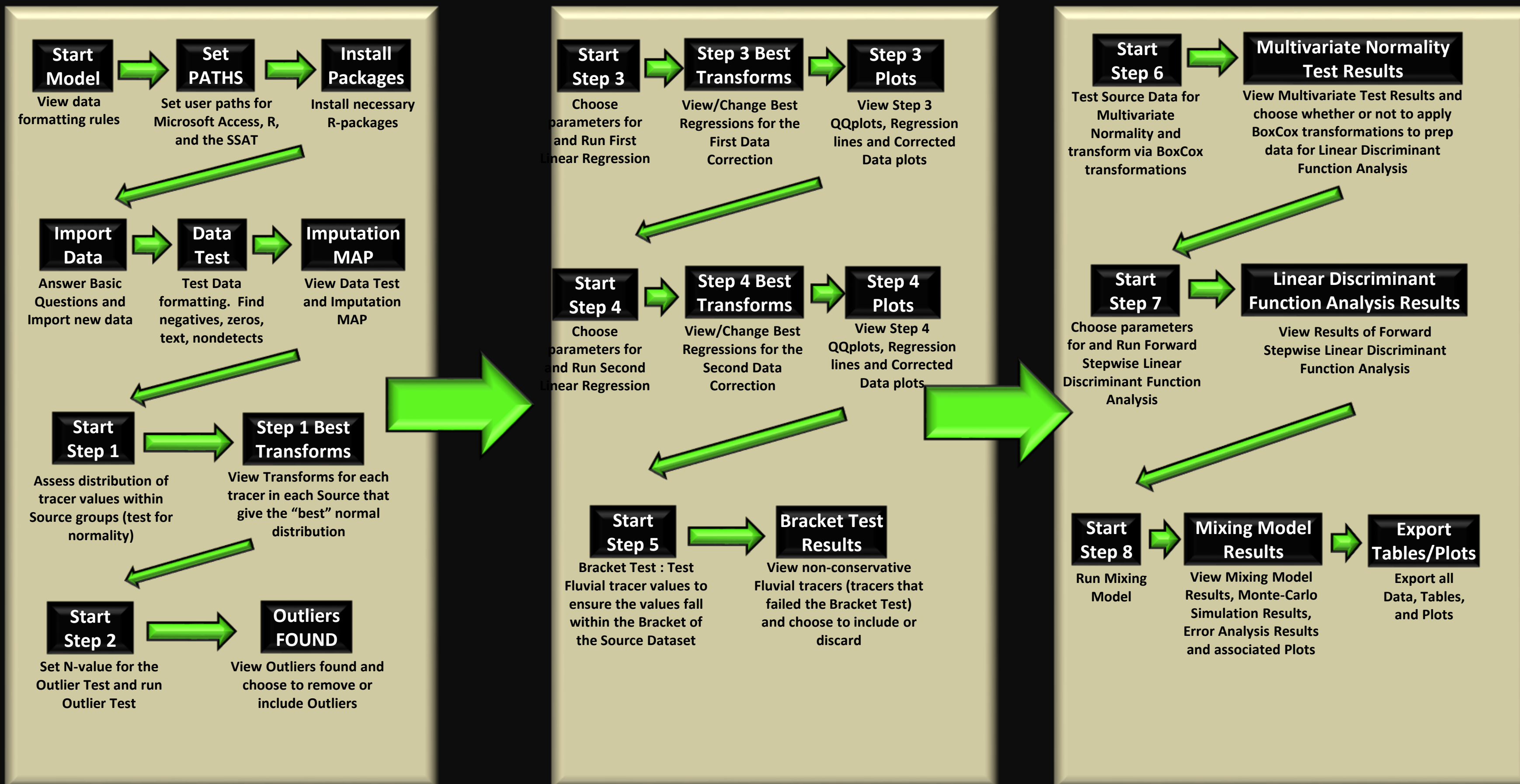
↓

Multivariate *unmixing* model

↓

Error Analysis

Sed_SAT PROGRAM MAP



Gorman-Sanisaca et al., 2017

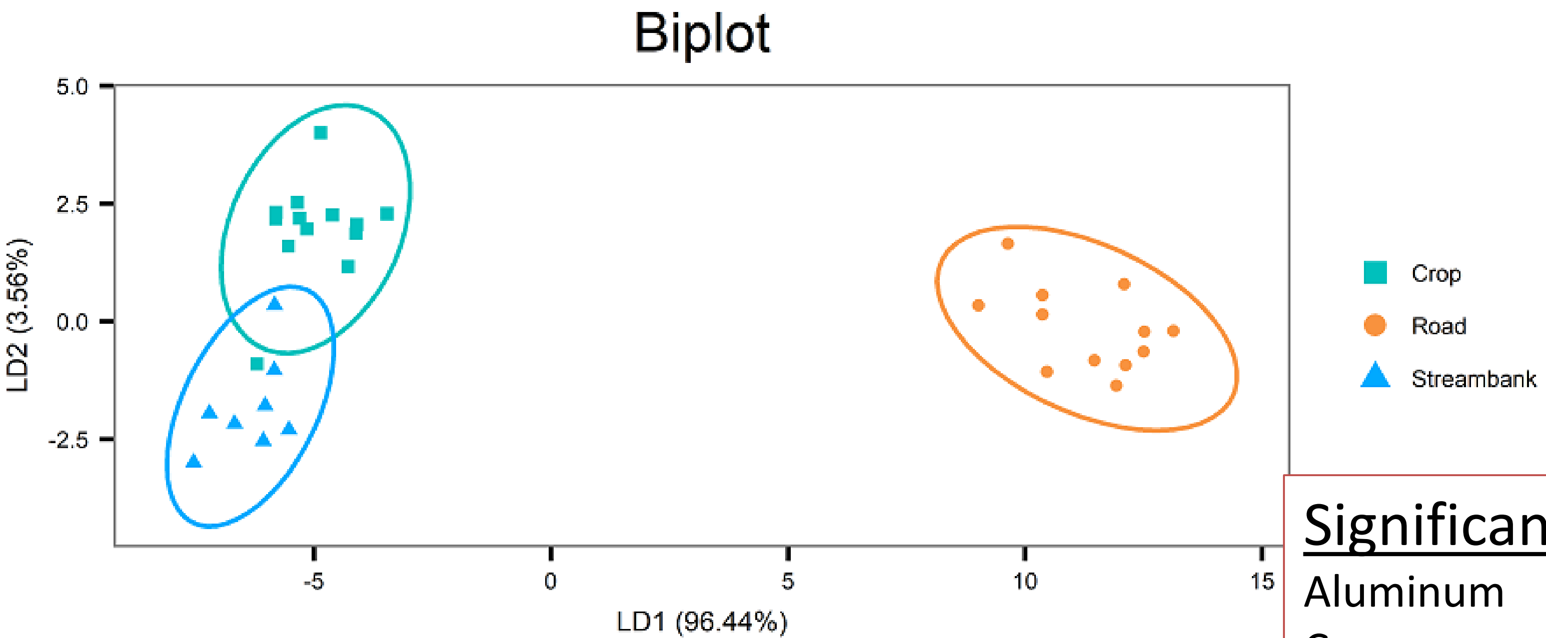
available at: https://doi.org/10.5066/F76Q1VBX

