

# Analysis of Road Sediment Accumulation to Monumental Creek using the GRAIP Method

Introduction (from <http://www.neng.usu.edu/cee/faculty/dtarb/graip/#over>): The Geomorphologic Road Analysis and Inventory Package (GRAIP) is a process and set of tools for analyzing the impact of roads on forested watersheds. GRAIP uses information from USFS Global Positioning System (GPS) road surveys to analyze the impacts that the construction and use of forest roads can have on geomorphic processes and erosion patterns in forested basins. It is designed to help forest managers to effectively manage road and road drainage system and hence minimize the negative impacts of forest roads. GRAIP performs the following analyses to derive information on the environmental impact of roads on forested watersheds:

- Calculates and analyzes the production of road-based sediment and the input of that sediment into the stream network.
- Calculates the impact of road drainage on terrain stability and the potential for the formation of gullies due to erosion.
- Identifies fish passage passability at road-stream crossings and analyzes the resulting contiguity and fragmentation of the stream network fish habitat.

Several tools were developed as part of GRAIP and are part of the download, including the GRAIP Preprocessor and the GRAIP ArcGIS Toolbar. In addition, GRAIP also requires the use of several other software packages that are not included in the GRAIP download. This includes ArcGIS 9.1/9.2, TauDEM, Hawth's Tools and SINMAP2.0.

The Tarboton Group and the USDA Forest Service (USFS) developed the GRAIP (Geomorphologic Road Analysis and Inventory Package) process. Charles Luce and Thomas Black of the Forest Service developed much of the theory and the road inventory based approach which forms the foundation of GRAIP. Most of the work on the GRAIP tools was done by Ajay Prasad as his MS project under the supervision of David Tarboton with support from the USFS. The Forest Service's GRAIP page can be found here: <http://www.fs.fed.us/GRAIP/index.shtml>.

Overview (from <http://www.neng.usu.edu/cee/faculty/dtarb/graip/#over>): The construction and use of forest roads can have a significant negative impact on geomorphic processes and erosion patterns in forested basins. To analyze this impact, the Tarboton Group and the USDA Forest Service (USFS) developed the GRAIP (Geomorphologic Road Analysis and Inventory Package) process. Charles Luce and Thomas Black of the Forest Service developed much of the theory and the road inventory based approach which forms the foundation of GRAIP. Most of the work on the GRAIP tools was done by Ajay Prasad as his MS project with significant revisions and updates by Kim Schreuders, both under the supervision of David Tarboton. GRAIP is designed to help forest managers effectively manage road and road drainage systems and hence minimize the negative impacts of forest roads.

The GRAIP process begins by creating a detailed road inventory using GPS (Global Positioning System) based surveys. Then, a GRAIP analysis uses a number of GIS tools including the GRAIP tools along with a DEM (Digital Elevation Model) to derive environmental impact information from this inventory.

The GRAIP analysis begins by using the GRAIP Preprocessor, a standalone application, to review the road inventory data for inconsistencies, document the inconsistencies, adjust and filter the data, and then builds the GRAIP database and the consolidated drain point and road shapefiles. This process ensures a minimum data quality and allows the data to be represented in a structured format that is more suitable for analysis.

The remainder of the analysis is performed using a number of tools including the GRAIP Toolbar, an ArcGIS 9.1/9.2 toolbar, that performs the heart of the analysis. In addition, a GRAIP analysis uses ArcGIS 9.1/9.2, TauDEM, Hawth's Tools and SINMAP2.0.

The GRAIP Toolbar performs a number of analysis functions. The first group of functions calculates the sediment production for each road segment from slope, length, road surface condition and flow path vegetation. Road segment sediment production is then accumulated at each drain point. Digital elevation model (DEM) derived overland flow directions are then used to accumulate the sediment input to each stream segment. The second group of functions analyzes the impact of road drainage on terrain stability by calculating the specific discharge due to road drainage and using this, together with slope, as inputs to an infinite plane slope stability model. An erosion sensitivity index calculated using slope and contributing road length at each drain point is also calculated to predict gullying. The final function group analyzes the fragmentation of stream network fish habitat due to potential blockage of fish passage at stream crossings.

**Goal:** Analyze road sediment accumulation to Monumental Creek using GRAIP protocols. The results would be in support of the Middle Fork Salmon TMDL.

**When:** June 18-21, 2007

**Weather Conditions:** No recent rain, although spring runoff was concluding. Some snow was remaining in shady locations. Trees had yet to bloom, but shrubs and annuals were.

**Participants:** Richard Lee (DEQ), Leslie Freeman (DEQ), Tom Black (USFS)

**Equipment:** A GPS unit (GEO Trimble 3) was used which contained a data dictionary (Invent 3) that was obtained from the USFS. To aid in reception, a magnetic antennae was attached to the roof of the vehicle.

