Conservation Easements and Biodiversity in the Northern Forest Region

Jerry Jenkins

The Open Space Institute and the Wildlife Conservation Society

Dear Colleagues,

Conservation, when done well, has a meaningful and long-lasting effect on the landscape. But it is not stagnant work. Each round of achievements invariably leads to a new level of inquiry and, in a continual evolution, action. Conservation in the Northern Forest Region has provided just such an opportunity to learn.

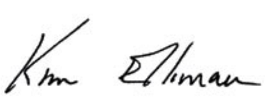
Over the course of the last decade, there have been major shifts in ownership in the Northern Forest, the 28 million acres of conifers and hardwoods reaching from the shores of Lake Ontario in western New York to the heart of the Maine Woods. In response, the Open Space Institute (OSI) created the Northern Forest Protection Fund in 2000 and, working in partnership with many other conservation groups, protected more than 1.4 million acres. Eighty percent of that protection was accomplished through the use of conservation easements, specifically working forest easements, which allow some forms of logging and forestry activities but permanently prohibit future development. Accomplishing protection on a landscape-level with this powerful conservation tool, OSI bolstered local economies and encouraged sustainable forestry practices and also helped support the rich biodiversity of flora and fauna that are endemic to this unique region.

Or did we? OSI realized that we simply didn't know whether working forest easements had a beneficial, harmful, or perhaps just neutral effect on the landscape. With land trusts holding six million acres of conservation easements across the country, simply *believing* that easements were effective was not sufficient.

Through the work of this report, *Conservation Easements and Biodiversity in the Northern Forest*, the Open Space Institute partnered with the Wildlife Conservation Society's Adirondack Program to begin to probe this fundamental question: how do easements affect the wildlife and plants of the places they strive to conserve? Wildlife Conservation Society scientist Jerry Jenkins has drawn on his rich background as an ecologist to undertake this assessment. Through an exhaustive review of the existing literature, biological surveys of six large working forests, and interviews with more than 60 conservation and forestry professionals, Jenkins begins to answer this question in the pages that follow.

OSI and the Wildlife Conservation Society hope to engage the conservation community in the dialogue necessary to further the effectiveness of our work, translating the ideas presented here into action so that we can collectively evolve to the next stage of conservation. In the process, we believe that we will better conserve the landscapes of the Northern Forest – for the people, flora, and fauna that are all dependent upon them.

Kim Elliman



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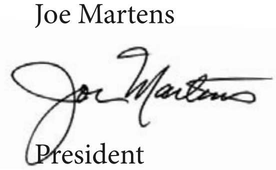

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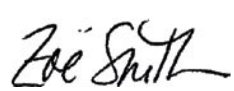


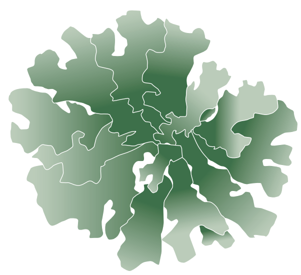
Director, Adirondack Program
Wildlife Conservation Society

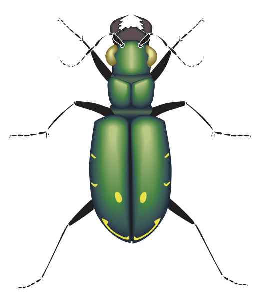
Dense river-bottom conifers, northern New Hampshire

Regenerating cut, western Maine

Conservation Easements and Biodiversity in the Northern Forest

Jerry Jenkins





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EXECUTIVE SUMMARY

This report examines the way that biodiversity—animals, plants, and natural communities—is being managed on several large working forests with conservation easements. It is based on scientific literature, fieldwork, interviews, and the author's observations over 40 years of biological survey work in the Northern Forest Region. It attempts to describe what there is in northern forests that needs protecting, how this might best be protected, how well protection is being implemented on existing easements, and how it might be improved on future ones.

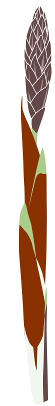
Working forests differ greatly in biodiversity. All have significant animal populations, and most have important wetland communities. Some, but only some, have significant forest communities, mostly associated with older and less disturbed forests, and high-diversity plant communities, mostly associated with limy bedrock.

The immediate job for biological conservation in the Northern Forest Region is to ensure the continued survival of the diversity that is already there. This is relatively easy to do: after 200 years of logging, most of the species in working forests are either tolerant of logging or found in places that are hard to log.

A suite of six conservation tools—biological surveys, special management areas, forested buffer strips, requiring sustainability, requiring a balanced forest structure, and standard wildlife management techniques—will suffice to protect most of the species and communities currently known in the Northern Forest Region.

These tools are well understood in the forestry community, widely used, and of proven effectiveness. The principal challenge in implementing them on easements is ensuring that they are used when needed. A review of the provisions in six working forest easements suggests that all the easements have good objectives; where they differ is in how well, if at all, the goals are being met.

To make sure easements really provide the biodiversity protection that they promise, this report recommends that both the goals and the criteria for meeting them be more explicit. Specifically, easements should require a separate biodiversity management plan, should protect priority communities and species through special management areas, and should include explicit standards for protecting waterbodies, ensuring sustainability, and keeping a balanced age distribution. In addition, the Forest Stewardship Council's certification standards provide a good framework for biodiversity protection, and should be adopted whenever possible.



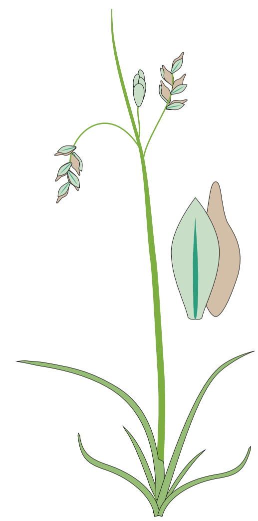
Plantain-leaved sedge is a common species that requires deep fertile soil, and thus a useful indicator of the rich-woods community. Sites where it grows often have many forest-interior species and should be considered high-priority communities. They can be logged selectively and can actually increase their diversity after logging, but great care has to be taken not to disturb the soil.

These provisions, if carefully drafted and implemented, will likely preserve most of the species and communities currently found on working forest easements.

A more difficult question is whether conservation easements should go beyond preserving the biodiversity that currently exists and attempt to restore working forests to a more natural state, which in practice means allowing them to become older and more continuous. The study discusses but does not adjudicate this question. It concludes, on the one hand, that late-successional forests are biologically and culturally important and that, by the precautionary principle, we need them as ecological insurance against the failure of systems that we now think are sustainable. But it argues, on the other, that it may be difficult and costly to do forests that now exist, but suggests that it may be cheaper and more effective to create new late-successional forests in reserves or on nonprofit ownerships than on for-profit ones.

In addition to the six tools mentioned above, several other techniques, particularly emulating natural disturbance regimes and creating landscape-scale patterns, are widely advocated in the literature of conservation forestry. But so far they are largely untried, and it is not known whether they are important for biodiversity protection in our region.

The overall conclusion from this study is that much of the biodiversity in working forests can be preserved by requiring a biological survey, a dedicated biological management plan, and explicit biodiversity performance standards. For exceptional lands with rare natural areas, special management areas or ecological reserves will be required. And for lands where late-successional structure is desired, the harvest rate will have to be limited. Since the latter has only rarely been done, it is currently unclear whether it is possible or sensible to do this in a commercial context.



The hairlike sedge, *Carex capillaris,* is a rare northern species that grows in limy seepage in wetlands or on cliffs. It would probably never be encountered in a harvest area, but can be damaged by road construction near wetlands.

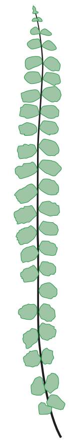
This paper attempts to answer a single question: How can conservation easements contribute to the protection of biodiversity in the Northern Forest Region (NFR). The question was posed to us in 2005 by Kim Elliman of the Open Space Institute, who said, "We are buying easements and calling them conservation easements, but we don't really know what they are conserving. Can you find out what the current generation of easements is doing and tell us how to make the next generation of easements better?"

The question is an important one. In the past 25 years conservation easements have become one of the most widely used conservation tools. Nationally, land trusts currently hold some 20,000 easements comprising 6 million acres. The Nature Conservancy, over half of whose transaction acreage is now easements, holds another 2,500 easements on 3.5 million acres. Regionally, there are now approximately 760,000 acres of easements in the Adirondack Park, and about 2 million acres of easements in the rest of the NFR, for a total of about 2.8 million acres of easements, or roughly 10% of the region. Since the NFR contains a total of about 7.9 million acres of protected land, this means that about 65% of the protected lands in the NFR are publicly owned, and the remaining 35% are privately owned lands with conservation easements.*

Considering that conservation easements barely existed in 1980, placing 10% of the entire Northern Forest Region under easements in less than 30 years time is a remarkable achievement. Its significance for *land* protection is beyond dispute: it represents a 50% increase in the amount of land that is permanently protected from development and, in the case of the Adirondacks where essentially all private lands are posted, a 25% increase in the amount of land open to the public.

But while the significance of working forest easements for land protection is clear, their significance for *biodiversity* protection is not. If protecting the land from development automatically protects the plants and animals on it, then the easements in the NFR represent a milestone for northeastern conservation. But if—and this is what Kim Elliman's question was getting at—there are dangers to animals and plants that the easements do not cover, then we have at best gotten much less conservation than we had hoped for, and at worst wasted precious time and resources that could have been used elsewhere.

In theory, determining how well easements were working should be straightforward. I planned a three-part study. I would start by searching the biodiversity literature to determine how forestry affected animals and plants, then determine how existing easements dealt with biodiversity, and finally would visit some easement lands and talk with their owners and managers, to see how



Maidenhair spleenwort, a small fern of moist and often limy ledges, is a forest-interior plant that is locally common in areas with rich bedrock and rare otherwise. It is one of a group of rich-woods species that are characteristic of high diversity sites and, because they have special site requirements, need special protection.

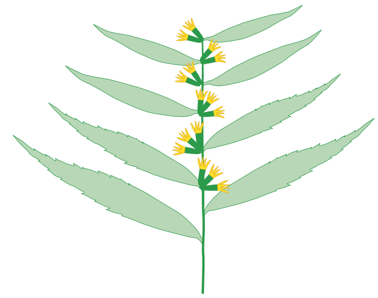
*Here and throughout I say that lands are protected if there is some assurance, either through public or nonprofit ownership or through easements and other encumbrances, that they will remain forested and not be subdivided and developed. Thus national forest, state forest, land trust, and Nature Conservancy lands, are considered protected, as are private timberlands with conservation easements. The strength of these assurances, and hence of the protection, varies greatly.

biodiversity protection was working and whether it seemed sufficient.

In practice, of course, it wasn't that easy. The reasons why it wasn't say something about how biodiversity protection has thus far been implemented, and how it may need to be changed.

One reason was that biodiversity protection, both in easement documents and on the ground, is to a large extent a silent partner in the forestry business. It is there and it is important, but it is hard to see. The easements, for example, just say that rare species and unusual habitats will be protected and that the forestry plan will encourage diverse and healthy forests. The forestry plan says that certain areas are special management areas and will be cut this way, and the rest of the forests are not and will be cut in other ways, but it rarely tells you why this is, or who is expected to benefit, or what the biological consequences of the harvesting plans will be. The biologists have not been around since they did their survey and so you can't ask them. The foresters are around and usually very knowledgeable and involved, but their concern is what they can cut and not what they can't, and so they often know less about what is being protected than you might wish.

None of this is necessarily bad, but it is frustrating when you are trying to find out how well the forestry-conservation match is working. One of my recommendations, and in fact the only one that represents a major departure from established practice, is that there be a stand-alone document that describes the biological assets of the property and the protection that they require. I propose that this be required by the easement, prepared by the survey biologists (it is they, and not the foresters, who have seen the species and know what they need), and that it be updated at five- or ten-year intervals when the forestry plan is updated.



Blue-stemmed goldenrod is a common species of dry fertile forests. It benefits from canopy gaps and seems to spread along logging roads, and so may be moderately tolerant of disturbance.

