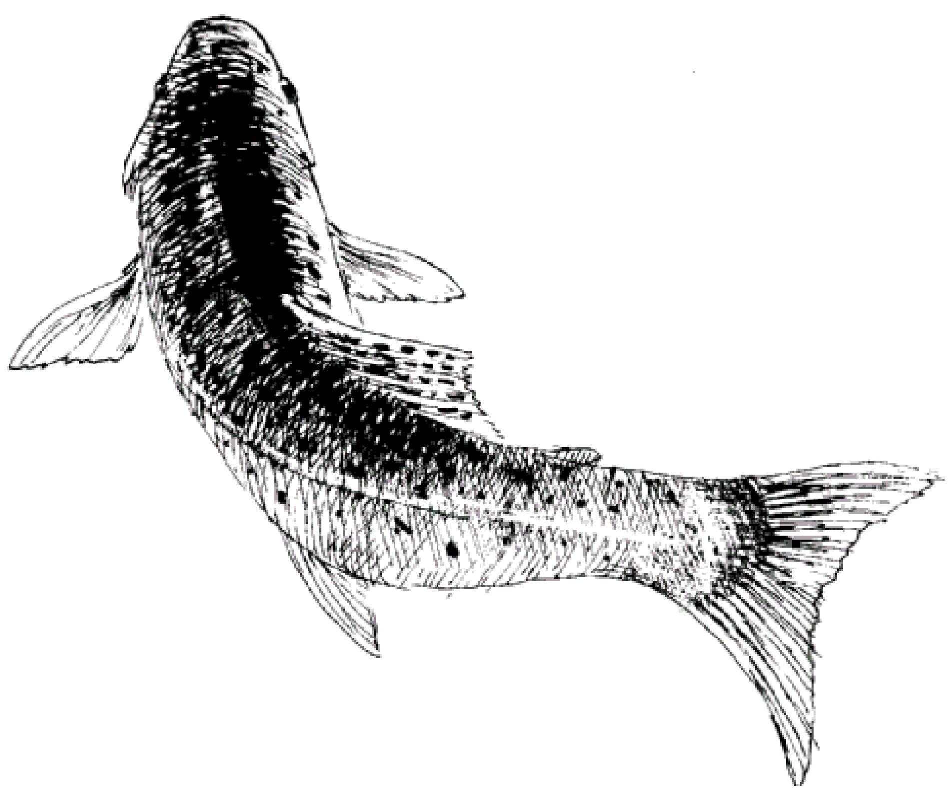
# Within the Beauty Strip:

## Forest Management as if Salmon Mattered



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Cover picture by Robert Savannah

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**Findings and Recommendations**

- Salmon have been an important part of human cultures for thousands of years. Salmon in Maine were considered so important through most of the 20th century that offerings of the first catch in the Penobscot were given to the president of the United States.
- Wild Atlantic salmon are now extinct on 84% of their original range in the United States and are threatened on the remaining rivers, despite millions spent on hatcheries, breaching dams, and cleaning rivers.
- Salmon face threats at every stage of their complex life cycles in both fresh water and the ocean.
- This report is focused on impact of forestry on fresh water habitat, but only correcting forestry problems is not sufficient to bring back salmon if the other threats continue.
- The main perspective of this report is the precautionary principle: that an ounce of prevention is worth a pound of cure.
- The chances for salmon recovery improve to the extent that salmon habitat is managed within the historic range of variability in which the salmon thrived.
- "Salmonids and their habitat comprise a single coevolved unit that cannot be separated for management purposes." This means that salmon are not only dependent on the types of habitats in which the fish evolved, but the habitats depend, to some extent, on the salmon.
- The fresh water stages of salmon life cycles, from egg to smolt, are dependent on forests.
- The modern "Acadian Forest," which has the intermingling of spruce-fir with northern hardwoods, did not start to dominate the landscape until 1,500 to 1,000 years ago, when spruce and fir increased in abundance along the southern margin of their range.
- Salmon may not have been abundant in Maine until around 500 years ago, during the "Little Ice Age."
- The presettlement forest, to which salmon were adapted, had cycles of catastrophic (stand replacing) disturbances that were many hundreds of years apart. Smaller scale disturbances were more of the rule, leading to complex stand structures that had large old trees and dead standing and dead downed trees.
- Fallen large trees are an important factor in salmon stream habitat.
- Maine's presettlement forest landscape ensured: pure, clean water, with minimal silt; cool water from ground waters sheltered from the direct heat of the sun; and dampening of extremes of waterflow.
- Forest practices in Maine have increased the intensity, size, and frequency of disturbances by adding logging in addition to natural disturbances and by accelerating natural disturbance cycles.
- Management that is based on short rotations falls outside the variability of natural disturbance regimes and loses important wildlife habitat features.
- Forest practices have not only changed forest structure, but also the ratio of tree species. These changes can affect wildlife habitat and timing of snowmelt.
- Increased percentage of heavily disturbed ground can have an impact on extremes of water flow. Extremes in stream flow can affect timing of movement, can affect stream temperatures, and can widen stream banks.
- Heavy cutting can raise water temperatures directly, through lack of shade, and indirectly through warming of soil through which groundwater passes and this can affect salmon survival.

- Forest practices can also affect dissolved oxygen levels, which are crucial to fish survival.
- Whole tree harvests can lead to lowered pH, which can exacerbate impacts of acid precipitation and poor buffering capacity of soils. Acidic water, low calcium, and high aluminum may be factors in problems of smolts adjusting from fresh to salt water.
- Herbicides and insecticides can have both direct (toxic) or indirect (changing habitat or harming food supply) impacts. Some of the sub-lethal direct effects can be subtle--such as affecting ability of salmon to avoid predators.
- The most serious impacts from logging are siltation and turbidity. Most of these impacts are from soil disturbance from trails, yards, and roads, rather than the cutting down of trees.
- The water bodies most sensitive to the above-listed forestry impacts are first order streams, not main-stem rivers.
- Maine has a combination of regulations (such as riparian zone restrictions and the Forest Practices Act) and voluntary guidelines (such as those found in Best Management Practices (BMPs), forestry certification, and easements). While supporters of these restrictions may be able to point to some progress in improving practices that these regulations and guidelines address, often the improvements are in spite of, rather than because of, the regulations and guidelines.
- State riparian zone regulations are inadequate for protecting or restoring salmon habitat. The regulations fail to require retention of large wood, have adequate crown closure, or protect headwater streams.
- The state's Forest Practices Act allows heavy cutting over an entire watershed and can lead to very short rotations.
- Best Management Practices are voluntary and are often not followed. Even when followed, they do not guarantee habitat protection in all cases, but they should be part of any solution.
- Certification schemes in Maine have good goals, but the actions on the ground do not always reflect the rhetoric of the goals.
- Easements have the potential to have strict riparian zone guidelines, but protecting mostly the main stem rivers (as is the case with many easements) is not adequate to protecting salmon if the first order streams are not in the easement and are thus only protected by current regulations.
- Rather than protect large streams and rivers with buffer zones and allow management within legal guidelines for the rest, this report recommends a whole landscape approach.
- Managers need to anticipate and plan for forest growth, development, and change.
- The most challenging habitats to plan for are late successional. If there is not enough early successional habitat on the landscape, this can be fixed in a matter of days. If there is not enough late-successional habitat in the landscape, it will take more than a century to remedy.
- Successful legacy retention needs to ensure that not only large snags are kept, but also recruitment large trees and snags.
- Diameter-limit cutting, which some landowners equate with "selection," is not an appropriate means of managing for late-successional, uneven-aged structures.
- A low-impact approach to riparian zones would have three, rather than two zones. Zone 1 would be no cut, and would be variable, based on slope and other site attributes. Zone 2 would allow cutting, but not soil disturbance. In zone 3, loggers can move equipment on trails, but not roads, and these trails would be reduced in size and distribution with low-impact techniques.

- Rather than restrict late-successional habitat to buffer zones along large rivers, it makes sense to have such habitat also in headwater regions. This ensures cross-watershed migrations and also protects the most sensitive water bodies from problems associated with frequent, heavy disturbance.
- This report emphasizes having *most* of the landscape be well-stocked, rather than just have such stocking in riparian zones.
- While low-impact forestry approaches will, eventually, lead to a landscape with ample old, large trees to supply habitat structure to streams, such trees will take many decades to develop and the salmon might not be able to wait that long. For this reason, salmon restoration biologists are recommending immediate remediation.
- Since the biggest cause of siltation is soil disturbance, rather than cutting down of trees, reducing the area of soil damage is a major strategy to minimize siltation.
- With low-impact logging, the quality of what is left is just as important as the quantity of what is removed. There needs to be a way to pay loggers to reward them for both results, not just removals.
- The best way to lower impacts is by having a sediment control plan before building anything.
- To have landscape planning and management may require cooperation amongst landowners. There are examples of such cooperation in both Canada and the US.
- Managing for an older, higher-volume, better-stocked forest would not be a sacrifice compared to current management; it would be an improvement.
- One long rotation is *more* productive of *fiber and value* than two shorter rotations because the larger sawtimber trees are worth so much more than pulpwood (in smaller diameters).
- The best strategy for having more large trees in the landscape is to have much of the landscape be managed by uneven-aged methods.
- It is possible that the productivity of older trees and older stands has been underestimated.
- Low-impact forestry cannot compete with short-term forestry for high immediate returns. It is patient money.
- Managing for big trees and snags requires some financial sacrifice (trees that will not be cut for money), but that cost can be seen as the price of ecological insurance.
- Low-impact forestry keeps options open for both the present and the future. It leaves an aesthetically pleasing forest with higher community values for both recreation and wildlife. It also avoids costs--such as the costs of trying to restore salmon in streams with unfavorable forest habitat.
- There are examples of landowners in Maine and Canada doing many of the things suggested in this report.
- The changes called for in this paper would make sense even if salmon were not endangered.

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Dam on South Branch of the Penobscot, 1927

**Within the Beauty Strip: Forestry as if Salmon Mattered**

*If the [Passenger] Pigeons plagued us by their abundance, the Salmon gave us even more trouble. So large a quantity of them enters into this river that at night one is unable to sleep, so great is the noise they make in falling upon the water after having thrown or darted themselves in to the air."*

Nicholas Deny writing about the Miramichi River in New Brunswick, 1607
Quoted in David Montgomery, *King of Fish: The Thousand-Year Run of Salmon*

## I. Introduction

**The King.** Called by Izaak Walton the "King of Fish," salmon have been a key food source for human cultures in Europe and North America for thousands of years. Indeed, in the Pacific Northwest, salmon were the primary food source for native tribes for more than 9,000 years. But salmon, with their impressive life force, have also captured peoples' imaginations as well as their palates. When the Romans invaded Gaul (now France) they saw these fish jump more than ten feet high and swim up waterfalls. The Latin name for Atlantic salmon is *salmo salar,* which means "the leaper from the sea."

Atlantic Salmon are also extraordinary for their complex life cycle. Indeed, some of the stages of salmon growth are so different that early Europeans thought they were observing distinct species. The metamorphosis and migration of salmon certainly rivals that of species such as Monarch butterflies.[1]

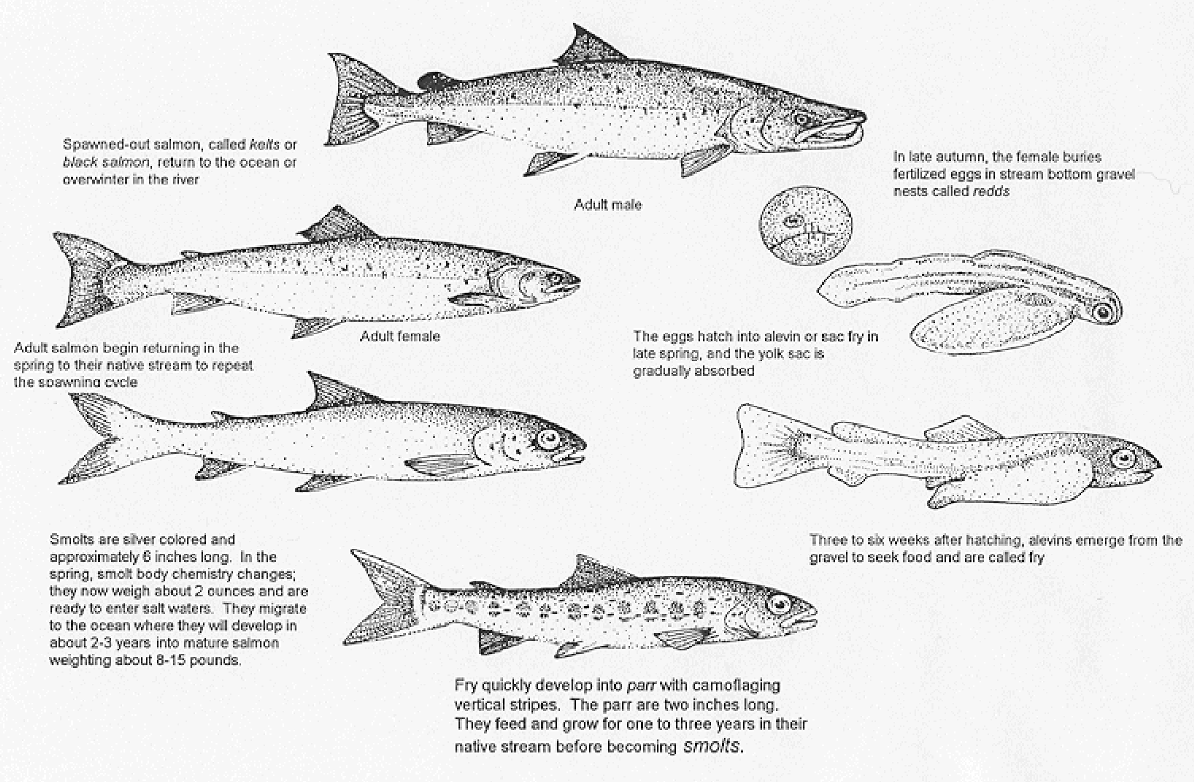


Figure 3.1: Life Cycle of the Atlantic Salmon (*Salmo salar*)

[1] diagram from US Fish and Wildlife Service at http://library.fws.gov/salmon/salmona2.gif

Adult fish swim upstream, often against swift currents, to find a suitable location for spawning. There the female makes a nest or depression in the stream bottom into which she lays her eggs. The young fish that hatch from the eggs may live in fresh water for years, and then they swim to the ocean. At this stage, they change from fresh-water fish to salt-water fish. In the ocean they swim thousands of miles. Most American salmon go to an area between Greenland and Labrador, while European salmon tend to go to the Norwegian Sea. The ocean salmon may return in a year or may stay at sea for multiple years. When they return, they somehow find the same river and same stream from which they originated, then spawn and start the cycle anew.

Even the words associated with the salmon life stages evoke a sense of magic and mystery. For example there is the redd (the nest female salmon make on river or stream bottoms to lay eggs), alevin (when the fish is hatched out, but still attached to the yolk sac), fry (stage after alevin, but before parr in mid-summer), parr (young fresh-water salmon with distinctive vertical bands), smolts (juvenile salmon that migrate to the sea), grilse (salmon that have spent one year at sea and then return to fresh water), or kelt (a salmon that has mated and is still in fresh water, but on its way back to the sea).

Salmon fishing may be the oldest regulated profession in the English-speaking world. Regulations of salmon fisheries in Scotland date back to 1030. Protection of salmon was even included in the Magna Carta in 1215.[2] Salmon remained abundant in Europe until the 1700s, when the industrial revolution introduced dams, pollution, and siltation to salmon habitat.

When the colonists came to Maine, they found plentiful salmon in the rivers. Indeed, the fish were so numerous that settlers used them as fertilizer to try to restore soils depleted from poor tillage practices. For Penobscots, according to anthropologist Frank Speck, the spearing of salmon on their annual run up the river in June, July, and August, was one of the great seasonal events.[3]

The industrial revolution, however, had the same impact on Maine salmon as European salmon. As mills went up, so did dams. Sawdust, pollution, and barriers to spawning, combined with leveling of forests and the driving of timber down rivers and streams, led to salmon population crashes.

By the early 1800s, laws and regulations were passed for key salmon rivers in Maine.[4] By the late 1800s, there were attempts to stock rivers with young salmon, create fishways for dams, prevent overfishing, and lessen pollution. During the latter part of the 20th century, millions of dollars were spent in Maine for salmon rearing and stocking, habitat recovery (including breaching of some dams), and cutting back on pollution. The populations of Atlantic salmon are now maintained primarily by hatcheries. There are numerous organizations, both local and international, working to bring back the salmon.

Maine has been so proud of its Atlantic salmon that, starting in 1912, it became an annual tradition to give the first salmon caught in the Penobscot River to the President of the United States. This ritual persisted until 1994, when restrictive angling regulations ended the practice.

