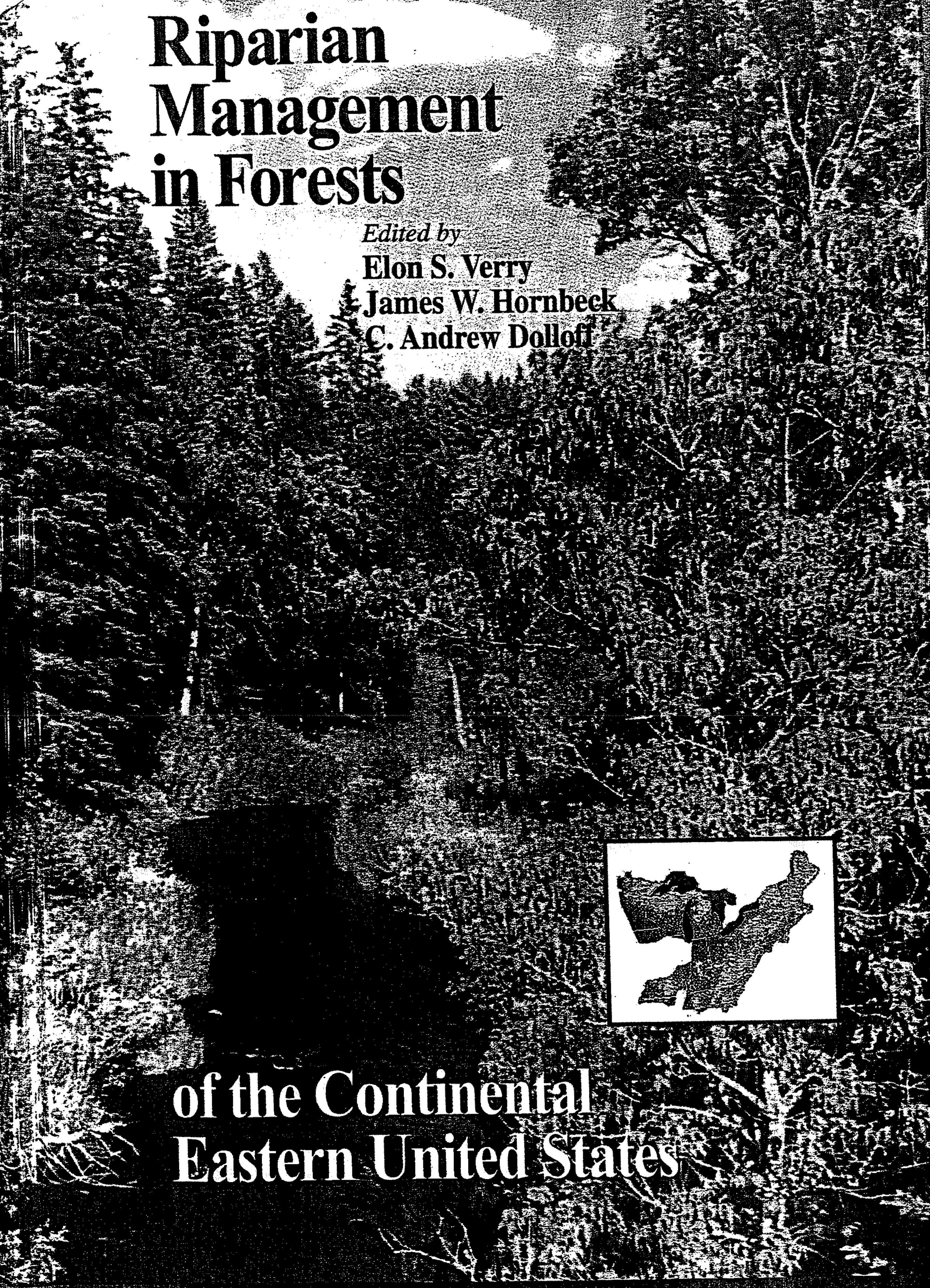
Riparian Management in Forests

Edited by

Elon S. Verry
James W. Hornbeck
C. Andrew Dolloff

of the Continental Eastern United States



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Chapter 7

Particulate Organic Contributions from Forests to Streams: Debris isn't So Bad

C. Andrew Dolloff and Jackson R. Webster

"Say you are in the country; in some high land of lakes. Take almost any path you please, and ten to one it carries you down in a dale, and leaves you there in a pool by a stream. There is magic in it. Let the most absent-minded of men be plunged in his deepest reveries — stand that man on his legs, set his feet a-going, and he will infallibly lead you to water... Yes, as everyone knows, meditation and water are wedded for ever." Herman Melville, 1851— Moby Dick