A second reason it proved hard to determine how well easements are working is that there is a great disagreement in the forestry and conservation biology literature about how well they should work. The disagreement reflects a striking gap between theory and practice—between what people feel working forests should be and what they usually are—and raises important questions about what levels of biodiversity we can expect in a commercial landscape and whose responsibility it is to protect them. How you answer these questions—which is to say what you think a working forest ought to look like and ought to contain—will determine how you think biodiversity should be protected, and hence whether you feel that the current easements are pretty good or that they are faulted and inadequate.

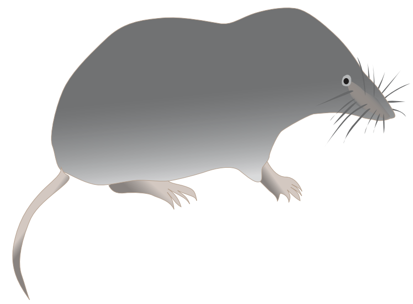
To think about these questions, I find it convenient to think about two pictures of working forests. The first picture, a pragmatic one, sees them as hard working and perhaps somewhat abused but still functional and biologically resilient. It notes that our current forests are young and altered in structure and composition from the presettlement forests that preceded them. But it also notes that many important natural features—rivers, large wetlands, lakes, alpine zones—are still intact and points to a significant regional literature suggesting that there have been almost no losses of vertebrates or higher plants from the working forests, and that the overall levels of biodiversity in clear-cuts and managed forests often exceed those of old, undisturbed forests.

The pragmatic view, in other words, sees the current working forest landscape as a conservation success. It accepts that the forests are greatly altered but argues that they could not be otherwise and still meet society's demands for timber and fiber. It points to the high levels of overall biodiversity, to the populations of large carnivores and herbivores, and to the intactness of the major features, and asserts that in no other working landscape—ocean, farm, suburb, university, whatever—has wild nature been so well preserved.

The second picture is more idealistic. It takes old, unlogged forests as an ecological norm and measures working forests by how far they depart from them. It sees our current forests, which are smaller, more roaded, and more dissected than unmanaged forests, as biologically compromised. It expects that they will differ in ecological function from unmanaged forests, and it can point to lower levels of coarse woody debris and decay as evidence of this. It draws on the general literature of biodiversity and landscape ecology to suggest that our current forests are fragile and impoverished, or will become so when the "extinction debt" induced by dissection and fragmentation is finally paid. It is, however, not able to come up with good lists of the species that have actually been lost from managed forests. And it is, in consequence, somewhat embarrassed by the literature showing the recovery of many elements of diversity in the first 50 years after clear-cutting.

The idealists, to a large extent, see the current working forest landscape as a conservation failure. They accept, grudgingly, that it has significant biodiversity but argue that it is the wrong kind of diversity. They point to the lack of big trees and multiaged stands and coarse debris and say that this indicates a lack of ecological integrity. They acknowledge that we have only a short list of old-growth species and almost no known extinctions of forest species in the Northeast, but argue, quite properly I think, that the fungi and invertebrates of our forests are barely known, and that studies elsewhere have shown that these groups are much affected by forest management.

The importance of these two pictures for us is that they set different goals for biodiversity conservation and recommend different tools for accomplishing them.



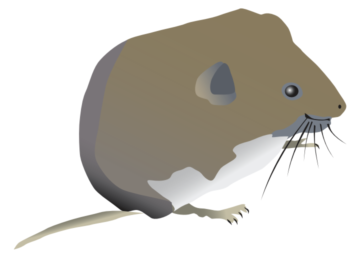
Many small mammals, like this least shrew, seem to be generalists that use both open and forested areas. The literature on their responses to logging is contradictory. Michale Glennon, who reviewed it for this report, said that "For every paper that showed that voles increase after clear-cutting there is another one which shows that they decrease." It may be that many species are ecologically tolerant and reproductively versatile; likely they survive most disturbances, and build their populations quickly in recovering habitats.

For the pragmatists, the chief goal of conservation is protecting what you already have, and the chief tools for it are buffers, special management areas, and other regulations that limit harvesting and keep it out of sensitive areas. The pragmatists are worried about how young the woods are and would like to see easements require a balance of age classes and generate more older woods. They acknowledge that these older woods will likely be even-aged and lack coarse woody debris but see this as the cost of doing business: "If you are selling vegetables," they say, "you don't throw your harvest on the ground to rot."

The idealists, while acknowledging the importance of protecting what you already have, want something more. They see working forests as basically deficient in some measure of ecological quality and would like to restore them. For them, the fundamental test of good forestry is whether it creates woods that resemble natural late-successional woods. They believe, on perhaps rather thin evidence, that this can be done in a commercial setting and recommend using specialized methods—long rotations, well-connected landscapes, cutting cycles supposed to resemble natural disturbance regimes—to do it.* For them, the only good forest is an old one with big trees and lots of dead wood: they are frustrated because few easements mandate long rotations and almost none use indices of late-successional structure to measure sustainability.

Although I have presented both positions in this report, in the end I have come down, somewhat against my own sympathies, on the side of the pragmatists. I agree with the pragmatists' point that no extractive landscape will be ecologically natural, and also their claim that, as high-productivity landscapes go, the northern working forest is better than most. I am impressed by how much extant diversity there is to preserve in the working forest landscape, and think that we will have done something of real conservation importance if we preserve it. And while I would like to buy into the idealists' vision of a restored forest, I am not sure either that the working landscape is the place to create it, or that the tools they would have us use—which are largely untried and unproven—are sufficient for the job.

But all that being said, I feel that the idealists make an extremely important point when they say that because our commercial forests are much altered from their natural predecessors, their long-term ability to support natural levels of biodiversity is uncertain. I agree fully with this and draw from it the conclusion that, while working forest easements can make a major short-term contribution to the protection of biodiversity, they may not be sufficient in the long term. If we want a long-term solution, probably the best we can do is to create a system of unmanaged, late-successional



A few mammals, like the rock vole, which lives on rocky northern talus slopes, seem to be ecological specialists. In this case the special habitat cannot be logged and needs no special protection. But even when protection is not needed, the identification of unusual species and habitats is an important part of assessing a property's overall biodiversity and conservations, and provides a baseline for judging future changes.

*Management techniques that try to recreate the conditions of natural woods have been called ecological forestry, natural-disturbance forestry, closed-canopy forestry, and so on. I refer to the general approach of imitating natural conditions and processes as *ecomimetic* forestry.

forests, somewhat resembling those of the Adirondack Park, that include a significant portion (a fifth? a quarter?) of the forested landscape. How and where to create those forests needs much discussion. My personal bias, explained later in the report, is create them on nonprofit public lands and thus keep them separate from commercial forests.

Sources, Authorship, and Supporting Documents

This report draws on the following sources:

A general review of the literature on forest biodiversity and on the effects of logging on birds, amphibians, and plants by the author.

Parallel reviews of the literature on biodiversity and forest management, with emphasis on birds and mammals, by Michale Glennon of the Wildlife Conservation Society's Adirondack Program, and of the literature on sustainable forestry, ecomimetic forestry, and biodiversity, by Charles Cogbill.*

A review of the literature on the biological effects of exurban development by Heidi Kretser and Michale Glennon of the Wildlife Conservation Society's Adirondack Program.

A review of the texts of about a dozen conservation easements, and of some of the general literature on easements, property taxation and property law.

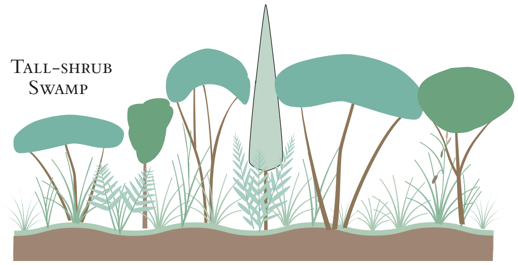
Interviews and conversations with about 60 loggers, foresters, forest managers, forest owners, forest scientists, and conservation professionals.

Field and air surveys of a week each on the lands of the Downeast Lakes Land Trust in eastern Maine, on the Katahdin Forest and West Branch easements in northwestern Maine, and on the Connecticut Lakes easement in northern New Hampshire.

My own biological survey work, focusing on rare plants and plant communities and now extending over 40 years, in the NFR.

And my biological surveys of 5 large working forests (Domtar, Finch-Pruyn, Champion, Whitney, and International Paper in part) in the Adirondacks, conducted between 1988 and 2005.

Jerry Jenkins directed the project, did the interviews and fieldwork, wrote the report, and took the photographs and prepared the graphics.** Charles Cogbill and Michale Glennon helped with the literature reviews, and Brett Engstrom and Patti Smith with the fieldwork. Many other people contributed time, expertise, and ideas; they are acknowledged below.



Tall-shrub swamps, often dominated by alder, are common in open river channels and drained beaver ponds. They do not usually contain rare species, but because they are fertile (alder is a nitrogen fixer) and because they have both open and shaded habitats, they are among our most diverse wetlands. They may contain more than 70 species of plants and 10 or more species of nesting birds, compared with less fertile wetlands of simpler structure that may contain half as many.

*These reviews focused on, but were not limited to, papers from the Northern Forest Region. The conservation biology literature is notoriously general, and we wanted to find out which of the general principles—say that the retention of patches of older forest helps carry forest-interior species through a cutting cycle—had actually been shown to be true in our landscape.

** About three-quarters of the graphics were prepared for this report. The others, as noted in their captions, are taken from other works by the author.

Much of this report is based on my own observations and synthesis of the literature. The notes (p. 94) give my most important sources, and the bibliography, which is organized by topics, is a full list of the works I consulted.

Two Definitions

Within this report, the *Northern Forest Region* (NFR) is an area of about 28 million acres in New York and New England that was studied by the Northern Forest Lands Study in the late 1980s, discussed in the policy forums of the Northern Forest Lands Council of the early 1990s, and is now one of the conservation targets of the Northern Forest Protection Fund and the 47 organizations that make up the Northern Forest Council.

The *biodiversity* of a region is the ensemble of the animals and plant species that occur there, plus the characteristic communities in which they live. Note that both species and communities are important and that communities are more than the species they contain: early-successional and late-successional forests, for example, contain many of the same species but are distinct communities.*

Acknowledgements

Many people contributed to this report, directly and indirectly, and not all can be mentioned by name. Special thanks go to Abby Weinberg and Peter Howell of the Open Space Institute; Tom Martin and Dave Smith of the New York State Department of Environmental Conservation; Mike Ferrucci of Interforest; Don Tase, Dan Kilgore, and Gary Donovan of Upland Forestry; Larry Dennis, Nate Gibbs, and Steve Coleman from Landvest; Alan Hutchinson and Jake Metzler of the Forest Society of Maine; Tom Murrow, Sean Ross, Peter Stein, and Rick Weyerhaeuser of Lyme Timber; Marcia McKeague of the Katahdin Forest; John Hagan and Andy Whitman of the Manomet Center for Conservation Science; David Foster, Dave Kittridge, and Glenn Motzkin of Harvard Forest; Steve Keith of the Downeast Lakes Land Trust and Roger Milligan, a consultant to the trust; Mike Burger and Jesse Bellamare of Cornell University; Craig Cheeseman and Todd Dunham of the Adirondack Nature Conservancy; Charles Cogbill of Plainfield, Vermont; Bret Engstrom of Marshfield, Vermont; my WCS colleagues Michale Glennon and Bill Weber; and to seven anonymous reviewers of the draft version whose comments resulted in many improvements in language and detail.