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[2] David R. Montgomery, *King of Fish: the Thousand-Year Run of* Salmon, Westview, Boulder CO, 2003, page 62

[3] Frank G. Speck, *Penobscot Man*: *The Life History of a Forest Tribe in Maine,* University of Maine Press, Orono, 1998 (originally published in 1940 by University of Pennsylvania)

[4] for examples of some of these regulations see the Atlantic Salmon History Project at http://home.gwi.net/~fks/historicrecords.html

Despite all the efforts on their behalf, wild Atlantic salmon have experienced a second wave of decline that started accelerating during the 1980s. The fish are now extinct on 84% of their original range in the United States. There are attempts to restore salmon in some rivers (such as the Connecticut and Penobscot) and help distinct population salmon (DPS) recover on eight rivers in Maine, where the wild salmon are in critical condition.[5] Few wild salmon are returning to these rivers from the sea. Salmon have been afforded emergency protection under the Endangered Species Act, despite efforts of our previous governor to halt such a listing.

*14* *Atlantic Salomon in Maine*

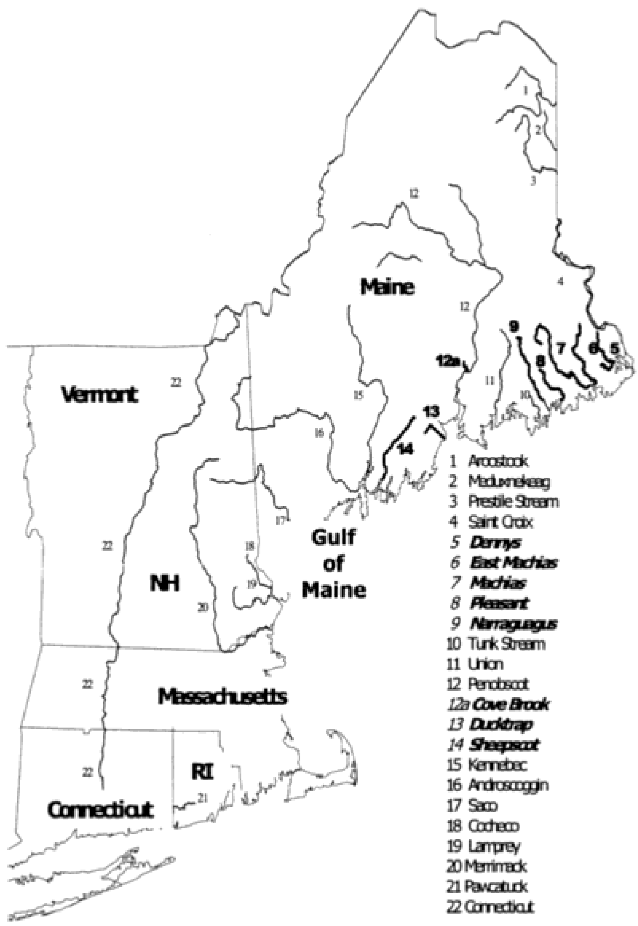


**FIGURE 1-1** USA Atlantic salmon rivers with active restoration/recovery programs in New England. The eight DPS rivers in Maine with Atlantic salmon listed as endangered under the ESA are: (5) Dennys, (6) East Machias, (7) Machias, (8) Pleasant, (9) Narraguagus, (12a) Cove Brook, (13) Ducktrap, and (14) Sheepscot.
Source: Baum et al. 2002.

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[5] World Wildlife Federation (WWF), *The Status of Wild Atlantic Salmon: A River by River Assessment*, Canada, 2001, map from National Academy of Sciences @ http://books.nap.edu/books/0309091357/html/14.html

**Salmon decline.** Salmon face threats at every stage of their complex lives. Fresh water ecosystems in Maine, according to an assessment of the state's biodiversity, "have been profoundly and adversely affected by exotic introductions, dam building, pollution, pesticide use, and excessive nutrient input."[6] These threats to aquatic ecosystems in general have also been threats to salmon in particular. Dams have either stopped or slowed the movement of salmon and changed the river habitats as well. Dams also can lead to extremes in water levels when water is released. Some agriculture industries have made excessive withdrawals of water from the river system at critical times. Some introduced species, such as Brown trout, Smallmouth bass, or Chain pickerel, are predators or competitors of young salmon.[7] In some freshwater ecosystems, salmon face threats from siltation, temperature changes, extremes in water flow, nutrient pollution, and loss of dissolved oxygen (these will be discussed in more detail later).

In Nova Scotia and parts of Europe, acid precipitation has led to salmon extinctions in a number of watersheds.[8] Liming of rivers in parts of Scandinavia, has increased the yield of grilse in following years. Since the passage of the Clean Air Act, most rivers in Maine have become somewhat less acidic, however, but there are still high levels of naturally occurring aluminum and low levels of calcium, and acidity is still thought to be a factor in the continual decline of salmon. Because some salmon rivers have not responded to the improvements under the Clean Air Act, the National Academy of Sciences is recommending a limited liming program in Maine to see if that might reverse the decline.[9]

In the ocean, salmon face threats from increased predation by seals, cormorants, and other species, over fishing, changes in temperatures, pollution, and fish farming. An assessment of the status of wild Atlantic salmon found the threats from salmon farming to be a major factor in Maine, due to disease and parasites from the caged salmon, and genetic contamination and competition from escapees.[10] Because many aspects of fresh water habitat have been improving in recent decades--rivers are getting cleaner and fish barriers are coming down--it is possible that changes in the ocean habitat are a major causation factor of the recent widespread decline in wild Atlantic salmon numbers.[11]

**Precautionary principle.** This report is written from an underlying philosophy: that an ounce of prevention is worth a pound of cure.[12] The chances for salmon recovery improve to the extent that salmon habitat is managed within the historic range of variability in which the salmon thrived. Salmon spend time in many types of habitats--streams, rivers, estuaries, and vast areas

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[6] Gawler, Albright, Vickery, and Smith, *Biological Diversity in Maine: An Assessment of Status and Trends in the Terrestrial and Freshwater Landscape*, Maine Natural Areas Program/Maine Forest Biodiversity Project, Augusta ME, 1996

[7] Ed Baum, *Maine Atlantic Salmon: A National Treasure*, Atlantic Salmon Unlimited, Hermon ME, 1997

[8] WWF, *The Status...*

[9] National Academy of Sciences (NAS), *Atlantic Salmon in Maine*, The National Academies Press, Washington, D.C., www.nap.edu, Dec., 2003, pgs. 7-8

[10] WWF, *The Status...*, page 92

[11] NAS, pgs. 39-40

[12] "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." Principle 15 from the Rio Conference on the Environment and Development, 1992

of ocean. The focus of this report only touches part of this habitat range--the streams and rivers running through forests. Some may argue that threats to salmon from activities in the ocean may be greater than those in fresh water. That may possibly be true, and *all* these threats must be dealt with, but it should not be an excuse to continue managing fresh water habitat under the older philosophy of minimal regulatory acceptability.

The difference in the two philosophies is as stark as the two sides of the yin and yang Chinese symbol. On one side it is white with a black dot, and the other black with white dot. In the old philosophy, the majority of the land can be managed in a way that is well outside the range of variability of optimal salmon habitat as long as there is a small amount of land, a buffer zone (the "dot"), that is retained. In the new philosophy, the land manager is trying to manage whole landscapes and functional ecosystems within that landscape. The "dot" is the human caused disturbance, not the remaining compatible habitat.

This new philosophy has been embraced by the Independent Multi-disciplinary Science Team (IMST) a blue-ribbon panel of experts appointed by the state of Oregon to make recommendations for recovering Western Oregon's salmon.[13] The IMST stated that "the goal of management and policy should be to emulate (not duplicate) natural processes within their historic range." Forest management removes biomass from an ecosystem and generally results in lower stocking and less dead wood than would be found a natural, unmanaged ecosystem. While forest management will not "duplicate" natural processes, it can be informed by them and can strive to retain key features of stand and landscape that are important to salmon and other creatures.

Even if there are more severe threats to salmon outside the range of impacts from forest management, it still makes sense to optimize habitat to best meet the needs of salmon, rather than to manage for minimal acceptability. The survival rate of salmon is determined by multiplying the rate of survival of each stage of life cycle. Hence, if there is (using average figures from Maine)[14] an 8% survival rate from egg to fry, a 30% survival rate from fry to parr, and a 50% survival rate from parr to smolt, that leaves a 1.2% survival rate from egg to smolt. By increasing these numbers just a little at each stage by providing more optimal habitats, one can have, for example, a 13% survival rate from egg to fry, a 35% survival rate from fry to parr, and a 53% survival rate from parr to smolt, yielding a 2.4% survival rate from egg to parr, doubling the number of salmon that go out to sea. These figures are all within the expected range of survival, but slightly higher than the current mean.

The IMST (p. 12) emphasized that, "Salmonids and their habitat comprise a single coevolved unit that cannot be separated for management purposes." This means that salmon are not only dependent on the types of habitats in which the fish evolved, but the habitats depend, to some extent, on the salmon. Ninety percent of an Atlantic salmon's weight is gained from its time at sea. When salmon and other anadromous fish return from the ocean, they bring trace minerals from the nutrient-rich ocean waters with them. As birds and mammals eat these fish, the nutrients enter the forest ecosystem. The salmon are thus as important to the forest as the forest is to the salmon.

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[13]Independent Multidisciplinary Science Team, *Recovery of Wild Salmonids in Western Oregon Forests: Oregon Forest Practices Act Rules and Measures in the Oregon Plan for Salmon and Watersheds.* Technical Report 1999-1 to the Oregon Plan for Salmon and Watersheds, Governor's Natural Resources Office, Salem, Oregon.

[14]Baum, pg. 32. Note: on some downeast rivers, such as the Narraguagus, the survival numbers are below the expected ranges listed.

Managing the landscape for its historic range of conditions will not only benefit salmon, but also support overall biodiversity. Even if salmon do not recover, the ecosystem approach will still benefit the whole range of other species both on land and in water. Other anadromous fish are likely to recover. More intact forest will create more viable habitats for more species and will allow better migration and dispersal of populations, rather than create isolated fragments or islands.

Using the precautionary principle as starting point, this paper addresses a number of questions regarding the protection and restoration of Atlantic salmon:

- What parts of the salmon life cycle are dependent on forests?
- What was the range of forest conditions to which salmon were adapted in presettlement times?
- How have past and current forest practices changed forest conditions in ways that impact salmon habitat?
- How effective are current forestry regulations and voluntary restrictions for preventing adverse impacts and/or for restoring ecosystem processes?
- What changes in forest practices would help restore habitat to be within the historic ranges to which salmon are adapted?
- Would lower-impact, more salmon friendly, forestry reduce productivity or economic and social benefits of the forest?

## II. What parts of the salmon life cycle are dependent on forests?

The fresh water stages, from egg to smolt, are all dependent on forests. Forests help maintain key habitat requirements for clean, cool water, streambank and channel structures, and for food. There are certain habitats that are key at certain times of year. These requirements need to be considered when developing management plans to prevent harm during vulnerable stages.

Though all stages of salmon growth are vulnerable to predation or habitat disruption, those that have the most specific needs and the least ability to move are particularly vulnerable--this includes eggs/alevin/fry stages and larger stages (parr or adults) that need deeper cooler water. Scouring from ice or "winter thaws" could impact eggs or alevins. Low flows, combined with high temperatures during July-September could negatively impact parr, low flows could also impact smolt migration during April and May.[15]

This report is advocating landscape-scale forestry planning. Biologists are now applying the concepts of landscape ecology to riverine landscapes.[16] Rivers and streams have distinct habitats, patches, and connections that, in the case of salmon, need to be considered if the fish is to be protected.

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[15]Ed Baum, personal communication

[16]John Wiens, "Riverine landscapes: taking landscape ecology into the water," *Freshwater Biology*, vol. 47, 2002

**Life Stages and Key Habitats of Atlantic Salmon in Maine in Fresh Water[17]**

| Life Stage | Location | Key Habitat | Time of Year |
|---|---|---|---|
| Returning adult | rivers | deep, cool, well-shaded pools | May-July (but range can be from April-November) |
| Spawning | rivers and streams | moving water 9.5-29 inches deep with clean, coarse gravel | October-November |
| Kelt (adult that has spawned returning to sea) | rivers | | fall, but also overwinters and returns to sea in spring |
| Egg | rivers and streams | same as for spawning | October to April |
| Alevin/fry | rivers and streams | need source of plankton, then insects, then small fish for food | May-June |
| Parr | rivers and streams | abundant food, cool pools during hot weather | 2-3 years (range is 1-4) |
| Smolt | river to estuary | | April-June |

**III. What was the range of forest conditions to which salmon were adapted in presettlement times?**

Maine's forest has been changing in species composition, disturbance patterns, and structure since the first closed-canopy forests recolonized the land, following the retreat of glaciers 12,000 to 9,000 years ago.[18] The modern "Acadian Forest," which has the intermingling of spruce-fir with northern hardwoods, did not start to dominate the landscape until 1,500 to 1,000 years ago, when spruce and fir increased in abundance along the southern margin of their range.

According to recent research by George Jacobson,[19] the Maine climate cooled during the Little Ice Age (ca. 1450 to 1850) and that is when both the spruce-fir forests became dominant in northern and eastern Maine and when salmon became abundant in Maine rivers. "Prior to the past 500 years or so," writes Jacobson, "salmon were likely absent from Maine, restricted to cooler regions to the north for most of the past 10,000 years."

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[17]based on information from Ed Baum in *Maine Atlantic Salmon: A National Treasure*, Atlantic Salmon Unlimited, Hermon, ME, 1997, pg.s 10-16

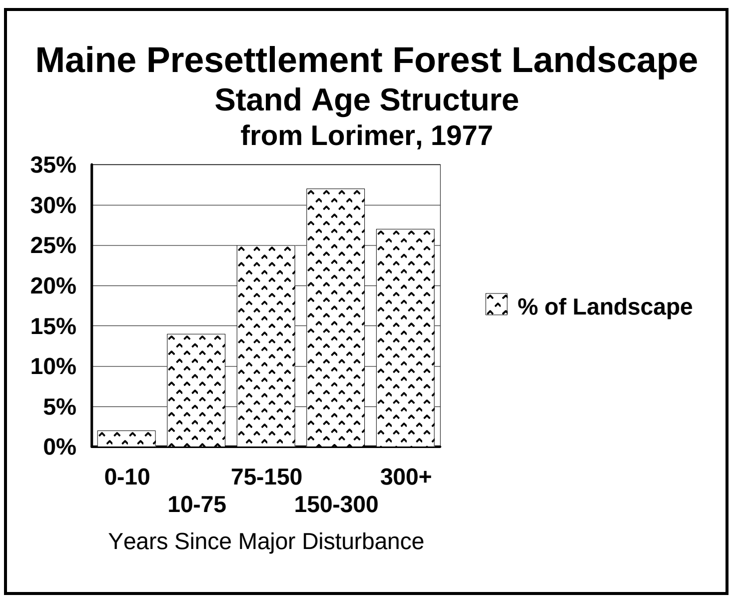
[18]George Jacobson, Jr., and Ronald Davis, "Temporary & Transitional: The Real Forest Primeval, The Evolution of Maine's Forests over 14,000 years," *The Northern Forest Forum*, Vol. 1, no.3, 1993

[19]George Jacobson, Jr., "Influences of Past and Future Climates on Atlantic Salmon,"at http://www.umaine.edu/mainesci/Archives/BioSciences/salmon-climate.htm, posted Jan 11, 2000

In support of this hypothesis, Jacobson suggests the archeological record shows that salmon were either not present or not abundant in Maine prior to the Little Ice Age. Archeological sites dating to the period prior to European settlement contain thousands of bones of other anadromous fish (such as sturgeon, and American shad), but only a few large salmonid bones. Sites from the 18th century, however, show abundant remains of Atlantic salmon. He also suggests that linguistic analysis of word origins shows that salmon "was not of long-standing importance to those peoples."

When the first European settlers came to North America, Atlantic salmon were found as far south as the Housatonic River in Connecticut. Atlantic salmon can still be found in rivers in Portugal and Spain,[20] so salmon may have more tolerance to heat than suggested by Jacobson. The lack of an archeological record for salmon bones in Maine could be significant, as salmon were impressively abundant when settlers first arrived. The National Academy of Sciences, however, suggests that salmon remains are best preserved when mixed with shellfish that neutralize acidity. Shellfish were eaten on the coast, whereas salmon were mostly eaten along the rivers.[21] In nearby New Brunswick, the native people on the Restigouche "adopted salmon as their tribal symbol, adorning their canoes clothing, and bodies with images of salmon."[22] Such identity with an animal bespeaks a longer relationship than a few hundred years, but it is possible New Brunswick rivers had a longer occupancy by salmon than Maine rivers.

**The presettlement forest.** Our knowledge of the presettlement forest is based, mostly, on witness tree data from early surveys, remnant old-growth forests, charcoal deposits in the soil, and pollen residues in lake and pond bottoms. In 1977, Craig Lorimer did a reconstruction of the presettlement forest of northeastern Maine using early surveys and concluded that large-scale, catastrophic wind and fire cycles were many hundreds of years apart. According to Lorimer, only 2% of the forest was in stands that were less than 10 years from the last stand replacing disturbance.[23] In contrast, 59% of the stands had been growing for more than 150 years, leading to mostly uneven-aged or all aged stand structures..