**Data Collection Methods and Locales:** Data collection followed USFS protocols for GRAIP. Specifically, data was collected along all of the roads within the Monumental Creek watershed which could potentially contribute sediment directly/indirectly to the creek. Data collection began at Monumental Summit, and continued to and past a bridge across Monumental Creek, then up Coon Creek for as far as road-related runoff flowed toward the bridge (Figure 1). All road-derived sediment discharge points were collected by GPS and described in the data dictionary. All road segments (GPS lines) which lead to their respective discharge points were also GPS'd and described in the data dictionary.

**Post processing:** The GRAIP analysis was conducted following the guidelines contained within the tutorial produced by Utah State University. The analyzing process requires the use of ArcGIS 9.1/9.2, custom tools, and other packages which can be downloaded from the internet. The tutorial can be obtained from <http://www.engineering.usu.edu/dtarb/graip>

**Results:** According to GRAIP analysis, the total road-related sediment production within the Monumental Creek drainage is 1,109.1 metric tons/Year (**Figure 2**). Almost all of the sediment production comes from two locales – Coon Creek and the headwaters of Monumental Creek.

Coon Creek is an east-flowing second order perennial stream that enters Monumental Creek at the bridge (**Figure 3**). Coon Creek exists within a fairly steep sided drainage consisting chiefly of decomposing bedrock, and the road was constructed in the floodplain as well as into the south-facing hillside, which has little vegetation. In many locations, the road is bound by the hillside and a berm (**Photo 1**), resulting in tire tracks being the only mode by runoff.

Coon Creek road building activities contribute approximately 660 metric tons/year of sediment to Monumental Creek over background levels (**Figure 4**). The primary source of sediment is via non-engineered drainage points (**Figure 5**).

The other section of sediment producing road is near the headwaters of Monumental Creek (**Figure 6**). These areas contain steep slopes, the surface material consists of unsorted mass wasting deposits associated with snow-slide events, and the area has been recently burned (within a couple years). Additionally, a large number of streamlets, and therefore stream crossings, are present where road construction has cut across and through hillsides.

In total, roads produce approximately 409 metric tons/year of sediment to Monumental Creek over background levels (**Figure 7**). The primary source of the sediment is via stream crossings and ditch relief culverts (**Figure 8**).

With regards to background sediment production, available data indicates that a value of 13.1 Mg/km<sup>2</sup>/yr is reasonable (Kirchner, et al). An analysis of Monumental Creek indicates that some stream segments receive over 200% more sediment from road discharges (**Figure 9**).



Figure 1. View (looking east) of Study Area along Monumental Creek and Coon Creek

