

Dynamics of Dissolved Organic Carbon in a Stream during a Quarter Century of Forest Succession

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Introduction

Dissolved organic carbon (DOC) is a heterogeneous mixture of compounds that makes up a large fraction of the organic matter transported in streams (Webster and Meyer 1997). It plays a significant role in many ecosystems. Riverine DOC links organic carbon cycles of continental and oceanic ecosystems. It is a significant trophic resource in stream food webs (e.g., Hall and Meyer 1998). DOC imparts color to lakes, regulating the amount of ultraviolet radiation reaching lake biota and influencing lake thermal regimes (Schindler and Curtis 1997). Cycling and biotic impact of metals are influenced by DOC concentration; for example, the concentration of methyl mercury in lakes and in lake biota increases with their DOC content (Driscoll et al. 1995). A synthesis of lake research identified colored DOC as a key characteristic of lakes, determining a lake's response to multiple anthropogenic stressors (Williamson et al. 1999). Because DOC regulates so many aspects of aquatic ecosystems, it is important to understand how natural and anthropogenic changes can alter its concentration in lotic ecosystems.

DOC transport in streams varies with watershed topography, extent of wetlands, soil type, nature of vegetation, fire history, hydrology, and land use. DOC concentration and transport increase as proportion of the watershed covered by wetlands or peat increases, and as soil carbon (C) content increases (e.g., Aitkenhead et al. 1999). Differences in soils' capacity for C sorption results in differences in stream DOC content (Nelson et al. 1993; see also Qualls et al., chapter 5, this volume). DOC export is less in watersheds with lower soil pH (Brooks et al. 1999). Forest type is an important predictor of DOC delivery to Adirondack lakes (Canham et al.

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2004). Increases in DOC delivery to lakes after extensive forest fires have been attributed to altered hydrology (Schindler et al. 1997). Human alterations of watersheds for agriculture, forest harvest, or development also influences DOC transport in streams (e.g., Eckhardt and Moore 1990).

The impact of forest-management practices, such as clearcutting, on stream DOC concentration and export is not the same in all landscapes. Clearcutting watersheds with extensive peatlands has resulted in elevated DOC concentration and export (Cummins and Farrell 2003; Nieminen 2004). Higher DOC concentration and export have also been observed after cutting in areas where extensive logging slash was left in the channel (Moore 1989). Clearcutting conifers in Oregon (Dahm 1980), hardwoods in New Hampshire (Johnson et al. 1995), and boreal forests in Canada (France et al. 2000) resulted in elevated DOC export as well as elevated DOC concentrations in downstream lakes (Carignan et al. 2000; Lamontagne et al. 2000). Elevated export has been observed for periods as long as 15 years after forest cutting (Johnson et al. 1995), although the chemical composition of DOC in streamwater was not altered by cutting (Dai et al. 2001). Selective cutting has also resulted in slight increases in DOC export, largely because of increased water yield (Kreutzweiser et al. 2004). In contrast, other studies of clearcuts have found either no difference in DOC export (Grieve 1994) or reduced export several years after cutting (Moore 1989). Previous studies at Coweeta Hydrologic Laboratory have observed decreases in streamwater DOC concentration and export after forest removal (Meyer and Tate 1983; Meyer et al. 1988). Experimental and hurricane-induced removal of riparian vegetation at Coweeta also resulted in lower concentrations of DOC in soil water (Yeakley et al. 2003). Coweeta streams with a history of forest removal had lower DOC concentration and export than reference streams when sampled 10–20 years after treatment, although differences resulting from forest practices were less than those resulting from changes in hydrology (Tate and Meyer 1983). In contrast, Qualls et al. (see chapter 5, this volume) observed elevated DOC concentrations and flux from Coweeta soil horizons during the first two years after the experimental clearcutting of an area on Watershed (WS) 2.

DOC concentration and transport in Big Hurricane Branch, the stream draining the clearcut watershed that is the subject of this book, were less than in the reference stream (Hugh White Creek) two years after the cut (Meyer and Tate 1983). These differences were attributed to lower DOC concentration in the subsurface water entering the channel and to reduced in-stream generation of DOC (Meyer and Tate 1983). Lower DOC concentrations and transport continued for three more years, although DOC concentration in Big Hurricane Branch was increasing relative to the reference (Meyer et al. 1988). Based on five years of data from the first seven years after cutting, Meyer et al. (1988) predicted that DOC concentrations in Big Hurricane Branch would continue to increase until they were indistinguishable from those in the reference stream.