Although stands may have gone more than 300 years from last major disturbance, individual trees did not, due to smaller scale disturbance. During the 1890s, Austin Cary, one of

[20]WWF, *The Status...*

[21]NAS, pg. 48

[22]Montgomery, page. 91

[23]Craig Lorimer, "The presettlement forest and natural disturbance cycle of northeastern Maine, *Ecology*, Vol. 58 (1977)

Maine's first foresters, determined the ages of 1,050 spruce logs from all major river systems and found that 72% were between 150 and 250 years old and less than 5% were under 125 years old.[24] Few were over 300, even though they might have come from stands that had not been burned or otherwise flattened for more than 300 years. Smaller-scale, wind, insect, or disease events tended to take down individual trees or patches of trees. The landscapes that predominated in the presettlement forest were a reflection of these disturbance regimes and often contained stands with complex canopy structures.

The old-growth stands remaining today are not "typical" of the forest that once dominated the landscape. These remnants were spared from the ax because of inaccessibility, or because they were unwanted for either farming or logging. They are also too small for scientists to accurately determine average return cycles for catastrophic natural events, such as fire or hurricanes.

These stands are also subject to conditions and stresses not found in the presettlement forest:

- extirpation of some species (such as large predators, caribou, or passenger pigeons);
- introduction of exotic species;
- changed fire cycles (acceleration of fire cycles following logging in the 19th century, and suppression of fires starting in the mid 20th century);
- accelerated spruce budworm cycles (due, primarily, to major increases in fir over the landscape);
- air pollution and acid precipitation; and
- climate change.

Existing old-growth stands in the region are, basically, uneven aged and have trees with maximum ages ranging from more than 200 to more than 400 years old.[25] They are also loaded with dead wood.

Seymour et al,[26] reviewed the literature for disturbance regimes in forests where there is an intersection of spruce-fir with northern hardwoods (the Acadian region and Lake States) to try to determine natural disturbance cycles. They came to the conclusion that large gaps due to catastrophic events such as wind and fire were natural, but rare. Such events might be more than 800 years apart. Small canopy gaps from wind, insects, or disease were much more common ways of regenerating the forest.

These researchers concluded that "widespread application of single-cohort silviculture on rotations of under 100 years thus creates a landscape that has no natural precedent for the types of forests we reviewed. Management that deliberately produces such stands thus cannot claim to be emulating natural disturbances, as in the common industrial situation where multiple, short rotations are planned, or where such stands dominate the landscape." "If the goal is to emulate most northeastern natural disturbance regimes faithfully, then the majority of the landscape must be under some type of continuous-canopy, multi-aged silviculture that maintains ecologically mature structures at a finely patterned scale."

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[24]R.S. Seymour, "The red spruce-balsam fir forests of Maine: evolutions of silvicultural practices in response to stand development patterns and disturbances," in M.L. Kelty et al., eds. *The Ecology and Silviculture of Mixed-species Forests: A Festshrift Honoring Professor David M Smith*, Klower Publishers, 1991, pg. 5

[25]Charles V. Cogbill, "The Ancestral Forest," *The Northern Forest Forum*, Vol. 1, No. 4, 1993

[26]Robert S. Seymour, Alan S. White, Phillip G. deMaynadier, "Natural disturbance regimes in northeastern North America--evaluating silvicultural systems using natural scales and frequencies," *Forest Ecology and Management* 155 (2002) 357-367

**Implications for salmon.** Maine's presettlement forest landscape ensured: pure, clean water, with minimal silt; cool water from ground waters sheltered from the direct heat of the sun; and dampening of extremes of waterflow. Even if much of a watershed were impacted by a major fire, the complex life cycle of the salmon ensured survival. The heat of the fire and loss of cover might destroy much of the juvenile salmon in a river system, but adult salmon sometimes stay at sea for years, giving the forest enough time to revegetate and stabilize soils before the fish returned to spawn. Also a small percentage of salmon stray from their own river systems and can colonize other river systems.

The age structure of the forest not only affected water quality, but also aquatic habitats. One product of an older forest is large woody debris as the trees die or blow over. Large fallen trees in streams are so important for salmon that salmon restorationists, dealing with a forest landscape where older trees are rare, will deliberately place large logs in crucial areas to improve habitat structure.[27] Large downed logs tend to resist movement in high water conditions. They are effective in:

- trapping smaller, more mobile pieces, that would have otherwise been transported out of the system;
- trapping and regulating the flow of sediment;
- creating pools and meanders and other complex patterns of hydraulic flow;
- providing thermal refugia for salmon (and other species) in warmer seasons; and
- keeping dead salmon from drifting into the ocean, thus keeping nutrients in the watershed.[28]

**IV. How have past and current forest practices changed forest conditions in ways that impact salmon habitat?**

Forest practices in Maine have increased the intensity, size, and frequency of disturbances by adding logging in addition to natural disturbances and by accelerating natural disturbance cycles. The heavier the cutting, the bigger the size of the cut, the greater the removal of biomass, the further these events lie outside the range of natural variability these. Seymour, White, and deMaynadier, for example state that the industrial practice of having 50 acre plantations managed on rotations of 40-60 years as being, "well outside the boundary of natural disturbances."[29] Openings of this size might have naturally occurred over periods greater than 300 years, not 50 years. Instead of large, intense disturbances being rare (and there is no natural disturbance that corresponds to removal of biomass), they are now occurring annually on most watersheds.

Cutting has also accelerated "natural" disturbances. During the 19th century, the size, intensity, and frequency of fires increased.[30] Old-growth stands were fairly resistant to fires because the forest floor was shaded and damp and because large trees rose limb free for dozens of feet and had thick, fire-resistant bark. In contrast, younger softwoods with branches nearly to the ground combined with big slash piles created major fire hazards. The acreage of forest burned declined in 20th century with advent of fire control, however.

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[27]Bob Bancroft, "Reparing Broken Rivers, *Atlantic Salmon Journal,* Winter, 1998

[28]IMST, pg. 81.

[29]Seymour et al, p. 361

[30]for a discussion of acclerating fire cycles, with references, see Mitch Lansky, *Beyond the Beauty Strip: Saving What's Left of our Forests*, Tilbury House Publishers, 1992, pgs. 98-99.

In the 20th century, the size, intensity, and frequency of budworm outbreaks increased. Heavy cutting of pine and spruce led to recolonization of stands by balsam fir, which is the most vulnerable species to spruce budworm.[31] Heavy cutting, especially diameter-limit cutting, where the most windfirm trees are removed and suppressed trees with poor root systems are retained, increases the frequency of blowdowns, especially in softwoods.

**Forest structure**. Shortened rotations lead to a lower proportion of stands with large-diameter trees and multiple canopies. Over the last three decades, landowners have accelerated the rate of clearcutting and overstory removals so that almost 5 million acres, or nearly 29% of the forest, is in seedlings and saplings, and nearly 38% is in poletimber.[32] In contrast, only around 16% of the landscape in the presettlement forest was in stands that were younger than 75 years (75 years is long enough to grow trees well beyond the pole stage).[33] Seymour, et al state that, "once single-cohort stands occupy over ca. 15-25% of the landscape, every stand that is converted or maintained in single cohort structure contributes toward an increasingly artificial landscape pattern."[34]

Large trees, living and dead, create important wildlife habitat. Wildlife biologist Malcolm Hunter estimates that 20 to 40% (and sometimes as high as 66%) of bird species will use cavities in trees. "If we consider cavities in both trees and logs, it is likely that most species of forest dwelling mammals, reptiles and amphibians seek shelter in cavities at least occasionally."[35] He also noted that, "just one small subset [of beetles] that makes its living on dead and dying wood outnumbers *all* the world's species of mammals, birds, reptiles, and amphibians at least two to one." The larger the diameter tree, the more species that can use it. Pileated woodpeckers, for example need a minimum tree diameter of 22 inches.[36]

As mentioned in a previous section of this report, downed large logs may be important to salmon habitat. Also, large trees surrounding streams are a major source of macroinvertebrates, which are an important source of food for juvenile salmon. Large, dead-downed wood is also of prime importance for: slow release of nutrients and organic matter; retention of moisture; a prime site for regeneration; and an important habitat for mycororrhizae fungi that are essential for tree health.

The IMST report concluded that, "The most productive habitats for salmonid fish are small streams associated with mature and old-growth coniferous forests where large organic debris and fallen trees greatly influence the physical and biological characteristics of such streams."[37] Because there is so little old growth left in Maine, one cannot prove that the same

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[31]J.R. Blais, "Trends in the frequency, extent, and severity of spruce budworm outbreaks in Eastern Canada," *Canadian, Journal of Forest Resources*, Vo. 13 (1983), pg. 539

[32]Kenneth Laustsen, Douglas Griffith, James Steinman, *Fourth Annual Inventory Report on Maine's Forests*, Maine DOC, USDA Forest Service, Oct. 1, 2003, Table 6

[33]see chart above based on Lorimer, 1977

[34]Seymour et al, page 364

[35]Malcom Hunter, Jr, *Wildlife Forests and Forestry: Principles of Managing Forests for Biological Diversity*, Prentice-Hall, Englewood Cliffs, NJ., 1990, pg. 162

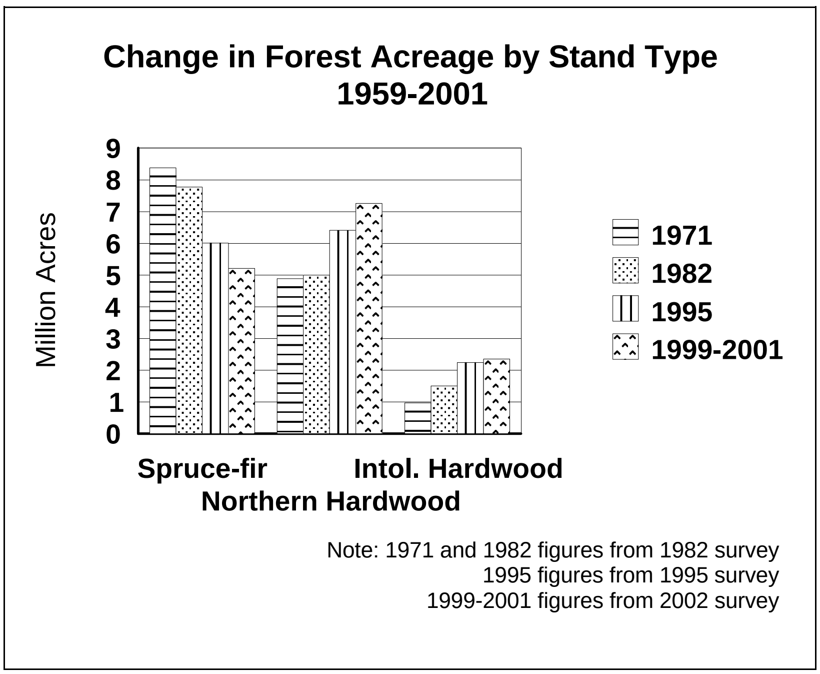
[36]Catherine Elliott, ed., *Biodiversity in the Forests of Maine: Guidelines for Land Management*, UMCE Bulletin #7174, University of Maine Cooperative Extension, 1999, pg. 146

[37]IMST, pg. 80.

increase in productivity from old-growth characteristics applies here, but benefits to salmon from such forests are likely.

**Species shifts.** Forest practices have not only changed forest structure, but also the ratio of tree species. Since presettlement times, there has been a gradual increase in the proportion of shorter-lived species, such as balsam fir, red maple, and intolerant hardwoods (white birch and poplar species) that are adapted to disturbance. An increase in these species, especially balsam fir, can lead to an increase in the rate of further disturbances (such as the spruce budworm). Since the 1970s, the acreage of the spruce-fir forest type has declined, while the area of northern hardwoods and intolerant hardwoods has increased. This shift has been due to highgrading (where softwoods are removed, but hardwoods left), heavy cutting (that encourages regeneration by intolerant hardwoods), and spruce budworm (which led to heavy mortality in fir and spruce).

Such species shifts can lead to earlier snow melt (see section on water flow). The increase in intolerant hardwood has also led to wildlife population changes that may affect salmon. Poplar, for example, is a favored food of beavers. In the last few decades, with a decline in trapping and a deficiency of large predators, beaver populations have exploded. Unlike in presettlement times, beavers now have few serious predators to control their population. Beaver dams can be a barrier to movement for salmon and can lead to changes in stream channels, temperatures, sediment, and nutrients that can harm salmon in some circumstances. The Maine Department of Inland Fisheries and Wildlife sometimes has extended beaver trapping seasons in salmon sensitive watersheds.




**Water flow.** Increased percentage of heavily disturbed ground can have an impact on extremes of water flow. Removing 25% of the vegetation in a watershed can impact stream flow.[38] Snow depth normally increases after canopy removal and snowmelt is accelerated, leading to higher flows, earlier in the year. This effect can last up to 15 years.[39] There can also be increased storm flow after harvesting.

A literature review on the impact of land use activities on Atlantic salmon habitat cited research that showed significantly higher stream flows in the East Branch of the Piscataquis

[38]Steve Kahl, *A Review of the Effects of Forest Practices on Water Quality in Maine*, Water Research Institute U Maine, Orono, 1996, pg.16.

[39]Kahl, pg. 17

River in April and May the year following clearcutting up to the stream. The authors concluded that this increased flow can have an important influence on Atlantic salmon populations.

There is a strong direct relationship between winter (and possible summer) discharge and survival of Atlantic salmon parr. There is also a relation between river flow and timing and extent of upstream movements of returning adult Atlantic salmon. "Any abnormally high flow can be especially critical for juvenile Atlantic salmon [...] juveniles pass through a short period in their life cycle when they are especially vulnerable to downstream displacement by high flows."[40]

Increased flow and earlier snow melt can also be affected by a global warming and by a conversion of softwoods to hardwoods. The combination of heavy cutting, type conversion, and climate change may be factors that have contributed to progressively earlier snowmelt on the Narraguagus River over the past few decades.

**Snow-Water Equivalent (SWE) (Amherst, Maine), Channel Ice Effects, and Median February and May Stream Flow (Narraguagus River), 1970-2000** [41]

| Year | March 1 SWE (in.) | March 15 (SWE (in.) | April 1 (SWE (in.) | Ice Effect (no. of days) | Feb. 1 Median Q ($ft^3$/sec) | May 1 Median Q ($ft^3$/sec) |
|---|---|---|---|---|---|---|
| 1970 | 5 | 5 | 4.5 | 60 | 300 | 600 |
| 1980 | 4 | 4.5 | 3.5 | 60 | 330 | 570 |
| 1990 | 3 | 3.5 | 2 | 55 | 350 | 520 |
| 2000 | 2.5 | 3 | 1.5 | 45 | 380 | 490 |

Drought may be enhanced later in the growing season due to loss of shade and higher soil temperatures.[42] High flows can widen stream banks. Lower flows later in the season in wider streams means shallower water more susceptible to warming.

**Water temperature.** Heavy cutting can raise water temperatures directly, through lack of shade, and indirectly through warming of soil through which groundwater passes. Lack of shade leads to greater extremes of temperatures, which can lead to greater stress to salmon. One study (in New Brunswick) found maximum soil temperatures of $90^0$ F in a deforested watershed compared to $65^0$ F in an adjacent forest watershed.[43] The water bodies most susceptible to warming are first-order streams, which have low volumes of shallow water, especially in late summer. Most of the water in higher order streams comes from headwater streams, not riparian zones. Thus, buffering only the higher order streams will not prevent the most serious impacts of warming of water.

Atlantic salmon have specific temperature requirements for various stages of growth. Temperatures above $12^0$ C can result in higher egg mortality. Juvenile salmon prefer $15\text{-}19^0$ C

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[40]John Moring and Kenneth Finlayson, *Final Report to the National Council of the Paper Industry for Air and Stream Improvement, Inc. Relationships etween Land Use Activities and Atlantic Salmon (*Salmo Salar*): a Literature Review*, Maine Cooperative Fish and Wildlife Research Unit, University of Maine, January, 1996, pgs. 28-29

[41]NAS, pg. 42

[42]Kahl, pg. 17

[43]Kahl, pg. 29

but can tolerate up to $27^0$ C. Upstream migration of adult Atlantic salmon decreases significantly in water temperatures exceeding $23^0$ C. Because salmon emerge partly in response to temperature, an earlier increase in temperature can lead to hatching of fry at a time when food supply is limited.[44] Higher temperatures can also affect the ability of smolt to tolerate salinity.[45]

An ongoing experiment in Maine found that unbuffered streams had greater extremes in water temperature than buffered streams.[46] Unfortunately, the experiment took place during a period of extreme drought, and some of the streams dried up. Because of this, only figures from June 15th to July 15th are listed in a comparative chart, because all the streams had water during this period. One stream that had no buffer, however, did have water throughout the season and had a maximum temperature of $20.5^0$ C in August. The experiment tested 3 buffer widths and found warming (above controls) in 2 out of 3 streams with an 11 meter buffer, and warming in 1 out of 3 with a 23 meter buffer.

