

Prepared in cooperation with the U.S. FOREST SERVICE

Data Summary and Loading Sources for Selected Water-Quality Characteristics of Streams in Blowdown Areas, North Fork Elk River Watershed, Colorado, March 1999–August 2000

ABSTRACT

On October 25, 1997, in and around the Routt National Forest and the Mount Zirkel Wilderness Area, a winter snowstorm occurred in conjunction with heavy winds that resulted in the destruction of thousands of acres of old-growth tree stands. The U.S. Geological Survey, in cooperation with the U.S. Forest Service, collected water-quality data at five sites in the North Fork Elk River watershed where most of the blowdown occurred. In this report, these data are used to characterize water quality in areas affected by the blowdown compared to that of relatively undisturbed areas. No difference was detected between loads of

the selected constituents from the five water-quality sampling sites.

INTRODUCTION

On October 25, 1997, in and around the Routt National Forest and the Mount Zirkel Wilderness Area, a winter snowstorm occurred in conjunction with heavy winds that resulted in the destruction of thousands of acres of old-growth tree stands (fig. 1). Maximum wind velocities of 120 miles per hour were recorded. This event, typically referred to as a "blowdown," is

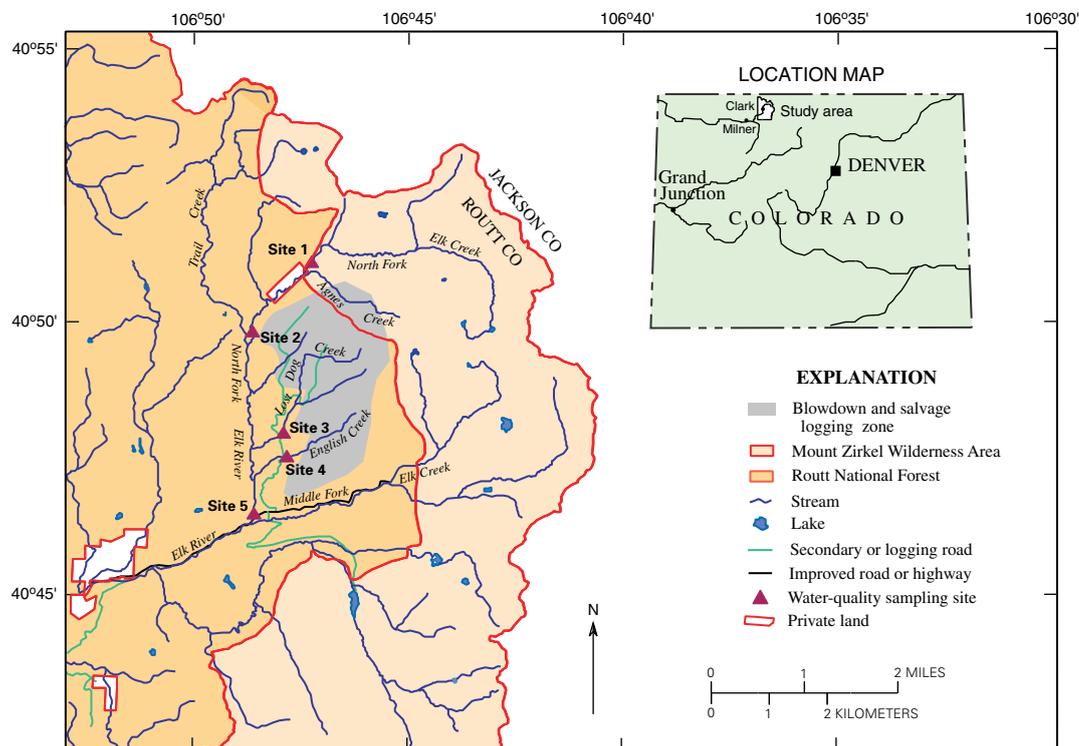


Figure 1. Water-quality sampling sites and area affected by blowdown in the North Fork Elk River watershed.

considered to be an anomaly usually associated with hurricane-force winds. The abundance of old-growth canopy such as Engelmann spruce and subalpine fir in the region indicates the rarity of this type of event in this area (Snook, 1999).