SHRUB-SEDGE MEADOW

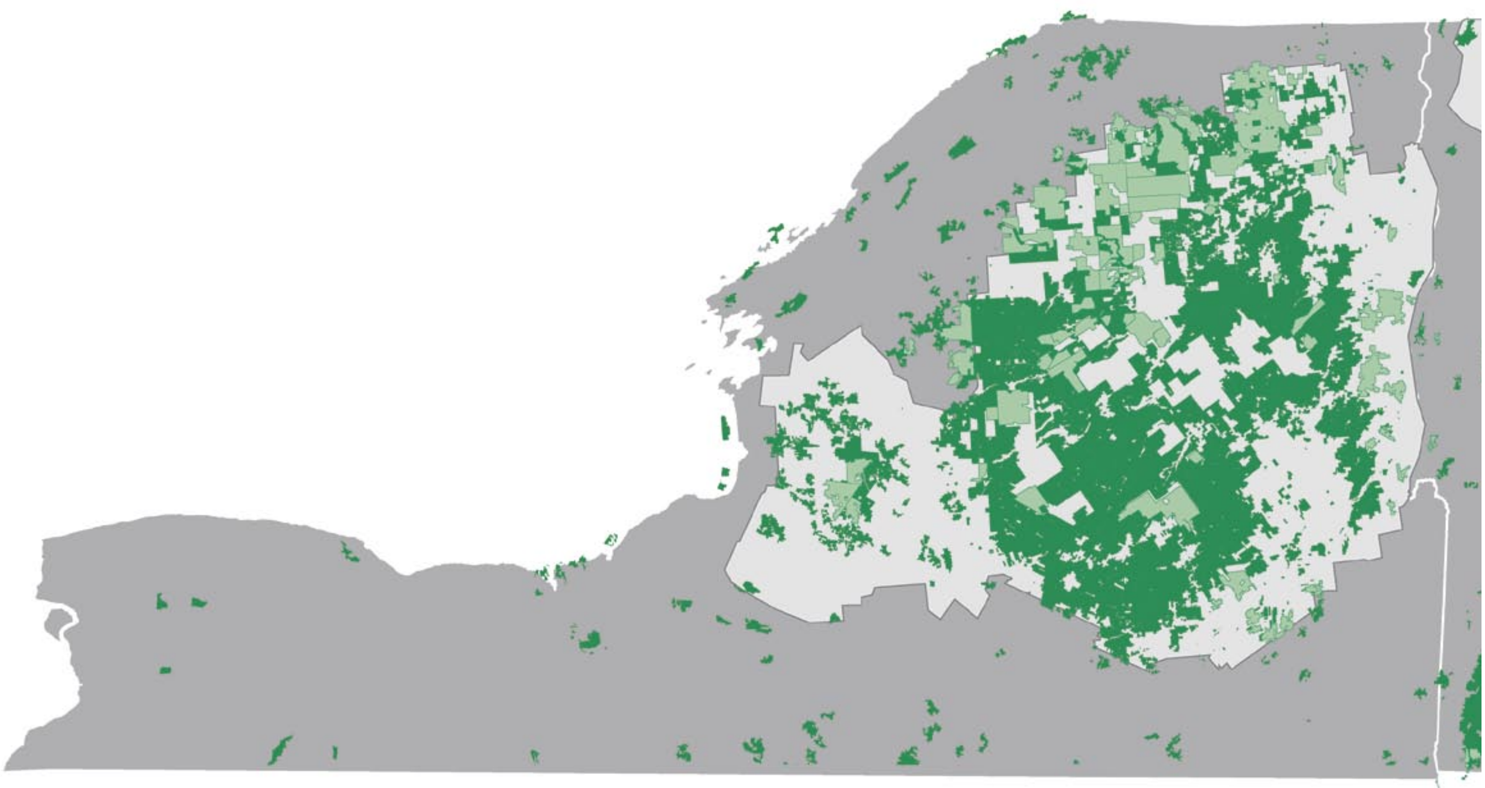
Shrub-sedge meadows, which are a type of open fen, are wetlands of intermediate fertility and diversity, less diverse than shrub swamps but more diverse than fens. They represent a successional stage in drained beaver ponds and a permanent community in open floodplains and peaty basins. They are a characteristic breeding habitat of Lincoln's sparrow and a feeding habitat for other birds.

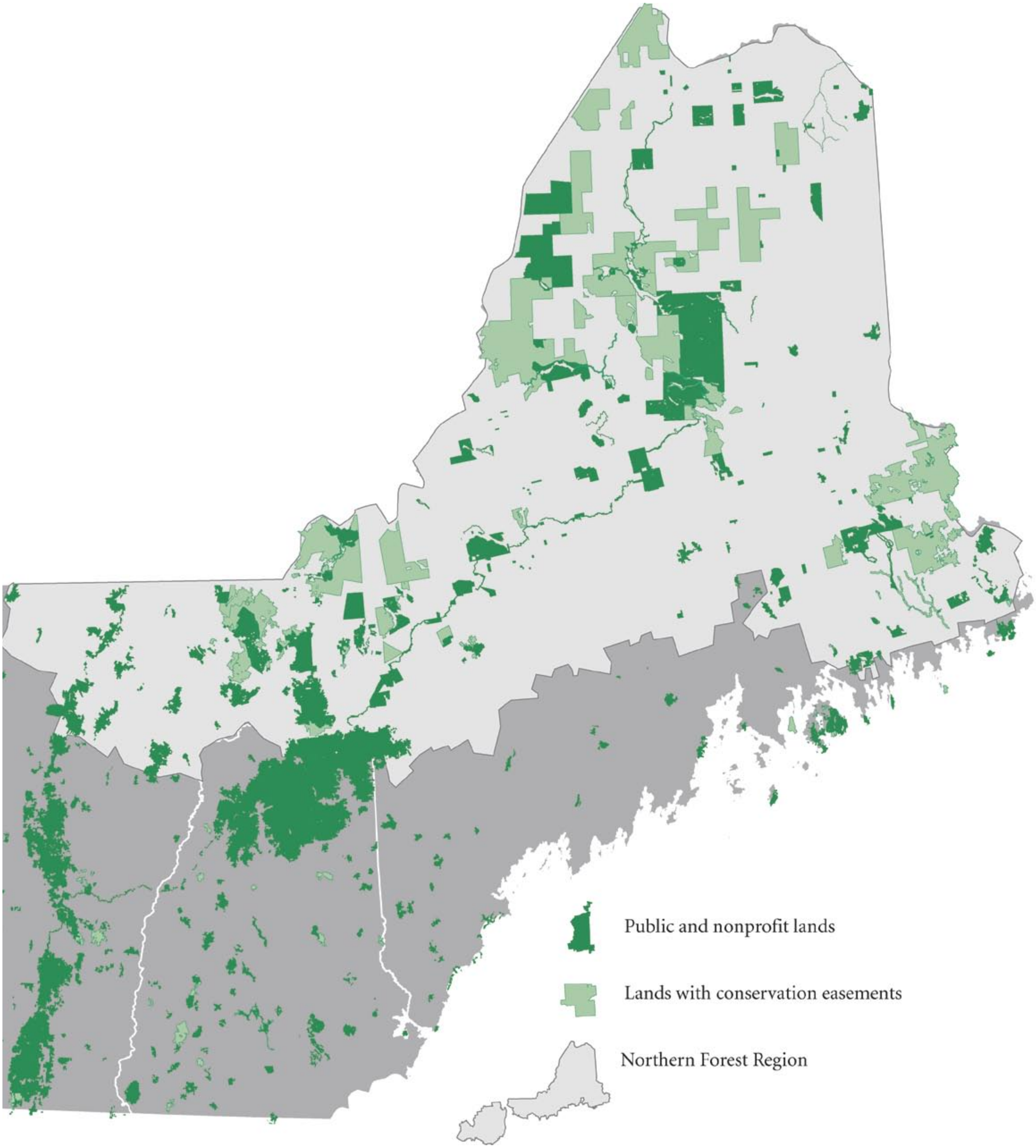
*For simplicity, and to parallel this use of biodiversity, I refer to the number of species in an animal or plant group as its diversity, avoiding the less familiar (and in this document unnecessary) technical term *species richness*.

PROTECTED LANDS IN NORTHERN NEW ENGLAND AND NEW YORK.

The map, based on data from the Adirondack Nature Conservancy and the Appalachian Mountain Club, shows protected areas of a thousand acres or more. The map shows about 8.8 million acres of protected lands, of which 6.1 million acres are "fee" ownerships belonging to governments or nonprofit groups, and 2.7 million acres, just less than a third, are in conservation easements on private lands. The largest fee ownerships are the Adirondack Forest Preserve in northern New York, the Green Mountain National Forest in Vermont, the White Mountain National Forest in New Hampshire, and Baxter State Park in Maine. The largest easements (identified in the map on pp. 84–85) are the Pingree lands, the Sunrise Tree Farm, and the West Branch, all in Maine; the Connecticut Lakes in New Hampshire; and the former International Paper lands, now held by Lyme Timber, in New York.

With the exception of the core lands of the Adirondack Park, most of these lands have been acquired and protected since 1900. The national forests, Baxter State Park, and many other state parks were created in the first half of the 20th century and expanded after 1950. The Nature Conservancy began major acquisitions in the 1980s. The first large conservation easements were created in the 1980s, and most of the growth in large easements has come since 1990.




Public and nonprofit lands
Lands with conservation easements
Northern Forest Region

The Northern Forest Region (light green), as defined by the Northern Forest Council, is an area of about 28 million acres, beginning on the Tug Hill Plateau in northern New York, extending east through the Adirondacks and the Green and White Mountains and including much of Maine. As so defined, it is mostly a nonagricultural region of sparse settlement in which, from about 1850 to 1970, timber, pulp, and paper were the principal industries. For a detailed map of conservation lands in the region, see p. 10. For a gallery of images of the region, see p. 20.

1 THE NORTHERN FOREST REGION

What is the Northern Forest Region like?

The Northern Forest region is cold, wet, fairly rocky, and continuously forested. It is flat in much of northern Maine and variously hilly to mountainous in northern Vermont, New Hampshire, and New York. Valley and lowland forests are typically conifers, midslope forests typically northern hardwoods, and upper-slope forests conifers again. As you move north, the conifers on the upper slopes descend to meet those in the valleys. The band of hardwoods between them becomes narrower and then, when you reach the boreal zone, disappears altogether.

The flat parts of the NFR have been used for timber production for 150 to 200 years and for pulp production for 100 to 120 years. The early cuts of the log-drive era, in both hardwoods and softwoods, were selective cuts.* More recent cuts, in both hardwoods or softwoods, have often been clear-cuts or phased clear-cuts (a partial or "shelterwood" cut followed by an overstory removal cut). Selective logging is practiced in some parts of some ownerships but, except in parts of the Adirondacks, is not the dominant form of silviculture.

*As used here, a selective cut removes less than 50% of the canopy and produces an uneven-aged stand. Clear-cuts and partial harvests, in contrast, are even-aged systems in which all the older trees are removed in one or two cuts and regenerating trees that replace them are about the same age.

Many parts of the NFR have suffered “stand-replacing” disturbances in the past century. Extensive fires, often associated with railroad logging, have occurred in many heavily cut areas. Major wind and ice storms occurred in 1938, 1950, 1995, 1998, and 1999.

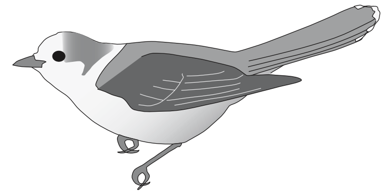
Widespread and severe spruce budworm outbreaks occurred in the 1910s, 1950s, and 1970s. Both storms and budworm attacks killed many trees and led to widespread salvage logging. Many of the regenerating clear-cuts in Maine were generated by salvage operations in budworm-affected stands in the 1970s and 1980s.

The combination of steady logging and major disturbances has created a forest that, excepting the Adirondacks, tends to be young, even-aged, highly dissected, and well roaded. In many places most of the trees are less than 60 feet high and 10 inches in diameter. In many recently harvested stands, skid roads cover 20 to 25% of the ground and are separated by 75 feet or less. On all except the steepest or wettest terrain there is a truck road of some sort within a mile of almost any point in a commercial forest.

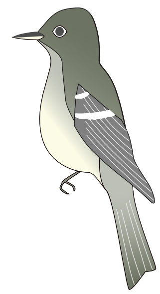
Larger and older trees occur in reserves, on lake and river slopes, and on hill slopes where there has been no recent forestry. They are almost completely absent from forests where there is active logging. The amount of land with trees 20 inches in diameter or more on the properties I visited in Maine was probably 5% or less.

Because there are few large living trees in the working forests, there are few large dead trees of the sort that are valued by wildlife. Where old dead trees from previous generations occur, foresters seem to be universally careful about leaving them. But large dead trees come from large living ones, and in a forest where there are few large living ones, the future supply of large dead ones will be low.