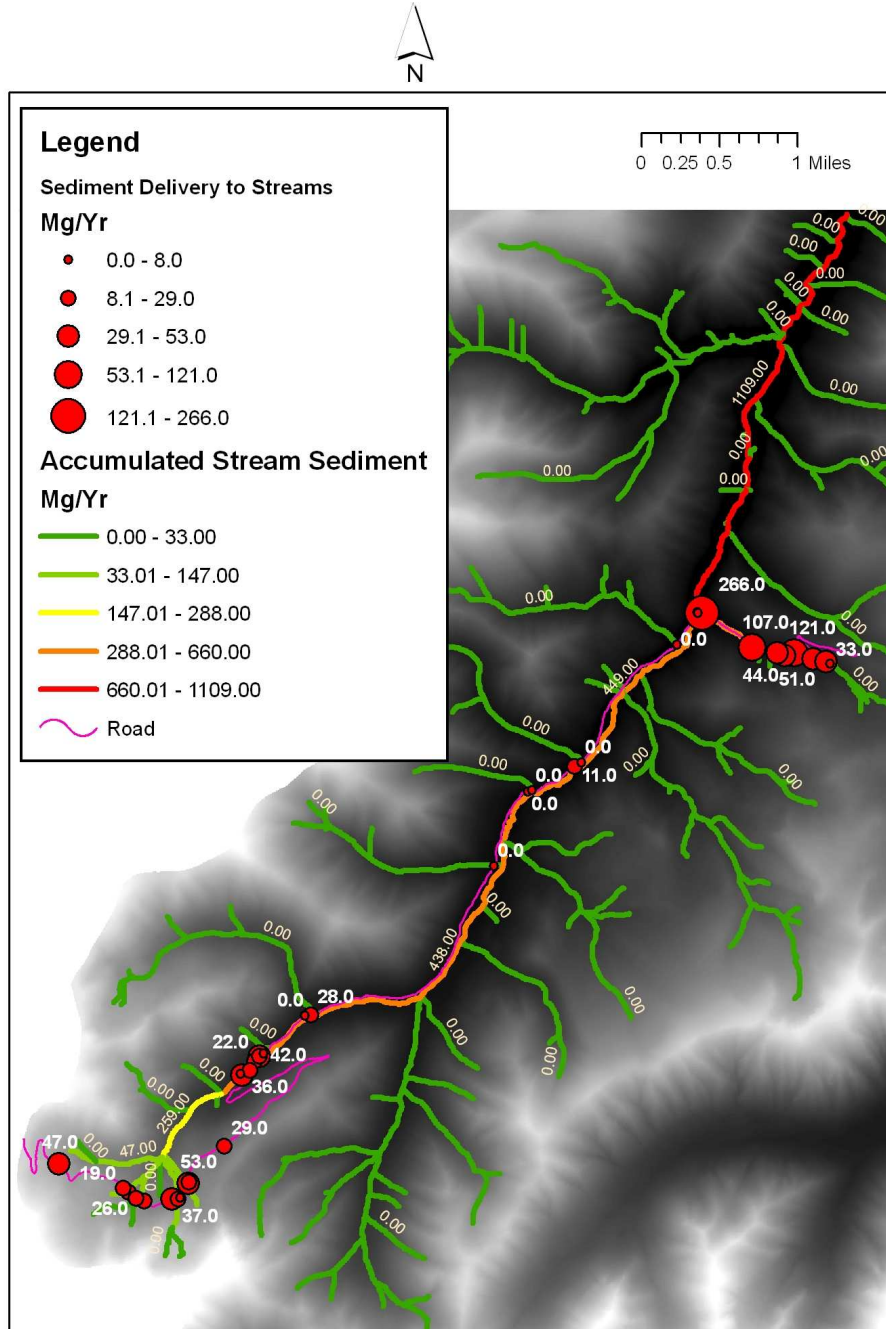


Figure 2. Total Sediment Accumulation by Monumental Creek, and Sediment Delivery Points within Monumental Creek Basin.



