USGS
science for a changing world

Identifying Sources and Sinks of Organic Carbon along Fanno Creek, Oregon

by Mackenzie Keith (mkeith@usgs.gov), Steven Sobieszczyk (ssobie@usgs.gov), Jim O'Connor (oconnor@usgs.gov), Stewart Rounds (sarounds@usgs.gov), Jami Goldman (jgoldman@usgs.gov)
USGS, Oregon Water Science Center, Portland, Oregon

Project Background

The goal of this project is to identify sources and sinks of organic carbon in Fanno Creek, a tributary of the Tualatin River, Oregon, by characterizing sedimentation patterns in the stream. Organic carbon, a water-quality concern, is commonly tied to the fine-grained, organic-rich sediment in the watershed (Bonn and Rounds, 2010). This study builds on previous research (Simon and others, 2011) that identified several sites along Fanno Creek that are widening and unstable. Final results from the current study will focus on determining erosion and deposition features (e.g., cutbanks and floodplains), quantifying sediment transport volumes, and producing maps identifying likely sources and sinks of carbon-rich sediment along Fanno Creek.

We are using an intensive field based approach to quantify volumes and rates of erosion and deposition at seven study sites. Study sites are distributed among three focus areas: upper, middle, and lower basin. Site selection was based on previous bank stability research by Simon and others (2011) and prior USGS studies in the Fanno Creek basin (Rounds and Doyle, 1997; Anderson and Rounds, 2010). A combination of erosion pins, deposition plates, and cross-sections are being used to monitor the interplay of sediment throughout the basin. Overall, our initial observations indicate that: (1) a substantial portion of the banks along Fanno Creek are undercut and likely a source of sediment to the channel, (2) more dynamic erosion and deposition occurs at stream meander sites than at more linear sites, and (3) sediment sources and sinks are largely determined by discharge and local stream geology (e.g., hardpan clay substrate).