DATA INPUT

ID	Source Type	Arsenic	Barium	Beryllium	Calcium _µg/g	Chromium	Cobalt	Copper	Iron	Lead
F1	FOREST	1.6	75.4	0.4	3040	2	4.5	10.8	2670	16.6
F10	FOREST	3.6	152	1	3050	12.1	12.4	11.8	13500	25
F12	FOREST	2.3	68.1	0.3	1740	6.3	1.9	4	11700	38.4
F20	FOREST	2.9	205	1.4	5700	6	15.2	9.2	10500	36.5
F3	FOREST	1.6	147	0.9	5780	3.6	4.2	4	5120	16.8
F15	FOREST	2.6	43.9	0.6	3290	6.4	7.5	17.7	6670	14.7
F7	FOREST	1	78.1	1.6	8170	12.7	9.6	6.9	12400	29.4
F11	FOREST	1.9	100	0.5	7290	5.6	4.9	2.6	6000	25.6
F19	FOREST	2.4	83.2	0.4	561	3.6	2.2	3	5780	37.3
F6	FOREST	6.6	38.6	0.7	5180	6.2	5.3	5.8	8220	27.4
F9	FOREST	1.8	213	0.9	1080	7.1	5.5	8.2	9080	31.6
F4	FOREST	1.6	56.8	0.3	3910	4.7	1.4	2.6	5900	12.6
F5	FOREST	2.1	81.9	0.6	5250	3	4.6	3.8	3890	24.2
F2	FOREST	2.5	204	0.9	2740	4.2	10.3	9.5	7040	44.8
P19	PASTURE	5.7	45.7	0.9	3470	10.7	5.4	12.7	10900	27.5
P2	PASTURE	1.3	61.5	1	7150	8.2	5.6	20.6	11400	12.2
P12	PASTURE	2.5	51.8	0.4	1340	5.8	3.7	18.3	6240	19.4
P20	PASTURE	4.3	76.9	0.7	5880	15	10	29.1	19500	61.6
P16	PASTURE	3	63	0.3	2970	6.2	4.7	12.3	7960	31.6
P3	PASTURE	2.1	73	1	3280	10.1	8.4	10.1	14500	17.1

Percent Classified Correctly by Linear Discriminant Function

93.269



Significant tracers

Aluminum
Copper
Manganese
Zinc

Mixing Model Results

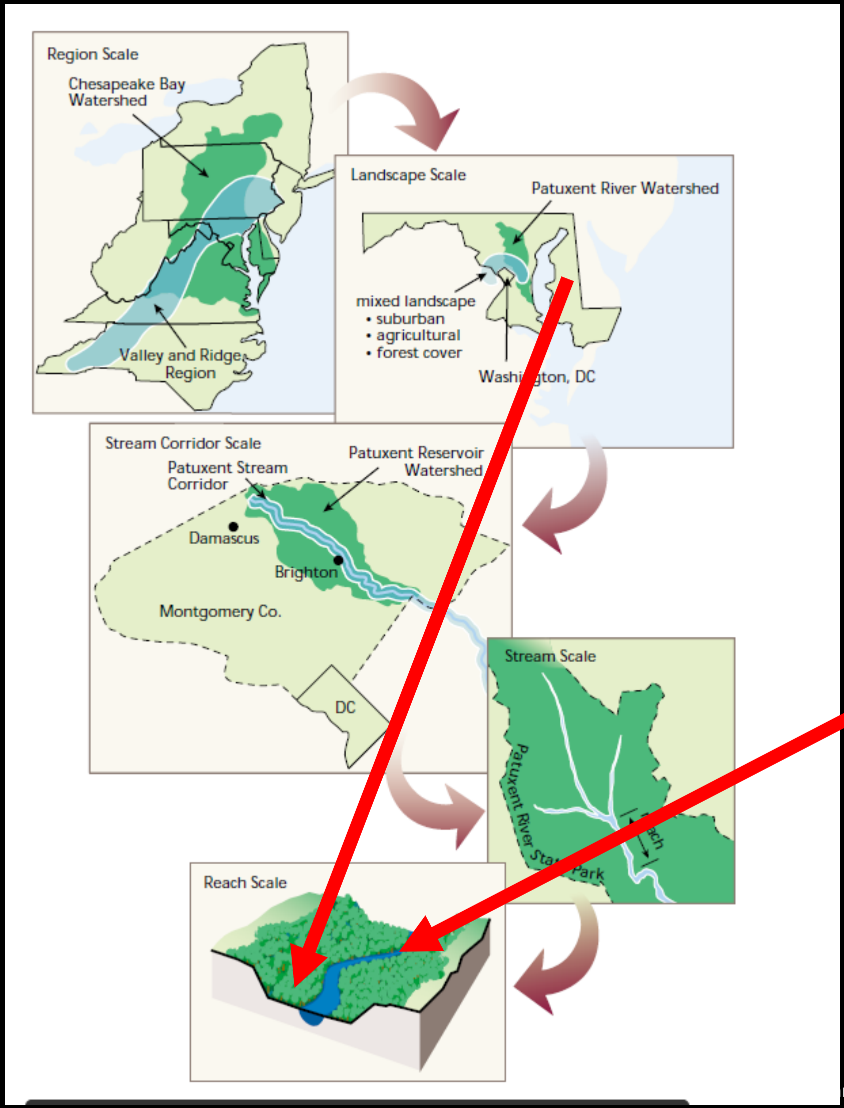
SampleName	Crop	Road	Streambank
BHLCORE22-24	0	21	79