Trees over a large area were uprooted, which disrupted the air-soil interface (fig. 2). As a result, the potential for increased sediment yield and mass wasting increased. Increases in sediment yield have been linked to issues concerning stream and forest habitat, floodwater conveyance, and stream-chemistry imbalance (Elliott and DeFeyter, 1986). Disturbance from salvage logging may increase sediment yield and affect stream chemistry; however, disturbance from salvage logging likely will occur on a smaller scale relative to the disturbance from blowdown.

The U.S. Geological Survey (USGS), in cooperation with the U.S. Forest Service, collected water-quality data at sites in the North Fork Elk River watershed where most of the blowdown occurred. In this report, these data are used to characterize water quality in areas affected by the blowdown compared to that of relatively undisturbed areas.

SITE SELECTION AND DATA COLLECTION

Water-quality sampling sites (fig. 1, table 1) were selected to represent undisturbed, disturbed, and salvage-logging zones. Water-quality samples were collected and concurrent streamflow measurements made at each site from March 1999 to August 2000. All water-quality and streamflow data were collected using USGS quality-assurance protocols (Wilde and Radtke, 1998; Rantz and others, 1982). Water-quality samples were analyzed for field parameters, major ions, dissolved nutrients, total phosphorus, total and dissolved metals, suspended sediment, and turbidity. The farthest upstream sampling site, on the North Fork Elk River just upstream from Agnes Creek (site 1), was chosen as a back-



Figure 2. Routt National Forest near North Fork Elk River after the blowdown of October 25, 1997.

Table 1. Sample collection site in North Fork Elk River watershed

[mi², square miles; USGS, U.S. Geological Survey]

Site number (fig. 1)	USGS station number	Site name	Drainage area (mi ²)
1	405057106451000	North Fork Elk River above Agnes Creek near Clark	12.3
2	404950106462700	North Fork Elk River above Trail Creek near Clark	19.3
3	40475106454200	Lost Dog Creek above mouth near Clark	3.2
4	404727106453700	English Creek above mouth near Clark	2.5
5	404620106461900	North Fork Elk River above mouth near Clark	41.4

ground site because blowdown was minimal in this subwatershed, and the site is upstream from a salvage-logging area. Site 2 was located on the North Fork Elk River upstream from the confluence with Trail Creek. The watershed for site 1 represents less blowdown than site 2. Both sites are upstream from where salvage logging is done. Igneous and metamorphic rocks underlie the watershed upstream from site 1. The geology that underlies site 1 continues into the watershed of site 2 and includes unconsolidated Pleistocene deposits and, to a limited extent, Mancos Shale (Tweto, 1979). The next two sites are on tributaries of the North Fork Elk River, Lost Dog Creek (site 3) and English Creek (site 4). Sites 3 and 4 were subjected to some of the heaviest blowdown outside of the Mount Zirkel Wilderness Area and represent basins where salvage logging is being done. The underlying geology in these basins is similar to that upstream from site 2 with the addition of some sandstone and limestone (Tweto, 1979). North Fork Elk River above mouth near Clark (site 5) is an integrator site for the entire watershed. Comparison of water-quality information from site 5 with water-quality information from sites 2, 3, and 4 characterizes water quality in the area affected by the blowdown and salvage logging and provides perspective on the water quality of tributary inflows from the west side of the watershed.

DATA SUMMARY

Summary statistics for field parameters, chemical constituents, and physical parameters are listed in table 2. All water-quality and streamflow data collected for this study are published in USGS annual data reports for Colorado (U.S. Geological Survey, 1999 and 2000). The Elk River and tributaries to the Elk River, including streams located within the Mount Zirkel Wilderness Area, are classified as “outstanding waters” by the State of Colorado and carry Aquatic-Use Class 1 and Recreation 1 designations (Colorado Department of Public Health and Environment, 2001).

Physical Parameters

Summary statistics for physical parameters are listed in table 2. These parameters are streamflow, suspended sediment, and turbidity. There are no State standards for suspended sediment or turbidity. However, comparison of suspended-sediment concentrations and turbidity between sites would indicate if there were any differences upstream from the major disturbance areas as compared to those measured downstream near the mouth of the North Fork Elk River. Suspended-sediment concentrations at site 1 ranged from less than 1 to 10 milligrams per liter and median concentration was 2.5 milligrams per liter. Suspended-sediment concentrations at site 5 ranged from less than 1 to 21 milligrams per liter and median concentration was 2 milligrams per liter. Ranges of concentration and median concentrations for suspended sediment were similar at sites 2, 3, and 4. The similarity of suspended-sediment concentrations between sites upstream and downstream from the areas in the watershed affected by the blowdown indicates that there was no measurable effect of the blowdown on suspended-sediment concentrations. Turbidity values measured at sites 1 through 5 also were similar.

