Appendix 4-A

Study Sub-basin Approach

Introduction

When a data gap or significant uncertainty was identified with the suite of sediment source data developed under previous efforts, additional studies were conducted within study sub-basins. Results from these studies were then used to develop generalized rates for application in this Elk River sediment source analysis.

In order to characterize specific erosion related parameters, discharge rates, and sediment loads in Upper Elk River, three of the seventeen sub-basins were selected for detailed study. The results of the sub-basin studies were used to develop generalized sediment loading rates (delivery per unit area) which were extrapolated, as appropriate, to apply to Upper Elk River. The three study sub-basins have similar physical characteristics with differing land management histories. Two of the sub-basins, South Branch North Fork Elk River (SBNFER) (Subbasin 18) and Corrigan Creek (CC) (Subbasin 20) have been subject to on-going logging activities while the third sub-basin, Upper Little South Fork Elk River (LSFER) (Upper portion of Subbasin 19), is a nearly pristine old-growth basin. The location of the three study sub-basins are shown in Figure 1.

Data from these three study sub-basins were used to compare the following erosional processes and their relative natural and management-related sediment loads:

- Drainage area needed to initiate headward incision of low-order stream channels.
- Rates of streamside landslides.
- Rates of stream bank erosion.
- Landslide feature size detection limits for aerial photograph analysis.

Additionally, these three study sub-basins are being monitored for streamflow, turbidity, and suspended sediment concentration.

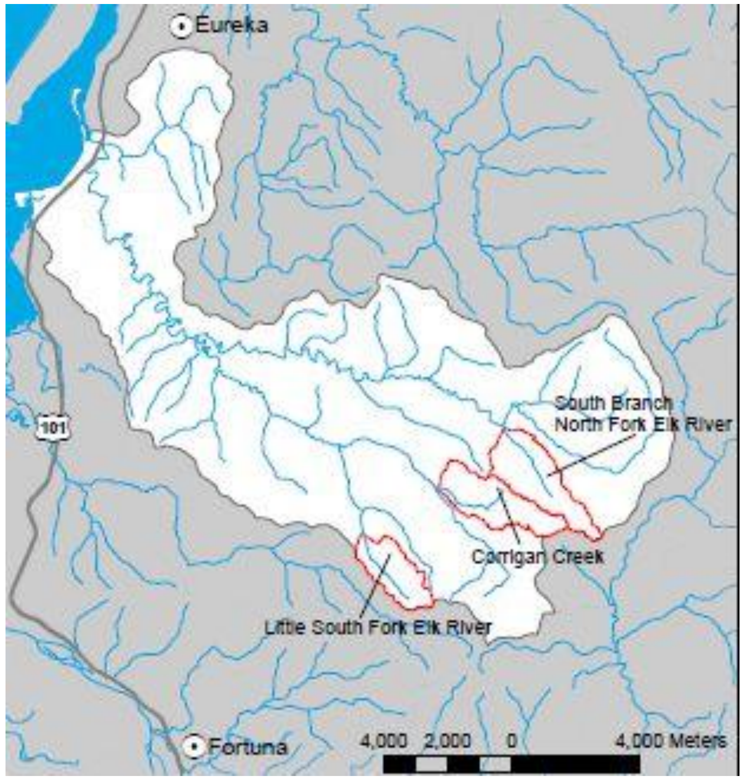

Figure 1. Location of study sub-basins within Upper Elk River (Buffleben (2009)).

Physical Characteristics of the Three Study Sub-basins

The three sub-basins selected for more detailed data evaluation have similar physiographic characteristics, including: drainage area (Table 1), orientation and distance from the ocean (Figure 1), geologic characteristics (Table 1), average annual rainfall (Figure 2), and hillslope gradients (Figure 3). Given the uniformity in physical attributes, it is expected that the three study sub-basins would be subject to similar natural processes, including the timing and magnitude of natural erosion trigging events. The relative uniform characteristics allow for the isolation of management effects on hydrologic and erosional processes.

The main stream channels in the three study sub-basins have down-cut through the overlying soft, erosion-prone Wildcat Formation to expose the harder, more erosion resistant Yager Formation, with its associated cobble and gravel component. Table 2 presents the lithologies as a proportion of the sub-basin area.

Figure 3 demonstrates the average rainfall rate of approximately 55 inches per year for the three study sub-basins.

Hillslope gradient (or percent slope) is an important parameter in developing sediment delivery rates. Figure 4 provides a graphic depiction of the relative similarities in hillslope gradients in the three sub-basins.

Table 1. Lithology of the study sub-basins (Buffleben, 2009).

