Chapter 1

The Challenge of Managing for Healthy Riparian Areas

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"Learn to read the land [the river], and when you do I have no fear of what you will do with it: indeed, I am excited about what you will do for it."
Aldo Leopold, 1966 — A Sand County Almanac

"There is a need to place such common resources as water, land, and air on a higher plane of value and to assign them a kind of respect that Aldo Leopold called the land ethic, a recognition of the interdependence of all creatures and resources."
Luna Leopold, 1997 — Water, Rivers and Creeks

Clearly, Aldo Leopold, a forest ranger, a wildlife biologist, a director of wood-use research, and a small woodland owner, called those in natural resource management to do two things: read the land and manage it — ". . . I have no fear of what you will do for it." Thirty-one years later, Luna Leopold, Chief Hydrologist with the U.S. Geological Survey, Dean of Geology at The University of California-Berkley, and river restoration advocate, emulated his father's "Round River" when he called us to recognize the interdependence of land, water, air, and all creatures. Neither rejected their past, and neither rejected the many uses nor many users of our forest lands. Aldo Leopold worked to restore his cut-over and worked-out Sand County farm and woodland to take a productive place in their Wisconsin community. At the heart of managing for healthy riparian areas is seeing them with this same sense of community. A central challenge to many of us is managing with shared decisions. This may be the hardest task we have. To paraphrase Gifford Pinchot, first Chief of the U.S. Forest Service and Dean of the Yale School of Forestry, be absolutely honest and sincere, learn to recognize the point of view of the other person, and meet each other with arguments you will each understand.

The challenge of managing for healthy riparian areas means coming to grips with our heritage, understanding how the land and streams change, dealing with diverse and divisive

issues, learning to read the land and rivers, expanding our set of management tools and most important, seeing with the vision of community. It is our purpose to bring an understanding of riparian values and riparian functions to a community vision of place, a landscape that holds ponds and lakes, grows forests, and gives of itself in a river that runs through it. This is a place where living includes both work and play, where working the land means improving the watershed's landscape.

Understanding Our Heritage

Streams, rivers, and lakes have influenced our lives in North America for more than 20,000 years. Since Ice Age nomads traversed the Beringia Plain, travel to, along, and on streams and rivers has formed the basis of family ties, commerce, and the flow of new ideas. Indeed, the history of North America and many fortunes and fates have been defined by how we used water-travel routes and the riparian lands beside them.

Native Americans and early settlers had a special relationship with streams, depending on them for bathing, fishing, hunting, travel, and trade. As populations expanded in the 1700s, this dependency slowly began to erode. Stream-side forests were cleared both to make way for towns and fields and later to fuel the fleets of steamboats that ferried cargos of people and goods. Even the rivers themselves were affected as snags and deadheads were removed from harbors and channels, and stream bottoms were dredged to allow passage of ever larger vessels. Slowly forests gave way to agriculture, and the accompanying erosion on the land (and in the channel) produced new sediment that reduced our capacity to navigate small rivers. On large rivers the sediment required constant dredging to keep them open to commerce. By the mid-1800s, railroads tied regions of the continent together. Rivers, although still of enormous everyday consequence, were frequently viewed as obstacles to be bridged, straightened, or used to lay track in. By the beginning of the 20th century, the special relationship among humans, rivers, and streamside forests was forever changed. Today, even though highways now connect us to virtually any place, our social collective has awakened a desire to regain the cultural, family, and personal ties lost when the steam-driven locomotive put railroads and highways on an equal footing with rivers. River walks, lake walks, and trail systems everywhere accentuate our riparian lands in both urban and rural settings. When we stop to rest, we stop at the water's edge.

Our heritage is one of natural resource exploitation, of wresting from the forest a family living, one of population movement, one of balancing the need for food, fuel, and transportation. Our heritage is also one of constant change: from hunter-gatherers to farmers, from pioneers to settlers, and from loose bands to complex tribes and villages. Our heritage now demands that we come to grips with sustainable resource use. Today we highly value streams and lakes and the land at their edge. Nevertheless, we either take for granted, or cannot see, the ties that bind a watershed to its streams and lakes.

Each of us sees riparian land and water differently; some of us see with eyes focused on opportunities for commerce, water supply, harvest of trees, fish, or waterfowl. Others see song birds, willows, beavers and the subtle harmony of a natural community. Some see the power of water and sediment to shape channels into predictable patterns of stream and valley geometry (stream habitat and geomorphology). Some of us — a growing number — see people and burgeoning demands for goods, services, and amenities. Our challenge is to see with a community vision rather than the vision of single use. We must see beyond the simple juxtaposition of trees and water. Our challenge is to understand how current forest and stream conditions have come to be, how the land and water function together, how their functions can be optimized, and how we can manage for a community vision of future condition.

But how are we to see? "There is no one alive today that saw what rivers, streams, and brooks looked like prior to being cleaned for barge, log and steamboat transportation (Rector 1951)." How do we judge current riparian conditions if we cannot see the past? Few, if any, of the world's river systems can be considered truly undisturbed, and they are too small to be representative. Even if we knew the pristine condition of streams and their forests, replicating all of their structure and composition may not be practical or desirable in today's society.

Fortunately, natural processes have restored many examples of healthy riparian areas in today's forests. From these we can derive the information we need to manage degraded sites. Our challenge is to understand the difference between degraded sites (the current condition at many sites) and those sites with a full suite of healthy functions. We need to learn all we can about these areas, for they are the basis of riparian restoration, and we need to use the eyes of many disciplines to build the foundation. We begin by examining how we developed rivers, streams, lakes, and riparian forests. The issues of today are old ones, formed and then debated throughout the last 200 years. How the debates have changed and how we have changed is a history of the riparian conditions we now have to work with.

The examples below are chosen not to second-guess how we developed resources, but to illustrate how our social institutions became established and to show what physical conditions we have to work with. They include resource depletion, resource regulation, habitat alteration, natural resource development, marshaling of a transportation workforce, a changing landscape with changing uses, squatters' rights and private owner rights, watershed analysis, watershed restoration, natural versus catastrophic fire, forest type and structure changes, forest harvesting and floods, and state subsidies for private land enhancement.