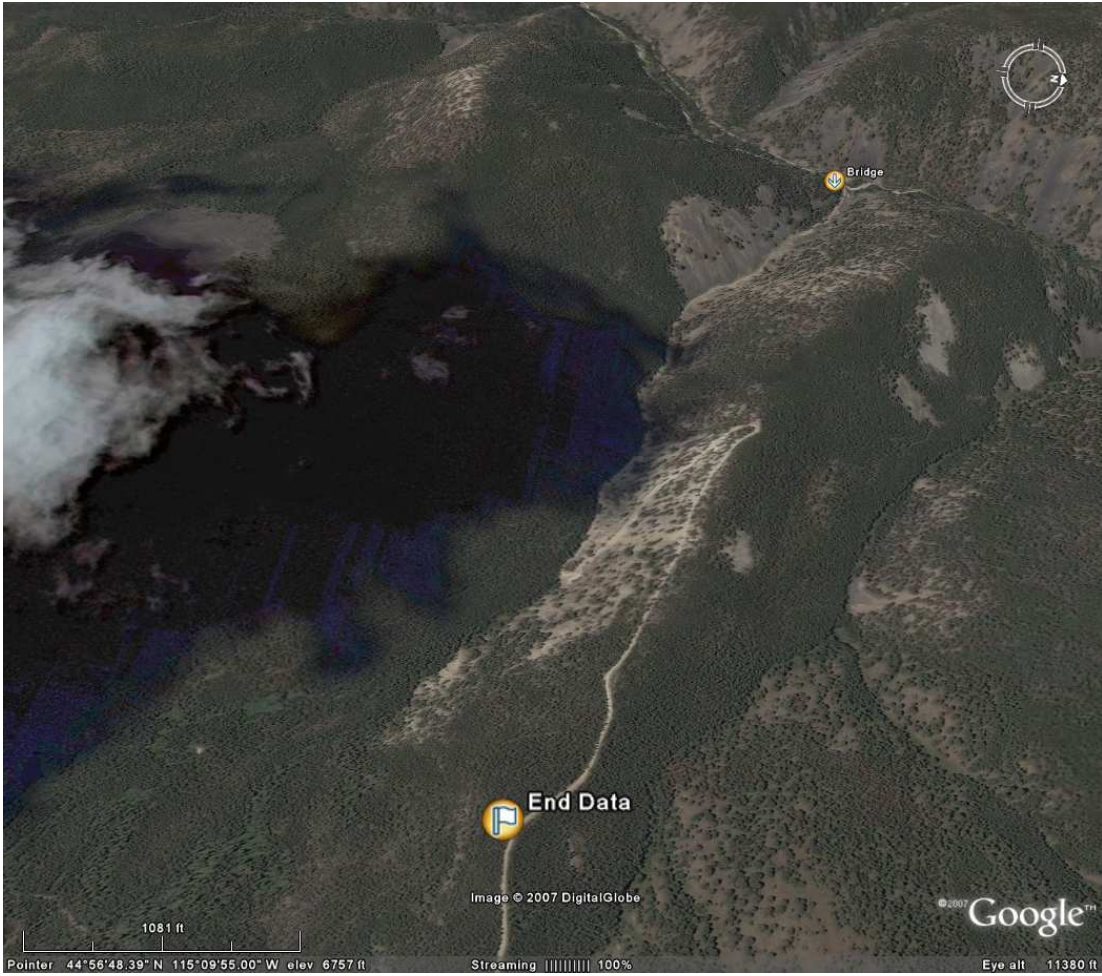


Figure 3. View (looking east) of roads within Coon Creek drainage that drain into Monumental Creek.



Photo 1. View looking east up the road adjacent to Coon Creek at a location approximately 500m from Monumental Creek. Notice the steep hillside on the left, and the berm on the right. The stream bed is on the right side of the berm. Water is running down tire tracks in the road.



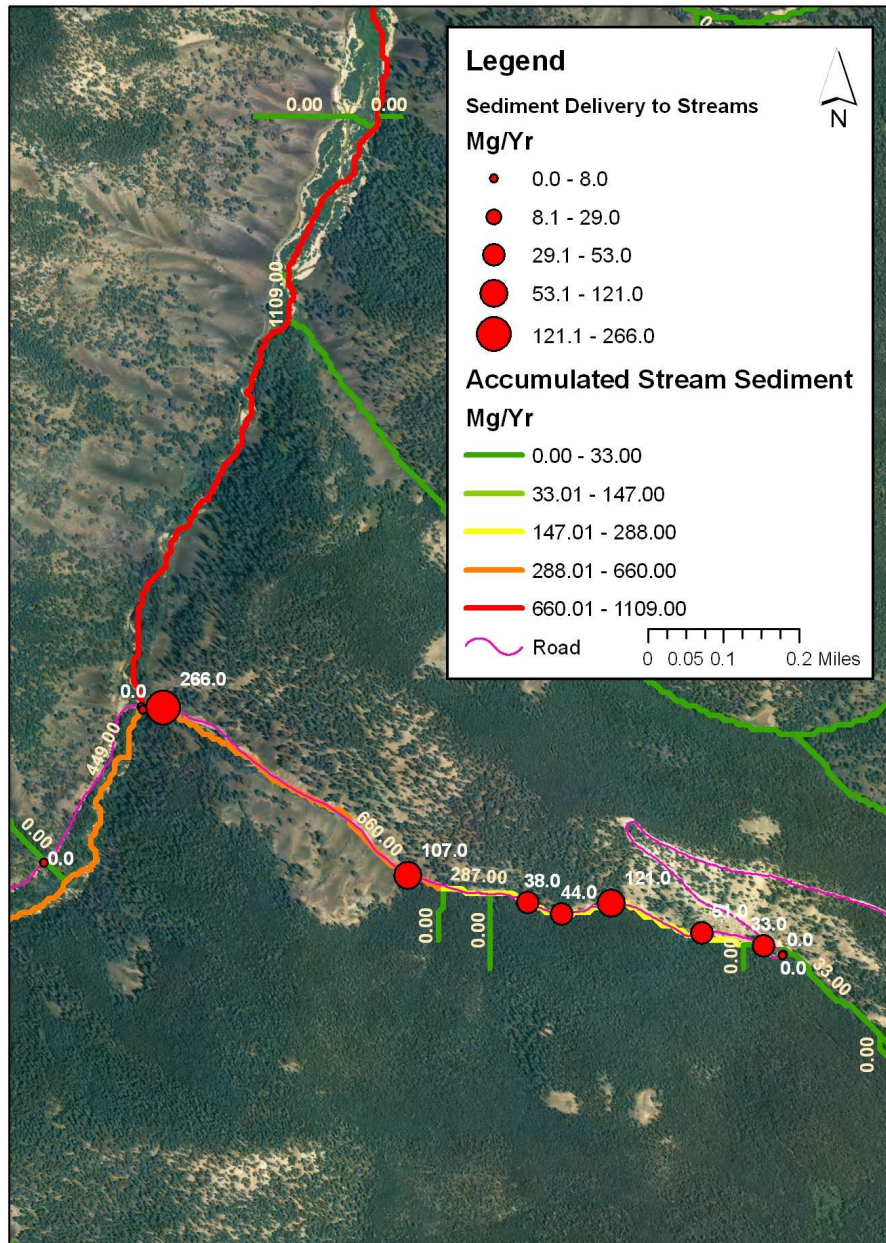


Figure 4. Sediment Accumulation by Coon Creek and the Sediment Discharge Points into it.