We now have an additional 20 years of data on DOC concentration in these two streams. One objective of this study was to determine whether the prediction based on those initial five years of data was correct, that is, whether DOC concentrations in Big Hurricane Branch became more similar to those in the reference stream as the forest on the clearcut watershed recovered. A second objective was to describe seasonal and interannual patterns of DOC concentration and transport in the two

streams. The final objective was to explore potential causes of the seasonal and interannual patterns observed.

Methods

Big Hurricane Branch drains WS 7, which was clearcut using cable logging in 1977 (see chapter 1 for a more detailed description of this operation). Hugh White Creek drains WS 14 (figure 6.1), one of the long-term reference watersheds at Coweeta (Webster et al. 1997). The two streams are similar in watershed size, discharge, gradient, length, and elevation, but they differ in aspect; WS 7 faces south; whereas WS 14 faces north (see Webster et al., chapter 10, this volume). We began collecting water samples from the two streams for DOC analysis in 1979, two years after the cut; we did not have DOC analytical capacity prior to that time. Samples were collected at two-week intervals for the first year of the study and weekly after that. In this chapter, we consider the data from July 1979 through July 2004.

Water samples were collected immediately above the weir pond in each stream, filtered through ashed glass fiber filters (Gelman A/E, nominal pore size 0.3 μm), and refrigerated for one to four weeks until analysis. From 1979 through 2000, samples were analyzed using a Dohrmann Envirotech DC-54 carbon analyzer or an Oceanography International Organic Carbon analyzer, both of which use persulfate oxidation. In 2001, we began analyzing samples using a Shimadzu TOC-5000A Total Organic Carbon analyzer, which uses high-temperature combustion in the



Figure 6.1 Upstream view of a 120° V-notch weir installation on Coweeta WS 14, October 2006. (Photo by J. Webster)

presence of a catalyst. Based on one year of samples analyzed using both methods, we determined that $PS = 0.196 + 0.731 HT$ ($r^2 = 0.78$), where PS is DOC concentration measured using persulfate oxidation, and HT is DOC concentration measured using high-temperature combustion. Because the longest record of DOC concentration was based on persulfate oxidation, all concentrations in this chapter have been converted to that method using this equation.

Mean DOC concentrations were calculated by month, season, and water year. The seasons were defined as follows: January–March is winter; April–June is spring; July–September is summer; and October–December is autumn. Water years begin November 1 and end October 31; for example, the 1980 water year is November 1, 1980, through October 31, 1981.

Gage height recorded at the time of sampling was used to calculate instantaneous discharge (L/s), which we combined with measured concentration to determine daily DOC transport. Monthly, seasonal, and annual means for discharge used in regressions were obtained from the US Forest Service's long-term record of discharge from these two watersheds.

In this chapter, we relate DOC concentrations to leaf standing crop in the stream benthos (benthic leaf litter) and soil organic C content. Benthic leaf litter was measured in both streams seasonally in 1985–1986 (Golladay et al. 1989); monthly, from August 1986–August 1987 (Stout et al. 1993); and every other month, from November 1993 to September 1994 (see Webster et al., chapter 10, this volume). Soil organic C content at depths of 0–10 cm and 10–30 cm was measured annually on WS 7 during 1979–1985, 1992–1994, and 1998 using methods described by Knoepp et al., in chapter 4 of this volume. Measures of soil organic C content are not available for WS 14, the reference stream's watershed.

Results

Both streams exhibited a consistent seasonal pattern in DOC concentration (figure 6.2). Concentrations were highest in autumn, declined through winter, reached a nadir in March, and increased through summer. Average DOC concentrations were higher in the reference stream in all months, and seasonal concentration excursions were also greater in this stream. The mean ratio of DOC concentration in Big Hurricane Branch to DOC concentration in the reference stream was less than one in all months (figure 6.2). The ratio had a seasonal pattern, with ratios ranging from 0.75 to 0.85 in December through April, hovering around 0.65 from May through September, and increasing in autumn. Hence, the difference in concentration between the two streams was greatest in the growing season and least in the dormant season.