As we meditate on the management of stream riparian areas, it is clear that the input of "debris" from terrestrial plants falling into streams is one of the most significant processes occurring at the interface of terrestrial and stream ecosystems. Organic matter — leaves, twigs, branches, and whole trees — provides energy, nutrients, and structure to streams flowing through forests. A host of vertebrate and invertebrate animals has adapted to life in flowing waters and depends on leaves and wood for food and habitat. Accumulations of leaves and wood also create refuges from the extremes of drought and flood and modify the downstream movement of sediment.

Despite all that we know about the importance of organic matter in streams, all too often wood and leaves in streams have been viewed as a liability at worst and a nuisance at best. Even the terms we use to describe it — debris, for example, — suggest something cast off or discarded. Although excessive amounts of organic matter have negative impacts in streams, such as lowering dissolved oxygen (Schneller 1955; Larimore et al. 1959; Hicks et al. 1991), buildup of toxic substances (Buchanan et al. 1976), and blocking fish migration (Baker 1979), most problems are local rather than symptomatic of a underlying pathology. All of these reasons aside, the main reason for our aversion to wood and leaves in streams is far more basic: it just plain looks bad (Dolloff 1994)! Peter Marshall's parable of the "Keeper of the

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Spring" (Figure 7.1) illustrates the most common of many misconceptions about wood and leaves in streams. For swans a swimming, irrigation, hydropower, and pretty views, perhaps clean streams are desirable. But for diverse, productive invertebrates and fish, for preservation of natural sediment and water regimes, and for overall stream health terrestrial plant debris is not only desirable but essential.

THE KEEPER OF THE SPRING

This is the story of the keeper of the spring. He lived high in the Alps above an Austrian town and had been hired by the town council to clear debris from the mountain springs that fed the stream that flowed through the town. The man did his work well and the village prospered. Graceful swans floated in the stream. The surrounding countryside was irrigated. Several mills used the water for power. Restaurants flourished for townspeople and for a growing number of tourists.

Years went by. One evening at the town council meeting someone questioned the money being paid to the keeper of the spring. No one seemed to know who he was or even if he was still on the job high up in the mountains. Before the evening was over, the council decided to dispense with the old man's services.

Weeks went by and nothing seemed to change. Then autumn came. The trees began to shed their leaves. Branches broke and fell into the pools high up in the mountains. Down below the villagers began to notice the water becoming darker. A foul odor appeared. The swans disappeared. Also, the tourists. Soon disease spread through the town.

When the town council reassembled, they realized that they had made a costly error. They found the old keeper of the spring and hired him back again. Within a few weeks, the stream cleared up, and life returned to the village as they had known it before.

Modified from Peter Marshall's "Mr. Jones: Meet the Master."

Figure 7.1 Our notion of a healthy stream has been influenced by the popular media, including literature.

Our task in this chapter is to outline what we know about the functions and values of leaves and wood in streams. In doing so we hope not only to dispel the common misconception that wood debris in streams is undesirable, but also to instill the concept of organic matter as an asset to be husbanded.

Definitions

Organic material that falls into a stream from the surrounding land is known as allochthonous input. Combined with the instream accumulation of primary production by algae and vascular plants — the autochthonous input — allochthonous input provides the support system for all instream life. Allochthonous inputs span a broad range of sizes; from leaf fragments to branches and entire trees. Although the size range of these inputs is continuous, individual pieces typically are classified by size and function and grouped for convenience. Fine particulate organic material (FPOM) encompasses all particles that will pass through a .04-inch (1.0-mm) fine mesh sieve. The largest pieces of wood, known as large or coarse woody debris (CWD), typically are greater than three feet in length and at least 2 to 4 inches in diameter. In between is CPOM or coarse particulate organic material.