	Little South Fork Elk River	Corrigan Creek	South Branch North Fork Elk River
	Percent area in Lithology		
QTw (Wildcat)	71%	75%	83%
Ty (Yager)	29%	25%	17%
Area (mi^2)	1.20	1.70	1.89

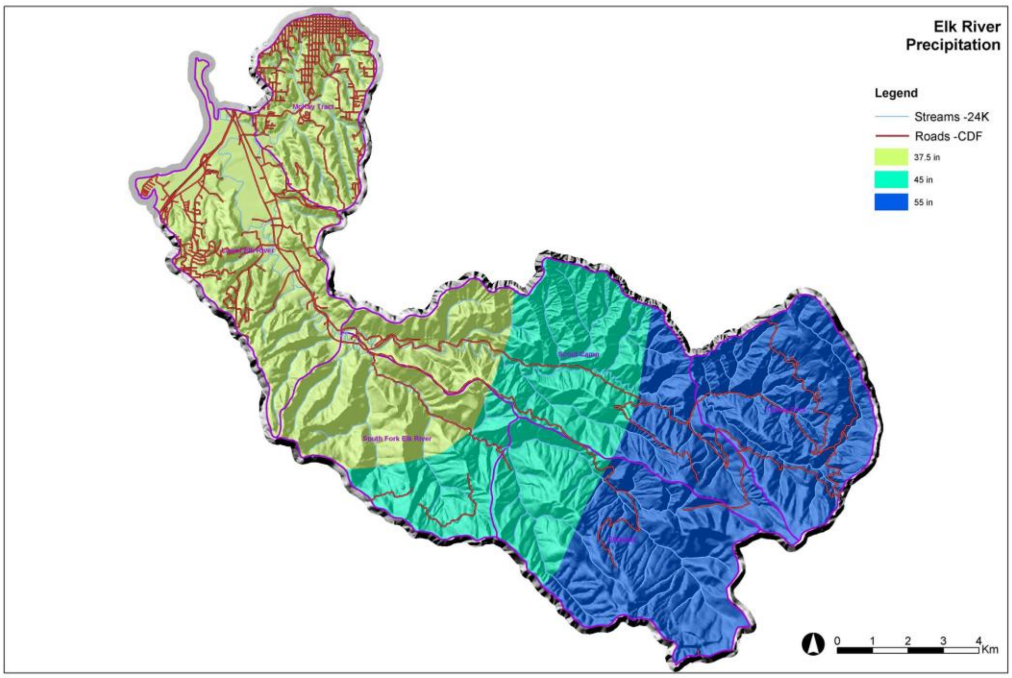

Figure 2. Annual average rainfall in Elk River (Stillwater, 2007).

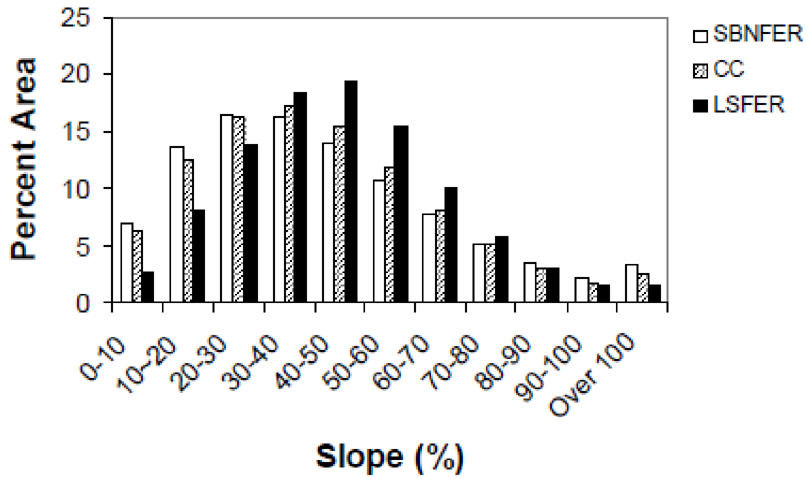

Figure 3. Distribution of hillslope gradients within the study sub-basins (Buffleben, 2009). SBNFER, South Branch North Fork Elk River. CC, Corrigan Creek. LSFER, Little South Fork Elk River.

Management History of the Three Study Sub-basins

The following section presents a summary of the management history for the three sub-basins selected for more detailed study.

Reference Study Sub-basin: Upper Little South Fork Elk River

The Little South Fork Elk River (LSFER) sub-basin has been subject to the least amount of documented land management activities in the Elk River basin. While the lower portion of the LSFER sub-basin was subject to past timber harvest activities, the upstream drainage area was never harvested and as such is comprised entirely of late successional, old-growth redwood and mixed conifer forest with a dense overstory canopy. As used in this analysis the LSFER sub-basin encompasses the old-growth portion of the watershed, and is coincident with the drainage area upstream of an established turbidity monitoring station (Chapter 3, Figure 3.3). This 1.20 mi^2 portion of LSFER serves as the reference watershed for the Upper Elk River TMDL analyses.

The only active land management identified in the upstream portion of the study sub-basin is a 1.44 mile length of road associated with a 1986 timber harvesting plan (THP 1-86-388 HUM). This 200-foot wide road, referred to as the “Worm Road”, began at the upstream boundary of the LSFER sub-basin and ran adjacent to the LSFER channel. This road was subject to a Regional Water Board staff enforcement action (Regional Water Board staff, 1989) that required the treatment and control of actual and threatened sediment discharge sources associated with the Worm Road.