SCALE

Modeling – Chesapeake Bay – major watershed

At the management scale (<250km^2) its important to differentiate upland vs channel sources

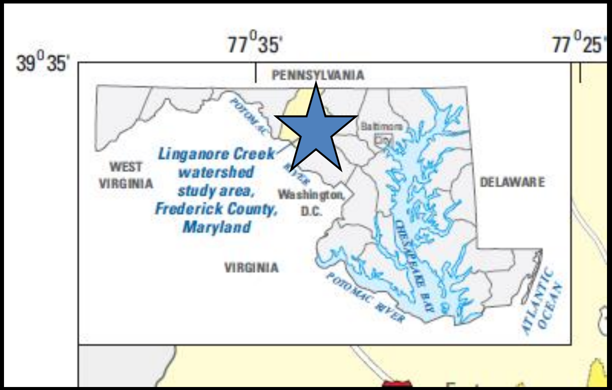
---effective scale for monitoring the effect of management actions to reduce sediment



rcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb104346

CASE SEDIMENT FINGERPRINTING STUDIES

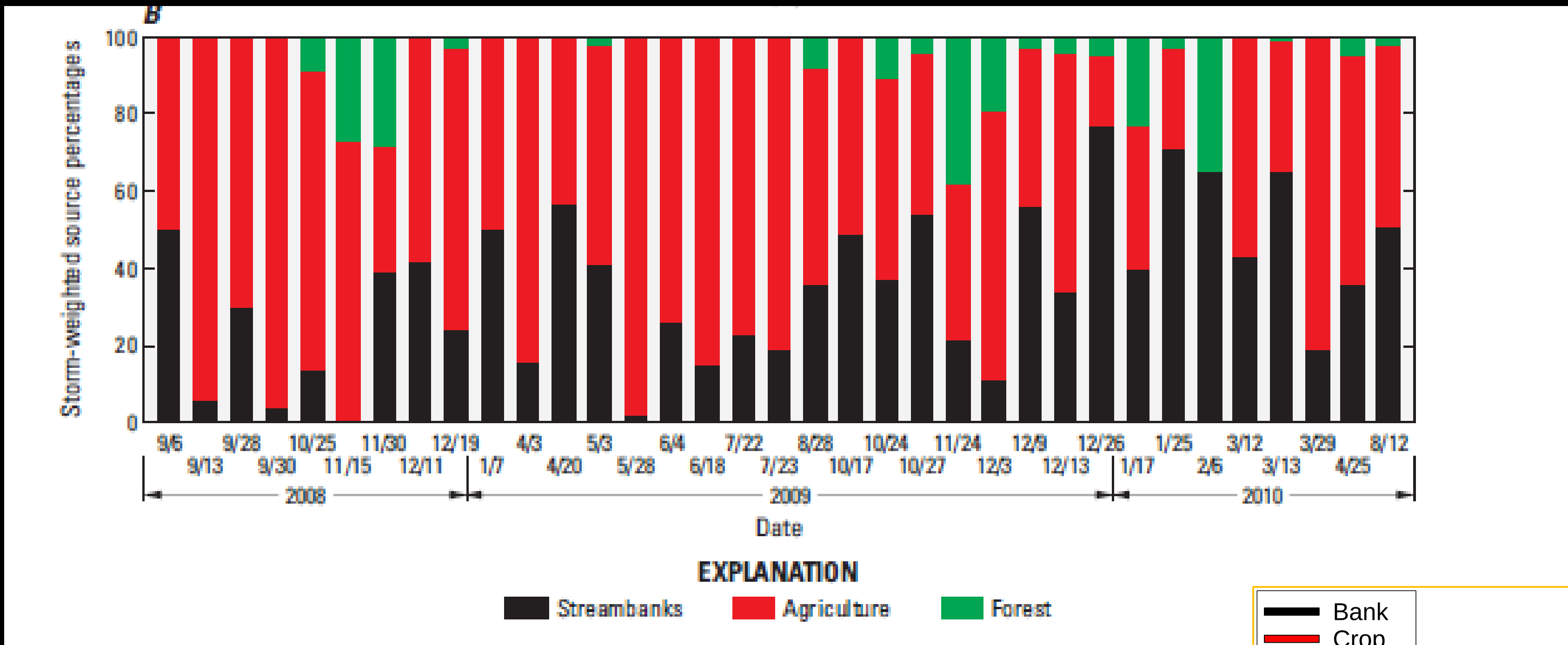
Linganore Creek 2008-2010 (147 km^2)
Piedmont – schist, gneiss
27% forest
54 agriculture (pasture and cropland)
11 % other



Fingerprinting Results Linganore Creek

Collected 200 fluvial samples over 36 storms, 2008-2010

Gellis et al., 2015



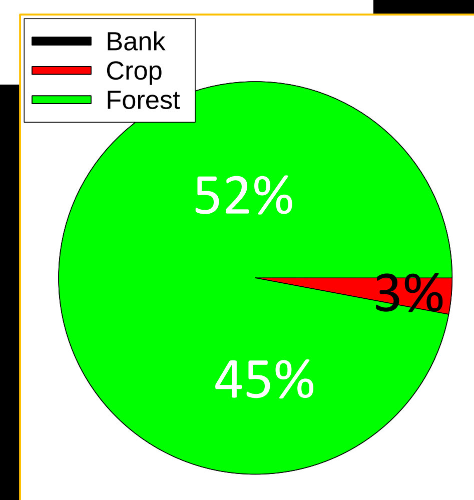
final set of tracers used
Al, C, δ^{13}C, Cu, Fe, Li, Mg, Mn, N, Ni, Pb P, V