Many parts of the NFR currently seem to grow softwoods and early-successional hardwoods exuberantly and late-successional hardwoods with difficulty. Softwood regeneration was vigorous and impressive wherever I went, and young softwood stands were often dense, thrifty, and fast growing. Hardwood regeneration and hardwood health varied much more. Sugar maple, the dominant hardwood in many stands, is regenerating poorly in the western Adirondacks and shows poor crown vigor in many other areas, making it difficult to manage selectively. Beech disease is throughout, and the management of beech-dominated stands, which tend to fill up with sprouts as the old trees die, is a silvicultural nightmare. Soft maple and yellow birch are doing relatively better and currently may be the most successful hardwoods. Forest managers generally say that they can grow softwoods well on most sites but hard maple only on the best sites and with the proper site preparation.



Gray Jay



Yellow-Breasted Flycatcher

Two northern forest birds. The gray jay is a generalist, nesting within forests but foraging widely in many habitats. The yellow-breasted flycatcher is a forest-interior species, nesting on the mossy floors of dense wet conifer forests, often in black spruce or tamarack.

What are the largest and most spectacular natural features in the NFR?

Throughout the region, the lakes, rivers, and wetlands. More locally, the high mountains, and the late-successional forests in ecological reserves. Even more locally, smaller but still dramatic rock features: cliffs, river gorges, and small rocky hills.

Where are the large tracts of private lands in the Northern Forest and who owns them?

The largest tracts of private land, ranging from 10,000 to 700,000 acres, are in northern New York, New Hampshire, and Maine. Formerly they were owned mostly by paper companies and private families. Starting in the 1980s, the paper companies began to sell their lands, and various forest investment groups (timber investment management organizations, real estate investment trusts) and smaller forest products companies began to buy them. Recently, several towns, land trusts, and conservation groups have bought forests of significant size.

Why have the paper companies sold their lands?

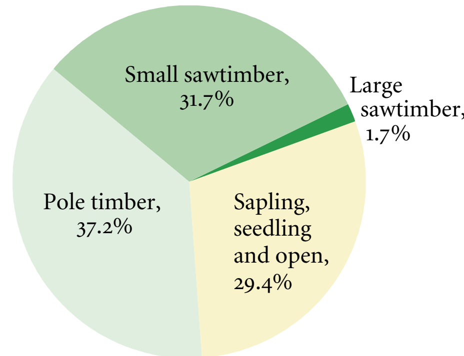
In the case of the small companies, because they were losing money and disposing of their assets. In the case of the large national or international companies, the proximate reasons were changes in tax laws (see Hagan et al. 2005) and the desire of their investors to see improved ratios of earnings to assets. Longer-term reasons were that growing trees is the least profitable part of the paper business, and compared with the southern United States and the tropics, the northern forest one of the least profitable places to grow them. The fiber industry is following many other industries out of the United States and into the developing world; the deindustrialization of the NFR is only a part of this larger shift.

Are the new investment ownerships short-term or long-term?

Most are short-term. They are bought by funds—groups of investors—that purchase land over three or four years, manage it for five to seven years, and then sell it over two to three years. Since much of the investors' return comes from the appreciation of the value of the land, the land must be sold for the investors to get their returns. Thus a typical timber investment company holds any given piece of land for 12 years or less.*

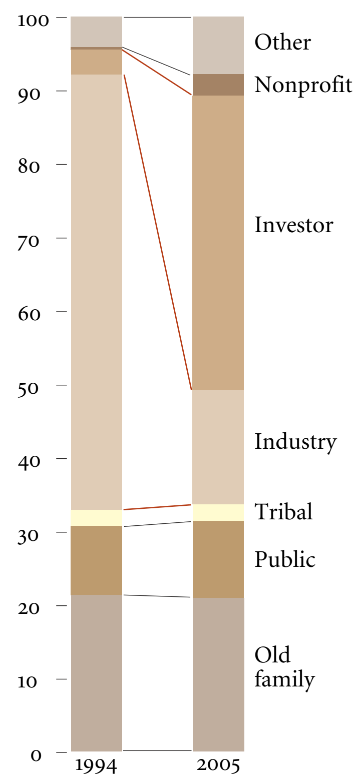
*See Rick Weyerhaeuser, *An Introduction to Timberland Investment*, Lyme Timber Company, available online at www.lymetimber.com/PDF/TimberPrimer.pdf, for a detailed discussion of timber investment funds.

TREE SIZES IN MAINE



The percentage of the total forest acreage dominated by trees of different sizes. In sapling stands the majority of the trees are less than 5 inches at breast height. Pole stands are 5 to 10 inches, small sawtimber 10 to 15 inches, and large sawtimber over 15 inches. From D.J. Mansius et al. *The 2005 Biennial Report on the State of the Forest and Progress Report on Forest Sustainability Standards.*

FOREST OWNERSHIP IN MAINE, 1994–2005



Changes in forest land ownership in Maine, 1994 to 2005. From data in J.M. Hagan et al. 2005, *Changing Timberland Ownership in the Northern Forest and Implications for Biodiversity.* The red lines show the decrease in industry ownership and the compensating increase in investment and nonprofit ownership.

Who will buy these lands 10 or 20 years from now?

No one knows. Currently timber investment funds often sell to other timber investment funds. This may or may not continue. Much will probably depend on how fast two competing markets—biofuels and carbon credits—develop.

What sort of forests are found on private ownerships?

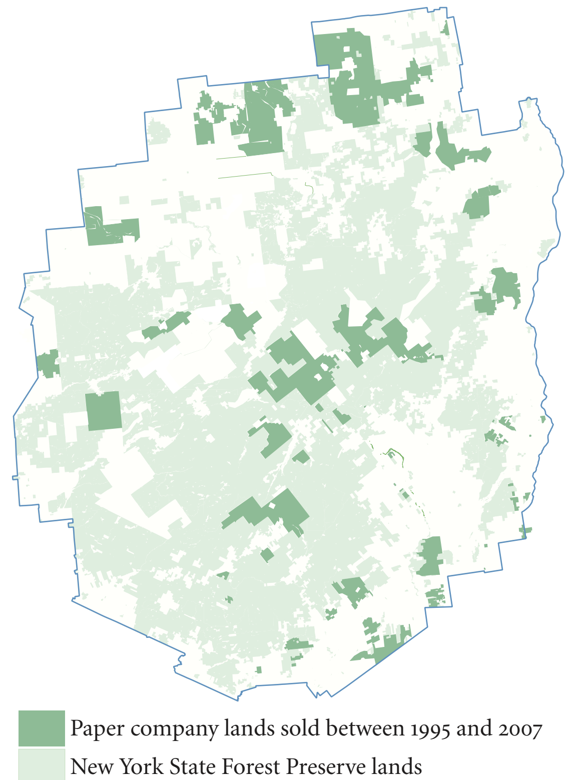
Various mixtures of northern hardwoods (birch, beech, maple, ash) and softwoods (spruce, fir, pine, hemlock), usually on acid glacial soils. Much more rarely, oak forests and high-diversity hardwood forests on limy soils. Oak forests occur mostly south of the Northern Forest Region and in the smaller ownerships on its edges. High-diversity hardwood stands occur extensively in western New England and to a lesser but significant extent in the eastern Adirondacks, but only rarely in the NFR proper or on the large ownerships considered here.

What do these forests look like?

They are a mixture of good and bad—forests that have been altered and even damaged by hard use but are still surprisingly diverse and functional. On the one hand, they are almost all primary forests that have never been cleared for agriculture and hence are almost completely weed free and have almost all of their original species. But on the other hand, most have suffered from beech-bark disease and many from spruce budworm attacks. Almost all have been cut repeatedly; many have been high-graded (best trees selectively removed) and many, but certainly not all, have been clear-cut. Some, especially in Maine, have been cut repeatedly for softwood pulp on short rotations, and some, also mostly in Maine, have been used for plantations. Most have relatively small young trees (typically less than 80 years old and 12 inches in diameter) and an extensive network of skid roads. Many have much soil disturbance and slash, a patchy structure, and other signs of frequent harvesting.

What products do they produce, and how much of them do they produce each year?

A mixture of sawtimber and pulp, with much fiber and low-grade wood. Maine is the only state for which I have been able to find good data. Overall, in 2003 the forests of Maine produced the equivalent of 2.6 million cords of sawlogs, 3.0 million cords of pulp, and 0.4 million cords of chips for biomass energy. Much of the sawlog production came from small ownerships; the large



In the past ten years Champion, Domtar, International Paper, and Finch-Pruyn sold all their Adirondack lands, which totaled nearly 700,00 acres (dark green). About a fifth of the land was purchased by New York State or by conservation groups; the rest is now owned by forest investment companies, with the state holding conservation easements.

industrial lands tend to grow small trees and be specialized for pulp production. In Maine, the total harvest of all species in 2003 was equal, within a few percent, to the estimated growth of all the stems in the forest. For fir and spruce, the two most important softwoods, sawlog-sized trees were being harvested two to three times as fast as they were growing.

Where do the logs from the NFR go?

There is, so far as I know, no overall comprehensive summary of the movement of logs. Formerly most were processed within the NFR or right on its borders. Now many go to Canada, and some may be shipped overseas.

Domestic markets for pulp logs, which are the least valuable product and so the least likely to be shipped long distances, have been decreasing (map on p. 18). In the 1990s there were at least 25 pulp and paper mills in the NFR or just across its border in Canada. Several of these, like the Fraser mill in East Millinocket, are running at reduced capacity. If mills continue to close at the rate they have been closing over the past ten years, the market for pulp logs in 2017 may be very different from what it is today.*

Do the large private ownerships contain some of the spectacular natural features described on p. 14?

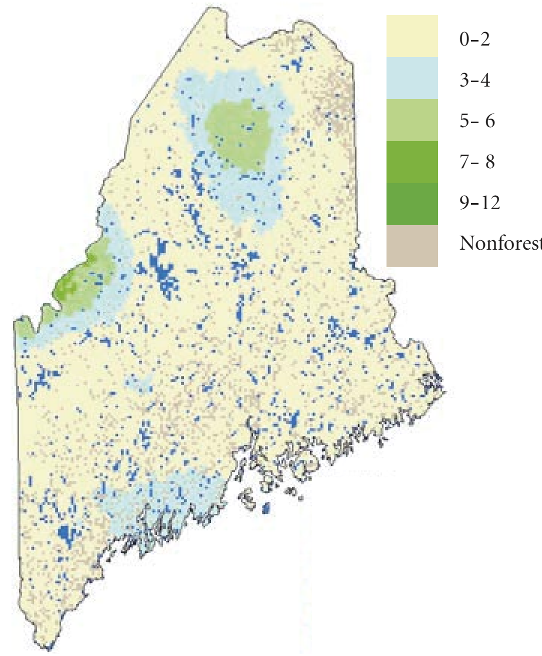
Because much of the best softwood was in the lowlands, they tend to contain many lakes, ponds, rivers, and bogs but relatively few high mountains. Many famous rivers—the Hudson, Moose, St. Regis, Raquette, Androscogin, Connecticut, Dead Diamond, Kennebec, Penobscot, Allagash, St. Johns, St. Croix,—begin in or flow through large commercial forests. Many equally famous lakes—Raquette, Tupper, Long, Indian, Schroon, George, the three Connecticuts, Umbagog, Rangely, Flagstaff, Moosehead, Seboomook, Chesuncook, Millinocket, Chamberlain, Grand—are connected to or were created by damming these rivers.

What condition are these large natural features in?

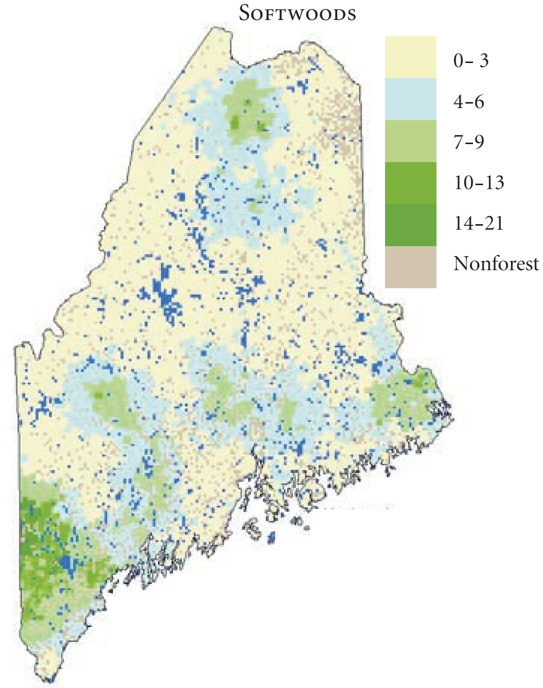
In general, very good. The wetlands, free-flowing rivers, and ponds are all in good condition. Because of the extensive use of the rivers for log driving, many of the large lakes are artificial or maintained at artificial levels by dams. But even when artificial, the large woodland lakes are spectacular natural features by any standards. Many of those in Maine are almost completely undeveloped and so are among the largest and wildest and for boaters the most glorious waterbodies anywhere within the contiguous United States. The lakes in the Adirondacks and New Hampshire are much more developed, but still have many wild parts.