The Primary Forests of the Continental Eastern United States and How They Changed

Environmental change since Colonial times from the East Coast to the tall-grass prairies has been thoroughly summarized by Whitney (1994). We have borrowed liberally from his accounts and extended some of his time series to show how primitive forests changed. The trees the first settlers saw were big and covered with epiphytes, and mosses grew on the forest floor. They were generally 200 with some even over 300 years old. Coarse woody debris on the forest floor is estimated at 6 to 12 tons/acre for the central hardwoods, and 16 to 21 tons/acre in the cooler hemlock/northern hardwood stands. The English colonists found the dense forests a stark contrast to the sparsely wooded landscapes of their homeland where, in 1696, less than 10% of the land was wooded. Pictures of old-growth remnants taken 200 years later in the Eastern U.S. confirm the large tree diameters ranging from 3 to 15 feet (Table 1.1). Except for jack pine on droughty sand, black spruce on peatland, and red spruce at high elevations, virtually all primary forest stands were a mixed type. Stand volumes ranged from 3,000-25,000 board feet/acre with a maximum development in multiple canopied white pine / hemlock forests of 100,000 board feet/acre (Table 1.2). Tree heights ranged from 70 to 130 feet tall, and basal areas from 120 to 392 ft^2/acre (Table 1.3).

Table 1.1 Diameters of old-growth trees in the Eastern U.S. (Based on photographs taken from 1875 to 1915)

Tree Species	Diameter Ft.	Location
Red spruce	3	White Mtns., NH
Sugar maple	3	Petoskey, MI
Hemlock	4	Ashuelat, NH
White oak	4	Allegheny Plateau, WV
Yellow birch	5	Colbroke, CT
Chestnut	6	Graham Co., NC
White pine	8	Cornwall, CT
Yellow poplar	8	Dickenson Co., VA
Yellow poplar	10	Vincennes, IN
Sycamore	15	Mt. Carmel, IL

Frequent natural disturbances ensured that most trees did not exceed 300 years of age. Fires on droughty sand and shallow soil over bedrock kept early succession birch, aspen, and jack pine stands in the 50 to 100 year range. They were most prominent in west-central and northeastern Minnesota. Red pine (often mixed with jack pine) and super canopy white pine stands ranged from 100 to 250 years old with the older stands protected from fire by water bodies. In southern New England, hurricanes kept tree ages between 100 and 150 years, while in central and northern New England, trees lived from 150 to 300 years. Along the Northeast Coast, the birch and spruce trees were 100 to 200 years old. Many of the hemlock, yellow birch, and sugar maple stands in Michigan and Wisconsin were 140 years old, and hardwoods in the rich Ohio and Wabasha River valleys were 100 to 200 years old.

Table 1.2 Average forest volumes of Eastern United States, primary forests circa 1800 (Whitney 1994). With permission.

State	B.F./Acre
VT (Williams 1794)	3000-11,800
ME	7700
IL	8000
OH	13,000
PA	17,500
IN- mixed hdwds	25,000
IN-W.Pine/Hemlock	100,000

Forests blanketed 454 million of the 552 million total acres in the Continental Eastern United States. With the exception of 98 million acres in western Minnesota, western Missouri, Iowa, and the prairie peninsula of central and northern Illinois, at least 95% of every state was forested. The conversion of forest land to agriculture in the eastern United States was perhaps the largest that has ever occurred in the span of nearly 200 years (Figure 1.1a-c Greeley's 1620, 1850, 1920 maps, Greeley 1925).

The loss of forests and subsequent reforestation in three states is shown in Table 1.4. Of the 454 million acres of original forest land, 99.999% was cutover; only 0.001% remains in primary (ca. 1650) forest stands (Whitney 1994). Forty-nine percent (224 million acres)

Table 1.3 Average values of basal area and height, measured in remnant old growth, mixed forests of the Eastern U.S. 1904 to 1988 (after Whitney 1994). With permission.

Mixed Type	Location	Basal Area $ft.^2$ / ac.	Height feet
Beech/Sugar maple	OH, IN, S. MI	130	114
Central Applach. hdwds	E. KY, S.E. OH, S. IN, S. IL	152	66
Northern hardwoods	Cent. NH, NH, MI-U.P.	157	82
Sugar maple/Basswood	MO, WI, S. MN	178	98
Oak/Hickory	KY, IN, NJ, S. IL	122	115
White/Red pine	MI, N. NY	209	118
Hemlock/N. hardwoods	VT, PA, MI-U.P., WI	235	-
Hemlock/White pine	PA, MI-L.P. S. NH,	283	-
Red spruce	NH	152	-
Red spruce/Balsam fir	ME, NH	174	-
W. Pine/Hemlock (gone)	Pisgah, NH (Foster 1988)	392	115
White pine (still there)	Hartwick Pines, MI (Rose 1984)	318	118

of the cutover forests regenerated to second growth forests, and 51% (231 million acres) were converted to and remained in agricultural or urban land as of 1990 (FIA 1998). The western Great Lake States, the Appalachian Mountain States, and the Great River States each account for about 31% of the converted forest land. The New England States and the Chesapeake/Delaware Bay States each accounted for about 4% of the converted forest land.

Overall, forest land in the Eastern United States has been reduced to 40% of its total area (Figure 1.2) How much of this forest cutting and conversion affected the riparian forests of How much of this cutting and conversion affected the riparian forests of the Continental Eastern United States? Virtually all of it! All riparian forests were cut and half of them

Table 1.4 Changes in forest land (%) for three states (adapted from Whitney (1994), Frelich (1995)and USDA Forest Service FIA Eastern Forest Database (1998))

Rhode Island			
1767	1875	1972	1990
77	32	67	74
Ohio			
1853	1883	1979	1990
54[1]	18	27	29
Michigan			
1820	1870	1980	1990
85	77	51	36

[1]In the 1600s, Ohio was at least 85% forested (Greeley 1925).