Fanno Creek Basin

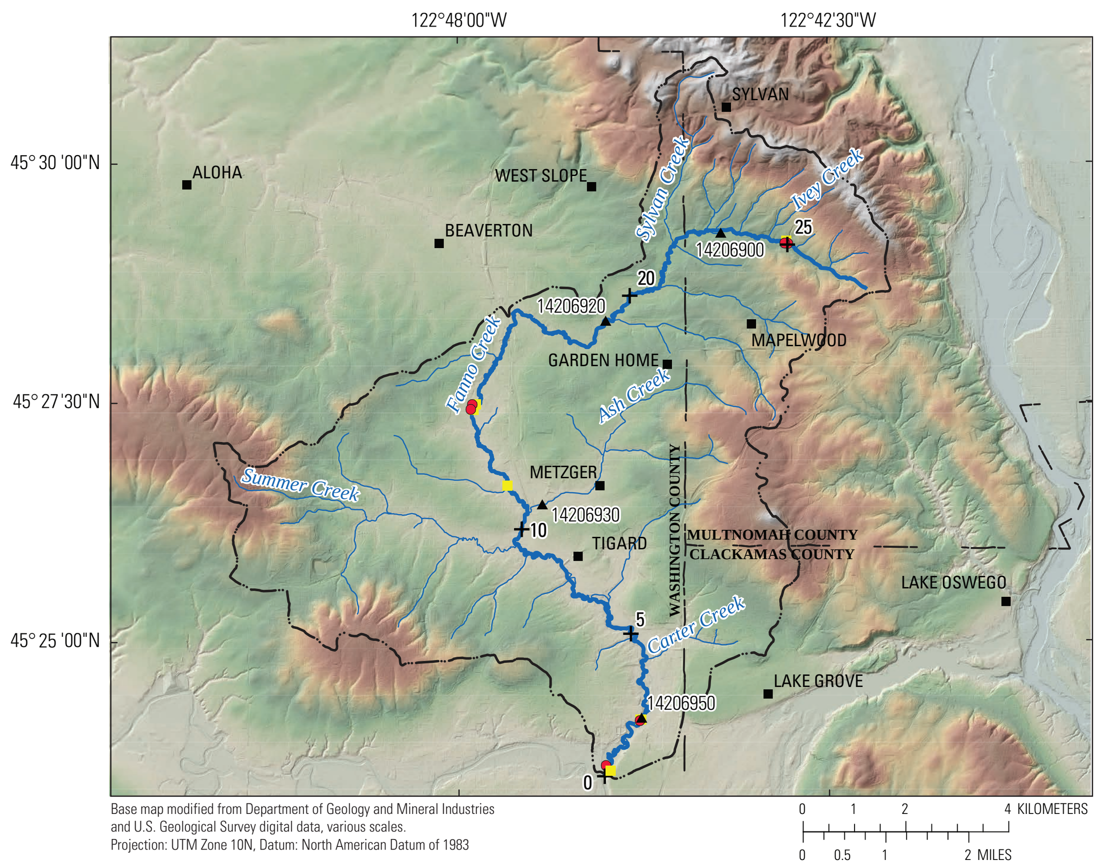


Figure 1. Map of the Fanno Creek basin, Oregon, with locations of erosion pin and deposition plates.

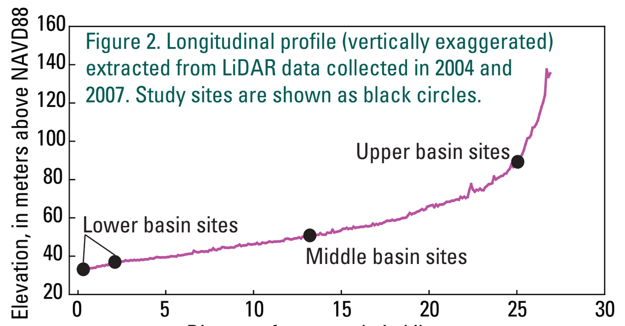


Figure 2. Longitudinal profile (vertically exaggerated) extracted from LiDAR data collected in 2004 and 2007. Study sites are shown as black circles.

Basin characteristics

Drainage area (km²)	82.4
Channel length (km)	27
Mean annual precipitation (cm)	107
Geologic setting	Columbia River and Boring basalts and Willamette Group terrestrial rocks dominate the headwater areas while Quaternary surficial deposits dominate most of the basin
Land use	Urban, 86.8%; Historically forested, now 22.8%
Major tributaries	Sylvan Creek, Ash Creek, Summer Creek

Erosion Techniques

Materials
- Following methods similar to Laubel and others (2000), Staley and others (2006), and Utley and others (2008)
- 30-cm-long steel nails
- Nail heads painted or spray painted for easy relocation in the field

Installation
- An array installed on both banks at each meander and straight site at low stage
- Arrays varied between 3 to 4 pins down by 3 to 5 across with 30 cm horizontal and vertical spacing
- Pins driven horizontally into bank leaving 5 cm exposed

Measurement
- Measure at low stage after high flow events (~17 m³/s at the Durham gage) or monthly, whichever is more frequent
- Measure exposed pin length with a ruler
- Reset/replace pin if more than 12.5 cm is exposed, the pin is completely buried, or the pin is missing