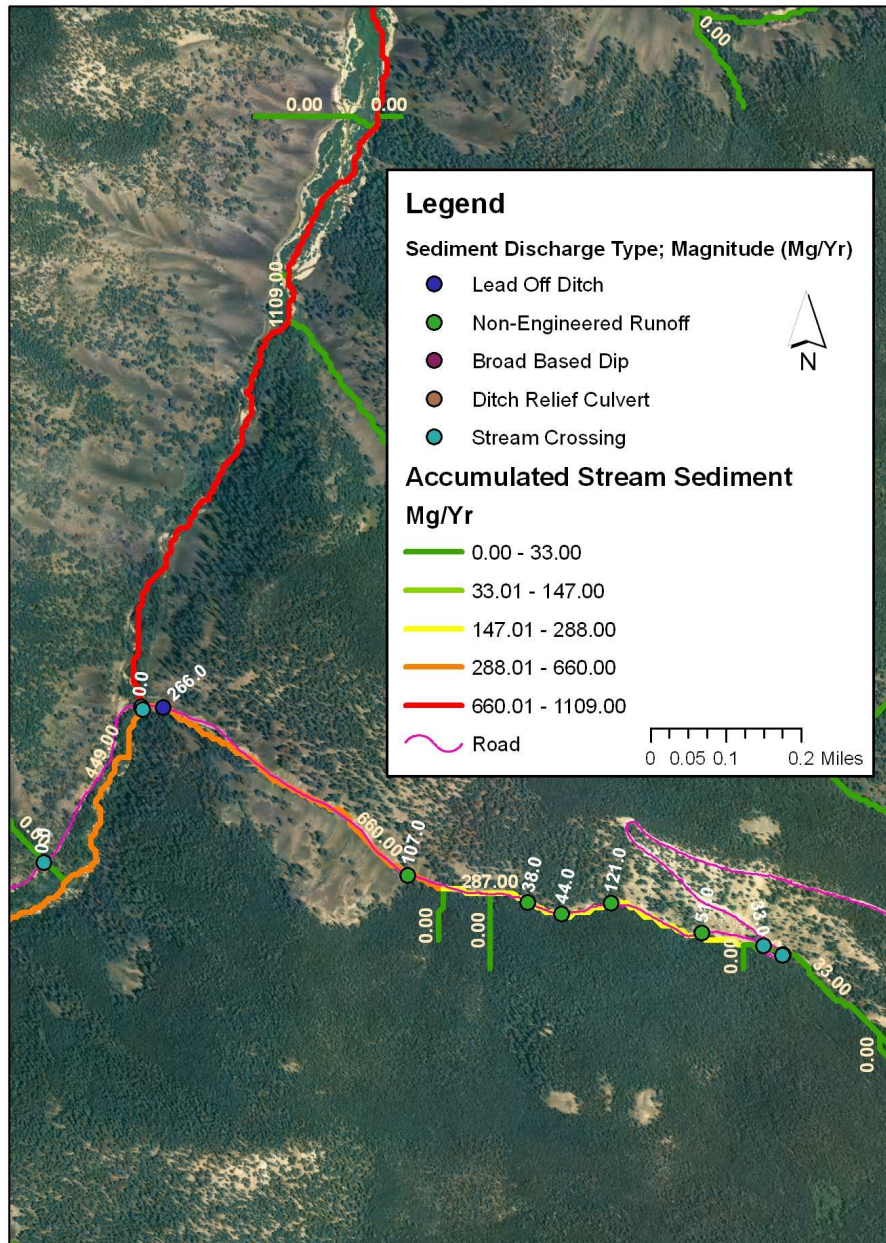


Figure 5. Map illustrating that most sediment discharge into Coon Creek is via non-engineered runoff points.