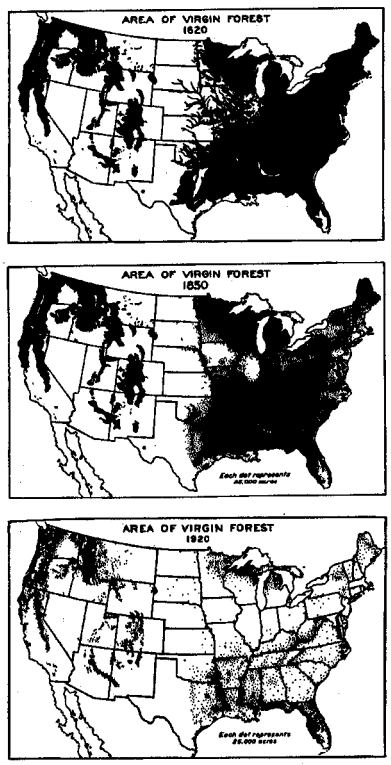

Figure 1.1a-c Virgin forest area in 1820, 1920, and 1950 (Greeley 1925). With permission.

were completely converted to agriculture. Many areas such as Cadiz township in Wisconsin, were nearly all converted to agriculture (Figure 1.3).

Throughout the Eastern United States, the old growth forests were replaced by early succession species. The aspens and birches, with light seed and root suckers or stump sprouts, and the cherries, with long-lived seeds invaded many of the cut-over acres. In shady areas sugar maple and balsam fir, both with wind-dispersed seeds, took advantage of canopy openings. White pine provided the super nurse canopy for hemlock in primary forests, but both declined from overlogging, the spread of blister rust, and harsh exposure. Beech, with limited reproduction in the first 50 years, declined while vigorous black cherry stump sprouts occupied the site. Similarly, short-interval harvest for pulpwood changed the ratio of red spruce to balsam fir in Maine. In 1902, the volume ratio of red spruce to fir was 7:1, but

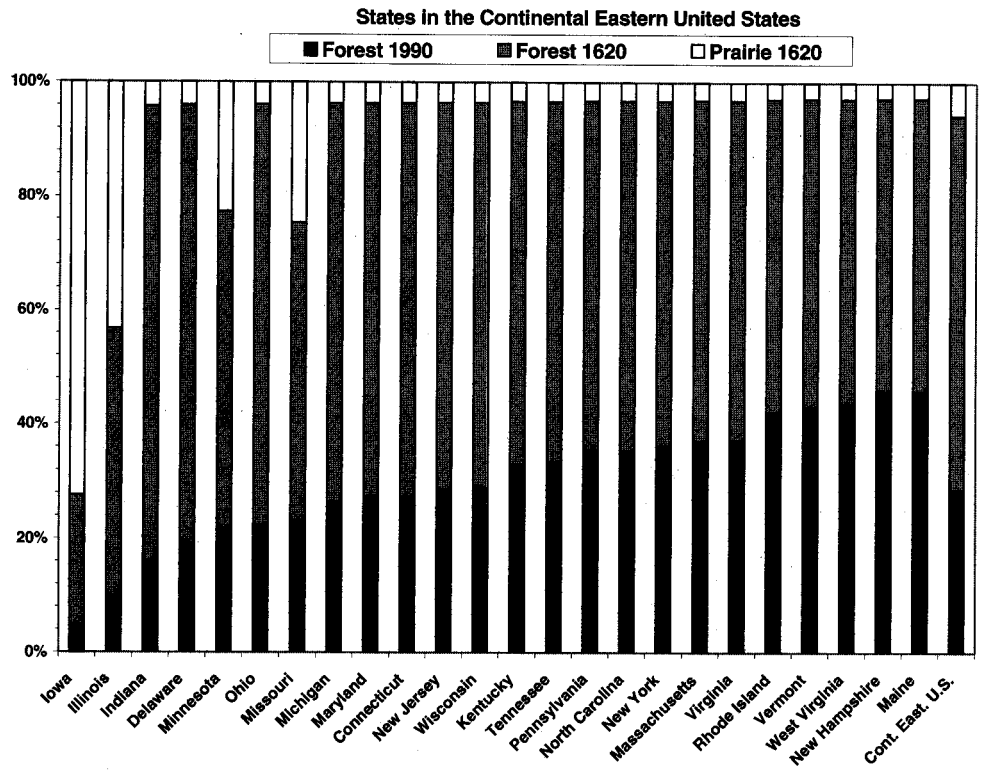

Figure 1.2 Land use in the Continental Eastern United States, 1620 and 1990 (derived from Greeley 1925; Whitney 1994; and USDA Forest Service 1998).

by 1972 it was only 1:1. This change in ratio resulted from repeatedly cutting second-growth stands and was exacerbated by slash-fed fires in the early 1900s. Wide-spread fires following original logging were often severe because fuel on the ground over large areas greatly exceeded that in old-growth forests and more-restricted, blowdown areas. Fire managers today call them catastrophic because of their size and the heat generated on the ground that could consume the entire forest floor. Although difficult to document, forest floors once 4 to 14 inches thick are now only 1 to 3 inches thick. Finally, Whitney (1994) considered grazing to be a problem for riparian forests in the eastern United States. It was ubiquitous; pig and cattle grazing were widespread in the Eastern United States and was the preferred method to complete the conversion from forest to pasture.

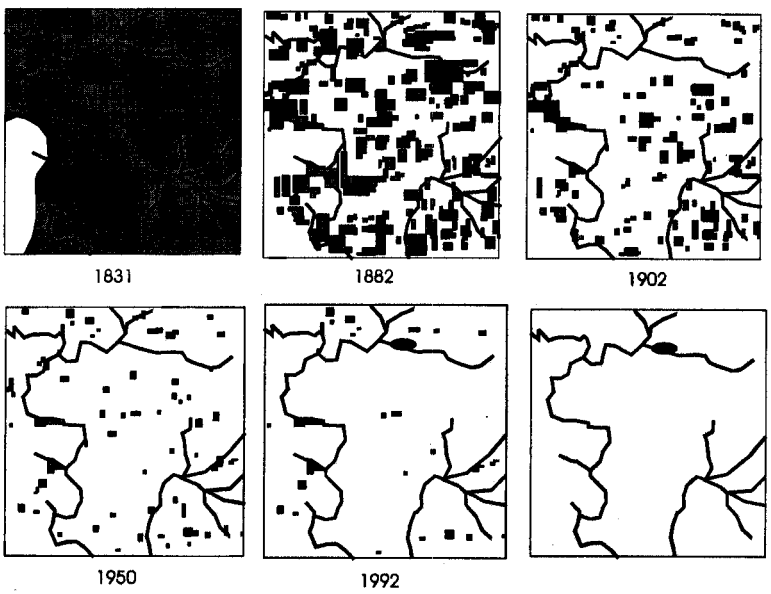

Figure 1.3 Forest area (shaded) in Cadiz Township, south central Wisconsin (derived from Curtis 1956 and DeLorme 1992). With permission.