Weighted Results

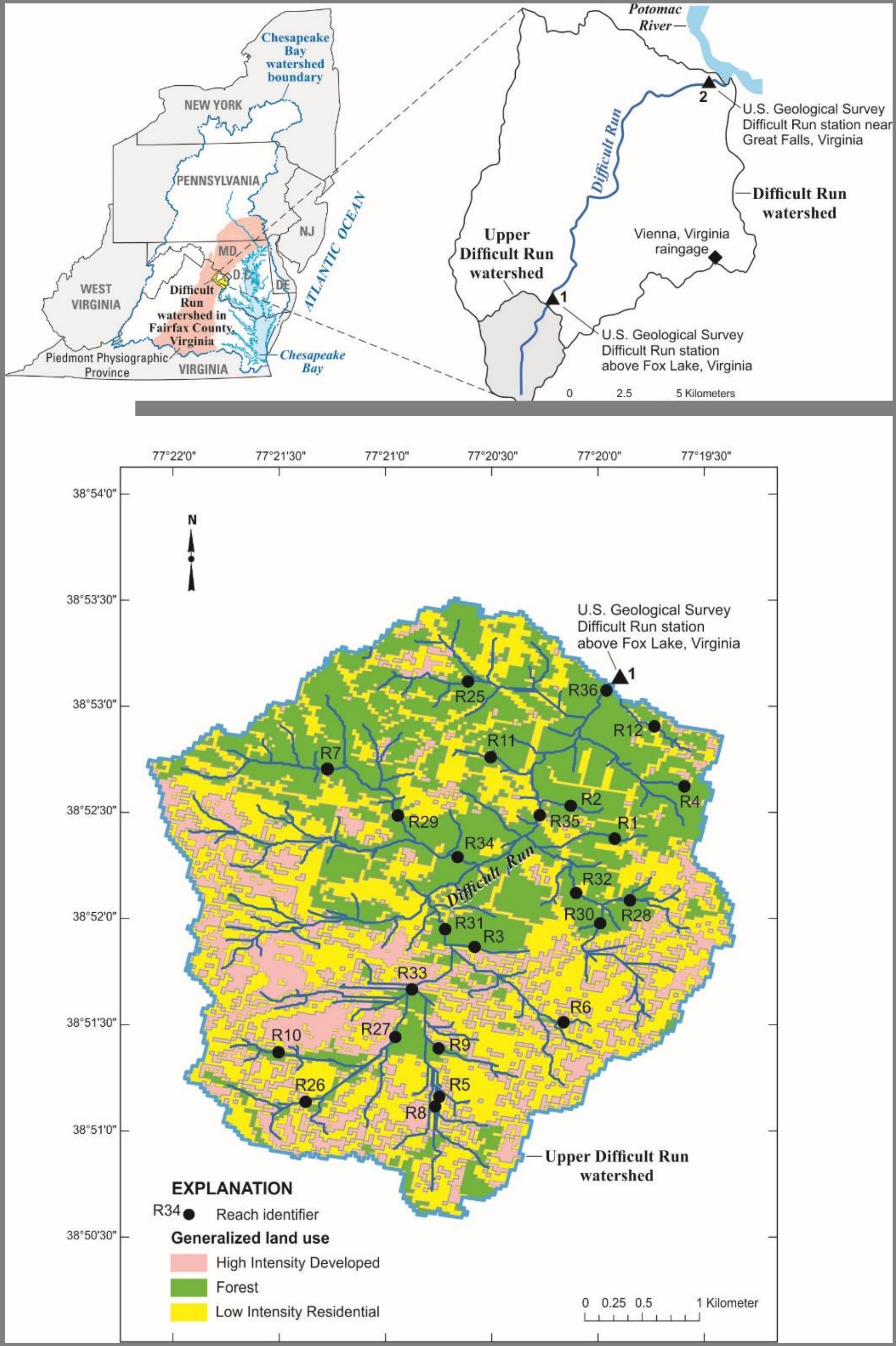
Banks = 52%

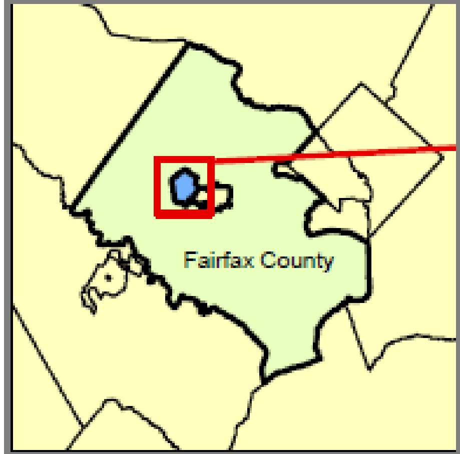
Ag = 45%

Forest = 3%



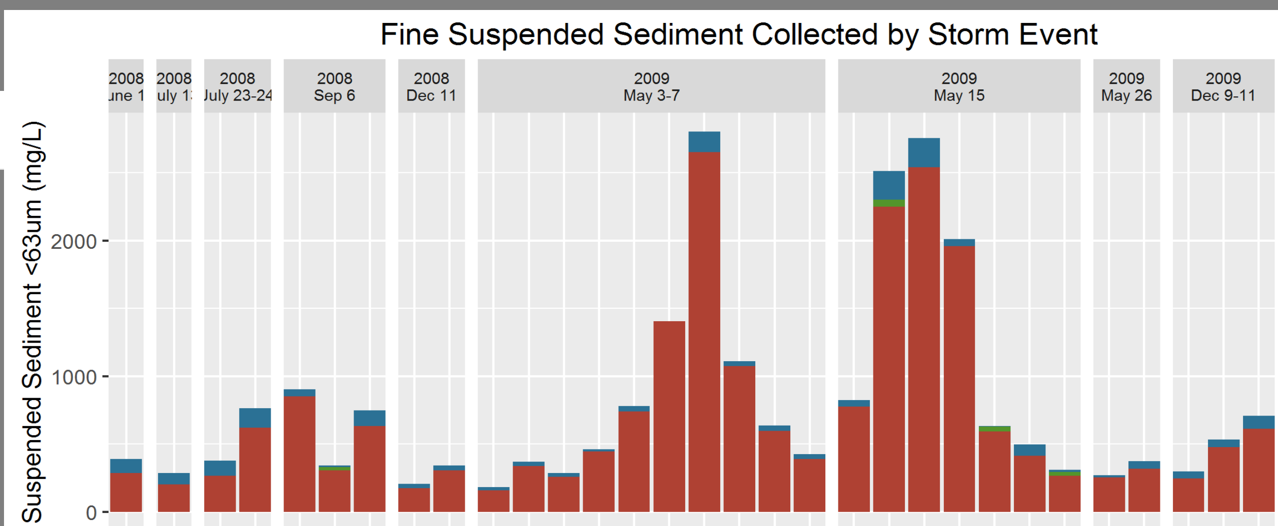
Sediment Fingerprinting Results Difficult Run, VA 2008-2009 (14.2 km^2)



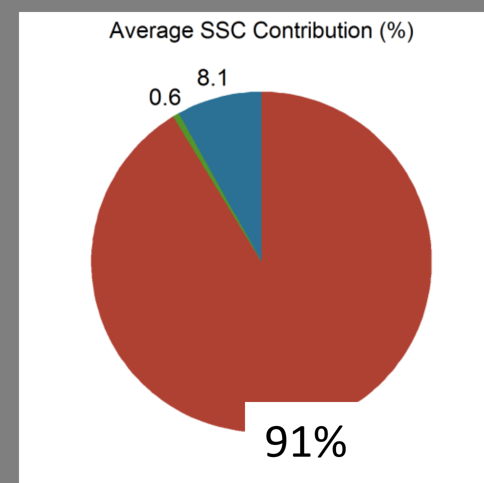


Bank erosion is a major source of sediment in urban areas – example from Difficult Run, Fairfax County, VA.

Difficult Run, VA above Miller Heights



Sediment fingerprinting results by storm event for Difficult Run [RED = banks; BLUE=road residue; GREEN forest]