Field Parameters

Field measurements were for dissolved oxygen, pH, specific conductance, and water temperature. Comparisons of summary statistics for each parameter at individual sites are listed in table 2. These data indicate that all values of dissolved oxygen or pH were in compliance with State instream standards. The State of Colorado Department of Public Health and Environment does not set standards for specific conductance or temperature for the North Fork Elk River watershed. Comparisons of the median specific-conductance values and water temperature values from the primarily undisturbed area (site 1) to those measured near the mouth of the North Fork Elk River downstream from watersheds that contained areas of blowdown (site 5) indicate that specific conductance and water temperature are similar at all sites.

Chemical Constituents

Chemical constituents such as major ions, nutrients, and trace elements can originate from a variety of sources. The ways in which solutes occur in natural waters are influenced by many environmental factors, especially climate, underlying geology, and biochemical effects associated with life cycles of plants and animals (Hem, 1985). Because there is minimal human impact

on the watershed of the North Fork Elk River, water-quality constituents are derived primarily from natural sources.

Except for dissolved solids and aluminum, chemical constituents listed in table 2 have instream standards set by the State of Colorado. All constituents sampled at all sites had concentrations less than the instream standard. Based on the comparison of median concentrations for constituents listed in table 2, water quality among sites is similar. For example, at sites 1 through 5, median concentrations of total phosphorus ranged from less than 0.004 to 0.007 milligram per liter.

LOADING SOURCES

Constituent concentrations and field-parameter values were similar among all sampling sites; however, constituent loading (the product of streamflow, constituent concentration, and a coefficient) could be affected by surface disturbance associated with the blowdown in a particular subbasin. To evaluate constituent loading among the five sampling sites, constituent loading per square mile was calculated for selected constituents at each site to determine if any particular subbasin contributed more loading per unit area than other subbasins. Median constituent loads per square mile for dissolved nitrite plus nitrate, total phosphorus, dissolved zinc, dissolved solids, and suspended sediment were computed (table 3).

Because constituent concentration among sites is a function of runoff and drainage-basin area, analysis of loading between sites may be useful. Except for nitrite plus nitrate and dissolved zinc, Lost Dog Creek (site 3) had the largest median load for the selected constituents. Median dissolved nitrite plus nitrate and dissolved zinc loads decreased from upstream to downstream on the main stem of the North Fork Elk River (sites 1, 2, and 5, table 3).

Loads for dissolved nitrite plus nitrate, total phosphorus, dissolved zinc, dissolved solids, and suspended sediment for the five water-quality sampling sites were compared using analysis of variance (ANOVA) (SPSS Inc., 1997). For the purpose of this analysis the data were ranked, and ANOVA was done on the ranks of the data (Conover and Iman, 1981). The grouped means of ranked data for the selected constituent loads among the five sites were not significantly different ($p > 0.05$). The study shows that there was no difference between loads of the selected constituents from the five water-quality sampling sites; therefore, the conclusion can be made that constituent loads from watersheds with large areas of blowdown and where salvage logging occurred were not different from loads in areas where minimal blowdown and no salvage logging occurred.

Table 2. Selected streamflow and water-quality data for sites located in North Fork Elk River study area

[ft³/s, cubic feet per second; mg/L, milligrams per liter; SC, specific conductance; NO₂ + NO₃, nitrite plus nitrate; μS/cm, microsiemens per centimeter; °C, degrees Celsius; μg/L, micrograms per liter; N, number of samples; NTU, nephelometric turbidity units; <, less than]