The range in mean annual DOC concentration over the 25-year record was the same as the range in average monthly concentrations (figure 6.3 cf. figure 6.2). The temporal pattern of mean annual DOC concentration over this quarter century was similar in the two streams (figure 6.3), and mean annual DOC concentrations in the two streams were highly correlated ($r = 0.86$, $P < 0.0001$). Average annual concentrations in both streams increased initially, then decreased, with highest

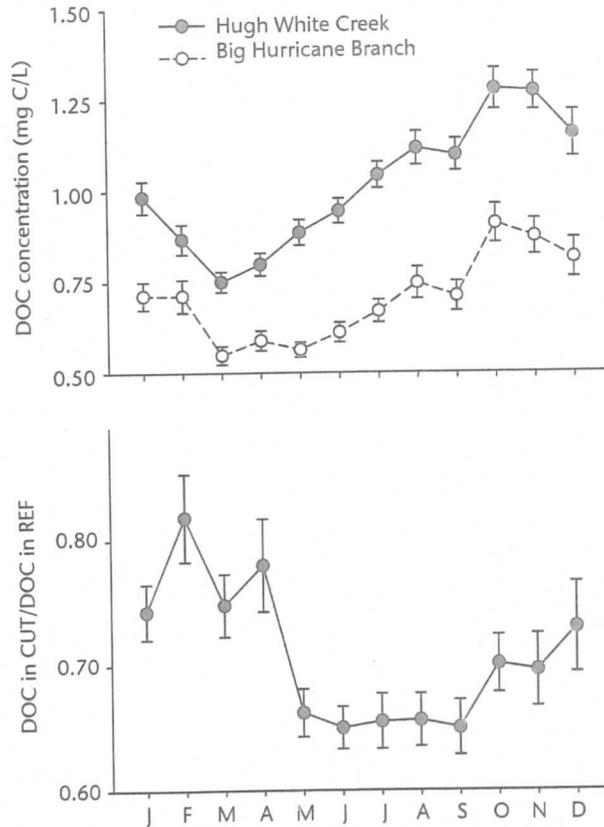


Figure 6.2 *Upper panel:* Mean (\pm SE) monthly DOC concentration in Big Hurricane Branch (clearcut watershed) and Hugh White Creek (reference watershed) over the 25-yr record. *Lower panel:* Monthly mean (\pm SE) of the ratio of DOC concentration in Big Hurricane Branch (CUT) to DOC concentration in Hugh White Creek (REF) over the 25-yr record.

concentrations 10–15 years after the cut (1988–1993) (figure 6.3). The annual mean of the ratio of DOC concentration in Big Hurricane Branch to DOC concentration in the reference stream showed a similar pattern (figure 6.3), indicating that concentrations initially converged and then diverged.

The pattern of DOC concentration was not simply a result of changing hydrologic conditions. Mean annual DOC concentration was not correlated with mean annual discharge in either stream ($r = 0.14, P = 0.50$ in Big Hurricane Branch; $r = 0.06, P = 0.77$ in reference). However, changing hydrologic conditions did impact the ratio of DOC concentration in the two streams. Multiple regression analysis ($R^2 = 0.35, P = 0.01$) revealed that the ratio of DOC concentration in Big Hurricane Branch to DOC concentration in the reference stream increased with increasing discharge ($P = 0.02$) and decreased with time since the cut ($P = 0.04$), although it was always less than one. Mean annual discharge in the reference stream was used