Trees 15 Inches or Larger per Acre

Hardwoods

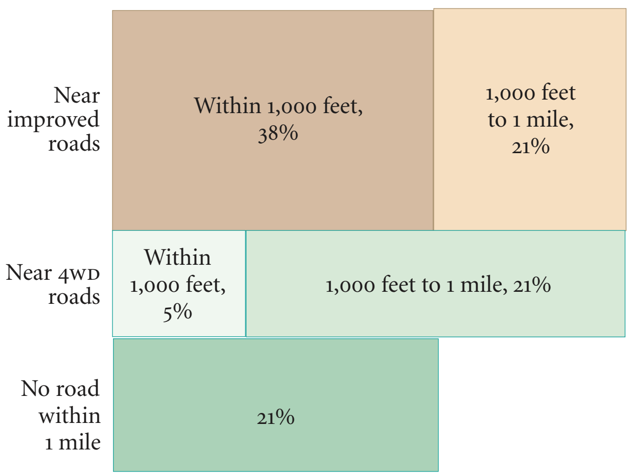


Softwoods

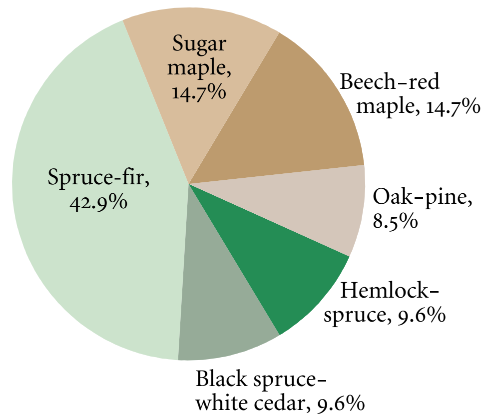


* A growth in biofuels or biomass generation could of course change this. Local papers in New Hampshire and Maine have reported on start-up companies proposing to use the Old Town, Gilman, and Groveton mills for biofuel plants.

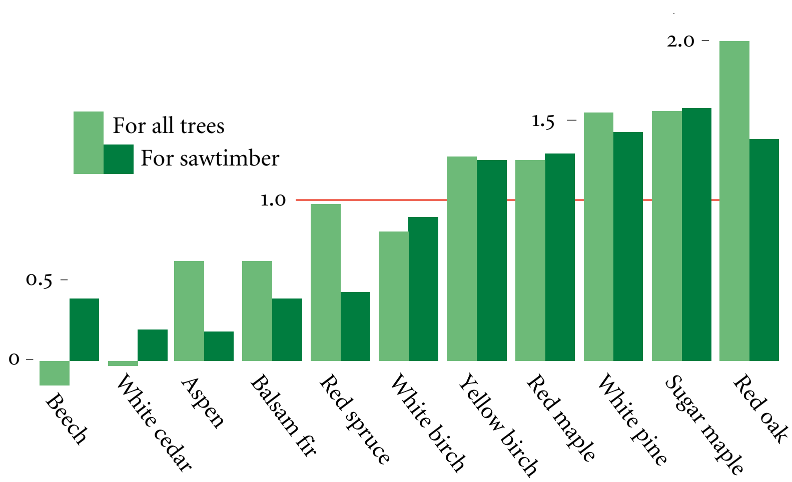
Survey Plots Within 1 Mile of a Road



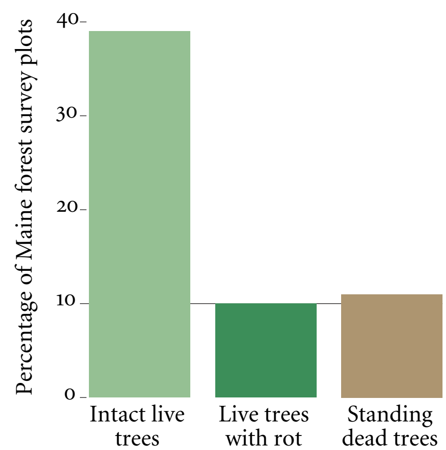
Forest Types



Ratio of Net Growth to Harvest



Survey Plots with Trees 15 Inches or Larger



The 2003 forest statistics for Maine, from McWilliams et al., 2004. Maine is the only state for which we have good recent data. Left page: the number of trees with large sawlogs 15 inches or more at breast height. Such trees, which would be considered small in an old-growth forest, are rare in Maine. The only areas with even modest numbers of large hardwoods are in the far north and northwest. The north has some large softwoods as well; most of the other large softwoods are in the south, and the greatest concentration is on small ownerships outside the NFR.

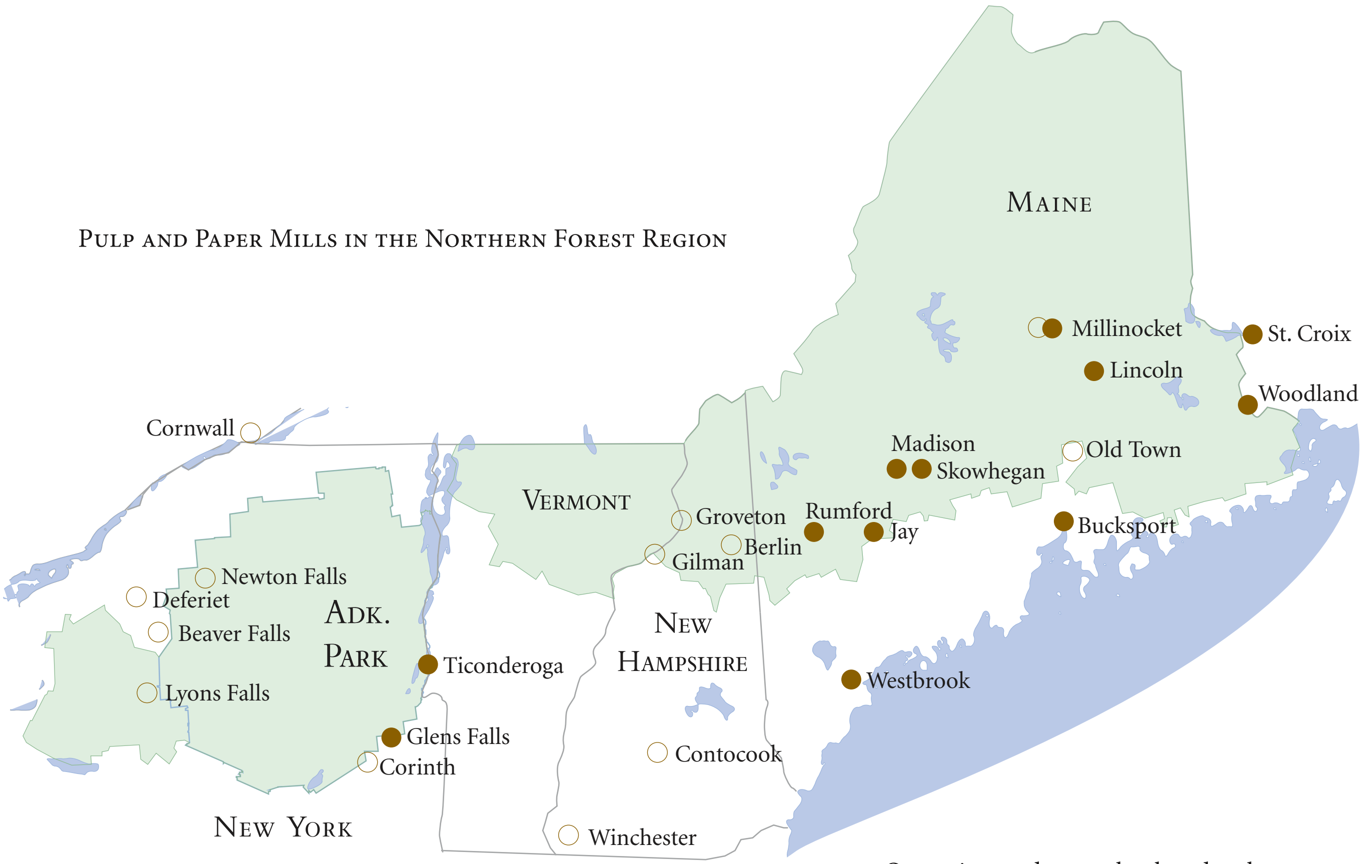
Above upper left: Maine forests are extremely well roaded. Almost 80% of the forest survey plots were within a mile of some sort of driveable road, and 59% within a mile of an improved road.

Above upper right: the percentage of land with different forest types. Conifer-dominated stands are twice as common (62%) as pure hardwood stands (28%), and spruce-fir stands the commonest of all (43%).

Above, lower left: the ratio of net growth (total growth minus mortality) to harvest. If the light green bar is above the red line the species as a whole is growing faster than it is being cut. If the dark green bar is above the red line, sawtimber is growing faster than it is being cut. Red spruce, balsam fir, white birch, and aspen, all economic mainstays of the northern woods, are being cut faster than they are growing.

Above, lower right, the distribution of large trees of various kinds on survey plots. About 40% of the plots have sound living trees 15 inches diameter or over, but only one plot in ten has a rotten live tree or a dead snag of the sort that animals use for cavity trees.

Pulp and Paper Mills in the Northern Forest Region



Operating and recently closed pulp and papermills in the NFR. There does not seem to be any adequate regional summary of the state of the paper industry. This map, prepared from online information, interviews, and my own observations, may be incomplete. It shows two Canadian mills near the U.S. border but does not try to show other Canadian mills.

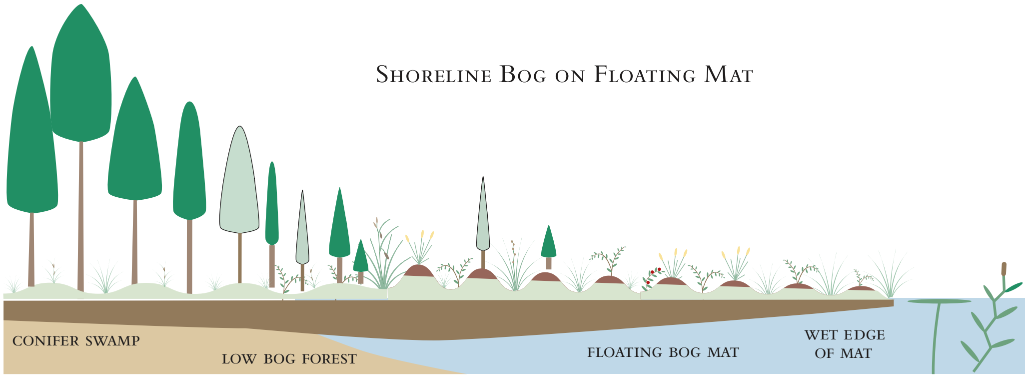
The map shows only mills which buy logs and make their own pulp. Other mills, not shown, recycle paper or use ready-made pulp. These do not buy logs and are less important to commercial forests. There are at least five paper mills in northern New York that do not buy logs, at least one in Vermont, and probably more than a dozen in New Hampshire and Maine.

In addition to these large features, do the working forests of the NFR contain smaller features of biological importance?

They do indeed. Perhaps the most important are natural communities with specialized species that don't occur in the working forests themselves (Gallery, p. 72). These include cliff and outcrop communities, montane and subalpine woods, some open summit communities, and a large variety of wetland and riparian communities. Among the latter, open and forested peat lands, open river shores, vernal pools, and the various meadow and thicket phases produced by the beaver cycle are particularly widespread and noteworthy. These communities typically cover only 5% to 10% of the area of an ownership, but may include a disproportionate amount—up to 50%—of its total plant diversity.

What condition are these smaller communities in?