Summary statistics	Physical parameters										Chemical constituents									
	Instantaneous stream-flow (ft ³ /s)	Suspended sediment (mg/L)	Turbidity (NTU)	Oxygen dissolved (mg/L)	pH, standard units	SC (μS/cm)	Water temperature (° Celsius)	Sulfate, dissolved (mg/L as SO ₄)	NO ₂ + NO ₃ , dissolved (mg/L as N)	Phosphorus, total (mg/L as P)	Aluminum, dissolved (μg/L as Al)	Cadmium, dissolved (μg/L as Cd)	Copper, dissolved (μg/L as Cu)	Iron, dissolved (μg/L as Fe)	Silver, dissolved (μg/L as Ag)	Zinc, dissolved (μg/L as Zn)	Dis-solved solids (μg/L)			
N	11	10	11	11	11	11	11	11	11	11	6	6	6	6	6	6	11			
Median	11	2.5	0.5	8.9	7.2	35	5	1.6	0.08	<0.008	44.5	<1	<1	24	<0.60	<20	23.1			
Maximum	218	10	2	10.9	7.5	43	11.6	4.5	0.18	0.01	51	<1	1	46	<1.0	<20	36.1			
Minimum	0.62	<1	0.3	7.9	6.6	21	0.5	1.1	0.05	<0.004	9	<1	<1	20	<0.20	<20	16.0			
North Fork Elk River above Agnes Creek (site 1)																				
N	11	9	11	11	11	11	11	11	11	11	7	6	6	6	6	6	11			
Median	21	2	0.7	8.9	7.2	39	6.6	1.6	0.06	<0.004	24.0	<1	0.75	35	<0.60	<20	26.7			
Maximum	282	79	2	11.3	7.8	52	14	2.9	0.14	0.034	60.6	<1	1	82	<1.0	<20	39.0			
Minimum	5.9	<1	0.4	7.7	6.9	21	0.1	1.1	0.03	<0.004	<15	<1	<1	20	<0.20	<20	16.0			
North Fork Elk River above Trail Creek (site 2)																				
Lost Dog Creek (site 3)																				
N	11	11	11	11	11	11	11	11	11	11	6	6	6	6	6	6	7			
Median	9.1	2	0.7	10.1	7.4	35	3.5	1	0.033	0.006	61.3	<1	<1	78	<0.60	<20	28.0			
Maximum	41	10	8	11	7.8	44	10.5	1.3	0.120	0.010	78.1	<1	5	130	<1.0	<20	37.0			
Minimum	2.2	<1	0.3	7.9	6.9	21	0.1	0.7	<0.005	<0.008	29.0	<1	<1	50	<0.20	<20	18.0			
English Creek (site 4)																				
N	11	11	11	11	11	11	11	11	11	11	6	6	6	6	6	6	11			
Median	5	1	0.6	9.2	7.2	33	3.4	1.1	0.011	0.007	62.3	<1	<1	76.5	<0.60	<20	31.0			
Maximum	26	9	2.4	10.6	7.6	39	10.9	1.4	0.093	0.010	75.6	<1	3	150	<1.0	<20	36.7			
Minimum	1.2	<1	0.3	7.8	6.8	19	0.2	0.7	<0.005	<0.004	34	<1	<1	51	<0.20	<20	17.5			
North Fork Elk River above Mouth (site 5)																				
N	11	11	11	11	11	11	11	11	11	11	6	6	6	6	6	6	11			
Median	44	2	0.6	9.8	7.5	54	3.9	2.5	0.033	0.007	40.8	<1	<1	55	<0.60	<20	38.0			
Maximum	422	21	9	10.6	7.9	74	15.7	4.9	0.101	0.021	67.9	<1	<1	79	<1.0	<20	49.0			
Minimum	16	<1	0.2	7.4	7.1	24	0	1.1	0.013	<0.004	12.0	<1	<1	30	<0.20	<20	19.1			

Table 3. Median load for selected constituents per square mile of drainage area

[NO₂ + NO₃, nitrite plus nitrate; lb/d/mi², pounds per day per square mile]

Site name (fig.1)	NO ₂ + NO ₃ , dissolved (lb/d/mi ²)	Phos- phorus, total (lb/d/mi ²)	Zinc, dissolved (lb/d/mi ²)	Dissolved solids (lb/d/mi ²)	Suspended sediment (lb/d/mi ²)
North Fork Elk River above Agnes Creek near Clark	0.60	0.02	0.49	186	12
North Fork Elk River above Trail Creek near Clark	0.32	0.02	0.53	222	12
Lost Dog Creek above mouth near Clark	0.60	0.09	0.45	465	33
English Creek above mouth near Clark	0.12	0.07	0.36	360	9.6
North Fork Elk River above mouth near Clark	0.25	0.04	0.35	169	4.9

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