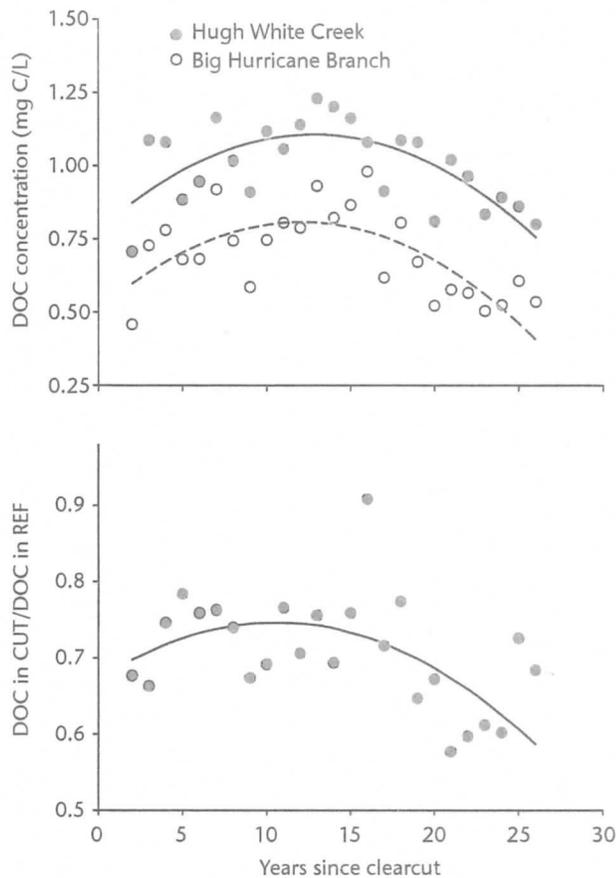


Figure 6.3 *Upper panel:* Mean annual DOC concentration in Big Hurricane Branch (clearcut watershed) and Hugh White Creek (reference watershed) plotted versus years since WS 7 was clearcut (1977). Solid line is the regression $y = 0.778 + 0.051x - 0.002x^2$, $r^2 = 0.43$, $P = 0.003$. Dotted line is the regression $y = 0.506 + 0.050x - 0.002x^2$, $r^2 = 0.47$, $P = 0.001$. *Lower panel:* Annual mean of the ratio of DOC concentration in Big Hurricane Branch (CUT) to DOC concentration in Hugh White Creek (REF) versus years since WS 7 was clearcut. Line is the regression $y = 0.672 + 0.14x - 0.0007x^2$, $r^2 = 0.29$, $P = 0.03$.

in this analysis as an indicator of hydrologic conditions; it was not related to time since the cut ($P = 0.9$). This analysis indicates that differences in DOC concentrations in the two streams were greatest (i.e., the ratio was farthest from one) in dry years and as forest succession proceeded.

The long-term temporal pattern of the ratio in concentrations differed by season (figure 6.4). The ratio was most variable in autumn but exhibited no consistent trend over the quarter century. In contrast, during both winter and summer, ratios increased in the first three to five years, followed by a decline. Ratios in spring increased for the first 17 years, but have declined since then. Some of this variation in seasonal ratios can be explained by mean seasonal discharge in the reference

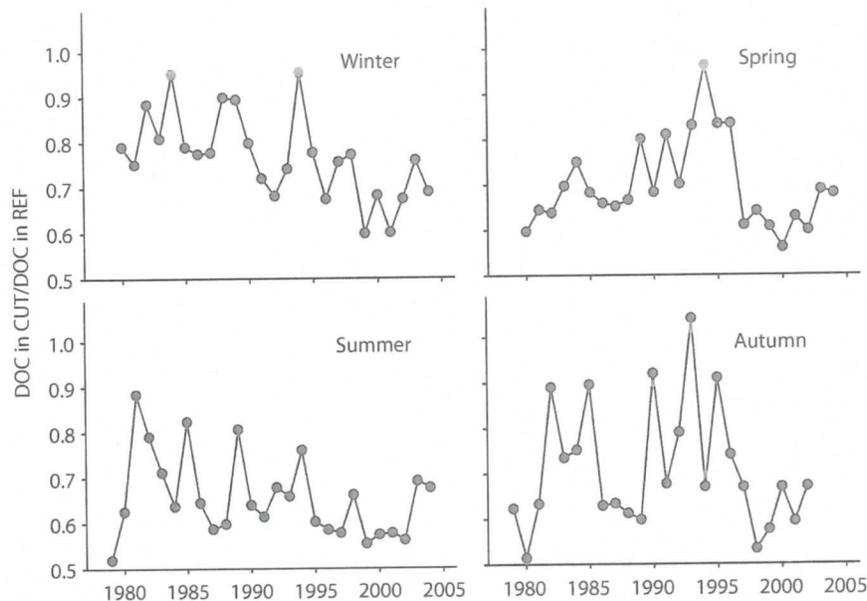


Figure 6.4 Seasonal mean of the ratio of DOC concentration in Big Hurricane Branch (CUT) to DOC concentration in Hugh White Creek (REF) for each season and year of record.

stream across years ($r^2 = 0.12$, $P = 0.0005$). Seasonal average DOC concentration declined with increasing discharge in both streams, but the decline was greater in the reference watershed; therefore the ratio of DOC concentration in Big Hurricane Branch to DOC concentration in the reference stream increased with increasing discharge. A multiple regression of seasonal ratios versus seasonal discharge in the reference stream and time since cut ($R^2 = 0.17$, $P = 0.0002$) is consistent with what was described for the annual data in the previous paragraph: the ratio remained less than one but increased with discharge ($P = 0.0004$) and decreased as forest succession proceeded ($P = 0.03$). Seasonal differences in DOC concentration in the two streams were greatest during dry seasons and as forest succession proceeded.

Some of the differences in DOC concentration over seasons and years can be explained by changes in amount of benthic leaf litter in the streams. The amount of benthic leaf litter explained more of the variation in seasonal DOC concentration in Big Hurricane Branch ($r^2 = 0.43$) than in the reference stream ($r^2 = 0.18$). When data from both streams were combined, the amount of benthic leaf litter explained 35% of the variation in seasonal average DOC concentration (figure 6.5). Including seasonal discharge did not improve this relationship.