Input Mechanisms and Loads

Leaves and wood are transported into streams by various mechanisms, ranging from the predictable fall of leaves in the autumn to the catastrophic input of major storms. Factors such as species composition, forest health, size and type of stream channel, and land-use history influence the input rate and total loading of organic materials.

Inputs of allochthonous matter should decrease in importance as stream size increases (Vannote et al. 1980). Although there have been few measurements of allochthonous inputs to larger streams, several studies have confirmed this prediction (Cummins et al. 1983, Conners and Naiman 1984). In large streams with well-developed floodplains, allochthonous inputs initially fall to the floodplain but may be washed into the river during floods. This interaction between rivers and floodplain vegetation is not well understood, but Cuffney (1988) estimated that the flood plain was the major source of organic matter to the Ogeechee River in Georgia.

In the absence of a catastrophic event, the weight of leaf material that enters a stream each year frequently exceeds that of wood (Table 7.1). In a summary of other studies of streams in the Eastern United States, Webster et al. (1995) found that direct fall of leaves into upland streams ranges from 1800 to 4800 lbs/acre/y, averaging 3100 lbs/acre/y. The average is somewhat higher for floodplain streams and streams draining wetlands: 5200 lbs/acre/y. Leaf inputs account for about 58% of total inputs. When non-leaf materials are included, total inputs average 5300 lbs/acre/y to upland streams and 6100 lbs/acre/y to floodplain and wetland streams. These numbers become even higher if we include lateral inputs, that is, the allochthonous material that blows or rolls down the banks into streams. With lateral inputs included, leaf inputs to upland streams average 4700 lbs/acre/y and total inputs average 6000 lbs/acre/y. In deciduous forests, annual variation in these inputs is not great. While catastrophic events may cause large inputs at unusual times of the year, annual leaf input will not be greatly affected.

Wood inputs to streams in the Eastern United States have not been extensively measured. Webster et al. (1995) summarized 13 studies, showing an average of 1300 lbs/acre/y direct wood input to upland streams and 1100 lbs/acre/y to floodplains. Lateral inputs averaged about 19% of total wood inputs. Unlike leaf inputs, which are predictable in streams draining deciduous forests, wood inputs are highly variable in both space and time. One winter ice storm accounted for 80% of the annual wood input to the Sangamon River in Illinois, and wood input the year of the ice storm was three times that of the following year (Peterson and Rolfe 1982).

Table 7.1 Allochthonous inputs and standing crops of allochthonous material in two undisturbed streams at Coweeta Hydrologic Laboratory, Macon county, North Carolina. FBOM is fine (< .04 inch benthic organic matter. CBOM is coarse (> .04 inch) benthic organic matter. Small wood is 0.4 to 2 inches diameter and large wood is > 2 inches. Grady Branch is a first-order and Hugh White Creek is a second-order stream. Input data from Webster et al. (1990) and standing crops from Golladay et al. (1989).

	Grady Branch	Hugh White Creek
Litter fall (lbs/acre/y)		
Leaves	4303	3707
Wood	2317	942
Lateral input (lbs/acre/y)		
Leaves	1218	792
Wood	92	81
Standing crops (lbs/acre/y)		
FBOM	1311	1481
CBOM	2177	1900
Small wood	2677	2784
Large wood	40,854	45,816

Logging, especially when all trees including those adjacent to streambanks are removed, has a profound influence on the loading of large wood. Webster et al. (1992) presented a hypothetical model for wood loading following logging (Figure 7.2). Provided that slash and wood deposited by natural processes are not removed, wood loads should be highest immediately following logging.