**Dissolved oxygen.** As stream temperatures increase, dissolved oxygen goes down. Lowered dissolved oxygen levels are thus another impact of clearcutting without a stream buffer.

If excess woody debris from logging or road construction get in streams, it can block fish passage of Atlantic salmon, restrict stream flow, and affect dissolved oxygen levels.[47] Dissolved oxygen can also decrease due to heavy sedimentation. It is documented that dissolved oxygen levels of less than 6.0 mg/l can affect growth and survival of Atlantic salmon and such values have been recorded following logging near streams (but not in New England).[48]

**Stream acidity.** Stream acidity can influence the development and health of fish. When pH levels go below 5.5, for example, this can affect the ability of salmon to acclimate from fresh to salt water.[49] Even temporary pulses of acidity can make salmon more vulnerable to predation.[50]

Whole tree clearcutting can lead to nutrient leaching, increased soil acidity, and increased stream acidity with higher aluminum levels. The clearcut itself removes a significant amount of minerals, such as calcium, magnesium or potassium, in the biomass. After the clearcut, the increased temperatures accelerate the breakdown of organic matter in the soil, but since there is minimal vegetation to take up these nutrients, they leach out of the system. In some cases, the leaching, which can last up to 10 years, can remove more nutrients than the initial harvest.[51]

The breakdown of organic matter causes a process called "nitrification," which occurs as organic nitrogen compounds are transformed into inorganic forms (nitrates) that plants can utilize. Nitrification makes the soil more acidic. Acidification from nitrification may increase aluminum concentrations that may result in downstream acidification and concentrations of

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[44]Moring and Finlayson, pgs. 17-18

[45]NAS, pg. 35

[46]John Hagan, "The effectiveness of different buffer widths for protecting riparian values on headwater streams," in *Cooperative Forestry Research Unit Annual Report 2001-2002*

[47]Moring and Finlayson, pg. 40

[48]Moring and Finlayson, pg. 20

[49]NAS, pg 7-8

[50]NAS, pg. 75

[51]C.T. Smith, M.C. McCormack, Jr., J.W. Hornbeck, and C.W. Martin, "Nutrient and biomass removals from a red spruce-balsamfir whole-tree harvest," *Canadian Journal of Forestry Research*, Vol. 16 (1986), pg. 382

aluminum that are toxic to fish.[52] The important figure for pH is not the average, but the peak. The combination of acidified soils with acidified precipitation can lead to problems when there are pulses of waterflow (such as spring snow melt).

Kahl cites estimates that one whole-tree harvest is the equivalent to 50 years of pH 4 acidic precipitation for the impact on soil acidification and cation (postively charged ions, such as calcium, magnesium, and potassium) leaching. In Maine, that translates to 150 years of leaching by the present pH 4.6 precipitation.[53] This increase in acidity is in addition to acid precipitation and naturally acidic soils.

Kahl cites a number of studies showing increased downstream acidity resulting from forest harvesting.[54] Moring and Finlayson, however, conclude that, "the links between land use practices in Maine and pH and alkalinity are unclear. Equal numbers of studies suggest increases and decreases in stream pH following land disturbance. There are many confounding influences."[55]

Perhaps one of the confounding influences is that when cations are leached out of the soil system, there may be an initial increase in surface water calcium in some circumstances.[56] Another important factor is the buffering capacity of soils. Soils in eastern Maine tend to be low in calcium. Indeed, some scientists wonder if the lack of calcium in the water may be a more serious problem than the low pH.[57] The rivers and streams in this region are not responding as well to the results of the Clean Air Act and the National Academy of Sciences as well as other reports have recommended liming.

**Pesticides.** I will here only discuss the most commonly used forestry herbicides and insecticides, rather than deal with pesticides used in agriculture or rights-of-way.

*Herbicides.* Herbicide can impact salmon indirectly or directly. One indirect way is to knock down the pioneer species that recolonize clearcuts. These pioneer species stop the leaching of nutrients discussed above. Herbicide spraying can therefore prolong high soil temperatures and nutrient leaching. The chemicals can also lead to less diversity of habitat for macroinvertebrates. The two most widely used forestry herbicides used in Maine are glyphosate and triclopyr. Glyphosate is moderately toxic to rainbow trout, especially eggs and fry, and triclopyr is highly toxic to rainbow trout and coho salmon.[58]

While researchers have not detected high levels of the chemicals in streams, there is definitely a potential for stream contamination. Small headwater or intermittent streams are least likely to be mapped or protected, but are highly vulnerable. The regulations for spraying pesticides in Maine do not require buffer zones, but do allow spraying in winds as high as 15

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[52] Kahl, pgs. 21 and 22

[53] Kahl, pg. 26

[54] Kahl, pgs. 26 and 27

[55] Moring and Finlayson, pg. 55

[56] *Status and Trends of Water Chemistry in Maine Atlantic Salmon Watersheds: A Report on the Conference Findings & Round Table Discussion*, prepared for Project Share, by Barbara S. Arter, April 2003, pg. 5

[57] *Status...*, pg. 7

[58] Moring and Finlayson, pg. 37

mph. A certain amount of drift is legal. And sometimes it pours after a spraying and there is runoff from the ground into streams.

A study of use of Roundup (glyphosate) in British Columbia had a 10 m buffer around tributaries visible from the air, with no buffer for streams not visible. The tributaries got oversprayed and stream litterfall was reduced by 94% due to defoliation of red alder and salmonberry. This led to increased sunlight on the water, warmer stream temperatures, and increased erosion ( the plants are important for stream bank stability) for up to 3 years. Nitrate levels increased 3-fold during freshets due to release of nitrates from dead roots. Streamwater phosphates also increased for up to 2 years. There was a 10-100-fold increase in algal production the year following spraying. This may have been due to increased phosphates in conjunction with increased light. Aquatic invertebrate abundance declined by 40-50%. Caged coho salmon showed stress for 2 weeks, while resident coho avoided the oversprayed tributary for 3 weeks. The surfactant used in the formulation is more than 4 times more toxic to salmon than glyphosate itself.[59]

*Insecticides.* The most widespread insecticides used in the Maine woods have been targeted primarily at the spruce budworm, although insecticides have been used on a much smaller scale on other insects, such as the yellow-headed spruce saw fly, Gypsy moth, and balsam woolly adelgid. The following discussion will be about the most common spruce budworm sprays and their impacts.

Maine sprayed against the spruce budworm from 1954 to 1985. By the 1970s, spraying was annual and covered millions of acres--the peak being 1976 with 3.5 million acres. The chemicals used against the budworm had indirect and direct impacts on salmon. Sometimes, as we shall see, the direct impacts were subtle, and not easily detected.

The first insecticide used, DDT, an organochlorine that was persistent and could bioaccumulate in the food chain, had a serious impact on salmon in both Maine and Canada. Maine finally banned the chemical in 1967 (note: this was years after Rachel Carson described the impacts of the chemical, including to salmon, in her 1962 classic, *Silent Spring)*. The state switched to using organophosphates and carbamates.

These new chemicals had devastating impacts to stream invertebrates. The most commonly used chemical, Sevin-4-Oil, for example caused major reductions in mayflies and caddisflies. In some streams stoneflies were completely wiped out and did not return for as long a monitoring continued.[60]

These types of pesticides cause depressions of acetyl-cholinesterase in the brains of fish. Changes in brain chemistry can affect behavior and survival. A 1972 Canadian study on trout predation of salmon exposed to fenitrothion (a chemical that was used in both New Brunswick and Maine), found that when salmon were exposed to 1 part per million of the chemical, 95% were eaten. Only 50% of unsprayed salmon were eaten.[61]

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[59]Yuka Ota and Charles Restino, *A Review of Ecological Effects of Biocides Proposed for use in FSC Certified Forests of the Northeast United States and Eastern Canada*, Falls Brook Centre, Knowlville, NB, 2001 available at www.forestsfornb.org/biocides.pdf

[60]Paul R. Adamus and Charles J. Spies, III, *Environmental Risk Assessment of 10 Pesticides Used in Maine*, Board of Pesticide Control, Augusta, ME, 1985, pg. 46

[61]C.T. Hatfield and J.M. Anderson, "Effects of two insecticides on the vulnerability of Atlantic Salmon (*Salmo salar*) parr to brook trout (*Salvelninus fontinalis*) predators." *Journal of Fish Resources board Canada*, Vol. 29,

Both Maine and New Brunswick also used Matacil. The "inert" carrier used in New Brunswick, but not in Maine, was 4-nonyl phenol, a nonionic detergent metabolite. A number of studies at the time showed toxic effects to fish, mostly from the carrier. It now turns out that nonyl phenol is an endocrine disrupter. Nonyl phenol is implicated in salmon kills on the Restigouche river in New Brunswick. The chemical causes an inability of juvenile salmon to survive the physiological transition required to move from fresh water to salt water.[62] The chemical can also imitate female hormones and interfere with reproductive abilities.

**Logging.** I treat logging separately from forestry because the same silvicultural prescription can be carried out in dramatically different ways with dramatically differing results, depending on the logging technology and techniques used. The most serious impact of logging to salmon is siltation and turbidity. Siltation is natural, but logging increases both chronic and episodic rates of siltation. Numerous studies have confirmed that most siltation comes from logging roads, trails, stream crossings (including improper use of culverts), and soil disturbance, rather than from mere removal of trees.

Siltation can also occur from bank channel erosion and tree uprooting. Both of these causes can be a consequence of logging. Bank channels are more likely to erode if deep rooted trees are removed. Trees are more likely to uproot if there are thinnings that leave stands that are not windfirm, or where residual tree root systems are damaged.

The threat of siltation from logging increases as the area, intensity, and frequency of soil disturbance increases. Most logging in the industrial forest of Maine is done mechanically with feller bunchers, grapple skidders, delimbers, and slashers working within a whole-tree logging system. The trails required to pull out whole trees, which include branches and tops, need to be quite wide, around 18 feet for hardwoods. A logging operation might require 25% or more of the area in just skid trails--plus there is the land taken out for whole-tree yards and roads. This leads to a lot of exposed soil area, even with a "partial cut."

Exposed soil is more apt to move with water or wind than soil held together with fine roots and covered with duff. When soil is rutted or compacted, this closes the pores between soil particles, impeding absorption or percolation. Instead, the water runs on the surface, taking soil particles with it. These impacts are further affected by slope, soil type, season (in Spring, the soil is most vulnerable to compaction and rutting), and watershed characteristics (where, for example are trails or yards located in relation to water bodies?).

The impacts of siltation to salmon can be very serious:

- Excess sediment can settle in spawning gravel, filling in breeding habitat.
- High levels of sediment can interfere with alevin emergence by suffocating and/or trapping alevins so that they cannot leave the environment.
- High levels of suspended solids (turbidity) can cause gill raker abrasion.
- High turbidity can alter foraging and territoriality of salmon.
- Fish might leave an area with high turbidity to find a more favorable stream section.
- Macroinvertebrates are likely to decline as a result of sediment and turbidity.
- The phosphorus associated with soils and sediment can lead to blooms of algae and decrease dissolved oxygen levels.

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1972, pgs. 27-29.

[62]WWF, *The Status...*, pg. 36

**V. How effective are current forestry regulations and voluntary restrictions for preventing adverse impacts and/or for restoring ecosystem processes?**

Maine has a combination of regulations (such as riparian zone restrictions and the Forest Practices Act) and voluntary guidelines (such as those found in Best Management Practices (BMPs), forestry certification, and easements). While supporters of these restrictions may be able to point to some progress in improving practices that these regulations and guidelines address, often the improvements are in spite of, rather than because of, the regulations and guidelines. The issue here is to what degree the regulations and guidelines *compel* landowners to prevent damaging practices. Rather than discuss voluntary landowner practices that go well beyond what is mandated, I will here discuss situations where some of the damaging practices previously discussed are legal under the law, certifiable under certification, or allowable under some "working forest" easements. The question therefore is what can landowners get away with if their major concern is to maximize wood removal with little care for the future?

**State Riparian Zone Standards.** Riparian zone regulations are the most important legal barrier put in place to prevent problems of siltation or increased water temperatures. The state has several sets of riparian zone management standards: one for the unorganized territories regulated by Land Use Regulation Commission (LURC) and the other for organized territories regulated by the Department of Environmental Protection (DEP). Towns can also have their own standards (with DEP standards as a minimum). The LURC and DEP regulations are similar to some extent--for example, requiring 75 foot buffers for smaller water bodies, such as streams, and 250 foot buffers for larger water bodies, such as rivers or lakes. The thresholds of when these standards kick in, however, are different. The DEP and LURC standards also differ in definitions of terms.

The MFS has proposed new rules designed to be more consistent statewide. As of this writing, the MFS is in the process of taking over regulatory responsibility from the other two agencies. It is these new regulations that I will discuss here.

The MFS was supposed to not only reduce inconsistencies in regulation, but also make the regulations less prescriptive, more results oriented, and ensure a "balance" with land use and forest protection. The result was to offer landowners a menu of options. For larger water bodies, for example, landowners can cut 40% of the volume in the 250 foot buffers over a ten year period (the old standard), or they can leave a windfirm stand that has at least 60 square feet of basal area of "woody vegetation" greater than 1 inch in diameter at breast height (DBH) (and 40 square feet have to be over 4.5 inches DBH), or they can come up with an alternative method that "provides equal or better protection" than these rules.

Although these new rules are among the most important forestry regulations impacting salmon, they fail on a number of levels--such as retention of large wood, degree of crown closure, or protection of headwater streams--to meet the basic requirements for preferred salmon/forest habitat.

Allowing the cutting of 40% of the volume in a ten year period does not allow full recovery. Most Maine stands only grow at a rate of 2-3% per year. This means that in year one, there would be 60% of the original stand left, and by year 10, this would grow to only 72% of the volume of the original stand. If another 40% is removed at this time (which would be legal under the rules), then the residual would only be 43% of the original volume.

The LURC minimum diameter was 6 inches DBH, yet the MFS decided to go for the DEP minimum of 4.5 inches DBH, which is based on merchantability standards, rather than biology. In either case, these standards allow diameter-limit cutting of the biggest trees, leaving only minimum-diameter trees in the buffer zone. Yet, large trees, having diameters of 20 inches or more, are key to wildlife habitat, let alone salmon stream integrity. If landowners cut to the minimum standards, larger trees will not be available.

The stocking standard does not refer at all to degree of crown closure. Yet a number of panels of "experts," such as the Maine Council on Sustainable Forest Management (MCSFM) have recommended that buffers have around 65-70% of full shade from mature trees. In stocking tables, full shade would be the A-line (see stocking chart from US Forest Service on right).

A closed-canopy softwood stand with an average diameter of 8 inches would have a basal area of around 180 square feet. Even if there were 60 square feet of trees over 4.5 inches DBH, this would only be 33% of full shade. Small diameter trees (1 or 2 inches) cast relatively short shadows. To shade a 5 ft. stream in midsummer, a 1 inch tree would have to be right on the stream bank to cast a shadow on the water. A 4 inch tree would have to be within 5-8 feet, and a 6 inch tree within 15-20 feet.[63]

While headwater (or first order) streams are, because of their size, most susceptible to impacts of temperature, siltation, or pollution, under the MFS standards, these streams have almost no protection except for a requirement for "shade," which can come from any vegetation (not just trees) and for stable stream channels. No buffer is required at all. Yet the MFS, in its discussion of the justification for the standards states that "shading of surface waters can be very important on small streams and water bodies, whereas shade becomes largely irrelevant on

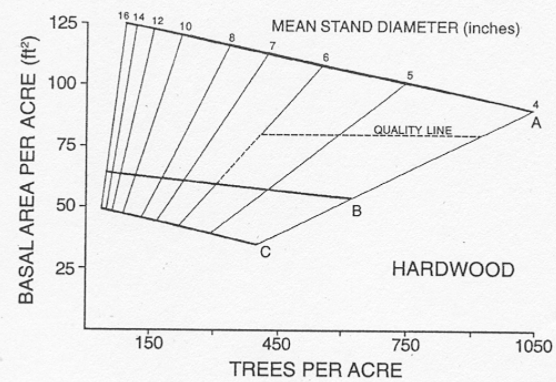


Figure 1.—Stocking chart for northern hardwoods is based on trees in the main crown canopy. The A line is average maximum stocking. The B line is recommended minimum stocking for adequate growth response per acre. The C line defines the minimum amount of acceptable growing stock for a manageable stand. The quality line defines the stocking measure in young stands for maintaining quality development.