These findings can be compared with data from two other Coweeta streams in which benthic leaf litter was altered experimentally by excluding leaf litter in one stream while keeping the other as a reference (Meyer et al. 1998). A regression of annual mean DOC concentration in the two reference streams, the clearcut stream, and the litter-excluded stream versus mean annual benthic leaf litter explained 34% of the variation in DOC concentration among streams and years (figure 6.6). These

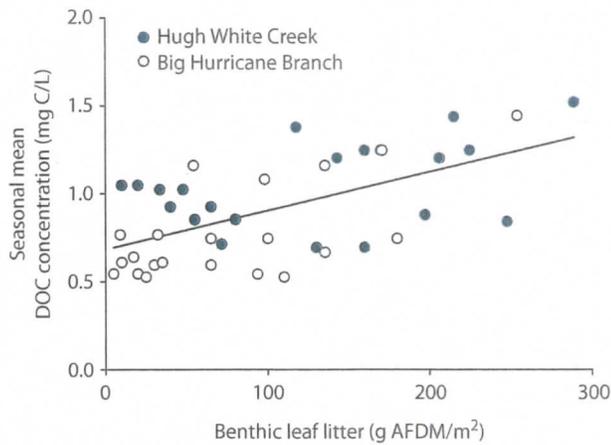


Figure 6.5 Seasonal mean DOC concentration in Hugh White Creek (reference watershed) and Big Hurricane Branch (clearcut watershed) versus benthic leaf litter in the stream. Line is the regression $y = 0.683 + 0.0022 x$, $r^2 = 0.35$, $P < 0.0001$.

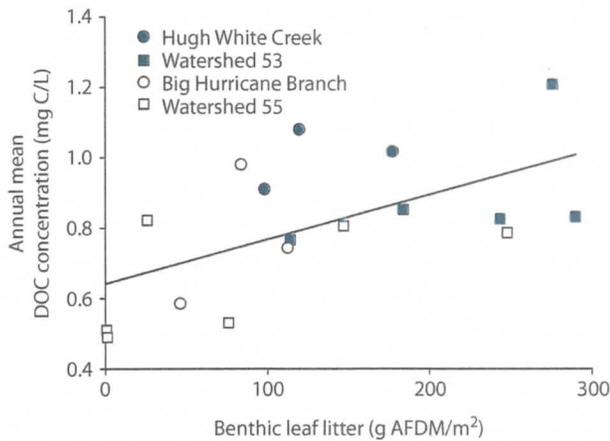


Figure 6.6 Annual mean DOC concentration in Hugh White Creek (reference watershed), Watershed 53 (litter exclusion reference stream), Big Hurricane Branch (clearcut watershed), and Watershed 55 (litter-excluded stream) plotted versus mean annual benthic leaf litter. Line is the regression $y = 0.642 + 0.0013 x$, $r^2 = 0.34$, $P = 0.01$.

data strongly suggest that leaching of benthic leaf litter is a significant source of DOC in these headwater streams.

Leaching of soil organic matter is another source of DOC to streams. It is likely that this DOC source varies as organic matter in the soil changes with forest succession and as the amount of water passing through the soil changes. We have expressed this potential source as annual average soil organic C in the top 10 cm divided by seasonal discharge (figure 6.7). Seasonal mean concentrations of DOC in Big

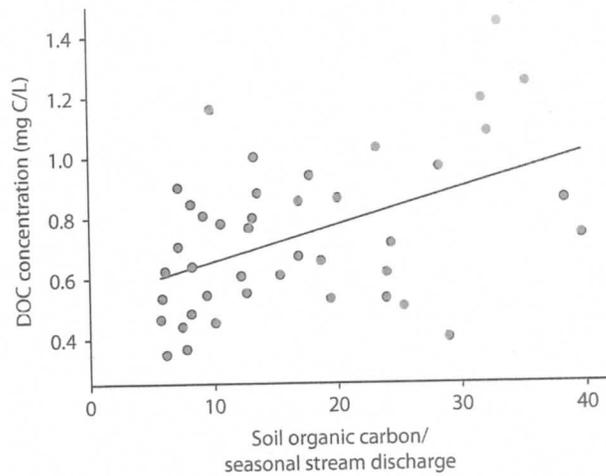


Figure 6.7 Seasonal mean DOC concentration in Big Hurricane Branch plotted versus the ratio of soil organic C content in the top 10 cm / seasonal discharge. Regression is $y = 0.535 + 0.012 x$, $r^2 = 0.22$, $P = 0.002$.