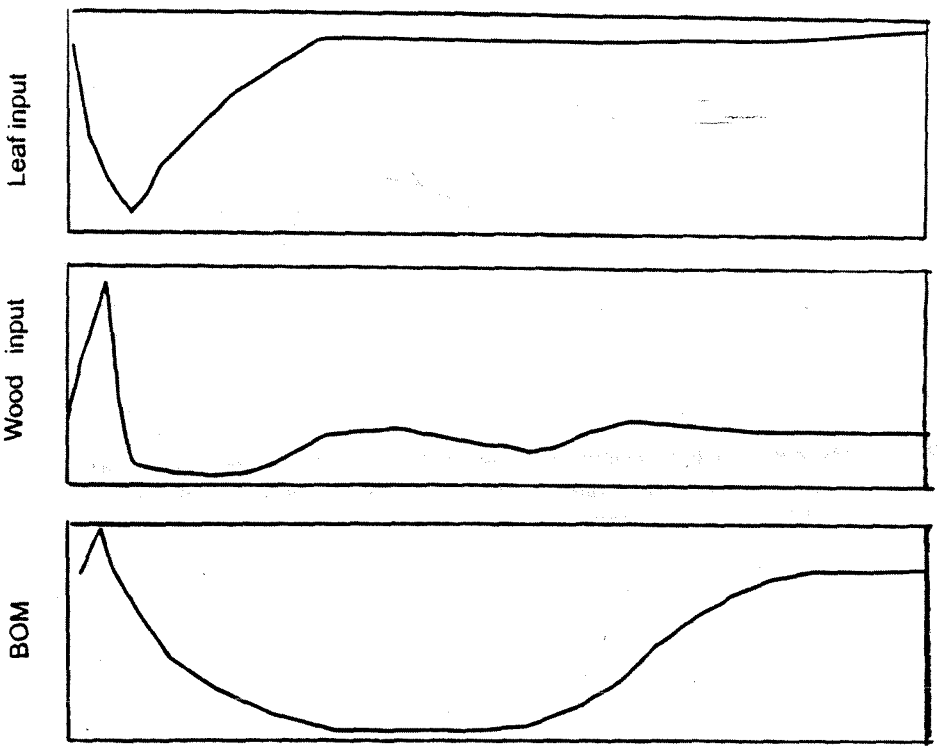

Figure 7.2 Hypothetical trends in allochthonous inputs and stream benthic organic matter (BOM) after riparian logging (modified from Hedin et al. 1988 and Webster et al. 1992).

These high loads should persist for 20 to 50 years before declining to lower levels. Loads should then gradually increase over many years as the riparian forest matures and provides a source of large wood. This last process may require centuries, depending on growth rates of riparian trees.

Wood inputs into wilderness streams provide the most reliable estimates of wood loading under undisturbed conditions as long as the wilderness encompasses true old-growth forest. Flebbe and Dolloff (1995) inventoried large wood in three North Carolina watersheds managed as wilderness. Right Fork of Raven Fork and Little Santeetlah drain true wilderness (never harvested or homesteaded), whereas about 80 years had passed since the second-growth forest surrounding Lost Cove had become established. Loadings of large wood in Right Fork (416 pieces/mi) and Little Santeetlah (291 pieces/mi) were at least three times greater than in Lost Cove (85/mi) which, along with logging, had experienced several major floods over the preceding 80 years.

Despite its obvious importance, however, logging history is but one of a host of factors that determine how much wood and what kind of wood a stream has. Insects, diseases, and storms, acting either singly or in combination, also influence wood loadings. Hedman et al. (1996) determined that the load of large wood was highly variable in 11 riparian forest-stream systems representing a 300-year range in the southern Appalachians. They attributed the lack of statistical difference among systems to particularly high variability among mid-successional systems. Wood loads in these systems were dominated by decay-resistant American chestnut and eastern hemlock derived from the pre-logging riparian forest. Although extirpated from the extant forest by the chestnut blight, American chestnut probably was a major component of the wood load in many eastern streams. Hedman et al. (1996) attributed the high variability in chestnut loads to the accelerated mortality and input of blight-killed trees which was offset in some systems by salvage logging.

Leaf inputs drop to nearly zero but recover fairly rapidly as trees regrow. Inputs of logging debris initially increase wood inputs and BOM, but inputs rapidly decline and remain at low levels. BOM declines more slowly as residual wood and debris dams decay and disintegrate. BOM remains low even after leaf input returns to near normal levels because of the lack of retention structures (wood and debris dams). In time, small wood is recruited as small early- and mid-successional trees die, but inputs of large wood, capable of forming debris dams and jams, don't occur for many years after logging. The time scale may range from about 50 to more than 200 years, depending on the rate of forest regrowth.