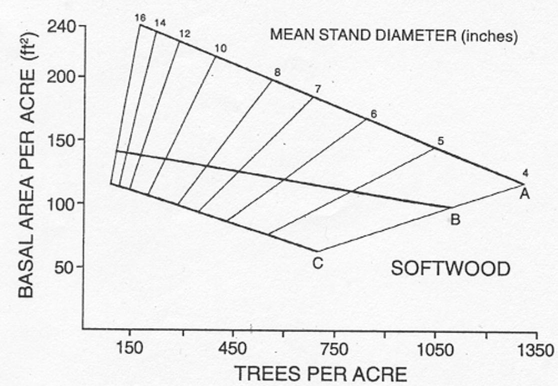


Figure 2.—Stocking chart for spruce—fir stands is based on trees in the main crown canopy. The A line is average maximum stocking. The B line is recommended minimum stocking for adequate growth response per acre. The C line defines the minimum amount of acceptable growing stock for a manageable stand.

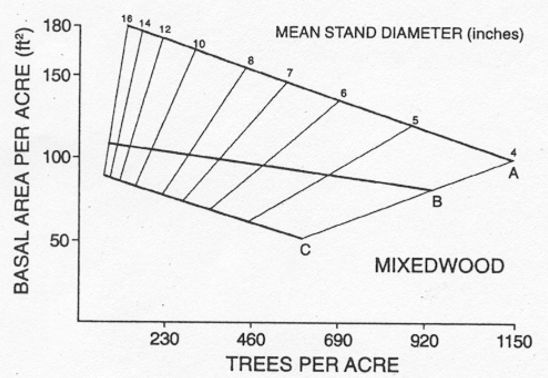


Figure 3.—Stocking chart for mixedwood stands is based on trees in the main crown canopy. The a line is average maximum stocking. The B line is recommended minimum stocking for adequate growth response per acre. The C line defines the minimum amount of acceptable growing stock for a manageable stand.

[63]Rob Bryan, letter to Maine Forest Service, 1/21/02 .

larger rivers and ponds."[64]

A literature review on impacts of harvesting to salmon habitat concluded that, "buffering small streams from fluctuations of water temperatures is especially important for Atlantic salmon, as small, first-order streams constitute 20-40% of the available habitat for salmon and represent the principal nursery habitat for juvenile fish in their first two years of life."[65]

The setbacks for roads are less for streams (which are more vulnerable to damage) than rivers and lakes: 100 feet for water bodies qualifying for larger buffers and 50 feet for those qualifying for smaller buffers. With trails, the figure for both is 25 feet. There is no setback requirement for headwater streams, but operators are supposed to avoid siltation.

In some cases, the flood plain of streams or rivers is wider than the trail set backs or even than required buffers. This means that high waters can flow over disturbed soil and cause siltation.

Riparian zone standards do have the potential to reduce some of the worst impacts of harvesting if followed. In the past, LURC has been severely understaffed to regulate cutting in shorelands in its 10.5 million acre district. It will be a challenge for the MFS to assure that riparian zone standards are adequately regulated over the half a million acres cut in Maine each year. In many cases, regulatory agencies do not know that a violation has occurred unless they are notified by the public. In many remote cutting areas, there aren't many people watching.

**Forest Practices Act.** Although the Forest Practices Act (FPA) does not specifically address riparian zone management, to the extent that required riparian zones are small or nonexistent (such as for headwater streams) the FPA regulations become the de-facto riparian zone rules. What happens outside of riparian zones also can have an influence on the degree of mature forest cover over a wide area and can thus influence extremes of water flow.

The FPA defines what is a clearcut, how large clearcuts can be, how far apart clearcuts must be separated, and what is the minimum stocking of wood in the separation zones. The FPA does not address such issues as overcutting or highgrading.

Clearcuts have dramatically declined since the FPA was enforced in 1990, but this reduction was not compelled, it was voluntary. The level of clearcutting in 1990 was legal under the FPA. The public, however, complained and there were several (failed) referendums to restrict clearcutting that sent a strong message to landowners. The heavy cutting of the 1980s was also, to some extent, a response to a spruce budworm outbreak that caused substantial mortality in fir and spruce. This excuse for clearcutting no longer applied during the 1990s.

A landowner who wants to maximize wood removal under the FPA can cut more than 90% of all the volume over a previously well-stocked landscape (excluding areas such as riparian zones and deer yards) by:

- making clusters of clearcuts smaller than 20 acres (thus a Class 1 clearcut),
- having a separation zone of 250 feet (in clustered clearcuts where the clearcuts are 20 acres, the separation zones would add up to 37% of the landscape), and
- leaving the minimum stocking in separation zones (30 square feet of basal area).

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[64]Maine Forest Service, *A report of the Department of Conservation's Maine Forest Service to the Joint Standing committee on Agriculture, Conservation and Forestry, Submitted in Compliance with Resolves, Chapter 101 of the 120th Legislature, 18 Feruary, 2003*

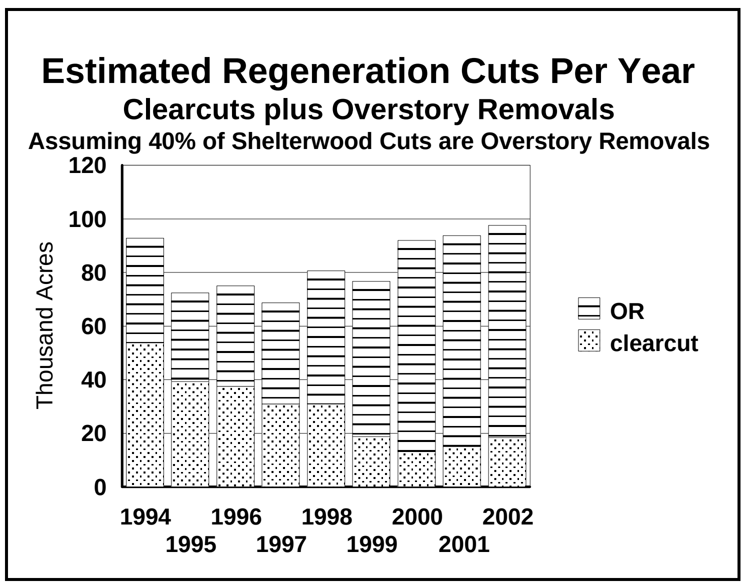
[65]Moring and Finlayson, page. 12

If the original stocking is 120 square feet, this would mean that one could legally remove 75% of the separation zone which would mean that over the landscape, less than 10% of the original stocking would be left (0% in the 63% clearcut and 25% of the 37% in buffer zones). Before 1999, the situation was even worse, as Class 1 clearcuts could be 35 acres.

What can be done, has been done. In 1995, the Maine Forest Service published a study that revealed that between 1991 and 1993 there were 68 townships that had more than 1,000 acres of clearcuts during the study period, and 48 of these townships had large clearcut clusters.[66] In 11 townships, these clusters covered 28,000 acres, or an average of 2,545 acres per township. Such large areas of clearcuts can dominate small watersheds.

While clearcutting has dramatically declined in acreage since the FPA was first enforced, shelterwood cutting has increased. Shelterwood is an even-aged system where the stand is first partially cut one or more times to establish regeneration before final removal of the rest of the stand. If a stand has advanced regeneration, removing all the marketable trees is not considered a clearcut--it is an *overstory removal*. Stands that have had overstory removals can have some of the same impacts on watersheds as clearcut areas that have grown a few years. For example, there can be rain-on-snow events that lead to extremes of water flow.

Changes in water flow can also be caused by changes in forest type. Hardwoods, which have no leaves in winter, offer less shade than spruce and fir. Snow tends to melt earlier and faster in the spring under hardwoods than under softwoods. Since 1982 the spruce-fir type has decreased from 7.8 to 5.2 million acres. The FPA has no influence over highgrading or type changes.




The acreage of official "regeneration cuts" (combined clearcuts and overstory removals) was actually greater in 2002 (97,583 acres) than in 1994 (around 92,800 acres), even though the acreage of clearcuts declined. These figures do not take into account the acreage of "selection cuts" that leave barely more than 30 square feet of basal area and are really regeneration cuts because the overstory is incapable of reaching canopy closure. Maine currently has close to 5 million acres of seedlings and saplings. This is an increase of around half a million acres since 1995, even though "clearcutting" has gone down considerably since then.

If desired, a landowner could, theoretically, liquidate most of a watershed quite legally under the FPA. The constraint to prevent this has more to do with markets and landowner objectives than with any regulatory restraint.

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[66]Maine Forest Service, *An Evaluation of the Effects of the Forest Practices Act*, MDOC, Augusta, ME., 1995

**Best Management Practices.** By Federal law, all states with commercial forests must have some rules or guidelines designed to minimize non-point source pollution to surface waters. In around half of these states, including Maine, these guidelines are followed voluntarily. Maine's guidelines are called "Best Management Practices," or BMPs. In Vermont, such guidelines are called, more appropriately, "Acceptable Management Practices," eliminating the misperception that such practices are the best one can do, rather than the minimum level of acceptability.

BMPs relate mostly to construction of roads, woods trails, landings, and stream crossings. They are designed to minimize or eliminate movement of soil from the forest to water bodies, where there can be adverse impacts to fish and other aquatic wildlife and to water quality. Loss of soil can also have adverse impacts to forest productivity.

With such voluntary guidelines, there are two major questions:

- To what extent do landowners follow the guidelines?
- How effective are the guidelines if followed?

*Compliance*. There are two recent studies that have addressed these questions.[67] A Forest Advisory Team, in analyzing compliance figures for the first study, gave out grades ranging from A to F, with more than 90% compliance rating an "A" and less than 60% compliance rating an "F." Of the 60 BMPs examined, 38% scored "F," but only 23% scored "A." The majority (53%) scored "D" or below. Some other findings were counterintuitive. For example, increased awareness of BMPs did not lead to increased use of BMPs. Also, forester supervision of harvesting had no better results than no forester at all.

The more recent study found slightly better performance, but the conclusion was that there is still "substantial room for improvement."[68] Once again, there were counterintuitive results. Commercial landowners (industry owned or large landownerships managed primarily for commercial timber production) only used BMPs appropriately 30.5% of the time. Non-industrial private landowners used BMPs appropriately 45.6% of the time. Also, BMPs were used appropriately 37.9% of the time with forester involvement but 46.2% with no forester involvement.

*Effectiveness.* Both studies showed significant improvements at preventing soil movement when BMPs were used appropriately. But following BMPs does not stop all problems. According to the 1996 study in some individual cases, compliance still resulted in major sedimentation. For example, around one fourth of compliant sites that followed the BMP for right-angle stream crossings and one third for hard bottom stream fords had major sediment movement. In contrast, 95-100% of non-compliant sites for these BMPs had major sediment movement. For a number of BMPs, compliant sites had a large percentage of minor sedimentation (movement of sediment but no delivery to surface waters), but, once again, non-compliant sites had much worse results.

The 2002 study had similar findings, but the percentage of sites where sediment reached the water when BMPs were appropriately used was even smaller, with a few (1.7%) being rated

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[67]Russell Briggs, Alan Kimball, and Janet Cormier, *Assessing Compliance with BMPs on Harvested Sites in Maine: Final Report*, CFRU Research Bulletin 11, Orono, ME, 1996, and
Maine Forest Service, *200-2001 Maine Forest Service Report on Forestry Best Management Practices Use and Effectiveness in Maine*, MDOC, Augusta, ME, 2002.

[68]MFS, 2002, pg. 11

as ineffective due to minor soil movement to water, and none having major soil movement into water.

Janet Cormier, a soil scientist who worked on the first study, issued her own report, where she discussed why BMPs are not always sufficient for halting sedimentation problems.[69] Although the BMPs do factor in slope, they do not deal with soil type (texture, drainage, erodibility, depth to limiting factors, etc.) nor with watershed characteristics (size, runoff or seepage amounts and patterns, location of site within a watershed, etc.). Some sites, she argued, may require exaggerated BMPs, while other sites could be unnecessarily disturbed if certain BMPs are followed to the letter.

Logging disturbances that expose mineral soil, for example, are not covered by BMPs, but can cause erosion and sedimentation. Even on well-crowned road surfaces, Cormier found that erosion can occur on long slopes, especially with the development of any ruts. Stream crossings, she concluded, were problematic and needed further refinements. Certain highly erodable soils (especially ground that is wet and does not freeze, and steep hardwood sites) are not well protected by BMPs. Cormier found skidder ruts on steep, wet slopes that became new stream beds.

Steve Kahl, of the Water Research Institute at the University of Maine, presented further critiques of Maine's BMPs in a literature review he did of the effects of logging on water quality.[70] Like Cormier, Kahl pointed out that BMPs do not deal with compaction, rutting, forest soil disturbance, and destruction of the organic pad during logging. But Kahl further pointed out that the *intensity* of cutting can also have major impacts on water quality.

Large, intense cuts (especially whole-tree clearcuts) can cause an increase in water flow. This can lead to more severe fluctuations of water levels, more erosion of stream banks, and more erosion of forest floors. To the degree that there is little vegetation on the ground, this can lead to increased temperatures (which can be damaging to cold-water fish species, including salmon), increased breakdown of organic matter, increased nitrification (leading to acidification of the soil), increased leaching of cations (such as calcium, magnesium and potassium), and higher proportions of aluminum to calcium (which can affect plant growth and the survival of fish).

Kahl cited research showing severe losses of the organic pad from some clearcuts. This can lower forest productivity and decrease the viability of softwood seedlings. Both Kahl and Cormier expressed concern over whole-tree logging where slash is not left on the site, but is instead left in huge piles roadside, creating problems in both cases. Kahl concluded that BMPs neither adequately protect water from short-term problems nor do they enhance forest sustainability.

Kahl was very concerned over the lack of protection for small tributaries and headwater streams. These are the most vulnerable to impacts from temperature change, increased water flow, sedimentation, and chemical change, yet these receive the least protection. The 2002 study by the MFS stated that intermittent and 1st order streams were by far the most prevalent water bodies in or near harvest areas. Indeed, these smaller streams were at 78.4% of these sites. Only 3.9% and 4.4% of the sites with water had 3rd order streams or lakes nearby.

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[69] Janet Cormier, *Review and Discussion of Forestry BMPs,* MDEP and USEPA. 1996

[70] Steve Kahl, *A review of the effects of forest practices on water quality in Maine*, UMaine, Orono/DEP, Augusta, 1996

**Certification**. Certification has the potential to encourage landowners to operate at higher standards than those found in regulations. Rather than use the "stick" of regulations and penalties, certification uses the "carrot" of public recognition, better market shares, or even market premiums. A number of very big buyers, including Home Depot or Time Warner, are placing an emphasis on buying certified wood.

There are two major certification systems in Maine: the Sustainable Forest Initiative (SFI) and the Forest Stewardship Council (FSC). They both offer a comprehensive set of goals and standards with third-party audits to ensure that the landowners are meeting these goals. By the summer of 2003, Maine had 6.5 million acres certified by a third-party audit by these two systems. Governor Baldacci's goal is to have 10 million acres of forest land certified in Maine by 2005.

Forest certification is a relatively new phenomenon. Maine's first certified landowner, the Pingree heirs, managed by Seven Islands, was certified in 1994 by Scientific Certification Systems. The company is now certified by both FSC and SFI.

Both certification standards, because they are relatively new, are evolving. Because they are responding to similar issues, they contain many similarities. But a number of studies, including a *Report of the Speaker's Advisory Council on Forest Certification, January 2002,* on *Certification in Maine*, have found significant differences as well. Many of these differences are a reflection of the origins of the systems: SFI was a creation of the American Forest and Paper Association, while FSC was initiated by international environmental organizations.

For the purposes of this report, I'll only deal with issues relating to riparian management zones and protection of biodiversity and endangered species. While both systems address these issues, the two differ in approach, level of detail, and degree of prescription. With protection of water quality, the Speakers Advisory Council found few differences. Both systems emphasized following Best Management Practices, and having written plans and trained staff.

With biodiversity, SFI talks about policies that "promote wildlife habitat diversity, forest types, ecological or natural community types and the conservation of biological diversity."[71] These standards also require programs to protect federally-listed threatened and endangered species and to protect sites associated with critically-imperiled and imperiled species and communities. FSC Northeastern Standards require protecting genetic, species, and ecosystem diversity. The goal is to "maintain habitat sufficient to support healthy and well distributed populations of all native species, except species dependent on old growth, at the landscape level." (old growth is dealt with under separate standards). Under FSC, not just federal, but also state and non-listed sensitive or rare species must be protected.

Given such laudatory goals, one would think that forest management in areas that could support salmon populations would be exemplary on certified acreage, no matter which system is used for certification. The reality, however has not quite lived up to the rhetoric yet.

All industrial landowners are certified under SFI. In 2001, industrial landowners, who, on an acreage basis, did 28% of the cutting, did 82% of the clearcuts, 83% of plantations, and 91% of herbicide spraying in Maine. As mentioned in the section on BMPs, commercial landowners (over 60% of whom are certified by SFI and/or FSC)[72] had a slightly worse record of following BMPs in an appropriate manner than noncommercial landowners.