Hurricane Branch increased as this source increased, and the regression explained 22% of the variation in seasonal DOC concentration (figure 6.7). Seasonal mean DOC concentrations were also significantly correlated with soil organic C from 10–30 cm divided by seasonal discharge ($P = 0.01$), but that regression explained somewhat less of the variation in seasonal DOC concentration ($r^2 = 0.15$). Including only DOC data from seasons with measures of both soil organic C and benthic leaf litter reduces the number of data points that could be used in a multiple regression from 42 to 8, and the two measures are correlated ($P = 0.03$). Therefore, we cannot use multiple regression analysis to determine if combining in-stream and watershed sources would better predict stream DOC concentrations than either variable alone.

Water samples were collected at weekly intervals without intensive sampling during storms. DOC concentration increases during storms in these streams (Meyer and Tate 1983), so these data have limited usefulness in determining annual transport of DOC from the watersheds. Multiplying concentration by measured discharge at the time of sampling does provide an instantaneous measure of DOC transport. We have calculated an annual average of these values, which we call the *mean daily DOC load*, but because it does not include systematic samples of storms, it is probably an underestimate of the true load. Mean daily DOC load was consistently higher in the reference stream than in Big Hurricane Branch, with a temporal pattern similar to that observed with DOC concentration (figure 6.8 cf. figure 6.3), though with greater variability, so regressions were not significant. Annual mean ratio of load in Big Hurricane Branch to load in the reference stream declined with time since cutting (figure 6.8). Including mean annual discharge in a multiple regression did not improve the fit. The mean daily load of DOC transported from the clearcut watershed relative to mean daily load transported from the reference watershed declined with forest regrowth.

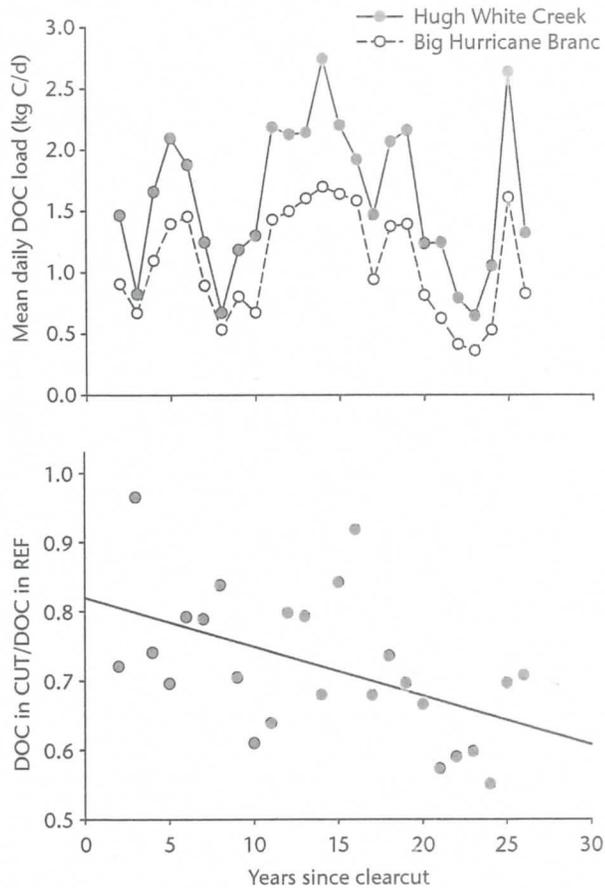


Figure 6.8 *Upper panel:* Mean daily DOC load (kg C/d) in Hugh White Creek (reference watershed) and Big Hurricane Branch (clearcut watershed) plotted versus years since WS 7 was clearcut. *Lower panel:* Ratio of mean daily DOC load in Big Hurricane Branch to mean daily DOC load in Hugh White Creek plotted versus years since WS 7 was clearcut. Line is the regression $y = 0.820 - 0.007x$, $r^2 = 0.25$, $P = 0.01$.

Discussion

An analysis of the first five years of data in this study led to a prediction that DOC concentrations would increase in Big Hurricane Branch, so that over time, DOC concentrations would be similar in the two streams (Meyer et al. 1988). DOC concentration increased initially in Big Hurricane Branch relative to the reference stream, but this trend was not sustained (figure 6.3). Therefore, concentrations in the two streams did not become more similar as the forest grew after cutting. In fact, during winter and summer, DOC concentrations in the two streams became more different over time (figure 6.4). Analyses of both annual and seasonal mean ratios of DOC concentration in Big Hurricane Branch to DOC concentration in the

reference stream indicated that DOC concentrations in the two streams were least similar during dry periods and later in forest succession. Hence, analyses of an additional 20 years of data showed that the prediction based on only the first five years of data was not correct. Long-term trends cannot reliably be predicted from short-term data sets.