Total sediment contributed by banks

SOURCES

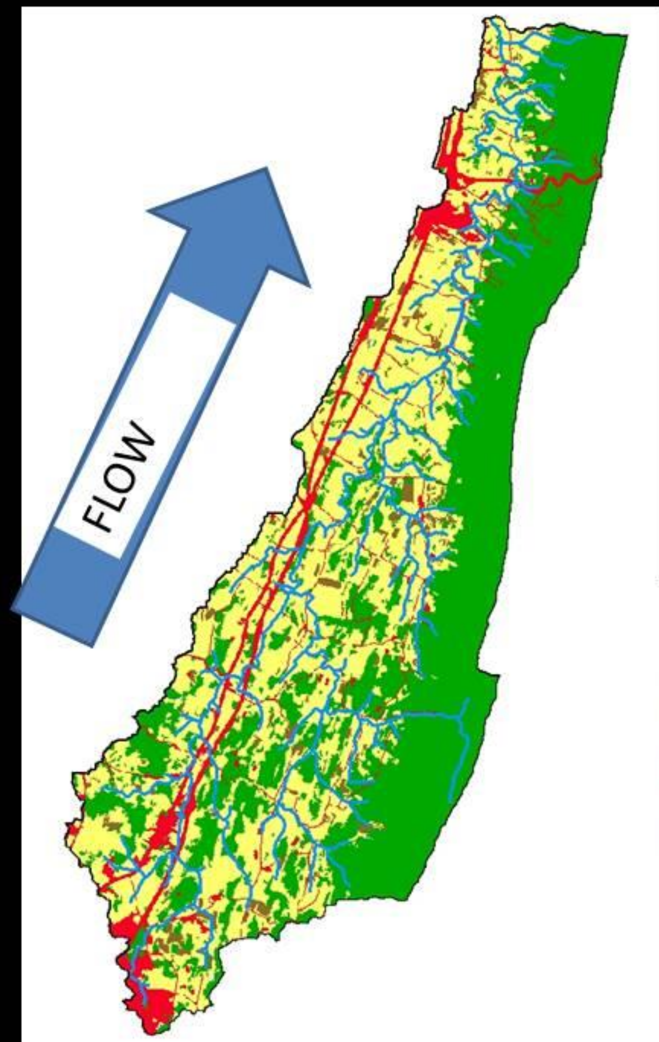
Smith Creek, Virginia 246 km^2

FOREST

PASTURE

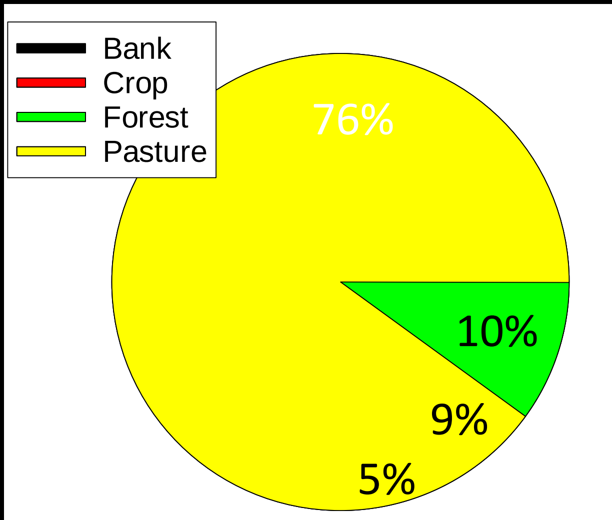
CROPLAND

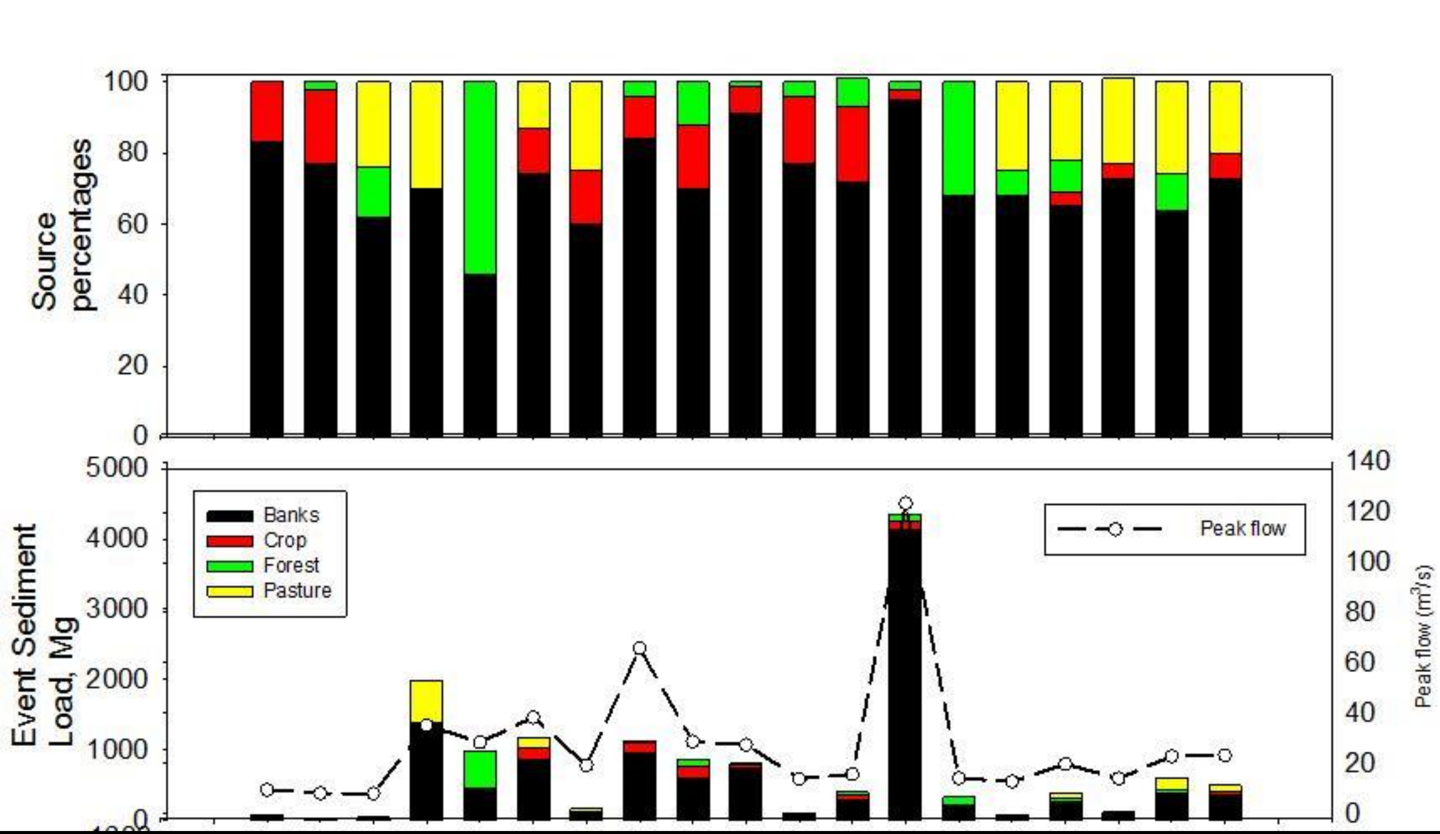
BANKS



Gellis and Gorman Sanisaca (in Press)