The Primary Rivers of the Continental Eastern United States and How They Changed

Early conditions on the rivers of North America are not well documented, but one example from the western wilderness comes from the journals of Daniel Greysolon, Sieur du Luth, who was dispatched from Quebec City in 1678 by the Governor of Canada to take possession of the land west of Lake Superior and find "The Great River." He describes his portage from the western end of Lake Superior to the Mississippi River: "In June 1680 . . . I took two canoes with an Indian, who was my interpreter, and four Frenchmen. I entered a river (northwestern Wisconsin's blue ribbon trout stream the Bois Brule). . . When, after having cut some trees and broken about 100 beaver dams, I reached the upper waters . . . and made a portage of half a league to reach a lake, the outlet of which fell into a very fine river (the St. Croix) which took me down into the Mississippi." (Winchell and Upham 1884). Two hundred years later in 1880, beaver dams still occurred every third mile, and lake trout, brook

trout, and the coaster brook trout of the Bois Brule River were carried in bushel baskets to residents of the new logging town named in the French explorer's honor (Duluth, Minnesota). The standing stock of mature trees, a mature fishery, and a mature beaver community were severely depleted over the next 50 years until hunting and fishing seasons, limits, fire protection, and forest management were begun in the 1930s. Sieur du Luth's route to the Great River bisects the St. Croix drainage that divides Wisconsin and Minnesota and produced a peak white pine yield of 8.9 billion board feet in a single year (1892); perhaps the largest annual harvest of wood ever (Rector 1951).

Exploitation of the St. Croix (named after Maine's St. Croix) repeated the pattern of land-use change witnessed in New England, New York, and Pennsylvania in the 70 years preceding North America's peak annual wood harvest — river and stream cleaning, bank-side harvest of big trees, harvest of most large trees within 5 miles of the stream, homesteading, conversion of half the cleared forest land to agriculture, and development of permanent dams for navigation, trade and the generation of electricity. Harnessing water to generate electricity mimics the spring surge release and the fall and winter head-building of splash dams, but changed the frequency from annual to daily. The first hydroelectric plant in the world was built on the Fox River at Appleton, Wisconsin, in 1882. It has taken a century to acknowledge what dropping the water levels each day (and building them each night) to provide for peak periods of power generation has done to stream habitat. Even in the humid East, water withdrawal for irrigation, snow-making, and water supply play a role in changing stream and lake habitats.

Logging has long been a feature of the Eastern North American landscape. The first sawmill was built in 1623 on the Salmon Falls (present day Piscataqua) River in what became the state of Maine. Splash dams, first employed centuries earlier in Europe and Asia, were built all over Eastern North America to expedite the transportation of logs to mills and markets downstream. Dam construction techniques ranged from crude piles of logs and debris fashioned for one-time "splashes" of logs during spring floods in smaller streams and brooks to precisely engineered structures of concrete, steel, and wood designed to allow year-round floods on larger streams and rivers. Log splashes (Figure 1.4) wreaked havoc not only on fish and their habitat, but also on riparian farm land. Farmers in many states vigorously opposed these violent drives as logs overran their fields, fences, and outbuildings. Many such dams operated into the 1920s in eastern Kentucky's Red River basin before road construction and dwindling timber supplies signaled their end (Coy, et al. 1992).

Logging in the first 200 years was largely restricted to forests near settlements on the fringe of the Atlantic shore. Many trees were cut simply to clear land for homes and fields and to provide fuel for cooking and heating. Logging provided timber both for local use and for trade with Europe. Rivers were the only means of transporting logs long distances, and logging along rivers was restricted to those areas within a day's pull for oxen and horses.

Figure 1.4 Splashing logs through the Breaks of the Sandy. Boulder fragments after dynamiting rock in the Russel Fork of the Big Sandy River near the present community of Haysi in Dickenson County, VA (just upstream of the Kentucky state line). Note the person near the center of the photo (American Lumberman, March 19, 1910).

In the early 19th century, logging was one of the major industries of the new country. In the 1810s the Saco River in New Hampshire (and Maine) was the first center of commercial logging. Bangor, Maine on the Penobscot River led the eastern states (colonies) in timber harvest from 1820 to 1850. White pine was selectively cut from Maine forests up to 1840 after which red spruce dominated lumbering in Maine into the 1900s. Steam-powered sawmills, centered around the Hudson River near Glenn Falls, allowed New York to surpass Maine in lumber production in 1850. Williamsport, Pennsylvania on the Susquehanna River was the top producer in 1860 (hemlock and pine). Timber production in the Lake States began in the 1840s and followed suit with an initial assault by river improvement companies to clean the rivers (nearly all of them). Production surged after the Civil War and peaked in 1892. Lake States white pine built mills and towns from Albany, NY, to Denver, CO, during the second great surge of immigration across the Midwest. Although never perceived as a lumbering center, the Ohio and central Mississippi Valleys (oaks, hickories, and sycamores) comprised 1/3 of the original forest land converted to agriculture before and after the Civil War. Thereafter, transportation changed the rivers forever.

Logging in the Appalachians (beech at first) served local populations, but in the late 18th and early 19th centuries, logging for the manufacture of charcoal used in iron smelting, and for iron and coal mine shaft supports, changed the impact of logging on the landscape. Large areas were cut over and then abandoned when the cost of transporting wood rose too high. But it was during the post-Civil War years of the 1880s when, prompted by the looming shortages resulting from over exploitation of Lake

States and New England forests, loggers moved both west and south into the Appalachian forests in search of red spruce, yellow poplar, and American chestnut.