In general, somewhere between quite good and almost undisturbed. Some of them, especially the upper mountains and large wetlands, have never been logged. Others, especially streams, ponds, and smaller wetlands, are fairly well protected (though not



Floating bogs are an example of a small community that is important for biodiversity. Bog mats develop slowly and are typically several thousand years old or more. They can tolerate small amounts of flooding, up to perhaps 2–3 feet, but are destroyed or altered by larger amounts of flooding. Mats in small, hydrologically isolated ponds are common and usually in good condition. Mats in lakes and rivers are rare, perhaps because of extensive damming for hydropower and log drives. In the Adirondacks at least perhaps half of large floating mats have been altered or destroyed by dams.

necessarily well buffered) under the management practices used by most large owners. And almost all of them, in striking contrast to the communities in the agricultural landscape, have unpolluted surface waters, relatively natural flow regimes, and largely native floras and faunas.

Summary: What features of the Northern Forest Region will most influence how we choose to protect it?

I would suggest three features. First, its uniformity. Much of the region has a similar climate and similar soils. Because of this, most species are widely distributed, and so we have considerable freedom about where and how we protect them. This is different than, say, the situation in the western United States, where every mountain range has endemic species that must be protected within that range.

Second, the spectacular wetland and water features. These are the jewels of the region, and indeed some of the jewels of the world. If you want to see mile-long bogs within the contiguous United States, or paddle a lake and see undeveloped shores extending to the horizon in both directions, you will have to go either to the upper Midwest or to the NFR. Any conservation plan we create will be judged on how well it protects the water features and will be considered to have failed if it does not protect them.

Third, and counterintuitively, the highly altered forests. Because most of the working forests have been cut so hard and so often, we don't really have to worry about whether there are species in them that are intolerant of logging. There won't be and can't be. But we do have to realize that because most of the working forests are young and altered, any late-successional forest is unusual, may contain species that are uncommon in the younger forests, and may deserve special management or protection.

High mountains: the Knife Edge, Mount Katahdin.

High mountains: the High Peaks from the south, Adirondacks.

The lower slopes of Crane Mountain, eastern Adirondacks, Johnsburg, New York.

Mature spruce and northern hardwoods on Green Mountain, West Branch Easement, Maine.

The upper limit of sugar maple, middle slopes of Megalloway Mountain, Pittsburg, New Hampshire.

Vigorous black spruce and tamarack along a boreal stream, Connecticut Lakes Easement, New Hampshire.

Old-growth hemlock and northern hardwoods, Grand Lake Stream, Maine.

Mountain holly and labrador tea within a boggy black spruce-tamarack stand, western Adirondacks.

Grand Lake, Maine.

Stillwater on West Branch of the Penobscot, Maine.

Big Bog, West Branch Easement, Maine.

Battery Acid Pond, Litchfield Park, Adirondacks.

Open wetland channel, Musquash Stream, Sunrise Easement, Maine.

Open floodplain with oxbows and alluvial conifer forests, West Branch of Penobscot, Maine.

Big Bog, West Branch Easement, Maine.

Large fens by the Hudson River, Newcomb, New York.

Bog pond in black spruce-tamarack woods, West Branch Easement, Maine.

Large raised bog, Katahdin Forest, Maine.

Flooded oxbows of the Raquette River, Tupper Lake, New York.

Artificial shores: fall drawdown on the Second Connecticut Lake, New Hampshire.

Artisanal logging: hemlocks thinned by a cut-to-length machine, Grand Lake Stream, Maine.

Salvage logging: a heavy cut in low-grade beech-maple, West Branch Easement, Maine.

Large-scale commercial logging: a shelterwood cut, Sunrise Forest, far eastern Maine.

Selective logging: a thinning cut in northern hardwoods, Casey Brook, Adirondacks.

Hand cutting: cable skidder, logs cut and limbed by chainsaw.

Mechanized cutting: Timberking cut-to-length machine thinning hemlock, Grand Lake Stream, Maine.

A 20-year-old clear-cut, West Branch Easement, Maine.

Young trees in a strip clear-cut, Katahdin Forest, Maine.

Gilded Age: Edward Litchfield's castle (arrow), Lake Madeline, western Adirondacks.

Prewar: camp on Nesawadnehunk Lake, Katahdin Forest, Maine.


Late 20th century: dispersed lakeshore cabins with setbacks, Grand Lake, Maine.


Early 21st century: a new year-round shoreline residence, Pittsburg, New Hampshire

To protect animals and plants we have to know what species we have and which ones need protecting. This section, based on the literature and my own 40 years of survey work in the NFR, gives a brief summary of our current knowledge.* Everything I say here is subject to the caveat that there has been little systematic work on invertebrates and fungi, that there are likely more species of them than everything else put together, and that at present their distributions, abundance, and diversity are too poorly known to summarize.

How many animal and plant species occur in association with working forests in the Northern Forest Region?

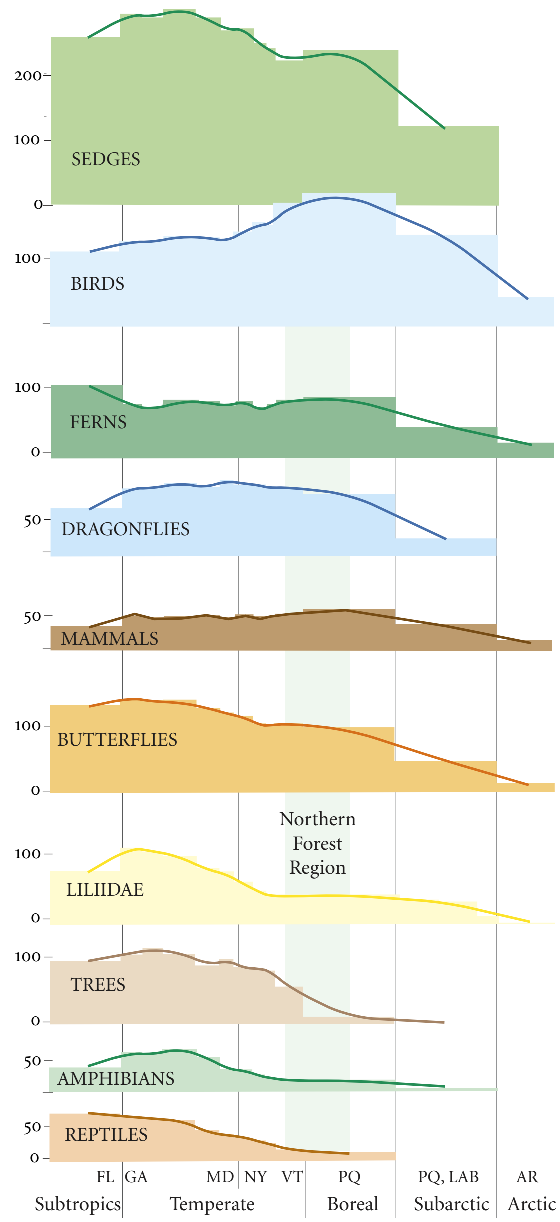
No one knows for certain. My estimate at right, of around 300 terrestrial vertebrates and a thousand species of green plants, is a minimum estimate of the species that regularly occur in working forests or in the special habitats found near them. It ignores highly rare species, and southern and lowland species (like the map turtle and the rattlesnake) that occur at the southern edges of the NFR but not within it. Adding invertebrates and fungi would greatly enlarge this number. Finnish biologists, for example, have estimated that Finland contains 45,000 species of animals, plants, and fungi and that at least 20,000 of these occur in forests.

How many of these species will occur on a single ownership or in a single stand?

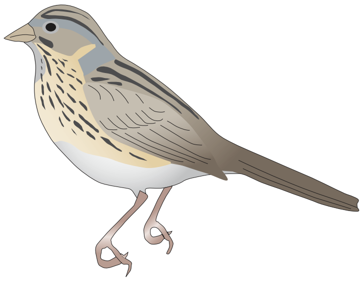
This will of course vary with forest type and the fertility of the soil. An average stand of hardwood forest of, say, 10 acres, on acid soils, might contain 10 to 12 species of trees, 20 to 40 species of shrubs or herbs, 20 to 60 species of mosses, 15 to 25 species of birds, and 5 or fewer amphibians. Mammals are harder to estimate because of their large ranges, but somewhere around a dozen resident mammals and another half-dozen to a dozen visitors might be appropriate.

The diversity of an average ownership, again on acid soils, will be larger than that of a stand but not immense. My 1990s survey of the Champion Lands in the northwestern Adirondacks (145,000 acres, now under a conservation easement) found about 300 species of higher plants, which is certainly an underestimate because the survey was brief and done in the late fall. The state Breeding Bird Atlas suggests that there are at least 120 species of birds on the property, and the state Herp Atlas suggest a maximum of about 13 species of amphibians and 7 reptiles.

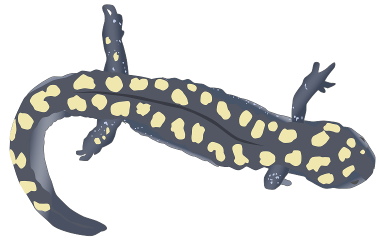
*I omit fish, about which I know little and which are less affected by logging than are terrestrial vertebrates.



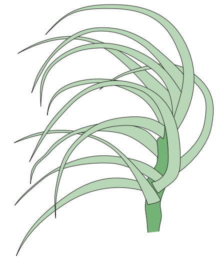
Some sense of how biodiversity varies within the NFR can be had by looking at how the total number of species in different groups varies from south to north. These graphs are compiled by states and provinces on a transect extending from southern Florida to the Canadian Arctic Archipelago. Note that the diversity of many groups (sedges, ferns, mammals, etc.) is fairly flat through the NFR and then declines as you enter boreal Canada. Trees, amphibians, and reptiles are southern groups whose diversity declines across the NFR. Birds on the other hand have a north temperate peak and reach their maximum diversity here. (Compiled by J. Jenkins.)



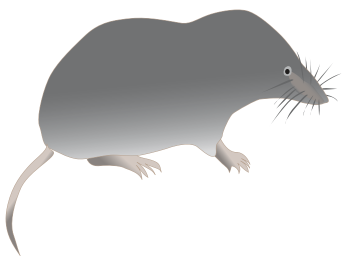
Birds. Approximately 200 breeding species, of which 40 to 50 have a strong association with forest interiors. Many of the neotropical migrants (warblers, vireos, thrushes, etc.) are forest-interior species.



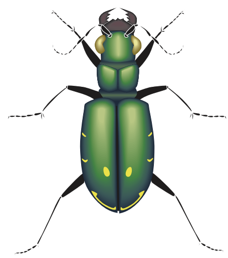
Amphibians. About 17 species, many associated with wetlands and vernal pools. Four or five occur regularly in forest interiors, and others pass through them in migration.



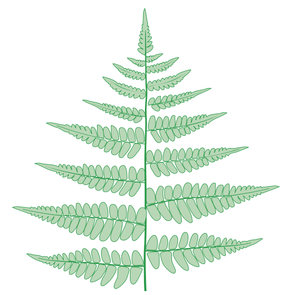
Mosses and liverworts. At least 400 species in the upland parts of the NFR. Many of these are found in forest interiors, but few if any are restricted to them.



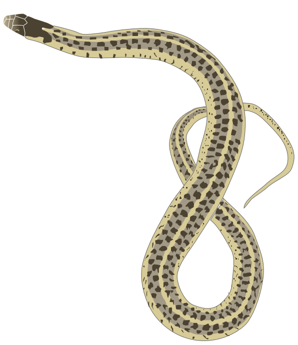
Mammals. Approximately 45 to 50 species, most of which are generalists that occur in many habitats. Most species occur in forest interiors at some time or other, but none are limited to forest interiors.



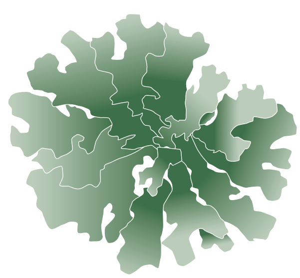
Invertebrates. Poorly known but certainly many thousand. No estimates of the number of forest-interior species are available.



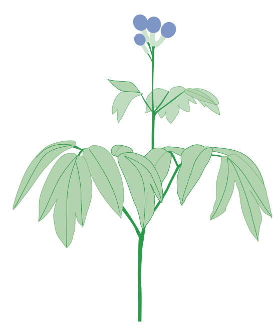
Ferns and fern allies. Approximately 50 species in the NFR. Only a few, perhaps 10, are strongly associated with forest interiors.