Worrall et al. (2005) measured inorganic C flux from weekly samples taken in Big Hurricane Branch and used estimates of DOC and particulate organic carbon (POC) flux to calculate total C flux from reference and cut watersheds. We have revised their estimate of total C flux using more recent data for organic C (table 6.1). Both DOC and POC fluxes are higher than reported by Worrall et al. (2005), so total C flux estimates are also somewhat higher. Total C flux from the clearcut watershed is somewhat lower than from the reference watershed, but the range of flux estimates overlap (table 6.1). DOC remains a relatively small component (7%–8%) of total C flux, which is dominated by inorganic C flux (Worrall et al. 2005). For these estimates, POC flux exceeded DOC flux, which is somewhat unusual. However, this may be a result of sampling technique. POC sampling included intensive storm-water collection; whereas DOC calculations are based on weekly grab samples.

Observed DOC concentrations are the net result of DOC supply and in-stream DOC consumption. Limited measurements of in-stream DOC uptake showed little difference between Big Hurricane Branch and the reference stream when labile DOC was added to both streams two years after clearcutting (Meyer et al. 1988). This suggests that differences in rate of supply may be more responsible for the differences reported here, although we do not know how uptake has changed over time. As Webster et al. report in chapter 10 of this volume, leaf litter inputs to Big Hurricane Branch were lower immediately after the cut; but input amount was nearly the same as in the reference stream within five years. However, the quality of the inputs differed in that successional species having less refractory litter dominated the clearcut watershed. Because of the differences in litter quality, stream

Table 6.1 Total fluvial carbon flux ($t\ km^{-2}\ yr^{-1}$) from the reference and clearcut watersheds.

	Reference watershed		Clearcut watershed		Source
	Mean	Range	Mean	Range	
Dissolved CO_2	3.72	2.33–13.94	3.48	1.68–14.7	1
DIC	4.25	1.0–11.0	2.89	1.0–10.5	1
DOC	0.99	0.40–1.64	0.69	0.26–1.05	2
POC	2.9	—	2.0	—	3
Dissolved CH_4	0.26	0.12–0.40	0.26	0.12–0.40	1
Total	12.12	6.75–29.9	9.32	5.06–28.7	

Note: This table is an update of table 1 of Worrall et al. (2005) using more recent DOC and POC data.

¹ Worrall et al. (2005), 1979–1999 on WS 2 (reference) and WS 7 (clearcut).

² This chapter, using data from 1979–1999 from WS 14 (reference) and WS 7 (clearcut).

³ Webster et al. (1990), assuming POM is 50% C and using data from 1984–1985 from WS 7 (clearcut) and an average of WS 14 and 18 (both reference). These POC data include storm sampling; whereas the others are from weekly samples.

nutrient concentration, and stream temperature, leaf litter decayed more rapidly in Big Hurricane Branch so that little remained by late spring and summer. In addition, leaf litter could more easily be washed downstream in Big Hurricane Branch because there was less wood in the channel. The seasonal pattern of DOC concentration in the two streams (figure 6.2) was consistent with these differences in litter quality, decay rate, and retention in debris dams. DOC concentrations were the most similar in autumn and winter, but they diverged in spring and summer, when most of the litter inputs had decayed or been washed downstream in Big Hurricane Branch.

The bioavailability of DOC leached from riparian leaf litter differs by species, and the leachate from early successional species is more bioavailable (McArthur and Richardson 2002). Although uptake rates measured using the same labile DOC source were similar in the two streams shortly after clearcutting (Meyer et al. 1988), we have no data on uptake rates for DOC naturally entering each stream. Since leachate from early successional leaves falling into Big Hurricane Branch was likely more bioavailable, the observed lower ambient DOC concentrations are what would be expected in that stream. The reference stream showed consistent downstream increases in DOC concentration; whereas downstream concentrations did not change in Big Hurricane Branch two years after the cut (Meyer and Tate 1983). This observation is consistent with more rapid removal of DOC in Big Hurricane Branch, although we do not know if these differences in longitudinal patterns have been sustained over the years in these streams.