Before the 1850 census in the United States, at least 100 million acres of forests had been converted to agriculture east of the Mississippi River (Williams 1989). George Perkins Marsh was the first to speak for land and water conservation in 1864 when he published *Man and Nature*. This early call for resource conservation was taken seriously by James D. Porter, Assistant Secretary of State in 1886, when he asked his ambassadors in Europe to trace what was happening to forests and forestry there. It had long been the practice in Europe to clean big trees from rivers, both large and small. As a result, rivers and streams have changed from structurally diverse systems to aquatic highways. "The intensity and ubiquity of human influence on the amounts, dynamics, and functional importance of [coarse woody debris] have been tremendous." (Harmon et al. 1986). The removal of logs and limbs from streams has occurred for hundreds, even thousands, of years. In the Medieval Ages (500 to 1500 A.D.), the Volga, Elbe, Tiber, Po, and Rhine Rivers in Europe were extensively used for log transportation.

As recently as a century ago in Europe, concepts of land and water stewardship were widely expanded, not unlike that occurring in North America today. The following are paraphrased from various parts of Europe in 1886 and capture the origin of many issues, values, and processes debated today (underlined below for emphasis) (Porter 1887).

> From the Consul of Thuringia (Germany): "Forestry is pursued (1886) in so careful and scientific a manner that not even ponds or marshes are allowed to be drained. It was here among the Teutonic Tribes (who terrorized Rome about 300 A.D.) that the practice of "squatters rights" and thus private rights began. Cleared land on the river and the adjacent forests became a right of ownership for the heads of families and tribes. By the early 1700's, in Europe, more wood had been consumed than could be grown in several centuries. Tree planting was well established in the mid 1700's, and the regulation of tree harvest by age and acreage (as opposed to wood volume) was well established at the end of the 19th Century in parts of Germany.
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> From the Consul of Italy: "Forests have been destroyed to gain lumber, pasture, and arable land.... The ususal results have followed: a decrease in the depth of navigable streams, an increase in rainy season floods, avalanches, landslides and denudation of mountains." Flooding and sedimentation.
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> The Consul to Austria-Hungary: Sad experience has taught the necessity of the greatest stringency in the forest laws in the mountain districts: ... even on the steep rivers, stonework can not withstand the torrents. Whenever a communal forest borders on these rivers, its maintenance is held to be of especial importance. In all these forests, therefore, not a tree can be felled without the consent of the state foresters.

No animals are allowed to pasture, and the greatest precautions are taken to guard against fire. State regulation of land use with mandatory "BMPs."

From the Consul at Nice, France: The law of 1882 provides for both stream and slope work to prevent sedimentation. The work is to be done directly by the state and by landowners with or without state aid. "Excessive grazing . . . (that) causes denudation has caused incalculable damage in the great mountain regions of France. When hillsides are covered with trees, the winter snowpack melts slowly in their shade; but when the trees are gone, the full force of the sun produces flood peaks similar to heavy rain storms." State and private landowner mitigation (with or without state aid – subsidies, tax breaks, or grants).

The Consul of Palermo (Switzerland): Stream restoration, and the concept of government-private cooperation in achieving a common public welfare, was debated in Switzerland as reported by civil engineer, Robert Lauterburg, in 1885: "It is well known . . . what great inroads upon river banks and what heavy landslides have been caused by running water." While our engineers and foresters have tried to check the devastation of floods and erosion, it is not within their province to compel owners to look after their own interests (private rights), even in cases where the public welfare is endangered.The stream Nolla near Thusis in the canton Graubünden: "has lapsed into such a condition that after *every* thunderstorm it pours down immense masses of earth, mud, and rock into the valley. . . . the rainfall, instead of being absorbed by the trees as formerly, pours in simultaneously from all sides in great masses into the bed of the stream, washes it away, undermines the banks, and finally sweeps away the entire mass of rubbish down into the valley." Regional sedimentation.

Herein lies a central argument that is being debated in North America today -- the impact of forest harvesting on floods. Chapter 5 will directly address what we now know about cause and effect in both flat and mountainous sections of the Eastern U.S. and the relative importance of catastrophic floods versus the approximately annual bankfull discharge that is incipient to flooding.

Although the preceding accounts are by our standards anecdotal, they clearly demonstrate that our 19th century counterparts were keen observers and highly perceptive. Many of the foresters, farmers, engineers, and politicians of the day understood the basic relationships between land use and water. Of course other, more contemporary arguments, such as the debates over recreation use by broad segments of society, were not part of the last century's debate on forest and water in Europe, but they are part of today's debate in both America and Europe. Now we will consider how European and Asian heritage was applied to the forests of the Eastern United States.

All across Eastern North America, log transportation played a major role in river widening, loss of sinuosity (the river's length divided by the straight line valley length), and

a loss of habitat. The first major use of log rafts occurred on the Delaware River during the 1750s. The advantages, particularly to part-time loggers and farmers, were quickly perceived and log rafts soon appeared on the Susquehanna, Allegheny, and other rivers in nearby New York and New Jersey (Williams 1989). Perhaps surprisingly, log drives, the transport of unbound logs en masse down a watercourse, were not common until at least 60 years later; the first recorded drive occurring in a tributary of the Hudson in New York in 1810.

Unlike log rafts, which required water deep enough to float the largest logs in the raft (and hence were confined to large, main-stem rivers), log drives occurred throughout entire watersheds. Trees were felled and rolled to the banks of tributaries during the fall and winter, ready for dumping into the high flows of spring to take their chilling ride to downstream sawmills. After the timber supply in a watershed was exhausted, the logging camps typically moved on. However, depending on the size and extent of the watershed, some rivers supported log drives for many decades. The Kennebec Log Driving company in Maine holds the record for longevity and intensity of log drives. Starting in 1835 when it served 63 sawmills, and for the next 141 years until 1976, the year of the last river drive in Maine, the company moved its logs down the Kennebec River. Between those years, nearly every major river in the Continental Eastern U.S., from the St. Croix in Maine to the French Broad in North Carolina and from the St. Croix in Minnesota and Wisconsin down the mighty Mississippi, streams and rivers were used by river-drivers to transport logs or log rafts to mills.