Reptiles. About 11 species in the upland parts of the NFR. Most are found in wetlands or open areas. Only the wood turtle (which is declining in many areas) spends significant amounts of time in forest interiors.



Fungi and lichens. Also poorly known. It is likely that 1000 or more species occur in the NFR and that a significant number are associated with forest interiors, but few studies of their distribution and ecology are available. Several lichens seem to be associated with old-growth forests.



Higher plants. Over 500 species in the NFR, of which about 150 occur regularly in forests and perhaps 50 are forest-interior species.

How does the number of species vary across the Northern Forest, and how does the NFR compare in diversity with other regions?

The species diversity of most groups changes only gradually as you move through the Northern Forest (gradient diagrams, pp. 36, 38). This is in part a result of a fairly uniform geology and topography, and in part a result of the geographic mixing caused by repeated glaciation. The diversity of many groups decreases as you move northward, and especially as you move from deciduous forest to conifer forest. Birds are an exception and are actually more diverse in the NFR than in the forests south of it.

Because many species have broadly overlapping ranges, the overall diversity of most groups is surprisingly high. The NFR is more diverse than the northern prairies and comparable in diversity to the Rockies and Pacific Northwest. Although we have fewer birds, mammals, butterflies, lilies, orchids, and grasses than the Rockies or Pacific Northwest, we have equal numbers of amphibians and reptiles and more ferns, sedges, and trees.

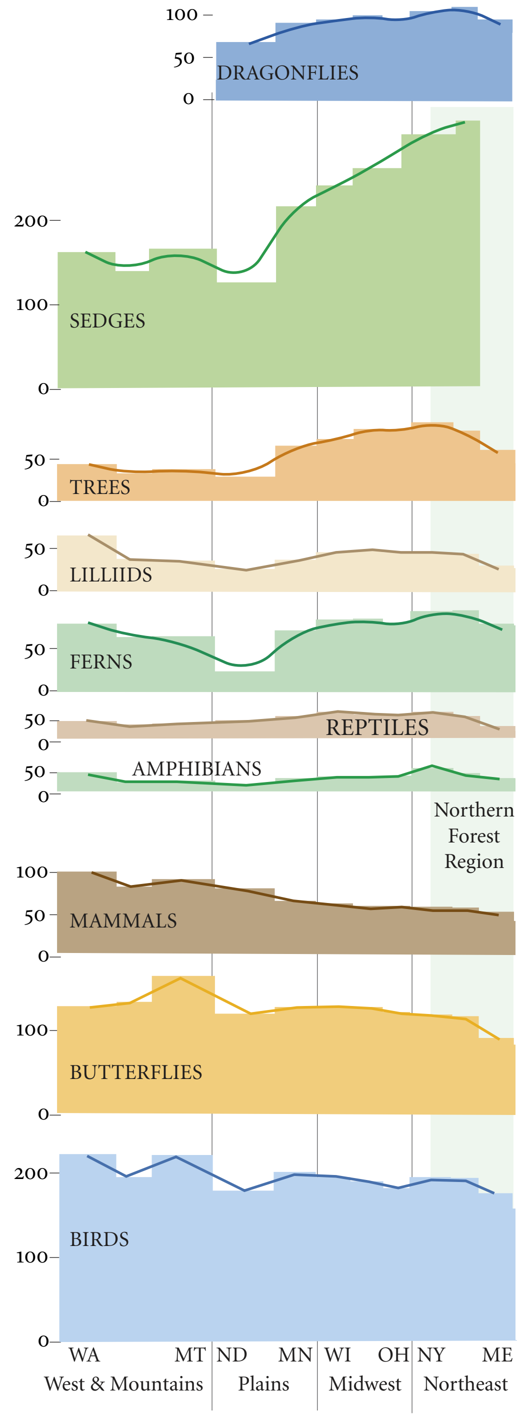
How many natural communities occur in association with working forests in the Northern Forest Region?

This depends on who does the counting, and how narrow or broad their concept of a community is. Without having to use unnaturally broad definitions, I can classify everything I have found on the large private forest ownerships of the Adirondacks using about 10 forest communities, 15 wetland communities, and 3 to 5 odds and ends like river bars and alpine tundra. If I had to classify the whole Adirondack Park, I might need another half a dozen rare communities.

How are the plant species distributed among the communities and which communities have the most species?

As a rough rule of thumb, in an ownership of, say, 50,000 acres, with significant wetlands and both forests and agricultural or postagricultural areas, I would expect to find the plant species evenly distributed, with about a third in the woods, a third in the wetlands, and a third in the open areas and along roads. In a forest ownership without openings, many open-country species drop out (though others still occur in clear-cuts and along roads), and the forests and the wetlands remain roughly equal, each contributing about half the species. Considering that wetlands rarely constitute more than about 20% of a town, this means that, on an area basis, wetlands add more species than forests do. Their preservation is correspondingly important.

The West-East Diversity Gradient



A graph similar to that on p. 36, showing diversity changes across the northern United States, from Washington to Maine. Note that the diversity of many groups is fairly flat from the Midwest through New England and then drops as you enter Maine. (Original work by J. Jenkins.)

Throughout the NFR the richest plant communities—defined as those with the largest number of species for a given area—are those on limy soils or in areas receiving limy seepage. This is true in every type of community. Our most diverse forests are limy forests, our most diverse wetlands limy swamps and fens, and our most diverse open communities limy shores, ledges, glades, and tundra.

After limy communities, our next-richest plant communities are probably open or shrubby wetlands of moderate fertility. Thus in the northern woods, medium fens and alder thickets are usually richer in species than, say, the bogs, the poor fens, or the conifer forests that adjoin them. This is another reason why the preservation of wetlands is important.

Are the animals of limy communities correspondingly diverse?

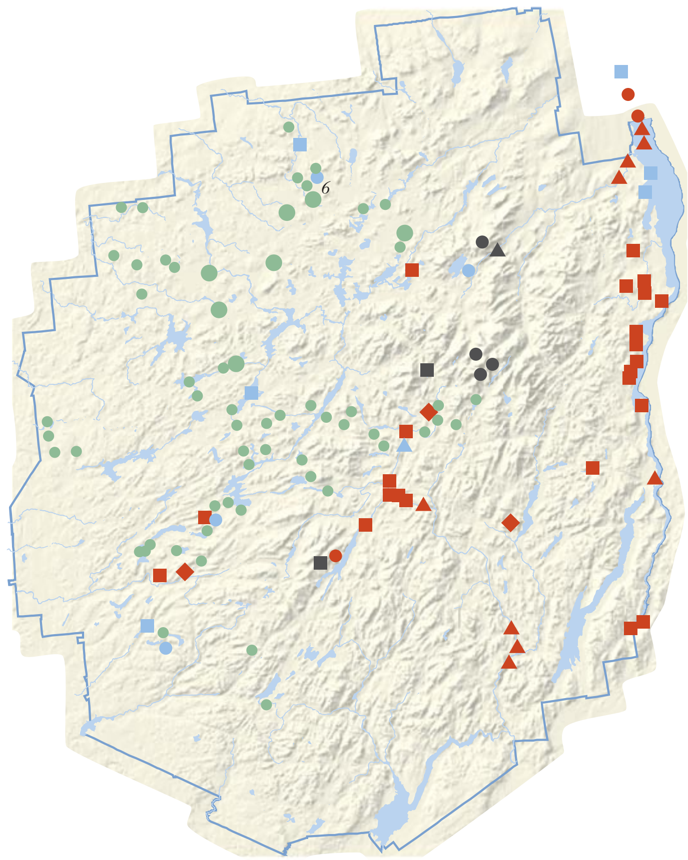
The vertebrates do not seem to be. The invertebrates have not been systematically studied.

How widespread are limy communities in the NFR?

They are quite local. They are largely absent from the western and central Adirondacks and occur regularly on metaigneous rocks in the eastern Adirondacks. They are widespread in Vermont and western New England but mostly south of the NFR. They are rare everywhere east of the Connecticut River but do occur locally in northern New Hampshire and northern and northwestern Maine. But with these exceptions they are very rare. In most parts of the NFR, if you ask about wild leeks or ginseng or want to see a yellow lady's slipper, you are out of luck.

Aside from limy areas, how much does diversity vary from one part of the NFR to another?

Surprisingly little, because of the wide distribution of species and the low gradients in species diversity shown in the graphs on pp. 36 and 38. In plant studies we find more woodland species at low elevations and in hardwoods than at high elevations and in conifers, and thus our most diverse sites are in river valleys or near the southern edges of the NFR. We find a similar pattern in amphibians and reptiles, but no overall pattern in wetland plants or birds. The maps of bird diversity for New York (pp. 44-45) show somewhat greater diversity outside the Adirondacks, but we do not know



A partial map of rare plant localities in the Adirondacks, from 25 years of survey by the author. Note that, given the size of the park, there are not that many known localities for rare plants; many large areas have none at all. Note further that the rare plant localities tend to be grouped, and that the majority of them are in limy habitats or peatlands. This further increases their predictability. From the *Adirondack Atlas* (Jenkins 2004).

whether this reflects habitat diversity or simply the difficulty of doing thorough surveys in wilderness areas.

What communities are rare, and where are they found?

Our rarest upland communities are probably alpine tundra, open limy ledges, and late-successional forests with big old trees. Our next-rarest upland communities, and probably the ones that are richest in plant species, are rich mesic hardwood forests and rich dry forests.

Our rarest wetland communities are limy fens and limy river shores. Large raised bogs and large floating bogs, though widespread in the NFR, are certainly uncommon overall as well. All of these communities are rare enough that they deserve careful protection wherever they occur.

How many rare species are there, and where are they found?

This is hard to evaluate because systematic surveys of forest plants and mammals have never been done. The best generalization I can make is that although there are uncommon species in many habitats, there are far fewer truly rare ones. The rare animals seem to occur sporadically. To a botanist's eyes at least, there are no clear patterns in, say, which forests have Tennessee warblers and which do not. The plants, on the other hand, follow a simpler rule: most of the truly rare species are in rare or uncommon habitats, and a disproportionate number are in limy habitats.

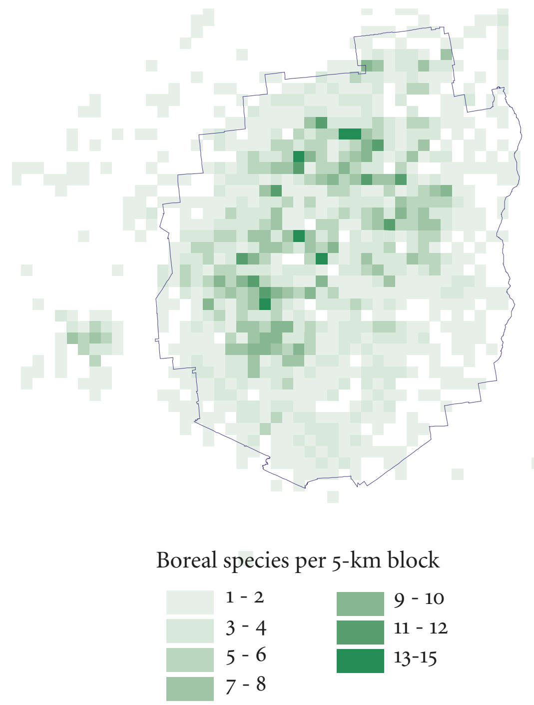
The regular occurrence of rare plants means that they are reasonably easy to find and thus to protect. If an ownership has rare habitats, it will likely have rare plants, and a good surveyor will be able to find them. If it doesn't have rare habitats—and many large ownerships don't—it will likely not have any rare plants.

Rare animals, or at least rare birds, are less predictable. They can occur in quite common habitats, and it seems much harder to predict what you will find or not find.

Do all rare communities have rare species?

Many do, but not all. Some of the uncommon conifer forest communities like red pine summits and jack pine barrens do not seem to have rare plants or vertebrates. Likewise, late-successional forests on acid soils do not, so far as we know, contain rare plants or vertebrates. They are reported to contain a group of lichen species that are absent from or at least uncommon in younger or more disturbed woods, and if this is true they may contain some *ecologically specialized species.** But it is not clear from the work done so far whether these species are rare or not.