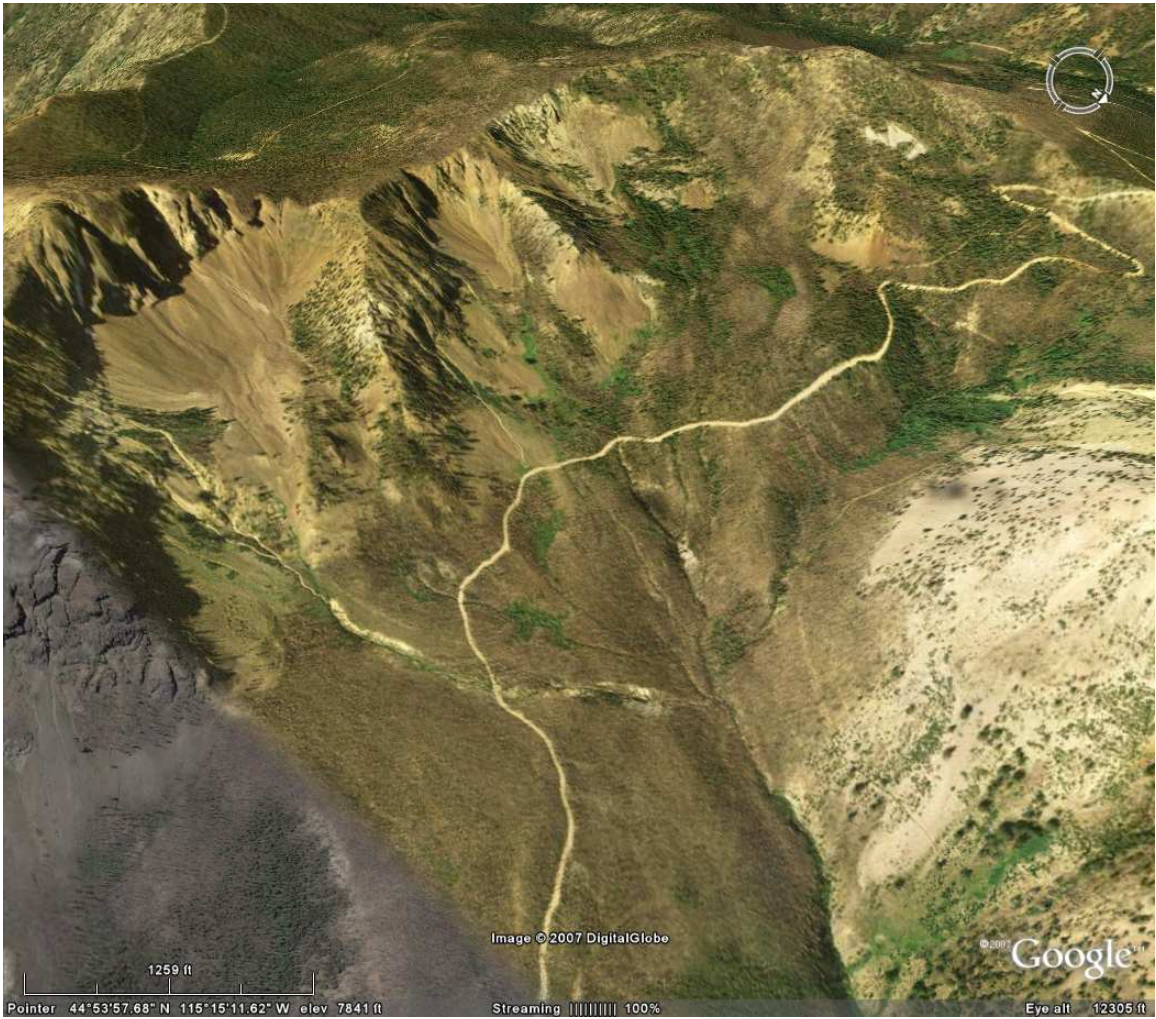


Figure 6. View (looking southwest) of Upper Monumental Creek illustrating fire evidence (dark brown areas) and steep terrain.