The entire LSFER sub-basin was acquired by the federal Bureau of Land Management (BLM) in 1999 as part of the Headwaters Deal. As part of Headwater’s

Forest Reserve Resource Management Plan (BLM, 2003), sediment inventories and associated restoration and sediment control work was prioritized. Among the first restoration projects embarked upon by BLM was the obliteration of the Worm Road which included treatment of 1.4 miles of road, seven stream crossings, and fourteen landslides (BLM, 2010). Decommissioning of stream crossings and re-contouring of the hillslopes began in 2000 and was completed in 2003. As part of the restoration work, BLM also conducted monitoring of treatment-related discharges by measuring post-treatment voids (Section 3.5.9). Native vegetation has become re-established along the re-contoured hillslopes and at the pulled stream crossings. Road density in the LSFER is estimated at 0.74 mi/mi^2 due to remaining effects from the obliterated Worm Road.

Despite the presence of the obliterated road, the upstream portion of LSFER best characterizes reference or natural watershed conditions for Elk River, given the extensive land management history in the North Coast Region. Importantly for this sediment source analysis, the rainfall-runoff relationship has not been modified by canopy removal, soil compaction, and stream diversions. With a virtually undisturbed or natural hydrologic regime, the stream flow-turbidity-suspended sediment responses also represent reference conditions. Erosion rates developed for the LSFER are considered in the Upper Elk River TMDL to be representative of background conditions, including stream bank erosion, small streamside landslides, and open-slope shallow hillslope landslides.

Corrigan Creek Study Sub-basin

Timber harvesting and road building in the 1.70 mi^2 Corrigan Creek (CC) sub-basin was first documented in the 1954 aerial photography. Timber harvesting activities at this time where located in the lower portion of the sub-basin. During the 1966 air photo time period harvesting continued primarily using tractor clearcut silvicultural methods. Only minor tractor harvesting was documented on the 1974 aerial photography. By the time of the 1987 aerial photography, the remainder of the middle portion and upper portions of Corrigan Creek were harvested, again using primarily the tractor clearcut method. During the 1997 air photo time period, a few localized areas were tractor harvested, primarily in the upper portions of the sub-basin. The lower portion of Corrigan Creek has undergone recent (since 2000) harvesting with approximately a quarter (25%) of the sub-basin harvested using a thinning silvicultural prescription with a few small clearcut units interspersed. The harvesting primarily employed tractor yarding, although portions were yarded using a cable system (PWA, 2006). Corrigan Creek has been entirely harvested over the 40-year photo period, though between 1987 and 2002, little harvesting occurred. In 2002 the lower portion (15%) of the sub-basin, which was dominated by advanced second growth, was harvested using primarily ground-based yarding thinning methods.

South Branch North Fork Elk River Study Sub-basin

Timber harvesting and associated road building were first documented in the lowermost portion of the South Branch North Fork Elk River (SBNFER) in 1954 aerial photography. The remainder of the 1.89 mi^2 sub-basin appeared to be uncut until the 1974 air photo time period. During this time period, the lower portion of the sub-basin was reentered and the upper quarter (25%) of the sub-basin was harvested using primarily tractor clear-cut methods (PWA, 2006). From 1982 to 1987, another quarter (25%) of the watershed was harvested. Between 1987 and 1992, an additional third (33%) of the watershed was harvested. In summary, the SBNFER study sub-basin was entirely harvested over the 40-year photo period, with about two-thirds (61%) of the sub-basin re-entered using clear-cut methods in the 10-year period between 1982 and 1992.

Summary of Management History in Study Sub-basins

The management history within the study sub-basins is summarized in Table 3.4. For the purpose of this sediment source analysis, the management history is limited enough in the reference study sub-basin to serve as the basis for characterizing natural conditions. Additionally, the management histories in the two managed study sub-basins are considered similar enough that the combined data could serve as the basis for development of generalized erosion rates associated with management-related influences.

Table 2. Summary of management history in the study sub-basins.

Study sub-basin	Drainage Area (mi^2)	Harvest History	Road Density (mi/mi^2)	Skid Density (mi/mi^2)	Total Tractor Compacted Area (% sub-basin area[1])
LSFER	1.20	None	1.2[2]	[3]	0%[4]
CC	1.70	1954-2003: 100% 1987-2002, little harvesting 2002: 15% thinned	9.0	50.5	10.4%
SBNFER	1.89	1954-2003: 100% 1982-1997: 61% clear-cut	9.8	52.9	11%

1 Assuming a road width of 16 feet and a skid trail width of 8 feet.
2 Effects from obliterated Worm Road.
3 A few short skid trails were built associated with construction of the Worm Road, but impacts were not quantified.
4 Assuming a 25-foot road width, 0.4% was compacted from Worm Road; restoration treatments addressed compaction.