The ecological consequences of these drives and the stream improvements they made necessary were doubtlessly devastating. Rector's remark on river stream and brook cleaning illustrates the prevailing mission of those whose job it was to prepare rivers for log drives: "Most of the rivers were not suitable for driving logs in their natural condition . . . Fallen trees must be removed from the channel: snags, rocks, and shoals needed to be cleared with ax, pick, and in the later decades, dynamite (Rector 1951) (Figure 1.4)." This was mean work. "The accumulations of centuries in the form of driftwood and fallen trees frequently covered the streambed for miles, and all had to be cleared away. If the ground was swampy, horses could not work in it, and everything had to be done by hand. Tree by tree, stick by stick, the obstructions had to be lifted out and put far enough away so high water would not float them back in again. Islands and shoals had to be dug away; stumps, bedded in the mud, had to be grubbed out; embankments had to be made at sharp bends. The sunken tree at the bottom of the stream had to be cut and worked loose in its bed (Pike 1967)." Although we have no ecologically based accounts of the impact that these stream improvements had on aquatic biota, the preceding quotations describe the complexity that once characterized, and is now largely absent, from most aquatic habitats. Figure 1.5 may be the oldest preserved photograph of "Carding the Ledges" for a Brook Drive in Maine (Smith 1972). (We have it on good faith from one astute reviewer that carding the ledges may have derived from the task of carding wool with a brush having short steel bristles (card) to straighten the fiber.

Although we focus on forest land, in fact many of our watersheds are mixtures of forest, farm and urban land uses. Observations in Pennsylvania at the turn of the 20th century

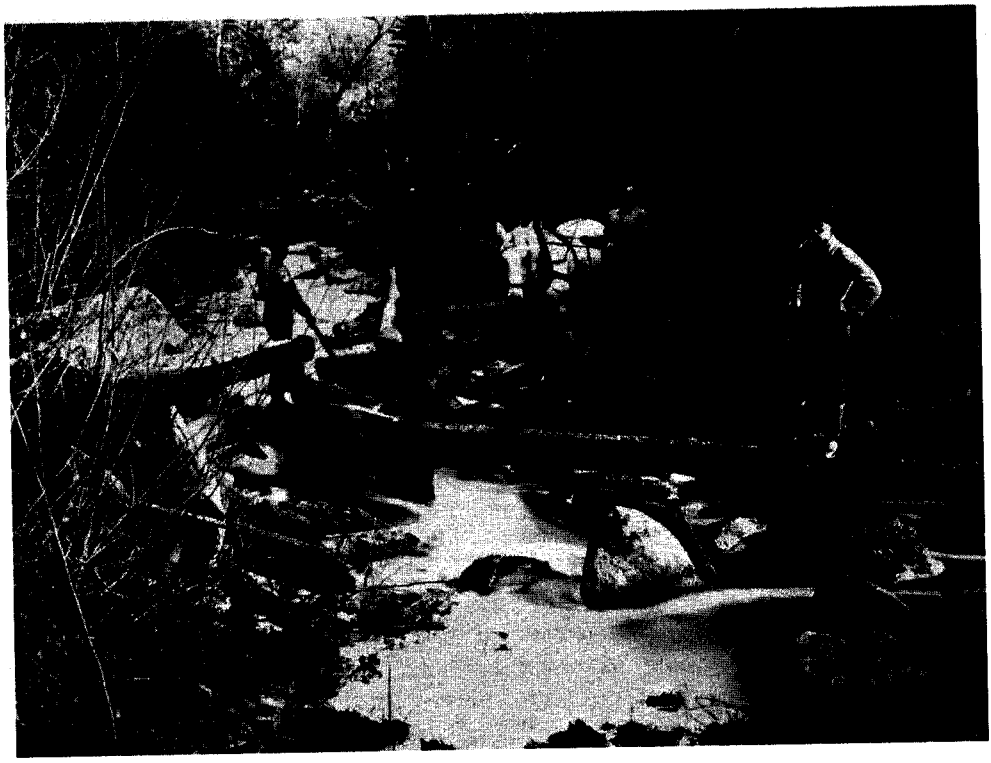


Figure 1.5 "Brook Drive - Carding the Ledges" in Maine. Note that only axes, picks, and one-man saws were available for clearing the riparian forest. From the Larson Collection, University of New Brunswick. Smith 1972. With permission.

illustrate the interaction of widespread logging and riparian agriculture development. J. T. Rothrock (1902), Pennsylvania's first Director in the Department of Forestry, writes after literally watching how land use changed stream habitat: "In all our alluvial valleys the frequent freshets work greater or less damage to the farm land. In fact, it can hardly be said that the beds of any of our rivers, which flow through wide valleys, are constant. They not only have entirely deserted the ancient water courses, leaving them off as back channels to one side or the other, but they are changing them from year to year before our eyes... Whilst it is true that a large quantity of valuable soil is sometimes deposited by these freshets on the surface of the land, it is also equally true that this same soil has come from the margin or river bank of somebody else's holding." The concept that river flow would change with land-use change and that the impact on stream habitat was the result of in-channel erosion and deposition was readily accepted by Rothrock.

Land clearing and farming in the Chesapeake Basin caused a fourfold increase in deposition, in the Gunpowder Estuary, shallowing or filling parts for over two miles (Brush 1986). Sediment export into southern Lake Michigan increased tenfold following conversion to agriculture (Davis 1976 as reported in Whitney 1994). A quote from Whitney (1994) details the impact of forest to agriculture conversion in southwestern Wisconsin:

> "James Knox (1977) was able to demonstrate an increase in the width of many of the headwater and tributary stream channels of the Platte River system . . . and a decrease in the width of the main channel downstream. The wider and shallower upstream channels were associated with bank erosion and an increase in the bedload of the streams following settlement. The changes reflect the geomorphic response of the channel to the occurrence of large and more frequent floods since settlement (Knox 1977). The reduced width of the main channel downstream was due to excessive overbank sedimentation and the deposition of the finer, suspended particles downstream. At their peak in the 1920s and the 1930s, historic rates of overbank floodplain sedimentation exceeded their presettlement rates by two orders of magnitude (Knox 1987)."