Smith Creek Results
2012-2015

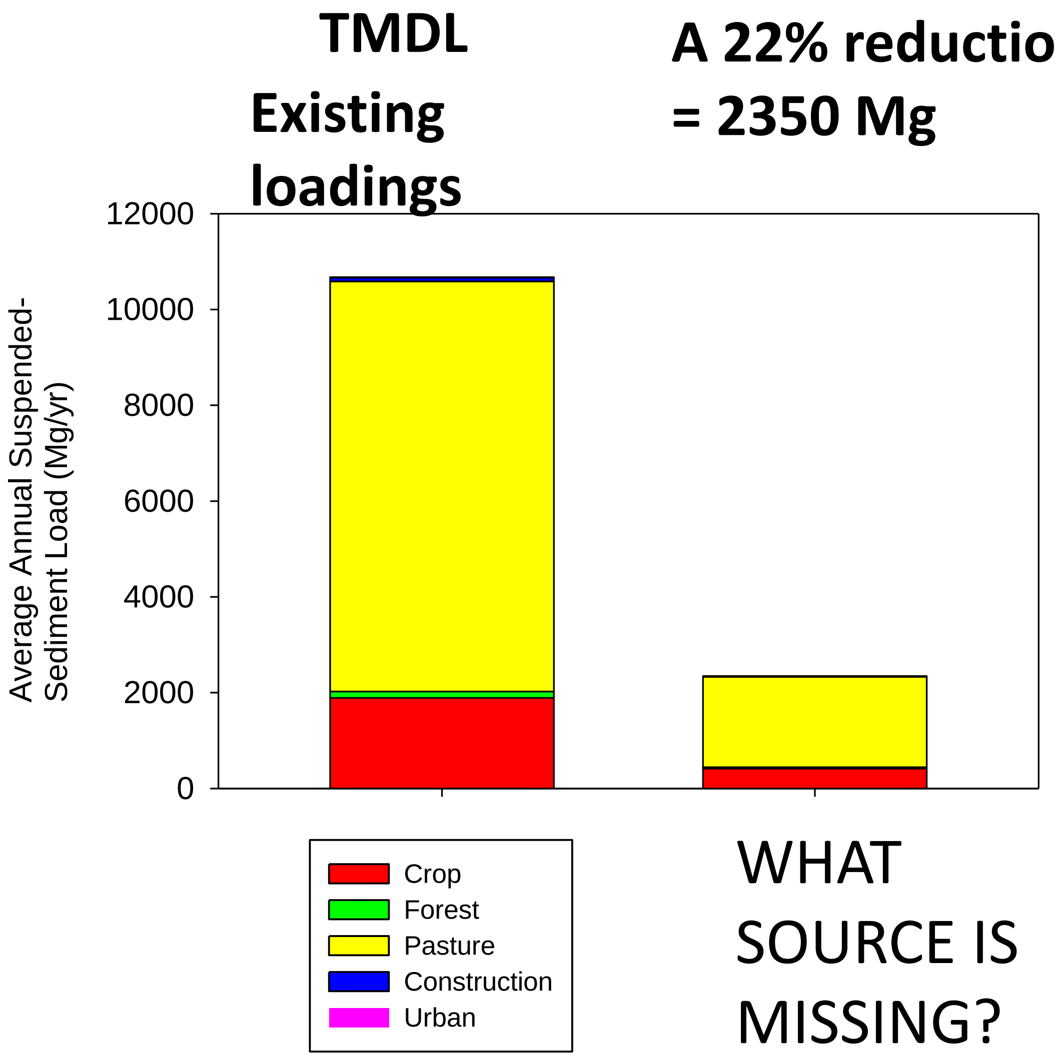




- Fingerprinting Source Results Compared to Sediment TMDL

Smith Creek TMDL, annual loadings 10,680 Mg/ yr (VADEQ, 2009)

TMDL Proposed
A 22% reduction
= 2350 Mg



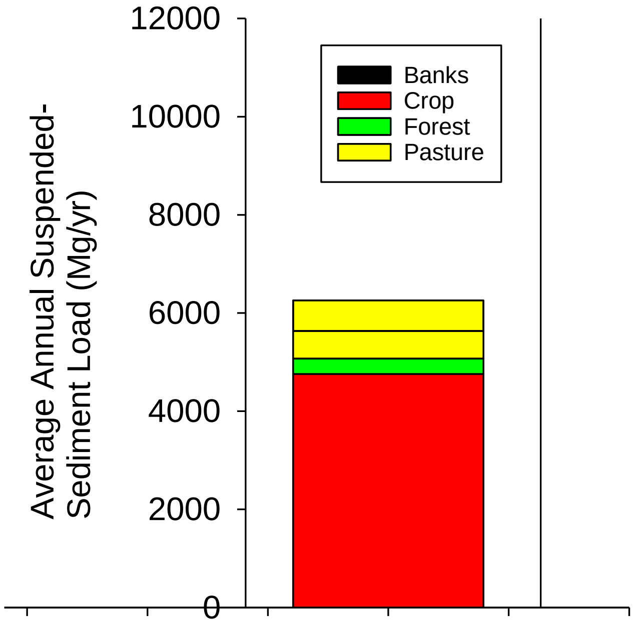