More dramatically, the high winds of hurricanes and tornadoes cause extremely high loadings. In 4 hours in 1989, Hurricane Hugo deposited more than a normal year's worth of leaves and woody debris on the forest floor and streams in Puerto Rico (Covich et al. 1991). Large accumulations of leaf litter were retained in debris dams in stream channels and remained in place for more than 8 months. Even after it was downgraded to a tropical depression, Hurricane Hugo more than doubled the load of large wood, from 76 to 186 pieces per kilometer, in streams of the Basin-Cove watershed, a tributary system of North Carolina's Yadkin River (Dolloff et al. 1994). Most of this input consisted of small trees and branches from the less than 60-year-old riparian forest. Because of its small size and susceptibility to rapid decay and transport out of the stream channel, this wood was unlikely to have long-term benefits for stream biota.

Floods, if severe enough, can produce large amounts of wood. A recent (1995) flood caused debris avalanches in several Shenandoah National Park watersheds. Torrents of water, rock, soil, and trees carved wide swaths from riparian areas many times the width of the stream channels. Beginning at the uppermost debris avalanche and continuing downstream beyond the Park boundary, the boulder-packed stream corridors were punctuated by huge piles of debris, composed of rocks, mud, and trees of all sizes, located at bends and other places where the flood's energy was dissipated.

Functions of Allochthonous Matter

Organic Matter for Trophic Processes

Although many benthic invertebrates feed on allochthonous organic matter (e.g., Hynes 1970), actually demonstrating the importance of allochthonous matter in streams is problematic. Fisher and Likens (1973) and many others demonstrated that allochthonous inputs can greatly exceed autochthonous production, but because of the low nutrient content of detritus compared to algae, the importance of allochthonous material was still unresolved. Recently, however, Wallace et al. (1997) eliminated allochthonous inputs to a small stream and documented the subsequent decline in invertebrate production. Increasing width in the downstream direction results in lower allochthonous inputs and allows more light to the stream, increasing autochthonous primary production (Vannote et al. 1980). However, even in larger streams the importance of allochthonous matter should not be underestimated. While leaves and sticks are usually retained and broken down near where they enter streams (e.g., Webster et al. 1994a and b), the initial consumption and use of the organic material is low. The unused material, now converted to fine particles, may be transported from small, headwater streams downstream into large rivers where it is ultimately consumed by invertebrates or assimilated by aquatic microbes and converted to CO_2.

All vegetative materials, including leaves, fruits and flowers, bark, roots, and boles ultimately contribute to the pool of FPOM and become available for further processing by microbes and macroinvertebrates. The proportion of fine organic matter derived from the decay and fragmentation of large wood is largely unknown in eastern streams but may be significant. In Oregon's western Cascades, Ward and Aumen (1986) estimated that instream wood processing could yield several times the fine material generated by needles and leaves. The amount of fine material from wood depends on the amount, type, and size of wood available for processing; small pieces of softwoods, with their relatively high surface-to-volume ratio, tend to disappear faster than large pieces of hardwood.

Large Wood

Before they are fragmented into FPOM or transported downstream, large pieces of wood play major roles in the habitats of invertebrates and fish (Bisson et al. 1987). Water flow around large wood forms pools and encourages scour from stream banks and bottoms (Shirvell 1990; Cherry and Beschta 1989; and many others). In addition to basic pool structure, wood provides complexity. Root wads, large branches, and multi-stem tree trunks partition the water column, providing cover and a measure of isolation for many species. Pools and other areas of slack flow created by wood provide refuges for obligate aquatic organisms during times of extreme high or low flows (Sedell et al. 1990).