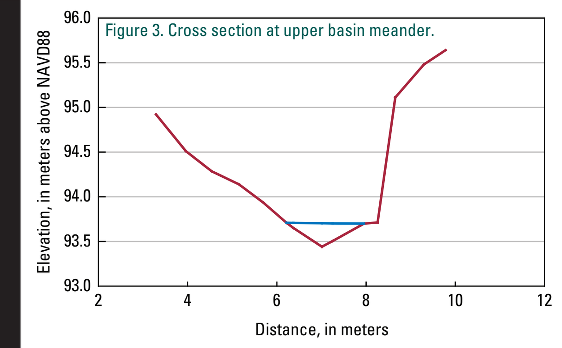
Deposition Techniques

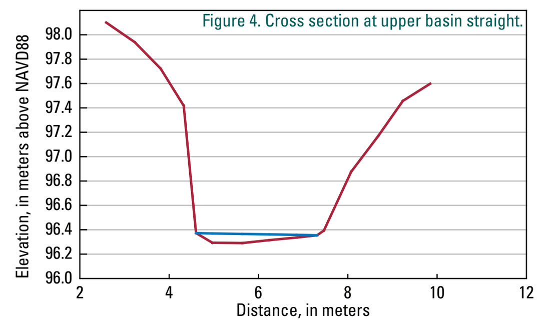
Materials
- Following methods similar to Kleiss (1996) and Heimann and Roell (2000)
- 30 cm by 30 cm square, acrylic glass plates
- Holes drilled in the center of the plates and plates were scuffed with sand paper on one side
- 30-cm-long rod, nuts, and washers to anchor plates

Installation
- Two plates installed at each site in the lower and middle basin, two additional at a site flooded from a beaver dam, and one at the upper basin meander site
- Anchored to ground on low topographic benches within the channel and on the floodplain

Measurement
- Collect sediment after high flow events or monthly, whichever is more frequent
- Scrape sediment from plate into plastic bag, record wetted weight in the field
- Freeze samples for future dry weight measurements, carbon isotope analysis, and grain-size distribution

Upper Basin



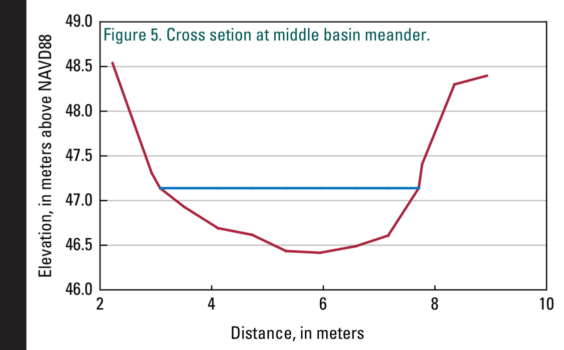


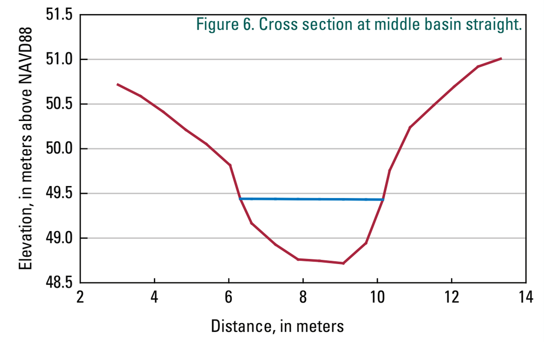
Erosion Pins
Meander
E1: Erosion (15.86 dm³) on outside undercut bank and deposition (4.25 dm³) on inside bank
E2: Erosion (7.08 dm³) and deposition (5.95 dm³) at outside and inside banks, respectively
Straight
E1: Minor erosion (0.85 to 3.40 dm³)
E2: Minor deposition (0.57 to 3.96 dm³)

Deposition Plate
Meander
D1: 12.9 g of sediment collected

Distance from mouth (km)	25
Drainage area (km²)	3.1
Drainage density (km/km²)	0.52
Beaverton-Hillsdale Reach slope (m/m)	0.0132
Mean annual discharge (m³/s, USGS 14206900)	0.09
Site geology: near the transition of terrestrial sedimentary rocks to catastrophic flood deposits (Hillsboro Formation/ Missoula Floods boundary)	