Curtis (1951) detailed the shortening of a stream with a conversion from forested to dairy farming over a span of 104 years in Jordan County in southern Wisconsin. In 1831 the county was 98% forested with 40 miles of stream, in 1902 it was 9% forested with 30 miles of stream, and in 1935 it was 4% forested with 25 miles of stream: a 36% loss of stream habitat.

The impacts of river cleaning, original logging, catastrophic fire, and conversion to agriculture can accumulate over the span of a century. We must deal with these conditions, even in forest regions today. Recent measurements of stream sinuosity on the southern Lake Superior Clay Plain illustrate how a sequence of land-use change can reduce the stream habitat. This is a landscape checkered by agriculture, mature forests, and recently cut forests, strung with roads large and small. Tree ages were used to date when the channels changed. They were aged in old channels, on existing flood plains, and abandoned flood plains on the first terrace to date channel down-cutting and a progressive loss of stream sinuosity. The tree dates group into periods associated with landscape changes: original stream cleaning (late 1840s), original logging (1870-1905), the catastrophic Hinckley Fire (1918) (it consumed the forest floor — once 4 inches thick, and now recovered to 1 inch thick), and agriculture development from two periods: the late 1920s to the early 1930s and the mid 1950s following the Korean War. While channel sinuosity does not indicate land-use changes in highly entrenched streams, all the channels in this study are E channel types with broad floodplains and a modal sinuosity of two (Rosgen 1994). Figure 1.6 shows the change in sinuosity (and a representative sketch) associated with cumulative land-use change. Percentage-wise, stream length (as reflected in their sinuosities) is shortened by 6, 30, 40, and 45% in the last time periods over 110 years (Figure 1.6). The streams still run in the same valley, so an eye not perceptive to habitat change may see no change.

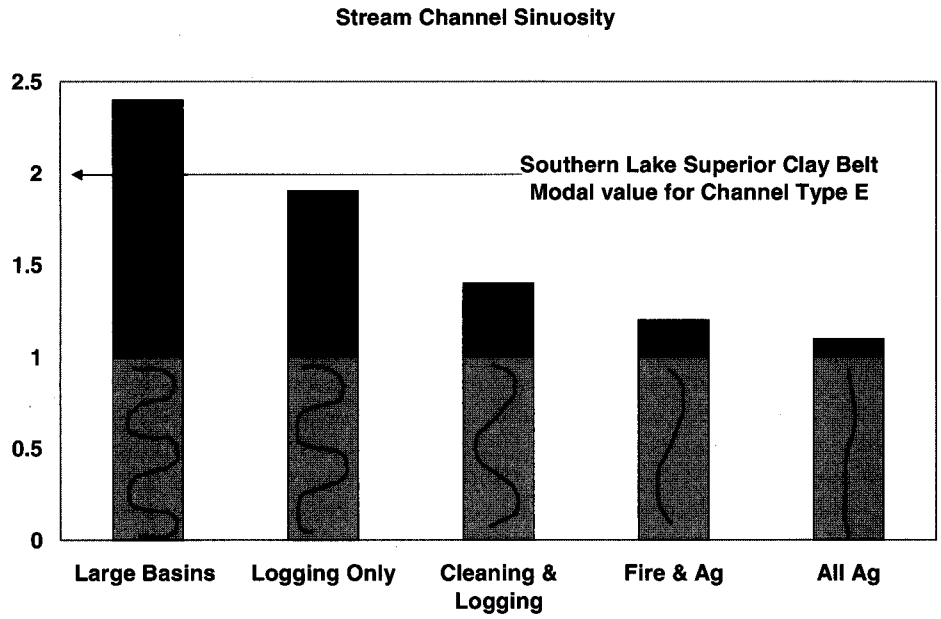


Figure 1.6 Cumulative changes in channel sinuosity caused by land use changes in basins of the Lake Superior Clay Plain. Sketches simulate channel length in each land use type to visually show how channel habitat is lost as streams shorten even though they flow through the same length of valley.

In a similar way, forest clearing for mining and for mine supports in the coal mining Appalachian Region, along with the development of roads that crowded streams into narrower meander belts, caused both longitudinal and cross sectional changes in stream habitat. Finally, mining which results in acid drainage to streams, can eliminate entire fish populations. For many resources, we simply cannot begin management with a clean slate because we have damaged these resources through ignorance or indifference. We cannot practice forestry beginning with the best stand conditions. We cannot practice fisheries management beginning with the best habitat conditions. We cannot practice farming beginning with the best fields. We cannot maintain ecosystem diversity beginning with fully diverse communities. The conditions developed in the Continental Eastern United States over the last 200 years, and the divisive practices pursued over those centuries frame the challenge of managing for healthy riparian areas.

The Issues Facing Riparian Area Managers Today

In a world characterized by uncertainty, a few facts are clear: more people are demanding healthier environments, greater recreational opportunities, and more products derived from wood. The demand for wood and wood products has increased dramatically since 1980. The rate of harvest (projected through 2005) is reminiscent of the wave of logging that surged through the Eastern States from 1865 through 1905. Today, as in 1905, the public debate revolves around questions of land use vs. protection. At the turn of the last century, many people were aware of the benefits of well-managed forests: "If you live at a distance [from the proposed Adirondack Forest Preserve], your benefits consist of not only wood in the form of houses, barns, furniture, paper or the cheerful fire in the grate, for there is no substance so widely used as wood, but the air you breathe and, in this instance, the stream that flows by or carries you or your product or turns wheels to give you light, transportation and large variety of other things." (O'Neil 1910). The difference today is that more of us are closer, both physically and philosophically, to the water's edge in our eastern forests. From the viewpoint of society as a whole, the issues are deceptively simple. We want it all: intact, functioning ecosystems; continuous supplies of high-quality water; and lumber, paper, and other forest products. But as individuals, we see things differently. As individuals we fear losses.