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[71] *2002-2004 SFI Standard and Verification Procedures* 4.1.4.1.1

[72] Speakers Advisory Council, 2002, pg. 48

Despite the admirable goals and guidelines, auditors have a tendency to cut landowners a bit of slack. Indeed, in 2002, a number of landowners certified under SFI or SFI and FSC not only violated voluntary guidelines, such as BMPs, but also violated state forest practices laws. For example, according to LURC records, Seven Islands and Pingree heirs (certified under both SFI and FSC) had 3 violations for culvert washout and unstabilized water crossings, J.D. Irving (certified under both SFI and FSC) had 2 violations for unstabilized water crossings and management roads in excess of standards, Bureau of Parks and Lands (certified by both SFI and FSC) had 3 such violations, and Plum Creek (certified by SFI) had unstabilized crossings around 2 streams.[73] During the same period, Plum Creek and J.D. Irving even violated the Forest Practices Act (which, given its low set of hurdles, is a rather dubious distinction).[74]

In early 2003, I did an intensive analysis of the FSC certification of J.D. Irving and found that auditors had engaged in serious grade inflation in some circumstances.[75] For example, SCS gave Irving a grade of "95" for watercourse management policies and programs. For SCS, an "ideal performance" would include management maintaining water quality and fish habitat and riparian habitat conditions associated with undisturbed forest. Irving has its own fisheries biologist in New Brunswick. The company does its own stocking of New Brunswick rivers with salmon. The SCS team was impressed that Irving has increased the riparian zone beyond what is legally called for (instead of a 75 foot buffer, Irving requires a 200 ft buffer), but they did not say what stocking Irving requires for this zone, especially for small and intermittent streams.

While the riparian zones take up 10% of Irving's certified land base, Irving has been getting 8% of its spruce-fir volume from this area. I visited the Blackstone district of Irving land in Maine and did not find 200 foot buffers of mature trees. In some cases, I wondered where the buffers were. I finally got to see the spec sheets of some logging contractors and found that loggers are allowed to do overstory removals to within 15 feet of a stream. Eighty seven percent of the 200 foot buffer, therefore, can be 5 foot high trees. This is a far cry from the recommendations (cited earlier) from the Maine Council on Sustainable Forest Management to have a minimum of 75 foot buffers with 65-70% of full crown closure.

In addition, around 85% of all cutting on Irving's Maine holdings are done with feller bunchers and grapple skidders. If loggers cut trails to the width and distribution specified on the contractor spec sheets, 25% of the area to be cut would be in trails. These are trails where whole trees, including branches and tops, are dragged. Wheel ruts in soft or wet soils can be deep.

If riparian zones are to function as wildlife corridors or nesting habitat, then they need to be a lot wider than 15 feet. A 15 foot buffer abutting 65 feet of overstory removals that abut clearcuts hardly resembles the "undisturbed forest" that would qualify as ideal performance. FSC certification tends to be more rigorous than SFI on ecological issues. Current performance, therefore, shows great room for improvement to meet stated goals. Because there are stated goals for protecting biodiversity and protecting endangered species, however, there is potential for certification to play an important role in protecting salmon habitat if enough people demand that the practices on certified lands are consistent with the certification goals.

The Master Logger Certification Program directly certifies loggers, rather than landowners. The logger has a series of harvest responsibilities and performance standards.

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[73]William Galbraith, LURC, personal communication, 7/11/03

[74]Donald Mansius, MFS, personal communication, 7/10/03

[75]see http://www.meepi.org/files02/irvintro.htm for this report on *Grade Inflation? SCS certification of Irving's Allagash Timberlands*

Some of these deal with protecting water quality and forest ecosystems. The performance standards require planning, proper use of BMPs and followup monitoring.[76] For this system to be effective at preventing harm in salmon areas, there would need to be an appropriate plan from the landowner, appropriate equipment that minimizes trails and yards, and effective monitoring of the loggers to ensure that they are really following all the performance standards.

**Easements**. Starting in the 1990s, a number of large industrial and non-industrial landowners have sold easements on hundreds of thousands of acres of Maine forest land. With full-fee purchase, the buyer gets all the rights associated with the land. With easements, the landowner is selling only part of the bundle of rights associated with ownership. In many cases, the most important issues addressed in the easement are the rights to subdivide the land and the rights to convert the land for development. This is true, for example, for the 762,000 acre easement sold by the Pingree heirs. This easement has little impact, however, on forest management.

Some of the easements contain specific language regarding protection of wildlife habitat or riparian zones. Easements, have the potential to tailor requirements for landowners to protect salmon habitat. In some cases, such as for the Machias River, easements have been written specifically to protect salmon habitat. Some of these new easements combine full-fee with partial fee arrangements.

On the Machias, the easement holder (The Nature Conservancy), has timber rights to the first 250 feet on either side of the river. These 250 feet represent a no-cut zone. Between 250 and 660 feet, the landowner can cut timber, but must leave 60 square feet of basal area of hardwood, 80 square feet of mixedwood, or 100 square feet of softwood. Between 660 and 1000 feet from the water, regular commercial cutting is allowed, but no development. Pesticide use is also restricted in the 250-660 foot zone to be used only in emergencies, but not restricted in the 660-1000 foot zone.

On the Dennys River, the Atlantic Salmon Commission bought (full fee) 1000 feet (some times less, and sometimes up to 3,000 feet) outright on either side of the river. This, therefore, is not an easement. The management plan by Kleinshmidt Consultants calls for three zones. The first Habitat Protection Zone calls for no cutting for 250 feet. The Limited Use Zone (from 250-1000 feet) allows limited cutting, leaving 100 square feet of basal area (regardless of timber type). The General Use Zone, allows cutting as usual.

The basal area requirements on either the Machias or Dennys would not leave the 65-70% crown closure recommended by the book, *Biodiversity in the Forests of Maine: Guidelines for Land Management.*[77] For softwood the basal area would have to be somewhere between 125 and 140 square feet, depending on average tree diameter. However, the 250 foot no-cut zone, before the cutting standards even kick in, is as big as the state-required riparian buffer, and the restricted cutting zone is in addition to this. Such a large no-cut zone insures minimal problems from siltation, or increased temperatures coming from the riparian zone..

Large riparian zones can play important roles for wildlife habitat. Narrow zones surrounded by clearcuts are mostly edge and are not adequate to support viable populations of wildlife that need interior habitat.[78] Riparian zones as wide as 656 feet are recommended by one

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[76]*The State of Maine's Master Logger Certification Program*, Professional Logging Contractors of Maine, Ft. Kent, October, 2002

[77]Elliott, pg. 52

[78]B. A. Meiklejohn, *The Value of Buffer Strips as riparian Habitat in Northern Forests*. M.S. Thesis, Univ. of

researcher to accommodate the breeding-territory requirements of most songbirds.[79] Large riparian zones also can act as wildlife travel corridors, for migration and dispersal.

These large, highly protected riparian zones, however, are not adequate, by themselves, to protect against the worst impacts to salmon. The most sensitive zones to siltation, temperature increases, extremes of water flow, or acidification are on the *smaller streams*, which, for the most part, have minimal protection on either the Dennys or the Machias, except when they occur in the 1000 foot zones around the rivers.

While the MFS riparian standards for 1st and 2nd order streams are minimal, some landowners in salmon habitat areas have voluntarily established higher levels of protection. Champion International, before it was bought out by International Paper Company, had 75 foot buffers for intermittent streams and 100 foot buffers for 1st and 2nd order streams where removal is limited to 30% over a 10 year period. On 3rd order streams the buffer is 330 feet, and 4th order 660 feet. Research by Project SHARE on the Narraguagus, however, still found siltation coming from land managed by that company due to faulty culverts, poor ditching, road runoff, and unstable shoulders.[80] Some buffers on small streams were also very thin. The study concluded that a shift from in-house road crews to road maintenance by contractors has led to a breakdown in communication regarding sites and decreased accountability.[81] If International Paper Company sells the land, there is no guarantee that the next landowner will adopt similar buffer zone standards.

To have true watershed protection, therefore requires more than just buying rights around major water bodies. The Nature Conservancy bought whole watersheds, including headwater streams, on the St. John River. On the St. John, TNC has no cut zones as large as 50-250 feet on streams that are 2nd order or smaller and 100 to 250 foot no-cut zones for 3rd order or larger streams. There are also expansion zones, to incorporate other wildlife habitats, such as deer yards (in Maine, around 85% of deer yards are in or near riparian zones). Cutting restrictions outside of these zones (up to 250 feet for small streams and 500 or more feet for larger streams) are based on removing no more than 33% of basal area per acre over a 20 year period. This ensures minimal disturbance.

## VI. What changes in forest practices would help restore habitat to be within the historic ranges to which salmon are adapted?

Rather than protect large streams and rivers with buffer zones and allow management within legal guidelines for the rest, this report recommends a whole landscape approach. A landscape approach is based on the precautionary principle, the common-sense approach of looking before you leap and keeping your options open. When there is the possibility of harm, an ounce of prevention is worth a pound of cure. It is easier to prevent species loss than to correct it. The idea is to ensure that the forest somewhat resembles the structures into which salmon and other creatures have been adapted for hundreds, if not thousands, of years. To the degree that

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Vermont, Burlington, VT. 41 pgs.

[79]D.F. Stauffer and L.B. Best, "Habitat selection by birds of riparian communities: evaluating effects of habitat alterations." *J. Widl. Manage:* 44:1-15, 1980.

[80]Barbara Arter, *Narraguagus River Watershed Nonpoint Source Pollution Management Plan* , for Project Share and Narraguagus River Watershed Council, MDEP at http://www.salmonhabitat.org/nr_wmp02.pdf, Project Share, 2003

[81]Arter, pg. 28

management veers far from such structures, all bets are off for long-term survival of the full range of species.

There is also recognition that this is a changing landscape, not a static one. Stands develop and change over time. Old stands can collapse and become early-successional. Early-successional stands grow into pole stands. Pole stands get bigger, becoming sawtimber. Trees die, and late-successional, uneven-aged qualities develop.

Managers, therefore, need to anticipate and plan for change. To ensure all native species are able to persist in the forest, managers need to make sure that all the habitats required by these species are present somewhere on the landscape. The most challenging habitats to plan for are late successional. If there is not enough early successional habitat on the landscape, this can be fixed in a matter of days. If there is not enough late-successional habitat in the landscape, it will take more than a century to remedy.

**Long rotations.** There are two ways to grow or maintain late-successional habitat; even-aged and uneven aged. With even-aged approaches, managers need to plan for long enough rotations for the recovery of large-diameter trees and snags. Such rotations are longer than what is common on industrial lands. Industrial landowners normally plan for rotations of 50-80 years. An analysis of the 2001 MFS inventory and annual silvicultural reports estimated that at least 60% of cutting on industry land is by even-aged methods (clearcuts or shelterwood) and, based on the acreage of regeneration cuts (clearcuts and overstory removals), the apparent average rotation time is around 60 years.[82]

A USDA Forest Service study in New Hampshire, found that rotations of less than 110 years in northern hardwoods only produce marginal amounts of large-diameter cavity-dwelling/foraging habitat. Rotations of fewer than 60 years would produce none.[83] A recent computer simulation by Maine Audubon concluded that 70-year rotations in either hardwoods or spruce-fir would be unlikely to meet goals of large wood and large snags, and that a combination of in-stand retention, longer rotations, and a mix of silvicultural techniques would be needed.[84]

If rotations are 110 years (long enough to produce marginal amounts of large snags), that would mean that less than 1% of the landscape would have this late-successional habitat. The formula for determining rotation length is R = L/(1-p), where: R = rotation length; L = length of time required to return to a late-successional structure; and p = target for proportion of the landscape with late-successional characteristics in the landscape.[85] Based on this formula, even a 150-year rotation (which is being used on some of the Bureau of Parks and Lands public lands) would only yield 27% late-successional habitat in the landscape.

**Refugia and recolonization.** Another challenge of planning on the landscape is to make sure that recovering late-successional habitat is adjacent to or near existing late-successional habitat.

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[82]Mitch Lansky, *Where are we Headed: An Analysis of Forest statistics for Maine, 2001*, Wytopitlock, 2003

[83]C. Tubbs and M. Yamasaki, "Wildlife Management in New England northern hardwoods," in John Bissonette, ed., *Is Good Forestry Good Wildlife Management?*, Maine Ag. Exp. Sta., U Maine, Orono, 1986, pg. 120.

[84]Rob Bryan, *Long-term Impacts of Timber Harvesting on Stand Structure in Northern Hardwood and Spruce-fir Forests: Implications for Biodiversity and Timber Production.* Maine Audubon, 2003.

[85]David Perry, "Ecosystem silviculture: ecological principles, implications for communities," *Canadian Silviculture Magazine*, July/August, 1994

Merely growing older trees does not mean that one is going to have the full range of species associated with those trees--if there are no source areas anywhere nearby to supply those species. Some of the species associated with late successional forests (insects, fungi, lichens, and mosses) have poor dispersal rates. Even if there is good dispersal ability, there needs to be suitable habitat conditions before the stand can be recolonized. Not losing such species is more cost-effective than trying to restore them later.[86]

The source areas of species are called refugia. They can be large blocks of intact habitat on the landscape, or they can be "biological legacies" (such as old trees, snags, downed logs, etc.) that are retained in a stand after a disturbance (including cutting). Simply leaving a few large dead trees in the stand and cutting everything else may not be adequate. Large, dead-standing trees normally disintegrate within 40 years, so with a 70 year rotation, there would be no such trees left.[87]

Successful legacy retention, therefore, needs to ensure that not only large snags are kept, but also recruitment large trees and snags. This can be done by retaining patches, or even individual trees in a stand (depending on what is being retained and whether even-aged or uneven-aged systems are being used). The best way to do even-aged management with retention is to use an irregular shelterwood, where the overstory is not completely removed during the regeneration cut. While the science of how much to retain is currently not definitive, it makes sense to retain something (the more the better) rather than nothing while waiting for more concrete results.[88] Leaving a few scattered reserve trees (9-13 square feet of basal area per acre) only offers limited benefits, while leaving significant reserves (44-65 square feet) starts to approach true multi-cohort structures.[89]

With uneven-aged management, it is far easier to ensure that there are well-stocked stands with larger trees and snags on the landscape.[90] Large old trees and large snags are less likely to blow over when surrounded by other trees, and it is easier to ensure recruitment of replacement older trees. Foresters can target slower-growing, suppressed trees for harvest and leave larger-diameter dominant trees that are still vigorous to keep growing.

Diameter-limit cutting, which some landowners equate with "selection," is not an appropriate means of managing for late-successional, uneven-aged structures. The object should be to *retain* large trees, not cut them all down once they have reached a determined diameter. Diameter-limit cutting can lead to less windfirm stands ( by cutting dominant, windfirm trees and leaving suppressed trees with poor root systems) and can degrade stands. A study at the Penobscot Experimental Forest in Bradley, Maine concluded that diameter-limit cutting "resulted in diminished stand quality, poor control of residual stocking, and unfavorable shifts in species composition [...] These findings imply that fixed diameter-limit cutting results in residual stands of slower-growing, smaller, and potentially less valuable trees."[91]

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[86]Andrew Whitman and John Hagan, "Legacy retention: a tool for retaining biodiversity in managed forests," *Mosaic Science Notes* #2003-1, April 2003, Manomet Center for Conservation Sciences, Brunswick Me.

[87]Bryan, 2003

[88]Whitman and Hagan, 2003

[89]Seymour et al, 2002, pg. 363

[90]Bryan, 2003

[91]Laura Kenefic, Paul Sendak, John Brissette, Kevin Sobal, and Michael Greenwood, "Diameter-limit versus selection cutting in northern conifers," from *Conference Proceedings of Eastern CANUSA Forest Science*

**Riparian zone management**. Part of landscape planning is identifying and protecting riparian zones. In our survey of regulations, easements, and landowner standards, we have seen that there is a great variation in recommended width and stocking for riparian buffers. For small streams, the recommendations range from the MFS, which requires "shade" and stable banks to The Nature Conservancy which has a 50-250 foot no-cut zone on the St. John watershed and a limit of cutting 33% in a 20 year period for the zone where cutting is allowed. In between there are basal-area requirements that range from 60 square feet for all timber types to 100 square feet for all timber types.

Kleinschmidt Associates wrote a report for the Maine State Planning Office on a *Method to Determine Optimal Riparian Buffer Widths for Atlantic Salmon Habitat Protection.*[92] This report suggests having two zones--a no-cut zone (35 feet wide), and a variable-width buffer where low-impact logging can occur. Using the method suggested by Kleinschmidt, landowners would determine primary attributes, such as slope, soil type, and degree of canopy closure, and secondary attributes, such as surface roughness, surface water features, groundwater seepage, sand and gravel aquifers, floodplains, wetlands, very steep slopes, and stream order. Based on these attributes, the landowner uses a key to determine buffer width, which can vary from 70 feet to 230 feet. The recommended minimum stocking for zone 2 (where cutting is allowed) is 80 square feet of basal area for softwood, 70 square feet for mixed wood, and 50 square feet for hardwood.

The recommendations to have a no-cut zone and to take into account watershed characteristics, such as slope and soil type, for the variable width area where cutting is allowed is sound. The no cut zone, however, should also be variable width. For example, if there are very steep slopes associated with a stream, the no-cut zone should increase.