Large pieces of wood influence flow velocity, channel shape, and sediment storage and routing (Harmon et al. 1986; Bisson et al. 1987). These individual pieces often accumulate to form the matrix of debris dams which are lined with leaves and finer particles of organic matter. The stairstep profile created by woody debris dams dissipates much of the energy in small, high-gradient streams (Heede 1972). For example, Bilby and Likens (1980) found that about 50% of the gradient drop in first- and second-order streams at Hubbard Brook occurred over debris dams (Table 7.2).

Table 7.2 Percent drop associated with sediment or rock and debris dams in Hubbard Brook (Bilby and Likens (1980). With permission.

	% Drop Caused By		
Stream Order	Organic Dams	Inorganic Dams	All Falls
First	52	16.3	68
Second	46	28.5	75
Third	10	28.0	38

Debris dams also increase water depth and decrease velocity, resulting in greater transit times for water, solutes, and suspended material (Trotter 1990; Gregory 1992; Wallace et al. 1995). A current study (Wallace et al. 1997) is also suggesting that leaves in streams also function in this way (J. R. Webster, unpublished). Woody debris dams have been shown to be extremely important in the retention of both particulate organic and inorganic matter (e.g., Bilby and Likens 1980; Mosley 1981; Speaker et al. 1984; Smock et al. 1989; Trotter 1990; Smith et al. 1993). These physical stream changes associated with large particulate matter indirectly affect stream communities. By adding logs to a stream at Coweeta Hydrologic Laboratory, Wallace et al. (1995) demonstrated major changes in the composition and production of the macroinvertebrate assemblage. Similarly, less than one year after Hilderbrand et al. (1997) added logs to two Virginia streams, they noted changes in macroinvertebrate assemblages associated with changes in habitat composition. In another Coweeta study, Tank et al. (Tank and Webster in press a; Tank et al. in press b) showed that elimination of leaf inputs to a stream decreased nutrient retention and indirectly affected microbial processes in the stream.

Impact of Land Use

When wood falls, blows, or rolls into a stream, particularly as a result of a storm or some other catastrophic event, the first reaction of most people and many governmental agencies is to pull it out. Our prejudice against wood in the water has caused us to anticipate the supposedly negative consequences of "allowing" wood into streams and rivers. The first reaction of most citizens and governments following a major influx of wood by floods or storms is to mobilize stream cleanup crews. Regulations and Best Management Practice in a number of states require that any wood entering streams as a result of timber harvest or other silvicultural activities be removed soon (Chamberlin et al. 1991; Hicks et al. 1991). These attitudes towards debris are not a product of recent ecological thinking but rather reflect the perspectives and practices of our forebears (Williams 1989; Maser and Sedell 1994; Whitney 1994; Verry and Dolloff Chapter 1), who viewed accumulations of debris as "unhealthy" (Figure 7.1.) or as obstacles to efficient movement of water and vessels. During the last 200 years, woody debris has been removed from nearly every major river in the continental United States (Sedell and Luchessa 1982). Sedell et al. (1982), Sedell and Froggatt (1984), and Triska (1984) documented the extensive geomorphological and habitat changes of rivers subject to woody debris removal. These and other studies conducted during the last half of the 20th century have caused us to revise our thinking about the effects of land use and the role of wood in water.

Aside from a complete loss of riparian forests, such as occurs when land is developed for highways, housing, or industry, the most obvious cause of woody input loss to forest streams is wood harvest. Following logging, organic inputs are greatly reduced (Webster and Waide 1982) although, with rapid regrowth of vegetation, leaf inputs may return to near pre-logging levels in 5 to 10 y (Webster et al. 1988, 1990). However, the composition of leaf inputs may remain altered for many years (Webster et al. 1983, 1990). Wood inputs are more drastically influenced (Likens and Bilby 1982; Webster et al. 1992). A one-time input of logging slash may be followed by many years of almost no wood input. After several years, self-thinning and competition may result in limbs and small trees dying and falling into the stream, but it may be hundreds of years before significant numbers of large trees begin to die and fall into the stream. Removing all trees down to the streambanks may result in a large one-time input of leaves (depending on the time of year) and large wood, which in time may be beneficial. But, in practice, much of the latter typically is removed either as part of the timber harvest or because of regulations requiring the removal of logging debris. Unfortunately, those who remove the debris may not be aware of the value and role of wood in the stream system and may accomplish far more than their assigned task when they remove all wood, regardless of how it got into the channel. Habitat damage from such removal or salvage may be long-lasting, resulting in changes in species distribution and fish production (Elliott 1986; Dolloff 1986). Particularly where riparian soils consist of unconsolidated or highly erodible sediments, pulling woody material out of streams will likely destabilize streambanks and channels and accelerate erosion.