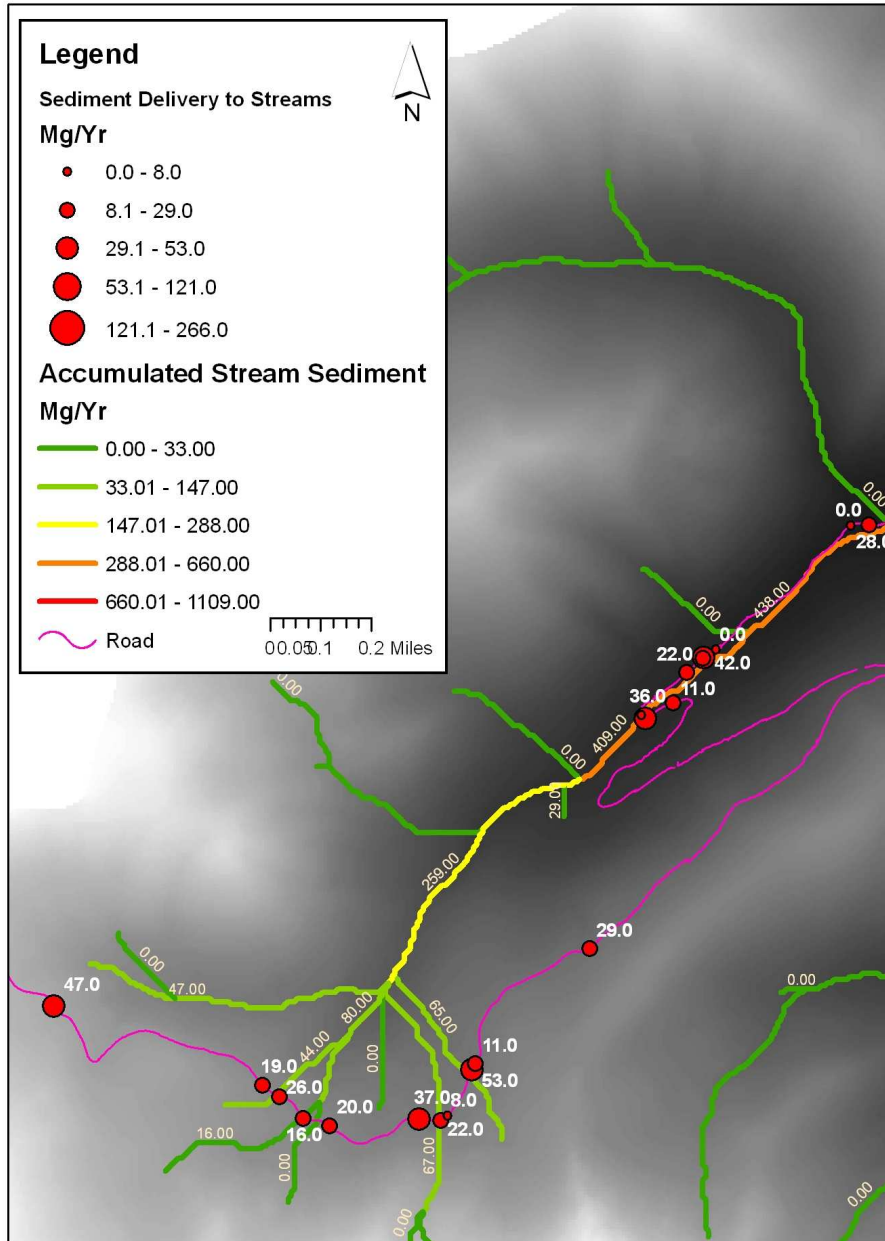


Figure 7. Sediment Accumulation by the Headwaters of Monumental Creek and the Sediment Discharge Points into it.