The Kleinschmidt stocking figures are much lower than the recommendation (already mentioned) of the Maine Forest Biodiversity Project and the Maine council on Sustainable Forest Management to have 65-70% of full shade. Kleinschmidt's recommendation is closer to 40-45% of full shade.

A low-impact approach to riparian zones would have three, rather than two zones. Zone 1 would be no cut, and would be variable, based on slope and other site attributes. Zone 2 would allow cutting, but not soil disturbance. Trees can be cut, for example, with chainsaws and winched out of this zone, but no heavy equipment requiring trails or other soil disturbance would be allowed. Equipment could be used in this zone, however, if the ground is frozen and there is no chance of soil disturbance. In zone 3 loggers can move equipment on trails, but not roads, and these trails would be reduced in size and distribution with low-impact techniques.

For example, on a stream with no problems of slope or other attributes requiring expansion, there could be a 35 foot no-cut zone combined with a 75 foot (based on length of cable on winch) cut zone but no soil disturbance. This would lead to a combined 110 foot no soil disturbance zone, even though trees, in part of the zone, could be removed. Beyond this zone, low-impact logging would extend the habitat benefits, but some soil disturbance would be allowed for trails. Cutting when ground is frozen or dry would prevent serious siltation problems arising from this zone.

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*Conference*, Oct 19-20, 2002, University of Maine, Orono

[92]Kleinshmidt Associates, *Method to Determine Optimal Riparian Buffer Widths for Atlantic Salmon Habitat Protection,* Maine State Planning Office, 1999

Besides the width and stocking of riparian zones, managers need to also consider tree size and species. In choosing what trees to retain, managers should select trees that are windfirm (preferably deep-rooted) and that are of long-lived species. Too often, loggers are told to cut by a diameter limit. This can mean cutting dominant, windfirm trees and leaving suppressed trees with poor root systems. When trees blow over, this can lead to soil disturbance that can contribute to siltation.

One of the more important management needs is to reduce the balsam fir content of stands, favoring red spruce, pine, cedar, and northern hardwoods. Fir is not only short lived and subject to blowdowns, it is also highly vulnerable to spruce budworm. Heavy cutting to "salvage" for spruce budworm has had a major impact on the stand structure of many landscapes in northern and eastern Maine.

Rather than restrict late-successional habitat to buffer zones along large rivers, it makes sense to have such habitat also in headwater regions. This ensures cross-watershed migrations and also protects the most sensitive water bodies from problems associated with frequent, heavy disturbance.

This report emphasizes having *most* of the landscape be well-stocked, rather than just have such stocking in riparian zones. The stocking tables developed by the US Forest Service are based on thousands of plot samples. Thinning to the B-line is recommended for an adequate growth response per acre, especially when tree quality is a concern. The B-line is around 60% of full stocking (more or less, depending on average tree diameter). Managing for growth and quality over the landscape means that riparian zones are not narrow, isolated bands of trees surrounded by heavily-disturbed openings. Instead, the riparian zone and the rest of the forest are part of a continuum and are functional, interior habitat, not just edge.

According to Seymour, et al, there is no justification to "emulate" large-scale catastrophic disturbances to prevent the loss of early-successional communities. "Most such disturbances will occur regardless of human activity."[93] Heavy disturbances, therefore, should make up a small percentage of the landscape, not dominate it with retention islands and buffer zones left to represent mature forest.

**Remediation.** While low-impact forestry approaches will, eventually, lead to a landscape with ample old, large trees to supply habitat structure to streams, such trees will take many decades to develop and the salmon might not be able to wait that long. For this reason, salmon restoration biologists are recommending immediate remediation. Restoration tools include: replanting, rock sills (to stop erosion), deflectors (used to narrow and deepen channels), digger logs (these imitate fallen logs that create stream complexity), cover logs (to deepen in-stream habitats), and large woody debris reintroduction to stream systems. Canadian fisheries biologist Bob Bancroft estimates that, given the value of each returning Atlantic salmon, such investments more than pay for themselves over time. [94]

**Low-impact Logging**. While Kleinschmidt and others recommend low-impact logging in riparian zones, they do not clearly define what this means. The book *Low-impact Forestry: Forestry as if the Future Mattered*, defines the goals of reducing the size and distribution of

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[93]Seymour et al, 2002, pg. 365

[94]Bob Bancroft, "Reparing Broken Rivers," *Atlantic Salmon Journal,* Winter, 1998

roads, yards, and trails, and of minimizing damage to residual trees and soil.[95] Since the biggest cause of siltation is soil disturbance, not cutting down of trees, reducing the area of soil damage is a major strategy to minimize siltation. Consider that feller buncher/grapple skidder systems may take up 25% of a logged area just for trails, and compare that with 10% or less for low-impact systems.

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**Example 1: Sam Brown on private woodlot**

Sam Brown has developed a low-impact logging system based on a small forwarder with a radio-controlled winch. Sam keeps his trails around 10 feet wide and separates these trails by 150 feet. This means that the trails make up little more than 6% of the area to be cut. He cuts trees with a chainsaw and limbs them on site. He winches single stems to the trail and loads the wood, cut to length, onto his forwarder. Carrying the wood on a forwarder does much less soil disturbance than dragging whole trees. His yards are small, just an extension of the trail--wide enough to pile a truckload or two of short wood.

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**Example 2: Dana Marble on Baskahegan Lands**

In 1994, logger Dana Marble did low-impact logging on Baskahegan Lands in Washington County using two horses and a conventional cable skidder. The permanent skid trails, around 14 feet wide, were spaced 400 feet apart. Loggers cut and limbed trees with chainsaws. The two horses pre bunched the wood to the skid trails where the skidder hauled the bunches to the yard. With this system, trails make up a little more than 3% of the area cut.

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**Example 3: Bob Matthews on Baxter State Park Scientific Forest Management Area**

Bob Matthews uses a narrow "miniskidder" with two radio controlled winches to pull wood out to forwarder trails that are spaced every 400-500 feet in the SFMA. His miniskidder, the Turbo Forest 42C, is only 6 feet wide and can maneuver off trails with minimal damage to residual trees. It has hydrostatic drive and is less apt to dig into the soil than gear driven machines. He operates when the ground is dry and often there is little sign of soil disturbance, since he does not make repeated trips over the same ground. The permanent trails are 14 feet wide, wide enough to accommodate a large forwarder. Though these big machines, making repeated trips with heavy loads, do leave ruts, the area taken up in trails is only around 3%.

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**Example 4: Harvester ghost trails**

Mechanized operations using single-grip harvesters, can minimize land in trails by using machines with long reaches and by using "ghost trails". Single-grip harvester reach can be anywhere from 25 to 35 feet, depending on the make and model. Many have a reach of around 30 feet. If the forwarder trails are 14 feet wide and there is 60 feet of forest between each trail, that would mean around 19% of the land would be in trails. Most of the damage to soil with such mechanized operations is from the forwarder, rather than the harvester. Forwarders carry repeated heavy loads over the same ground, thus some rutting is unavoidable.

Some operators minimize land in forwarder trails by having harvester "ghost trails" in between the forwarder trails. The harvester, instead of pulling the cut, limbed, and bucked wood

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[95] see chapters 2 and 6 of *Low-Impact Forestry: Forestry as if the Future Mattered*, edited by Mitch Lansky, MEPI, Hallowell, ME 2002

to the trail it is on, deposits the wood within reach of the forwarder in the next trail over. This system leads to less than 10% of the land being in forwarder trails.

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**Example 5: Winter logging**

If the object is to minimize rutting, compaction, and soil disturbance that can lead to siltation, then the best solution of all is winter logging. Small equipment working on frozen ground avoids serious soil disturbance and can cut in ways that allow a relatively closed canopy (rather than 16-18 foot wide trails for grapple skidders pulling out hardwoods).

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With low-impact logging, the quality of what is left is just as important as the quantity of what is removed. There needs to be a way to pay loggers to reward them for both results, not just removals. Planning, riparian zone restrictions, restrictions on technology and techniques can be part of the contract, but must be adequately compensated. Increased costs in logging can be justified by avoidance of stand damage, which is also a cost.[96]

**Roads and stream crossings**. The best way to lower impacts is by having a sediment control plan before building anything. Such a plan should incorporate the following:

- *Site*. Mapping out sensitive areas (soft, or wet soils, for example) and planning to avoid building roads or trails in such areas. In salmon areas, the streams should be mapped to indicate especially vulnerable areas, such as spawning grounds, that need to be avoided. The best way to avoid sedimentation is to avoid stream crossings whenever possible. In the Baxter State Park Scientific Management Area (SFMA), for example, the forester uses streams as compartment boundaries to avoid need for stream crossings.[97] Where stream crossings are unavoidable, the logger needs to find a place where the stream is straight and narrow and where the sides are not so steep that there would be a high probability of bank erosion.
- *Timing.* Sedimentation can be reduced if stream crossings are put in place when conditions are dry and water is low. The logger needs to be aware of salmon life cycles and not put in stream crossings at a time when the fish are most vulnerable to sedimentation.
- *Siltation prevention*. The logger needs to anticipate sediment problems and use silt fences, hay bale barriers, and geotextiles to keep sediment from reaching water bodies.
- *Appropriate stream crossings.* Where stream crossings are unavoidable, it is important to plan for the least disturbing method and to ensure the appropriate size. Stream crossings have major potential to cause significant impacts to Atlantic salmon and other fish. The effects can last as much as 10 years.[98] In general, properly installed bridges cause less siltation problems for shorter amounts of time than other methods, such as culverts or fording.[99] Undersized culverts run the risk of getting plugged up or washing out, leading to

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[96]for a fuller discussion of how to pay loggers to do low-impact logging, see Mitch Lansky, *Low-impact Forestry: Forestry as if the Future Mattered*

[97]Jensen Bissell, *Baxter State Park Scientific Forest management Area Mangement Plan*, 1998

[98]Charles Binn, Rick Dahlman, Lola hislop, and Michael Thompson, *Temporary Stream and Wetland Crossing Options for Forest Management*, USDA Forest Service, Gen Tech. Report NC-202, St. Paul, MN, 1998, pg. 34

[99]Binn et al, pg. 36

serious siltation problems. Culverts may also have to be modified to allow passage of juvenile and adult salmon.[100] Fish passage problems occur if the outfall drop is too great, there is a lack of resting pool below the culvert, there is excessive water velocity, or insufficient water depth.[101] For permanent stream crossings, the logger should plan size based on 100-year flood levels.

- *Conservative use.* The more roads, trails, and stream crossings are used, the more potential for erosion and siltation. When crossing bridges, it is best to carry, rather than drag wood. The logger should chose equipment with reduced ground pressure by going for high flotation tires, bogie trailers with tracks, tracked vehicles, or light-weight machines. This would reduce rutting and soil compaction.
- *Monitoring.* The logging/forestry system needs to incorporate regular monitoring of the condition of roads, trails, and water crossings and reporting problems to someone in the organization who will ensure prompt action. Such monitoring might lead to recrowning of roads to put water in ditches. Ditching of roads on long slopes however, can lead to problems as storm water rushes down ditches carrying a lot of silt. It is imperative to have frequent diversions into settling ponds and filter strips so that these ditches do not run directly into streams. Settling ponds, however, are temporary--they fill up. Therefore it is necessary for there to be regular monitoring of all roads to determine whether preventive maintenance is needed. Prevention of such problems is far less costly than remediation.
- *Restoration.* One of the most serious problems noted by researchers of BMP compliance is the failure to immediately remove and remediate temporary stream crossings and culverts.[102] Also a serious problem is dealing with older roads that were not built to proper standards and are causing siltation problems. If such roads can not be upgraded to meet BMPs, they need to be abandoned, stabilized, and revegetated.

Although "Best Management Practices" are considered "voluntary," they are a necessity in salmon habitat areas. Supposedly BMPs are a necessity for those landowners that are certified, but this requirement has not always been adequately enforced. Compliance may be higher when the logger is certified (as in Master Logger Certification Program). In salmon areas, BMPs *must* be mandatory and enforced. Loggers need to have training in proper use of BMPs, and landowners/foresters need to supervise to ensure loggers are doing proper practices. Road building and stream crossing have so much potential for siltation problems that following and improving on BMPs is essential.

**Landowner cooperation**. Landscape planning may be possible for very large landownerships, but these ownerships are, more and more, being subdivided and sold. To have landscape planning and management may require cooperation amongst landowners. There are precedents for such cooperation. In New Brunswick, for example, the government, and large and small private landowners are cooperating in the Greater Fundy Ecosystem Project and the Pollett River Private Woodlot-Watershed Management Project.[103] The goal of these landowner associations is to encourage landscape approaches to biodiversity.

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[100]IMST, pg. 58

[101]Binn et al, pg. 34

[102]Briggs et al, 1996

[103] see http://www.unbf.ca/forestry/centers/fundy/ and http://www.unbf.ca/forestry/centers/Pollett.htm for more information

The downeast salmon rivers have watershed councils that offer the potential for cooperation in learning about the issues, monitoring for problems or potential problems, and doing remediation where problems exist. These watershed councils and Project SHARE also have the potential to emulate the Canadian models of cooperative landscape planning for biodiversity. These councils have helped locate and remediate non-point source pollution from logging, agriculture, homes, and roads. On the Narraguagus, for example, these groups have found that ATVs can be a serious source of siltation, especially when there is fording of streams.[104] Such councils could also help to train loggers in BMPs and low-impact logging techniques.

**VII. Would lower-impact, more salmon friendly, forestry reduce productivity or economic and social benefits of the forest?**

Ironically, managing for an older, higher-volume, better-stocked forest would not be a sacrifice compared to current management; it would be an improvement. The 1995 USDA Forest Service inventory showed that the average net growth per acre per year in Maine was less than 0.3 cords.[105] The most recent surveys in Maine measure growth in basal area, rather than volume, so a more up-to-date figure is not yet available. The most recent survey, however, shows some of the reasons that growth per acre figures for Maine are so low:[106]

- Average volume per acre of pulpwood quality or better is 16 cords. In contrast, recommended residual stocking after a thinning in hardwood would leave around 25 cords, with mixedwoods around 30 cords, and with softwoods around 35 cords.
- Cut (as measured by basal area change, rather than volume) is greater than growth for both softwoods and hardwoods.
- The percentage of fully-stocked stands has declined while moderately-stocked and poorly-stocked stands have increased.
- Heavy cutting is leading to an increase in seedlings and saplings so this stand size class (which contributes little volume because it is below merchantable size) now covers nearly 5 million acres--an increase of nearly half a million acres since 1995.
- Highgrading, combined with past budworm mortality has led to a shift in species (a major drop in spruce-fir from 7.8 million acres in 1982 to 5.2 million acres in 2002).
- Regeneration is dominated by balsam fir--a species highly susceptible to spruce budworm outbreaks. Fir ingrowth (trees that reach minimum size for measurement) is greater than accretion (growth on existing trees) indicating fir is about to rebound. There is therefore an increased risk of a future inventory reduction when the next budworm outbreak occurs.

To look on the bright side, there appears to be great room for improvement. Low-impact forestry would lead to improvement. The USDA Forest Service silvicultural guide to hardwoods, for example recommends a *minimum* residual basal area of 70 square feet for hardwoods and 100 square feet for mixedwoods for uneven-aged management and similar figures (the B-line) for

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[104]Arter, pgs. 16, 23, and 27

[105]D.M.Griffith, and C.L Alerich, *Forest Statistics for Maine, 1995*, FIA Unit, NE Exp. STa. Resource Bull. NE-135, Radnor, PA, 1996

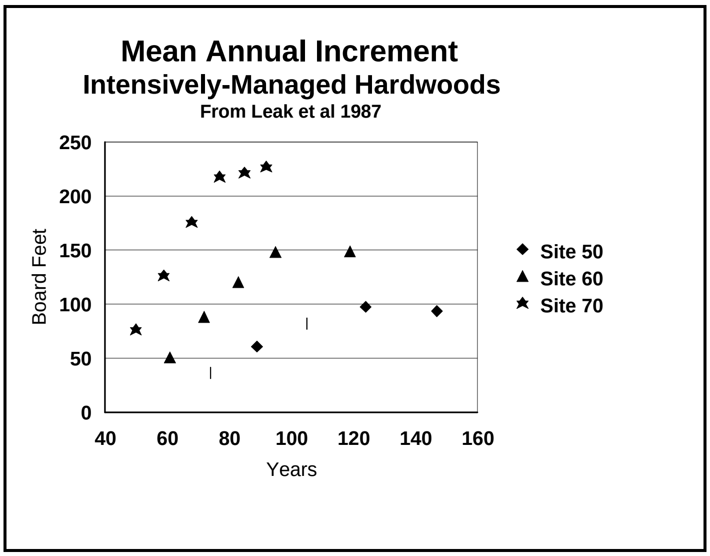
[106]K. Laustsen, D. M. Griffith, and J. Steinman, *Fourth Annual Inventory Report on Maine's Forests*, USFA Forest Service, Newton Square, PA and Maine Forest Service, Augusta, ME, 2003.

even-aged thinnings.[107] These figures, based on examination of thousands of plots, are recommended for a combination of productivity and sawlog quality. Following such standards is not a burden, it is a benefit.