Middle Basin



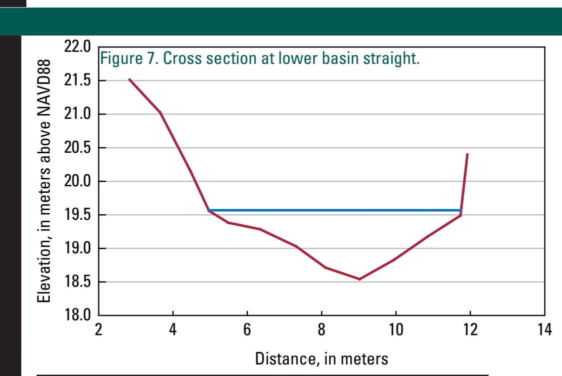


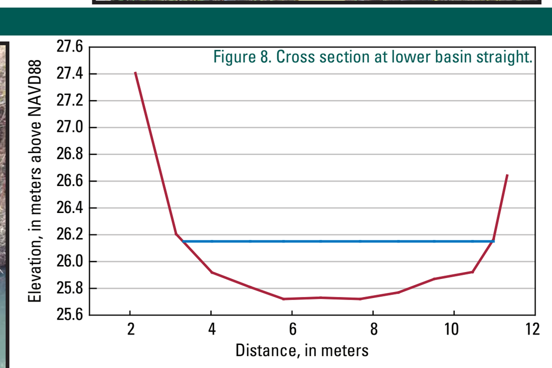
Deposition Plates
Meander
D1: 399.9 and 807.7 g
Straight
D1: 66.3 and 302.7 g
Beaver dam
D1: 83.2 and 198 g

Erosion Pins
Meander
E1: Erosion and bank failure (3.11 to 42.19 dm³)
E2: Erosion observed (3.96 to 9.06 dm³)
Straight
E1: Deposition on both banks (1.70 to 3.68 dm³)
E2: Some erosion (7.08 dm³) and minor deposition (0.28 dm³)

Distance from mouth (km)	13.6, meander; 13.5, straight
Drainage area (km²)	26.9
Drainage density (km/km²)	1.16
Greenway Reach slope (m/m)	0.0010
Mean annual discharge (m³/s; OWRD 14206920)	NA
Site geology: Catastrophic flood deposits (Missoula Floods)	

Lower Basin





Deposition Plates
Meander
D1: Submerged, no measurement
Straight
D1: 389.2 and 455.5 g

Erosion Pins
Meander
E1: Submerged, no measurement
E2: Submerged, no measurement
Straight
E1: Erosion (15.29 dm³) and deposition (8.50 dm³)
E2: Erosion (0.85 dm³) and deposition (4.25 dm³) on same banks

Distance from mouth (km)	2.35, straight; 0.35 meander
Drainage area (km²)	80.5, straight; 82.1, meander
Drainage density (km/km²)	0.91
Durham Reach slope (m/m)	0.0016
Mean annual discharge (m³/s; USGS 14296950)	1.24
Site geology: catastrophic flood deposits (Missoula Floods) at the straight site; Quaternary surficial deposits (Tualatin River) at the meander site	

Preliminary Assessment

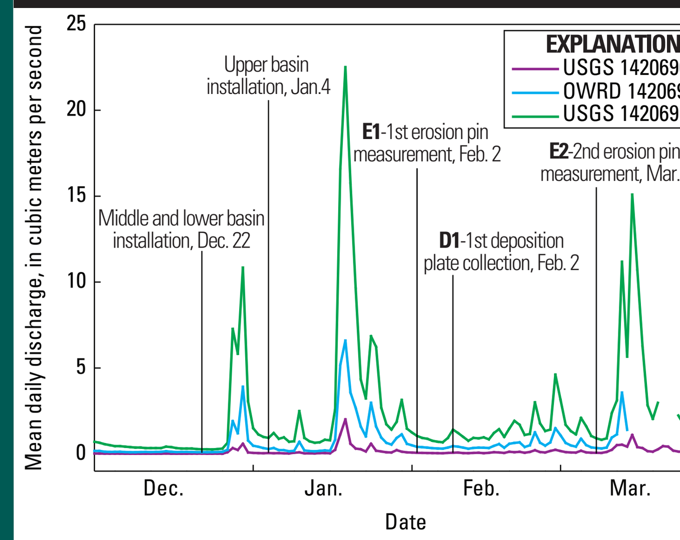


Figure 9. Mean daily discharge between December 1, 2011 and March 31, 2012 at 3 streamflow-gaging stations along Fanno Creek (fig. 1) and dates of erosion pin and plate installation, erosion pin measurements (E1 and E2), and sediment collection from deposition plates (D1).