Other disturbances to allochthonous inputs include defoliating insects such as gypsy moths. Severe and repeated defoliations kill trees and change the composition of riparian forests. Even though they may not kill trees, defoliations can drastically alter many instream processes. Most gypsy moth defoliations occur at the time of leaf-out in spring, resulting in large inputs or leaf fragments and frass, which may not be fully used by stream invertebrates adapted to autumn inputs. Less well described is the interaction of defoliation and water chemistry, particularly in watersheds that have been impacted by acid precipitation. In some areas, concentrations of nitrate in stream waters have increased dramatically following forest defoliation. Although nitrogen (N) compounds contribute to the acidity of precipitation, surface waters associated with forested upland watersheds typically have negligible nitrate concentrations due to plant and microbial use of nitrogen as a nutrient. However, defoliation disrupts the normally tight cycling of N and allows nitrate, an acid-anion, to "leak" from watersheds (Swank et al. 1981). Observed effects include increased frequency and severity.

Similar disruptions of normal inputs are caused by diseases such as chestnut blight, various forms of air pollution, and changes in tree species composition. In the Eastern United States, many forests have been converted from multiple-species deciduous forests to faster growing pines. The loss of the normal diversity of leaf species falling into the stream may severely disrupt the benthic invertebrate assemblage where various species are adapted to different types of leaf material (Cummins et al. 1989). For example, Woodall and Wallace (1972) found lower total weights of benthic invertebrates in a stream draining a white pine plantation than in a stream in a mixed deciduous forest.

Frequently Asked Questions

In this chapter we have only briefly reviewed the importance of organic materials in stream ecosystems. Because the intent of this book is to provide practical information for managers, we have attempted to answer some of the most frequently asked questions about the management of woody inputs to stream systems. Note: the views expressed reflect the biases of the authors and should be considered accordingly because each will change as new information becomes available.

OK, I'm convinced that organic debris — leaves, twigs, branches, and even whole trees — plays an important role in stream ecosystems. Now what? I need to know:

1. How do I balance the seasonal needs for leaves and small woody materials with the long-term need for large wood? Do I need to worry about that?

   The answer to this and most questions begins with, "It depends." In this case, "it depends" on the goals of management (desired condition) for both the riparian forest and the stream system: the composition of the riparian forest and the specific activities planned for the streamside forest. Managers first need to ask if the area under consideration meets or exceeds desired conditions for such attributes as species composition and age-class distribution of the forest and pool: riffle ratio or number of pieces of large wood per mile for instream habitat. In forests that meet the goals and have tree and understory species that represent the area, little management may be necessary. In forests characterized by a few species that have low potential for providing large wood or where exotics have become established, some manipulation of the riparian vegetation may be desirable. For example, it may be desirable to remove (by mechanical means or fire) dense thickets of rhododendron which in monoculture provides neither high-quality detritus nor long-term potential for large wood recruitment.

2. How much is enough? What sizes are appropriate?

   The simple answer is no one knows, or more accurately, no one has reported examples of streams that, at least from an ecological viewpoint, are so overloaded with wood that natural processes have been compromised. But, of course, where a catastrophic event has deposited large amounts of material directly upstream of a bridge, culvert, or some other structure, we could conclude that the system was indeed overloaded. All sizes of wood are desirable, but in general, the larger the better, both to promote stability (large pieces are more resistant to being moved) and persistence (large pieces have slower rates of fragmentation and decay).

3. Can I (should I) control the amount of both small and large wood that enters my streams?

   To a limited extent it is possible, although costly, to control the amount of wood that enters a stream. In the context of ecosystem management, provision for recruitment of large wood can be incorporated as a component of other strategies such as gap management. Perhaps more importantly, because most major inputs of organic materials tend to be associated with storms and other catastrophic events, we need to be ready to "manage" the aftermath of disasters by carefully weighing the costs and benefits of stream cleanups; for example, removing debris jams that threaten buildings or roads but limiting other instream work to that necessary to maintain infrastructure such as water intakes.