Foresters generally measure productivity of even-aged stands by looking at the mean annual increment (MAI)--the average growth per acre per year since the stand was regenerated. The culmination of the mean annual increment (CMAI) is the year when the annual growth equals the mean annual growth. When this happens, the mean annual increment no longer rises. This is considered the peak of productivity, although this moment may not be the best time to cut the stand as the peak of *volume* may not correspond with the peak of *value*. In some species, the value can increase greatly with increased diameter as the wood qualifies for higher value markets. For example, hardwoods need to reach a diameter of 16 inches to qualify for veneer.

The CMAI also depends on how the growth is measured. The CMAI comes earlier if the growth is measured in cubic feet (more appropriate for pulpwood) but later when measured in board feet (more appropriate for lumber). With intensively-managed hardwoods, depending on the site class (the higher the site class number, the richer the site and the faster the trees grow) the culmination of the MAI may take an 100 years or more, and once reached does not drop precipitously.

Thus, growing longer rotations will *not* lower productivity. In fact, one long rotation is *more* productive of *fiber and value* than two shorter rotations because the larger sawtimber trees are worth so much more than pulpwood (in smaller diameters). For example, based on the same data, at site class 70, the mean annual increment at age 50 is 76.7 board feet, but at age 92 it is 227.3 board feet. For site class 60, at age 61 the MAI is 50.9 square feet, but at age 119 it is 148.9 square feet. And for site class 50, the MAI at age 74 is 36.5 square feet, but at age 147 it is 93.7 square feet.




For uneven age, foresters look at the CMAI of individual trees, rather than the whole stand. The USDA Forest Service in the White Mountain National Forest has the following guide (based on diameter and site index) for cutting individual trees in selection management:[108]

[107]William Leak, Dale Solomon, and Paul DeBald, *Silvicultural Guide for Northern Hardwood Types in the Northeast (revised)*, USDA Forest Service, Northeaster Forest Experiment State, Research Paper NE-603, Broomall, PA, 1987

[108]USDA Forest Service, *Land and Resources Management Plan: White Mountain National Forest*, 1986

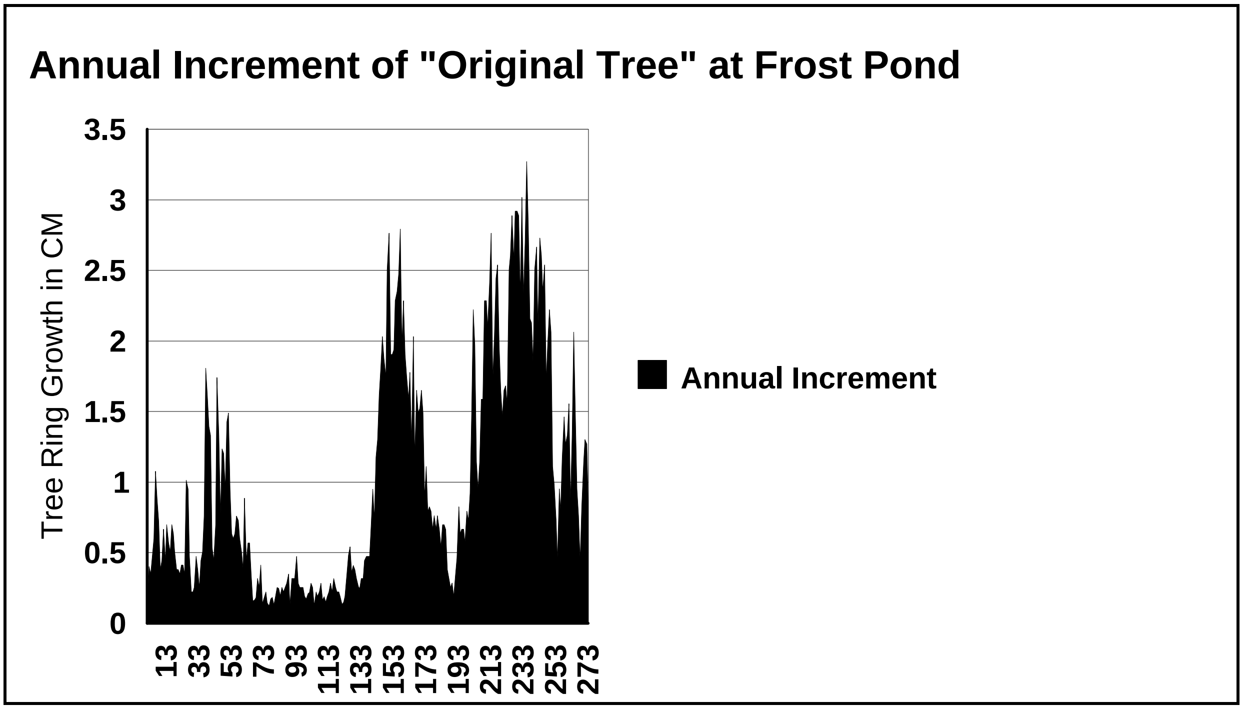
**Peak Growth Diameters by Site and Species in White Mountain National Forest**

| **Species** | **Site index 70+** | **Site index 60-69** | **Site index 50-59** |
|---|---|---|---|
| Sugar maple | 26 | 20 | -- |
| Red maple | 24 | 18 | -- |
| Paper birch | 14 | 10 | -- |
| Hemlock | 26 | 20 | 16 |
| White pine | 26 | 22 | 16 |
| Red pine | 22 | 20 | 16 |
| Red spruce | 22 | 16 | 10 |
| Balsam fir | -- | 12 | 8 |
| Beech | 20 | 16 | -- |
| Yellow birch | 24 | 18 | -- |

These large diameters would require growth over more than a century. Recent tree ring data of old red spruce, however, brings into question just how old or how big trees can get before the mean annual increment culminates. For example a red spruce tree (graphed below)[109] from Frost Pond at Baxter State Park appeared to have a significant decline in annual increment at age 50, but then it showed a burst of growth starting at age 140. At age 160, it went into another growth decline (probably a spruce budworm outbreak), but then at age 200, it had a major jump in growth that peaked at around age 240. Even at age 260 the tree (recovering from another

[109]Data supplied by Baxter State Park SFMA forester, Jensen Bissell

budworm outbreak) had another burst of growth. Other trees in the area had similar up and down patterns.




An older red spruce stand at Weymouth Point, analyzed by Robert Seymour, had nearly 75 cords to the acre of spruce and was growing, at the time it was measured, around 1.3 cords per acre per year. This is as good as expected for "intensive management" of softwoods (using thinning and herbicides for a short rotation) on a better site. This growth, of high quality sawlogs (short rotation stands have trees with fat growth rings, knots, and taper, lowering quality), however, was on site index 40, which is a fairly poor site. The stand had two cohorts--one regenerated after the spruce budworm outbreak of 1911-1919 and the other with older spruce, some as old as 275 years.

The annual growth was greater than the average growth for both the trees that started after 1920 *and* the older cohort of trees. This means that the *mean annual increment had not culminated*, even for the older trees.

**Stocking and growth of a fully stocked, two-aged, red spruce stand on the Weymouth Point Control Watershed, T4R12, Maine. Volumes are total stemwood; site index = 40**[110]

| Cohort | Trees per acre | Basal Area ($ft^2$/acre | 1995 Volume ($ft^3$/acre | 1920 Volume ($ft^3$/acre) | 1990-94 Growth | Mean Annual Increment since 1920 |
|---|---|---|---|---|---|---|
| 1920-Origin | 500 | 108 | 2,615 | 0 | 52.8 | 34.9 |
| Pre-1920 residual | 180 | 121 | 3,368 | 735 | 50.5 | 35.1 |
| Total stand | 680 | 229 | 5,983 | 735 | 103.3 | 70 |

[110]From "Growth and Yield," by Robert Seymour in the *1995 Annual Report of the Cooperative Forestry Research Unit*, University of Maine, Orono, 1996

**Economic considerations.** Coming up with a cost benefit analysis to two decimal points for an abstract proposal is, obviously, impractical. There are too many variables, such as stand type, stocking, product mix, accessibility of wood to be cut, distance to markets, availability and cost of loggers, market fluctuations, who sells wood (landowner or logger?), degree of vertical integration (selling stumpage or planed boards?), choice of discount rates, etc...

These considerations, of course, have not stopped various studies from doing economic analyses anyway. The USDA Forest Service silvicultural guide for hardwoods, for example, looked at net present value and internal rate of return of managed, vs. unmanaged stands and showed that by moving to a mix of wood with higher product value and speeding up the growth of trees, the managed stands were clearly superior to unmanaged, or highgraded stands, with the peak of net present value (at a 4% discount rate) coming at around 100 years, and falling only slightly for decades after that.[111]

There are problems, however, of applying standard economic calculations, such as net present value, to long-term, multi-generational investments, such as forests. Net present value calculations assume that individuals live forever and therefore would want to weigh the benefits of cutting trees that they plant now in 50 years versus 100 years based on discounted present value. The higher the discount rate, the shorter the rotation to maximize net present value. The shorter the rotation, the more wood this landowner can cut *now*.

In 50 years, the original landowner will be dead. The new landowner would surely not cut the stand based on the financial calculation of a half century before. Instead, the landowner might decide to do a thinning and let the stand grow to higher value products.

Using high discount rates to determine what a forest many decades from now is worth to the landowner now is somewhat absurd since the person doing the calculation will not live to see the benefit. The benefit goes to someone else, who is not, and cannot, be consulted on the issue. The landowner who discounts the future ends up cutting more heavily now, leaving a younger landscape with fewer options for the future. The future landowner would most likely prefer a better stocked forest with more options.

Low-impact forestry cannot compete with short-term forestry to get high returns. The economically best "forest management" is to buy a lot, flatten it, subdivide it, and sell the parcels. The parts, in our current economic climate, are worth more than the whole. This style of forestry, however, is clearly not sustainable. It comes at a cost to wildlife (perhaps salmon), to the local community, and to future generations. These "external costs" are not included in the current economic calculus.

If a starting assumption is that forestry must be sustainable--for centuries--then low-impact forest practices make eminent sense. Low-impact forestry is "patient money." It is a system that acts as if the future matters and that tries to internalize all costs--not externalize them to others. It is a system that looks at *total value* (removals plus residuals), not just what is removed.

Looking only at the value of what one removes can lead to forestry capital depletion. A forest, to use a simplifying metaphor, is both a factory and a product. Depleting the forest capital (the stocking, diversity, vertical structure, wildlife habitats, predator/prey balances,, soil integrity, etc.) hurts the ability of the forest to produce the product (trees) over the long run. As the capital

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[111] Leak, et al, 1987, pg. 31

declines, so does the annual sustainable "interest" (what can be taken from the forest without diminishing the ability to take out the same in the future). Unfortunately, current economic thinking allows confusing "income" with capital depletion. Certainly there are plenty of banks willing to give loans to forest liquidators.

If one assumes that forestry is for the long term, however, low-impact forestry has many economic advantages:

- *Growth.* Low-impact forestry leads to higher growth than standard mechanized approaches because it leaves more trees. Instead of taking out 25% for trails, low-impact logging takes out from 3-9% in trails. By leaving better stocking of dominant trees (rather than trees with poor crowns and root systems) growth is also superior to standard diameter-limit systems. Low-impact logging also does less damage to soil and residual trees, factors which can impact growth rates.
- *Species mix.* LIF favors long-lived species suitable to the site. These longer-lived trees can grow to larger diameters with higher values. With frequent entries, the landowner can influence the species mix in the overstory. For the same sized tree, a rock maple sawlog can be worth more than twice as much as a red maple sawlog, so the species choice can have economic consequences.
- *Product mix.* LIF not only grows larger trees, it avoids damage to residuals that might lower product grade. As trees increase in grade there can be dramatic increases in value. For the same volume of wood, rock maple veneer can be worth 70 times as much as rock maple biomass. The Baxter State Park Scientific Forest Management Area recently started managing an older stand that has abundant large-diameter red spruce. The manager is trying to maintain the old structure and can justify the higher logging expenses by the value of the products--tonewood for guitar sound boards, canoe gunwales, and large timbers for post and beam construction. Some of the tonewood sold for as high as $4,785.00 for a thousand board feet.
- *Value growth above inflation*. Lower grade commodities, such as biomass, pulp, or utility 2x4s tend not to increase much in value above inflation. Higher grade products, such as top grade lumber or veneer, can increase greatly in value above inflation. During the 1990s, for example, rock maple veneer increased in value at 20% above the inflation rate.
- *Risk.* All investments have a degree of risk. With forestry, stands are subject to fire, wind, insects, and disease. Low-impact forestry reduces the risk by managing for diversity and stability. Well-stocked stands, for example are less subject to windthrow. Trees damaged during logging are more susceptible to insect and disease problems. To the degree that stands are simplified beyond what would naturally occur on the site, risk of catastrophic problems (such as spruce budworm in stands dominated by fir) increases. Simplified stand structures can lead to reduced habitat for predators and parasites of pests.

Managing for big trees and snags requires some financial sacrifice (trees that will not be cut for money), but forest ecologist David Perry sees that cost as the price of insurance: "Everyone who can afford it goes out and buys some insurance--this is a hedge against uncertainty. We don't think twice about why we pull some money out of our pocket to buy insurance; it's obvious to us why we're doing that. We need to translate that concept into managing natural ecosystems. It may cost something, in terms of short-term profits, in order to maintain more diversity in the system and help buffer it against disturbances and unexpected surprises. But that cost is a legitimate cost of insurance; it's the only insurance that we can buy in forestry--maintaining complexity, drawing on the mechanisms that have evolved in nature to maintain integrity, preserving those mechanisms, enhancing and restoring them where necessary. We should count that as part of the legitimate cost of doing business."[112]

Low-impact forestry keeps options open for both the present and the future. It leaves an aesthetically pleasing forest with higher community values for both recreation and wildlife. It also avoids costs--such as the costs of trying to restore salmon in streams with unfavorable forest habitat.

## VIII. Conclusion

This report concludes that you can do forestry as if salmon really mattered. It requires managing for a landscape that does not stray far from the structures in which salmon are best adapted. It requires special care in management of riparian zones to ensure ideal habitat structures, temperatures, and waterflow and to minimize unwanted siltation and nutrient pollution. It would also include reserved, uncut areas. Not just thin ribbons around rivers, but substantial areas in headwater areas as well. These reserves would not only protect habitat, but serve as "controls" to compare to managed areas. And it would include low-impact logging that minimizes land in roads, yards, and trails and minimizes soil disturbance and siltation.

Such an approach can actually increase productivity from current levels and improve long-term economic prospects. These recommendations are not just abstractions--there are landowners doing them now, at least in part:

- The Bureau of Parks and Lands is managing for a substantial part of the landscape to be late successional. The Bureau manages 525,000 acres. Only 67% of total acreage is considered in the sustainable timber base. One third of this public land is not cut due to reserves, biodiversity, or recreation. Of the 67% of forest that is "regulated" for timber, 80% is managed for multiple age classes. Of the 20% managed for single-age classes, rotations are from 100-150 years, except for stands that are mostly fir or poplar. The Bureau does almost no clearcutting (less than 1% of all cutting). Clearcuts, when they are used, need to be smaller than 20 acres. Single-aged stands are regenerated by the shelterwood system, usually with two thinnings and two regeneration cuts. Not all logging is by low-impact methods, however.
- Baxter State Park Scientific Forest Management Area relies on partial thinnings and small patch cuts. Its even-age rotations (in the patches) are 140 years. At Frost Pond, the Park is using low-impact logging to sustain an old stand structure that includes some trees that are hundreds of years old.
- The Nature Conservancy has established extensive riparian buffers on the St. John and Machias River watersheds that include substantial no-cut zones.
- The Greater Fundy Ecosystem Project has shown that cooperative landscape planning, with public, industrial, and small private owners, is possible.
- There are also initiatives, such as certification, BMPs, easements, and watershed councils, that hold promise to lead to improved results in the forest as actions catch up with stated philosophies.

These approaches to forestry, however, can not alone bring back the salmon. There needs to be an integrated strategy to deal with the full range of threats, including acid precipitation,

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[112]in Mitch Lansky, *Low-impact Forestry*, pg. 46.

global warming, pollution, dams, fish farms, overfishing, and others. If salmon succumb to any of these other threats, then improved forestry and logging will have been done in vain--for salmon. But not for the full range of other species and forest benefits.

**About the Author**

Mitch Lansky is the author of *Beyond the Beauty Strip: Saving What's Left of Our Forests*, published by Tilbury House Publishers in 1992, and *Low-Impact Forestry: Forestry as if the Future Mattered*, published by Maine Environmental Policy Institute in 2002. For further information about low-impact forestry, the author, or his work, see www.lowimpactforestry.org