The absence of a longitudinal increase in DOC concentration in Big Hurricane Branch is also consistent with the lower rates of DOC supply from the clearcut watershed. The correlation of DOC concentration with both benthic leaf litter (figure 6.5) and soil organic C content/seasonal discharge (figure 6.7) provides even stronger evidence for differences in both in-stream and watershed sources of DOC to the two streams. The importance of in-stream DOC sources is not unique to these two streams. Mean annual DOC concentration in four very different Coweeta streams can be predicted by benthic leaf litter (figure 6.6) despite the fact that watershed size (~60 ha vs. ~6 ha), discharge (~20 L/s vs. < 2 L/s), and streambed area differ by an order of magnitude. The amount of water flowing over and leaching DOC from benthic leaf litter is similar per m² in these streams, so DOC concentration is related to benthic leaf litter expressed per m². Data from other southern Appalachian streams show a similar pattern of autumn peaks in DOC concentration and evidence of significant in-stream generation of DOC (Mulholland and Hill 1997).

Organic C reservoirs in the soil have been identified as a significant source of DOC in streams and lakes in many settings. Differences in soil organic C storage explained 91% of the variance in annual streamwater DOC fluxes among 17 British rivers (Hope et al. 1997). Soil organic C pools correlated with mean DOC concentrations in Scottish watersheds of different sizes, with the strongest relations in the small (< 5 km²) watersheds (Aitkenhead et al. 1999). Predictive models of stream DOC export have been developed in which a terrestrial reservoir of soil DOC builds up during low-flow periods and then flushes when the water table rises into this reservoir (Boyer et al. 1996). The relationship between

the DOC concentration in Big Hurricane Branch and the organic C content of the top 10 cm of soil in its watershed (figure 6.7) is consistent with these findings from other ecosystems.

A variable fraction of DOC leached from organic matter in the upper soil horizons is sorbed in the mineral soil, leading many researchers to conclude that sorption and hydrology are the main regulators of DOC losses from terrestrial ecosystems (e.g., Neff and Asner 2001; see also Qualls et al., chapter 5, this volume). High levels of DOC adsorption in the mineral soil at Coweeta have been attributed to the soil's high content of Fe and Al oxyhydroxides (see Qualls et al. chapter 5, this volume). Although we do not have data on the Fe and Al oxyhydroxide content of soils from the reference or from the clearcut watershed, we know that the Fannin soil series is a dominant on the clearcut watershed and that Trimont is a dominant on the reference watershed (Thomas 1996; see Knoepp et al., chapter 4, this volume). Analyses from soil pits characterizing these soil series reveal Fe and Al oxyhydroxide content of Fannin series soils to be about a third of the Fe and Al oxyhydroxide content of Trimont series soils (USDA 2005). Hence the lower DOC concentrations in Big Hurricane Branch cannot be explained by increased DOC sorption in its mineral soils because the Fe and Al oxyhydroxide content of its soils is less than in the soils from Hugh White Creek's watershed.

A 25-year record of DOC concentration in stream water does not exist for many other streams. Two larger British rivers have long records (30–40 years) during which DOC concentration increased 1 mg/L and 3 mg/L (Worrall and Burt 2004). These increases were attributed to increasing temperatures and drought, resulting in accelerated decomposition of peat via release from inhibition by phenolics (Worrall and Burt 2004). A 20-year record showed a 50% decline in DOC export to Canadian lakes as a result of drought-induced forest fires and, especially, lower water yield (Schindler et al. 1997). The long-term pattern of DOC concentration and export in Coweeta streams showed neither sustained increase nor decrease. Mean annual DOC concentration was not simply a function of stream discharge but also changed as a function of the amount of leachable organic matter in both the stream and the soils of its watershed. As these stores of leachable organic matter changed during forest succession, so did DOC in streamwater. The long-term trend of declining mean daily DOC load in Big Hurricane Branch relative to the reference stream (figure 6.8) suggests that there has been a depletion of DOC sources during the first quarter century of forest recovery from clearcutting.

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CLEARCUTTING IN THE
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EDITED BY
Wayne T. Swank
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Our North American forests are no longer the wild areas of past centuries; they are an economic and ecological resource undergoing changes from both natural and management disturbances. A watershed-scale and long-term perspective of forest ecosystem responses is requisite to understanding and predicting cause and effect relationships. This book synthesizes interdisciplinary studies conducted over thirty years, to evaluate responses of a clear-cut, cable-logged watershed at the Coweeta Hydrologic Laboratory in the Nantahala Mountain Range of western North Carolina. This research was the result of collaboration among Forest Service and university researchers on the most studied watershed in the Lab's 78-year history. During the experiment, a variety of natural disturbances occurred: two record floods, two record droughts, a major hurricane, a blizzard of the century, major forest diseases, and insect infestations. These disturbances provided a unique opportunity to study how they altered the recovery of the forest ecosystem. This book also shows that some long-term forest trends cannot be forecast from short-term findings, which could lead to incorrect conclusions of cause and effect relationships and natural resource management decisions.

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