Undercut banks along Fanno Creek contribute large amounts of sediment to the channel. Based on our inital field measurements, greater volumes of sediment are being eroded and deposited at stream bends than at straight segments and the middle basin sites are more active. Also, sediment volume measurements likely are dependent on discharge and local stream geomorphology and substrate. Further observations at the study sites and field-based mapping will support where and how much sediment is moving through the Fanno Creek basin.

Investigation continues.......

Future plans for characterizing the balance between erosion and sedimentation in the Fanno Creek basin include:

1) complete preliminary, remote mapping of potential sediment sources and sinks from LiDAR topography, including analysis of LiDAR derivatives such as slope and curvature maps

2) expand mapping effort with field-intensive investigation during the low-flow season to pinpoint discrete areas of sediment exchange that are critical to the role of organic carbon in the Fanno Creek basin

3) continue measurement of erosion pins and deposition plates over the course of the water year and resurvey cross sections at current sites

4) analyze deposited material for grain-size composition and use the composite site samples for isotopic analysis of carbon

References

Anderson, C.W. and Rounds, S.A., 2010, Use of continuous monitors and autosamplers to predict unmeasured water-quality constituents in tributaries of the Tualitin River, Oregon: U.S. Geological Survey Scientific Investigation Report 2010-5008, 76 p.

Bonn, B.A. and Rounds, S.A., 2010, Use of stable isotopes of carbon and nitrogen to identify sources of organic matter to bed sediments of the Tualatin River, Oregon: U.S. Geological Survey Scientific Investigations Report 2010-5154, 58 p.

Heimann, D.C. and Roell, M.J., 2000, Sediment loads and accumulation in a small riparian wetland system in northern Missouri: Wetlands, v. 20, no. 2, p. 219-231.

Kleiss, B.A., 1996, Sediment retention in a bottomland hardwood wetland in eastern Arkansas: Wetlands, v. 16, no. 3, p. 321-333.

Laubel, A.R., Kronvang, Brian, Larsen, S.E., Pedersen, M.L., and Svendsen, L.M., 2000, Bank Erosion as a Source of Sediment and Phosphorus Delivery to Small Danish Streams: *in* Stone, M., ed., The Role of Erosion and Sediment Transport in Nutrient and Contaminant Transfer, p. 75-82.

Rounds, S.A. and Doyle, M.C., 1997, Sediment oxygen demand in the Tualatin River basin, Oregon, 1992-1996: U.S. Geological Survey Water-Resources Investigations Report 97-4103, 19 p.

Simon, A., Bankhead, N., Klimetz, L., and Thomas, R.E., 2011, Evaluation of bed and bank stability along selected stream reaches within the Tualitin River basin: Agricultural Research Service National Sedimentation Laboratory Technical Report 75, 179 p. and appendix.

Staley, N.A., Wynn, T.M., Benham, Brian, and Yagow, Gene, 2006, Modeling Channel Erosion at the Watershed Scale - Model Review and Case Study: Center for TMDL and Watershed Studies, BSE Document Number 2006-0009, 123 p.

U.S. Geological Survey, 2012, Oregon StreamStats interactive map: U.S. Geological Survey, accessed at http://water.usgs.gov/osw/streamstats/oregon.html.

U.S. Geological Survey, 2012, National Water Information System: Web interface: U.S. Geological Survey, accessed at http://waterdata.usgs.gov/or/nwis/current/?type=flow&group_key=basin_cd.

Utley, B.C. and Wynn, T.M., 2008, Spatial and Temporal Changes in Bank Retreat Rates in a Small Headwater Stream: American Geophysical Union, Fall Meeting, abstract #H44A-06.