WHAT SOURCE IS MISSING?

Smith Creek TMDL, annual loadings 10,680 Mg/yr (VADEQ, 2009)

USGS load 6,260 Mg/yr (Hyer et al., 2016)

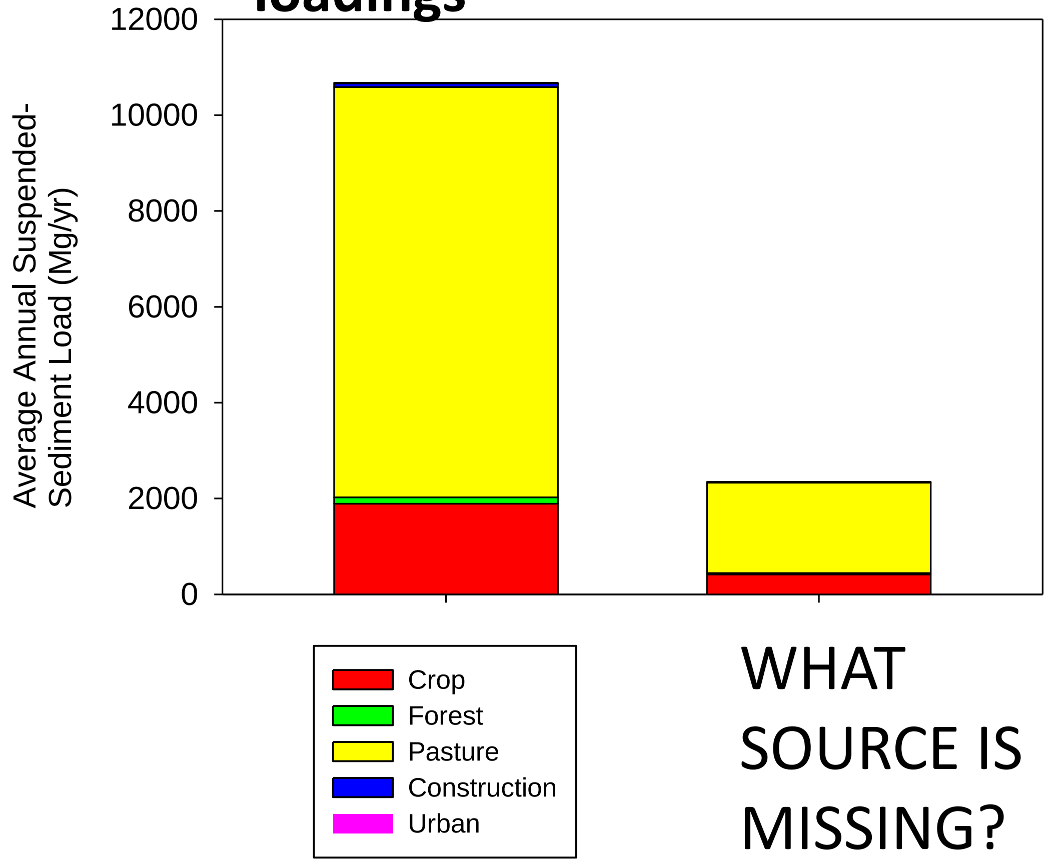
TMDL Proposed
A 22% reduction

Fingerprinting



TMDL

Existing loadings



WHAT SOURCE IS MISSING?