4. What tree species should I be managing for in my riparian areas?

In general, management should be based on native species typical of riparian areas in the region. Much research is currently underway to address this question and to develop specific silvicultural prescriptions for "designer" riparian areas.

5. How do I get organic materials into (and keep them in!) a stream?

Simply putting leaves into a stream will not maintain or restore natural functions. Managers need to consider synergisms and feedback mechanisms. In most situations, the most appropriate method for managing organic inputs may be to manage the riparian forest to enhance natural inputs. On the other hand, there has been no shortage of creative solutions to the problem of how to get wood into streams, ranging from directional felling by chain saw or explosives to direct input using heavy equipment. Where recreational fishing or endangered species are a major consideration, we need to distinguish the passive riparian input strategy from the strategy of active habitat improvement. In streams where biologists have determined that populations are limited by habitat availability and quality, and where public interest is high, the placement of habitat structures such as k-dams, log weirs, and "lunker structures" can be effective (Hunter 1991). But habitat improvement is expensive and can be applied only to limited sections of a few streams. Additionally, recent studies have questioned the suitability and benefits of many habitat improvement projects (Frissel and Nawa 1992). While both active and passive strategies have their place, the passive strategy has the most potential for cost-effective, long-term, widespread benefits.

6. Can I salvage dead and down trees in a riparian area?

Meet objectives for riparian structure and function first! In general, it is probably better not to salvage trees because of the potential for damaging the integrity of streambanks. Depending on the characteristics of the floodplain, wood may be transported long distances from upland sites into stream channels during storms. Also, amphibians and other animals benefit from wood debris located on floodplains (see Chapter 10).

7. If I build it, will they come? Will additions of large wood enhance the chances for species persistence or recovery?

   For some species, probably yes; particularly macroinvertebrates and salmonids. But for other fish and invertebrates such as mussels, it depends on their specific habitat requirements. Recovery of extirpated populations is more difficult if only habitat niches are provided, a necessary but not singular condition for success. In addition to questions of genetic integrity, presence of other species, and other considerations, there must be a source of recruitment, either by natural means from adjacent habitats or by artificial means provided by managers.

8. Is control of exotic insect pests such as gypsy moth desirable from the standpoint of stream ecodynamics?

   This question usually arises when considering more comprehensive plans for pest management. Managers of aquatic systems need to consider such things as background water chemistry, the probability of changes in water quality, the effect of the pesticide on non-target macroinvertebrates, and the effect on stream water temperature if the riparian forest is allowed to defoliate.

9. Should debris-removal BMPs be modified or eliminated?

   Turn it around — if a tree falls into a stream during logging, require that it not be removed without consulting a biologist or hydrologist. There would then be two new outcomes: one, fewer trees will "accidentally" be felled into streams; two, if they do fall in, good! This does not, however, suggest that streams can become dumping grounds for slash which tends to be unstable and easily transported in all but the smallest streams. And, of course, debris may be removed from areas immediately upstream of bridges, dams, and other structures.

10. Why not simply stay out of riparian areas and allow natural succession to occur?

   To someone interested in preserving the status quo, this sounds like an attractive strategy; just say 'no' to any activity that could change the content or character of riparian areas. The problem is that change will occur and disrupt the status quo whether we do something or not. For some riparian areas, the prediction for the outcome of unmanaged change may be positive, resulting in the creation or maintenance of desirable attributes. The structure and function of many other riparian areas, however, in particular those that bear the legacy of land abuses, can more rapidly be restored by judicious application of the many tools at a manager's disposal. But despite the recently accumulated wealth of scientific knowledge and practical experience with riparian areas, "to manage or not to manage" remains a social — rather than an ecological — question.

Large woody debris is a must for stream function in this bedrock system in northern Minnesota (above). In very large systems it is needed too, but some (in Virginia) would rather avoid it (bottom).

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