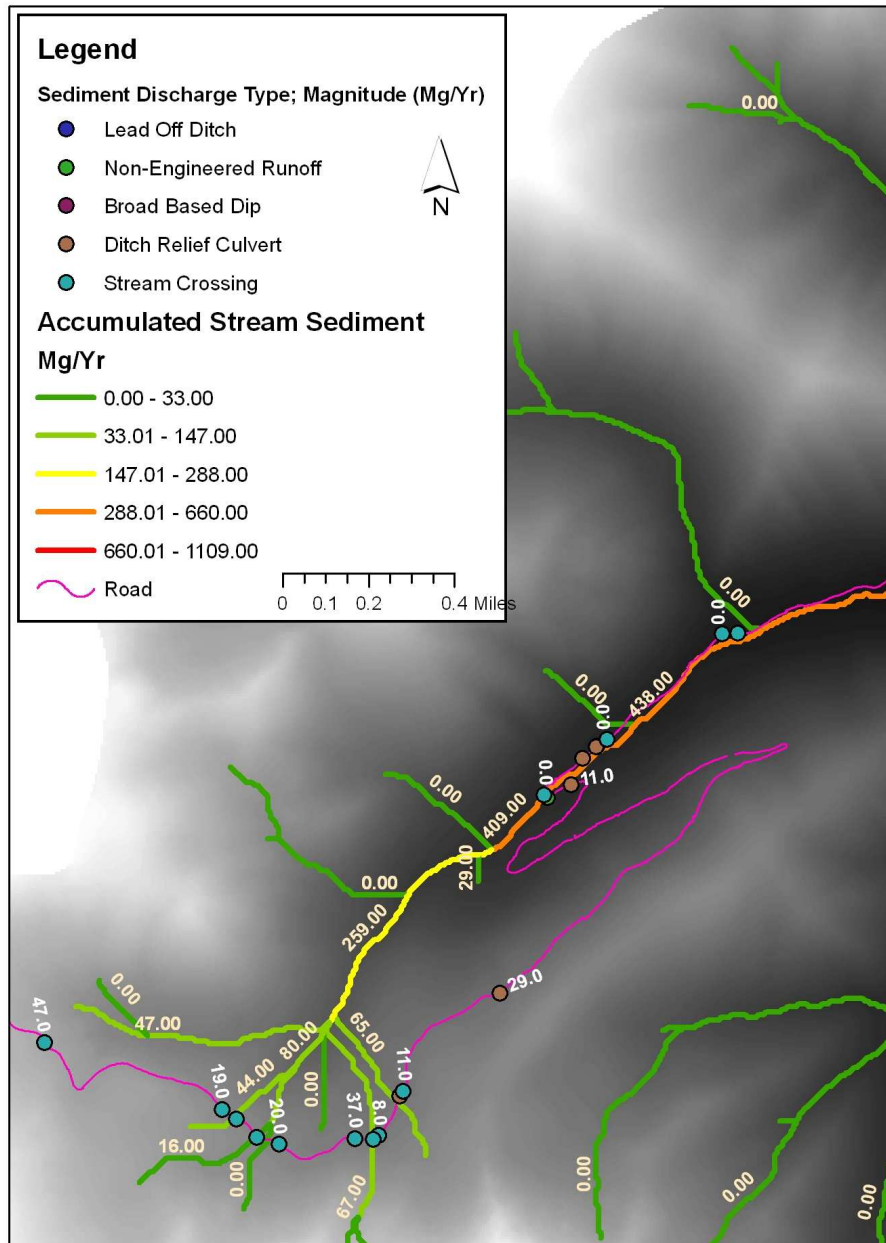


Figure 8. Map illustrating that most sediment discharge into Coon Creek is via non-engineered runoff points.

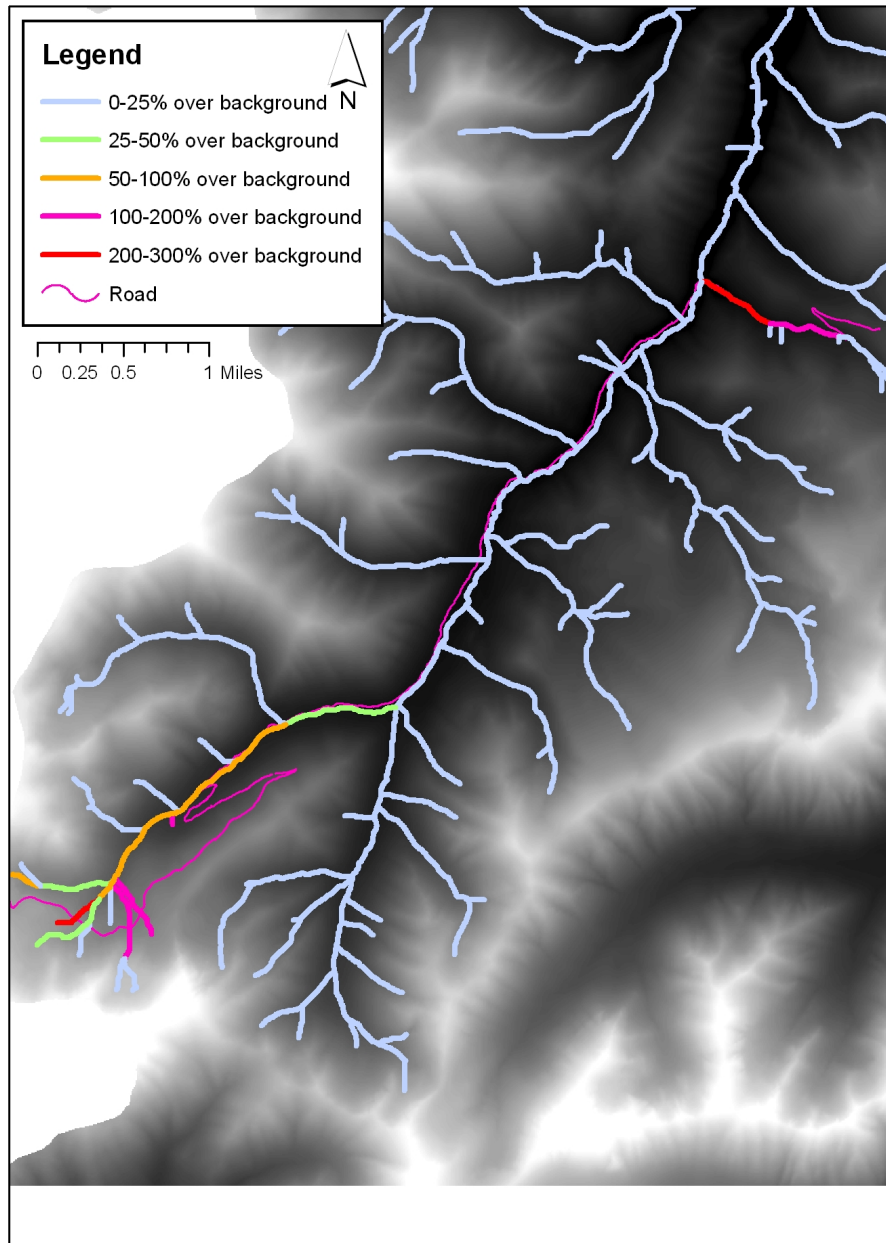


Figure 9. Sediment Accumulation by Stream Segment as Compared to Background Levels of 13.1 Mg/km<sup>2</sup>/yr (Kirchner, et al.)

## Bibliography

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