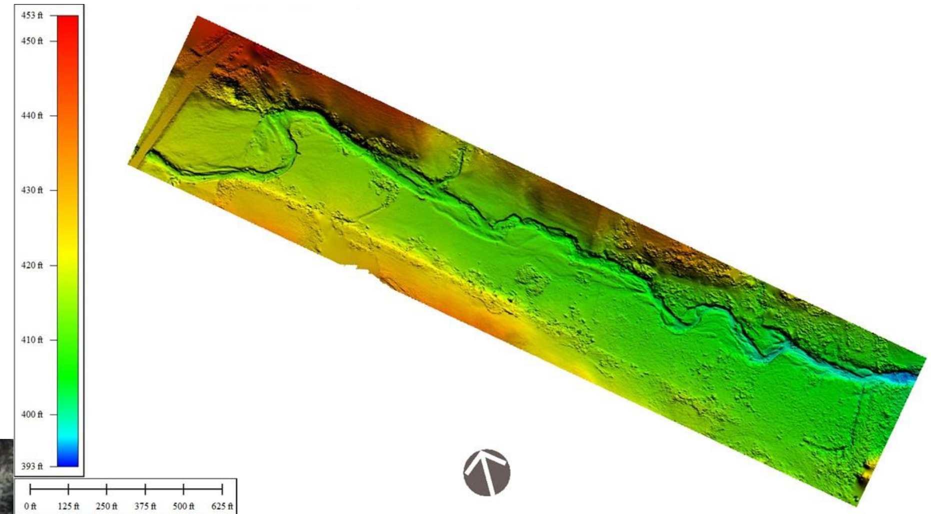
Smith Creek Watershed

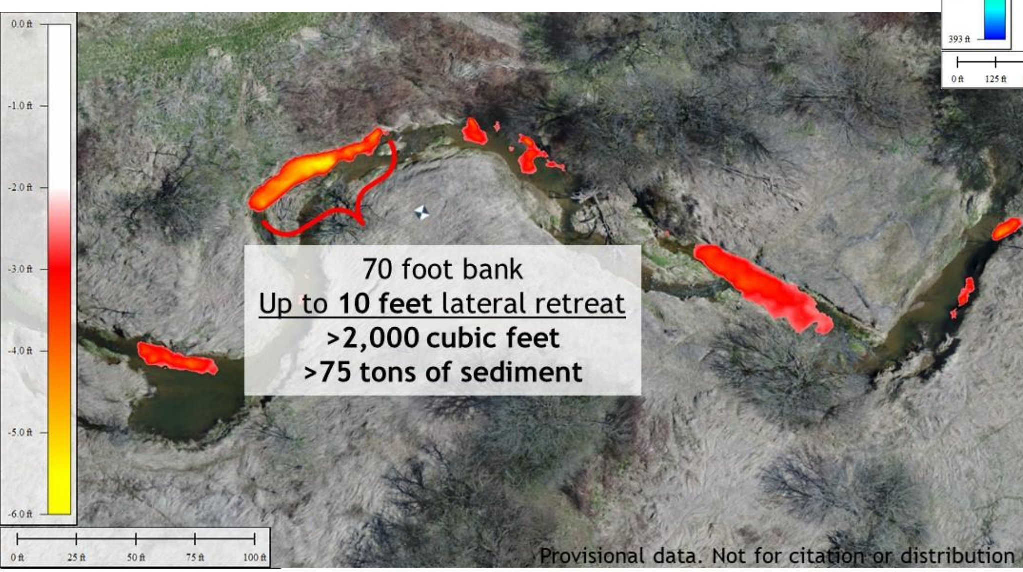
TMDL Implementation Plan;

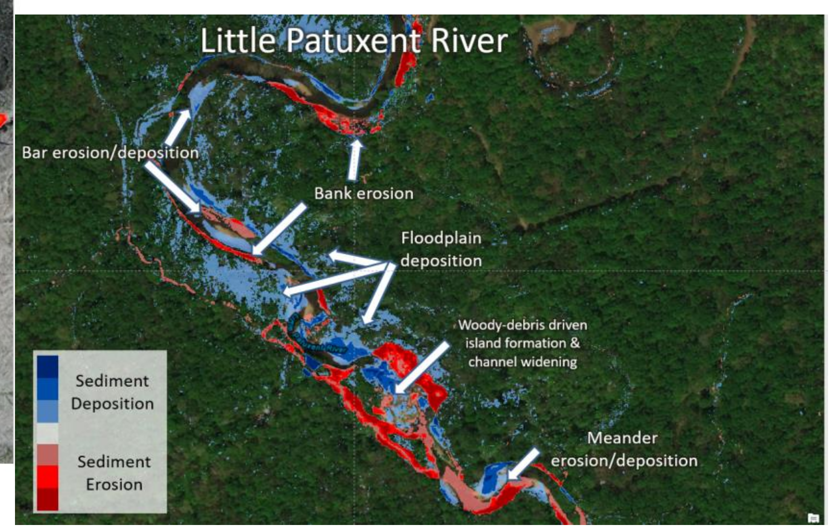
Rockingham and Shenandoah Counties, City of Harrisonburg, and Town of New Market, Virginia

The next generation of tools for targeting and monitoring

- Lidar, drones, Structure from Motion







Summary

- **Sediment fingerprinting to allocate sources (Sed_SAT)**
  - Channel vs uplands
  - Allocating Sources at Management Scales
  - Combined with 'state-of-the art' technologies – target sources and monitor the effectiveness of management actions in reducing sediment

  - Education- training for Sediment Fingerprinting and "State-of-the Art' technologies

THANK
YOU