If we protect riparian areas, we fear the loss of:

- Wood and wood products
- Access to minerals and mining
- Opportunities for hydropower
- Grazing and cropland
- Water withdrawals
- Freedom to manage private land

If we do not protect riparian areas, we fear the loss of:

- Water quality and quantity
- Habitats for plants and animals
- Native plant and animal species
- Recreation and aesthetic qualities
- Natural filtering of sediment
- Connectivity with other landscapes

Quite naturally, we want the opposite of these losses. As we struggle to achieve our goals for riparian area management, we need to know what the rules are. We need to know:

- How to define riparian areas
- How to classify waters and valleys
- How to assess the impacts that may have accumulated within a watershed
- How have riparian functions been impaired (what's the problem?)
- What silviculture is appropriate for riparian forests
- How does forest and water management influence animal populations
- How to balance & sustain agriculture, forestry, recreation, and urban land uses
- How to recognize and evaluate a healthy functioning condition of riparian areas
- How to plan for desired future conditions
- How to work together across landscapes with many ownerships
- What techniques can we use to restore riparian ecosystems
- How we can enhance natural processes to manage the routing of water and sediment

The chapters that follow will give you some of the answers to this "need to know" list. In summary, how do we establish the ethic and practice of land and water stewardship that protects riparian functions in the Continental Eastern United States? The fears and wants are similar to those mentioned previously by George Marshall in 1864 and those recorded by James Porter for Europe in 1897. We cannot answer all these questions to everyone's satisfaction. However, in the chapters that follow, we present a set of tools and concepts that will help in the search for solutions to the land and water issues we each face. We hope that readers will not only obtain an understanding of aquatic and riparian ecology but also strategies for the sustainable restoration and management of both aquatic systems and riparian forests. The challenge is not to find the easy answer but to find the knowledge to read the land and read the river. Then we will have no fear of what you will do for them.

Meeting the Challenge for the 21st Century

Our challenge is first to understand current and healthy conditions for a wide range of riparian forest and water resources. This is the melding of management experience and the research that shows cause and effect along with the error of interpreting measured effectiveness. It is the base that defines the realm of possibilities. But the accumulation and synthesis of knowledge is only the beginning. "The acid test of our understanding is not whether we can take ecosystems to bits and pieces on paper, no matter how scientific, but whether we can put them together into practice and make them work (Bradshaw, 1983)." Equally important, or perhaps more important, is the common vision of what we want to see

across our riparian landscapes. Deriving this vision, the socially derived, desired future condition will not be easy because of the very feature that makes it so powerful: all of us must participate.

Each of us realizes we must be competent in our own discipline, and each of us suspects we may lose competence as time moves on in spite of our experience. A training course to keep up is useful only when we apply our new knowledge with on-the-ground experience. Often, one course is not enough. We may need two, three, four . . . and more. We should not see disciplinary knowledge as the quiver of arrows carried into a consensus building session, but as our own base of confidence we can share with other disciplines and with other viewpoints. A greater challenge is to learn parts of other disciplines important to our own. Build not only your base of confidence but also your base of understanding.

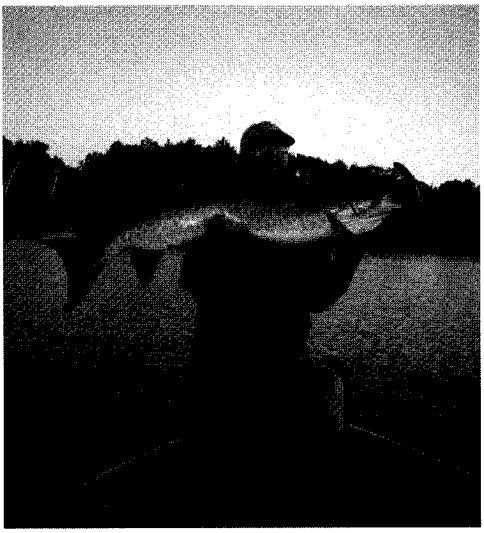
When we walk beside streams and through forests, we sometimes are proud of what we see. We are sometimes discouraged by what we see. Sometimes we see evidence of stewardship and integrated management. At other times, we see a landscape (or pieces of a landscape) dominated by a single use. Is the integrated vision by chance? Or, did someone understand what it meant to do integrated management? Our purpose in this book is to reduce the element of chance. Our purpose is to give each of us the eyes of the other, to help develop the common understanding, appreciation, and vision to manage riparian areas in the Continental Eastern United States.

Sandy Verry

A municipal trail comes to the water's edge in West Duluth, Minnesota.

Sandy Verry

Fine sand from a native material road crossing (above) fills the spawning gravel and cobble of a brook trout stream.



Ana Marie Becker

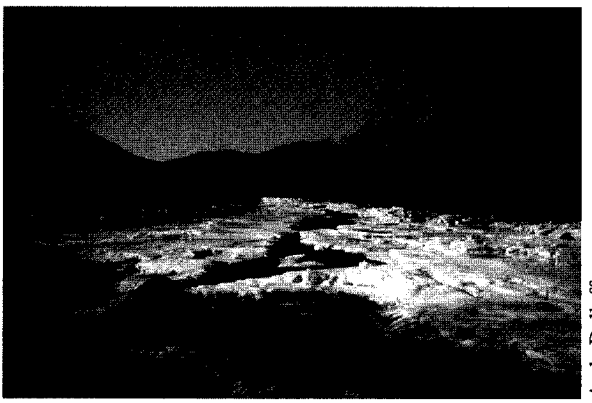
Catch and release! Secret Muskie waters. It's the fishing!

Sandy Verry

Canoeing the Au Sable River in the Huron-Manistee National Forest, Michigan.

Bob Leibfried

Headcuts in the Nemadji River basin. Part of the Lake Superior Clay Belt on the Minnesota,Wisconsin border. Glacial land-rebound, and landuse changes cause channels to change.



Andy Dolloff

Thaw reveals the winter thalweg in an over-wide Virginia river.

Sandy Verry

A 5-inch storm washed an 8-foot channel around a 3-foot-wide culvert in a local access road. The brook trout stream above and below the culvert is 8 feet wide at the bankfull elevation.

Sandy Verry

Autumn in the Suomi Hills Semi-Primitive Recreation Area. Chippewa National Forest, Minnesota.