Boreal Bird Diversity, 2000



The number of boreal bird species reported as possible, probable, or confirmed breeders by the 2000 Breeding Bird Atlas project. The concentrations of boreal birds indicate fairly accurately the largest areas of boreal habitat, but with great variation from block to block. Because of this variation, it would be essentially impossible to establish a standard level of boreal bird diversity that a given ownership ought to attain.

*Which are not the same thing as rare species. The pitcher plant and wild leek, for example, are both specialized species in the sense that they demand special habitats, but both occur widely wherever their habitats are found, and neither is rare.

The existence of late-successional lichen species is well established in Britain and Scandinavia, and less researched, but likely true, in eastern North America as well.

How accurately can biological diversity be assessed, and how difficult is this to do?

For green plants and birds, diversity can be assessed reasonably accurately but not quickly. On a large ownership it may take several years to do a complete survey. For the cryptic groups like amphibians and mammals, it is much harder. Various kinds of searches and traps are used, but all have their drawbacks. All methods are labor intensive, most are biased, and most disturb the populations they are measuring. Mammal and amphibian studies are typically quite local and rarely done on large ownerships.

Can proxy measurements, either of forest structure or of selected indicator species, be used to estimate overall biological diversity?

I am not sure. The matter is much discussed in the literature on sustainability and forest monitoring, but it has barely been tested. There is much evidence to suggest that forest structure is a fair predictor of bird species diversity but little to suggest that a small suite of bird or plant species can be used to predict overall species diversity.

How variable are assessments of overall biological diversity?

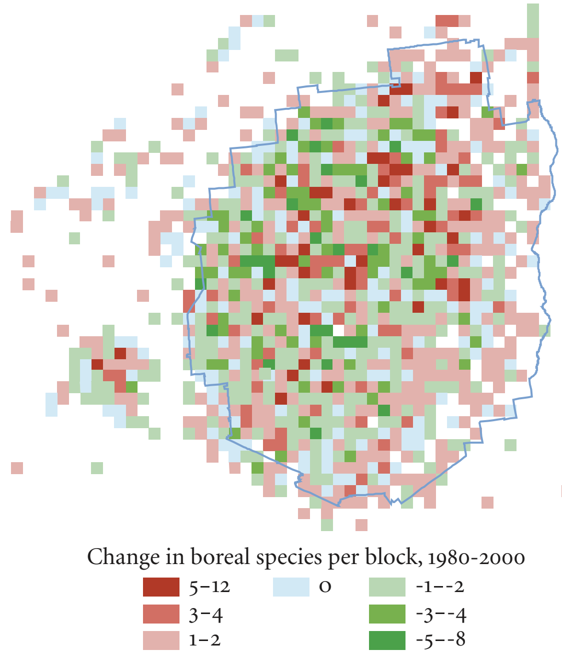
Very variable, in both space and time. Twentieth-hectare forest plots (a common survey unit) in the same forest type may have as few as 15 species or as many as 60. The 5-kilometer squares used for breeding bird surveys may have from 50 to 100 species, and may exceptionally have over 130 species. Successive surveys of the same area at different times, as in the two Breeding Bird atlas surveys shown at right, often report significantly different numbers of species.

Given this variability, can measurements of overall diversity be used normatively to tell us how well a forest is being managed?

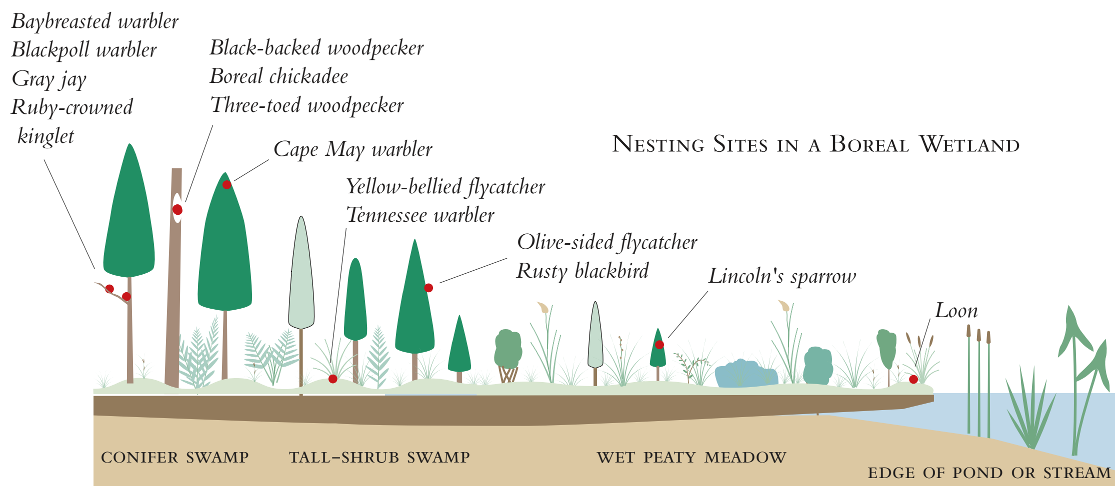
It is tempting to believe that measurements of overall diversity—say the total number of bird or amphibian species or understory plants—can provide a measure of ecological health and so be used to determine whether a property has been well managed. And there is a certain logic to this: if we are managing to conserve biodiversity, shouldn't we be monitoring biodiversity to see whether it has been conserved?

There are really two questions here. The first is whether we can go on to a property, do a short biological survey, sum the number of species, and determine whether the forest is well or poorly managed. The answer to this is clearly no. Properties differ too much,

CHANGES IN BOREAL BIRD DIVERSITY, 1985-2000



The difference between the number of boreal bird species reported as possible, probable, or confirmed breeders by the 2000 and 1985 Breeding Bird Atlases. Note that more blocks have changed than have stayed the same. The pattern is complex though not random. In general, blocks with large numbers of species in the 1980-1985 survey tended to have fewer in the 2000-2005 survey, and blocks with few species in the 1980 survey tended to have more in 2000. This suggests that either the birds or the surveys are varying around a mean. It may be, for example, that high boreal bird diversity is hard to maintain or hard to survey; in either case, it is likely that a repeat survey will report fewer birds. For whatever reason, repeated measurements of bird diversity are highly variable and thus unlikely to be good indices of the quality of management.



Breeding bird habitats in a boreal peatland. The number of species in the habitat may be related to management, but not in a simple way, and not to management alone. Management both harms and benefits: the loss of habitat by forest disturbance for some species may be compensated by a gain in habitat for others. Further, at least some species are probably climate sensitive, and their numbers are decreasing as climates warm. This mixture of complex effects and shifting baselines occurs in many habitats, and makes it hard to use diversity measurements as a management tool. From the *Adirondack Atlas* (Jenkins, 2004).

and overall diversity is too hard to measure and too sensitive to too many things besides management. Low diversity may reflect management, but it may also reflect past land-use history or be characteristic of a particular community or a particular successional stage.

The second question is whether a monitoring program that looked for changes in total diversity could provide useful management information. Here the answer is more equivocal: monitoring total diversity will certainly yield *interesting* information, but the information may be hard to interpret. On the one hand, a relatively constant total diversity may mask a significant ecological change, as when late-successional species are replaced with early-successional ones. And on the other, many things besides management can cause total diversity to change. If you log around a wetland and see fewer butterflies in it a few years later, it might mean that you have removed larval habitat. But it also could mean that a dry summer killed many larvae, or that several butterfly populations are hitting their cyclical low points together, or even simply that the survey team came back on a cloudy day.

Can more targeted studies of indicator species give us useful management information?

I think that they definitely can, and recommend this approach for monitoring easements. Whenever you have particular biological goals, you will need to monitor the species you are interested in to know whether your management is succeeding. This is only good sense, but it is surprisingly rarely done. Thus many managers who are trying, say, to improve habitat for rabbits, have no idea whether the rabbits are responding. And many forest management plans with provisions for increasing the number of snags do not know how many snags currently exist, and so will not know whether the number has changed.

Summary: What do the patterns of biodiversity in the NFR mean for conservation?

The overall pattern is a uniform, relatively low-diversity landscape with, like raisins in porridge, some sweet high-diversity spots. This means that a significant part of our management will be devoted to finding and protecting those sweet spots. In particular, what we know of species distributions suggests that we should:

Not worry too much that many working forests are low in plant, reptile, amphibian, and mammal diversity. They probably always have been.

Realize that birds are one of the most diverse groups, animal or plant, in working forests, and manage forest structure in a way that maintains their diversity.

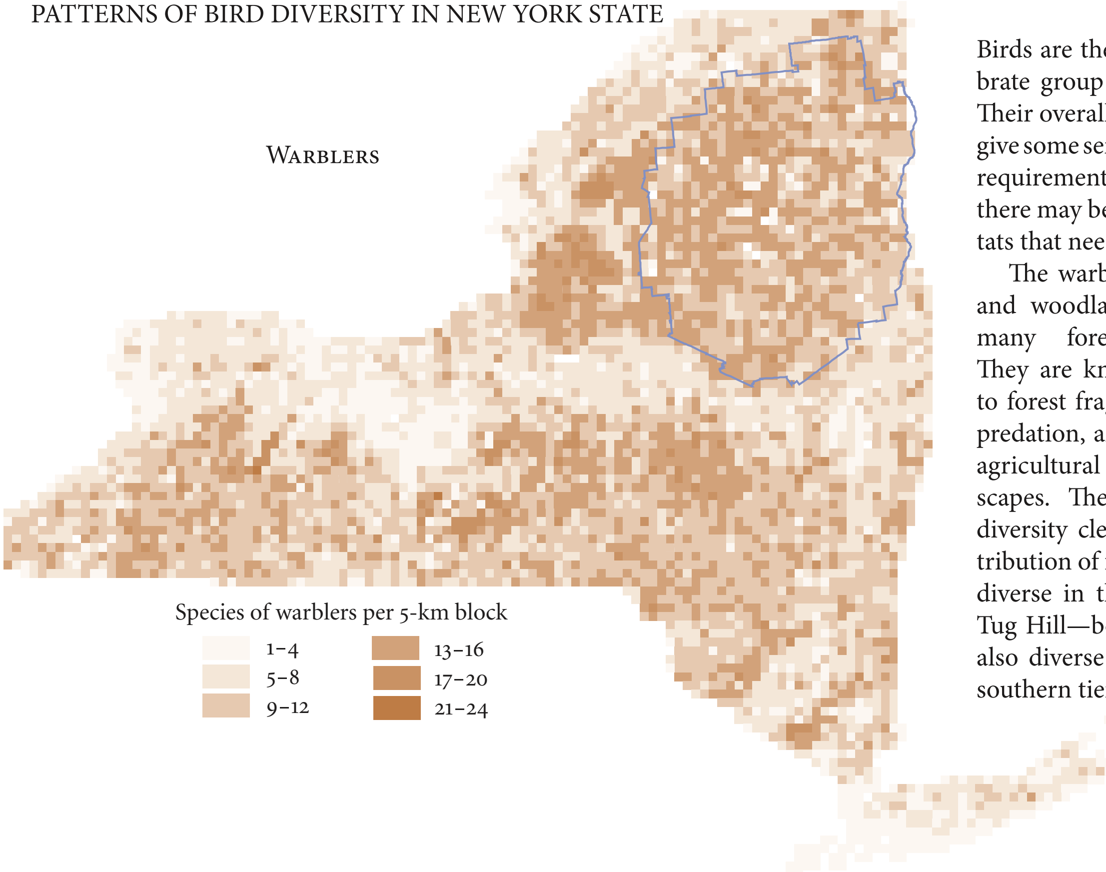
Realize that both bird and plant diversity are high, especially relative to area, in wetlands, and also that plant diversity is high in limy habitats and other special communities. Devote your resources to finding these and protecting them, and don't worry too much about the occasional stray rarity in ordinary woods.

Monitor species that you are particularly interested in or worried about, and monitor forest structure because it is a key indicator of forest diversity. But do not worry about monitoring overall diversity. It is difficult and sometimes disruptive to do; it is guaranteed to vary, and it is unlikely that the variations will have any clear message for management.

In summary, the porridge-and-raisin model—low overall diversity with hot spots—suggests that mapping and protecting special habitats are important ways of managing overall diversity, and that monitoring overall diversity is much less so.

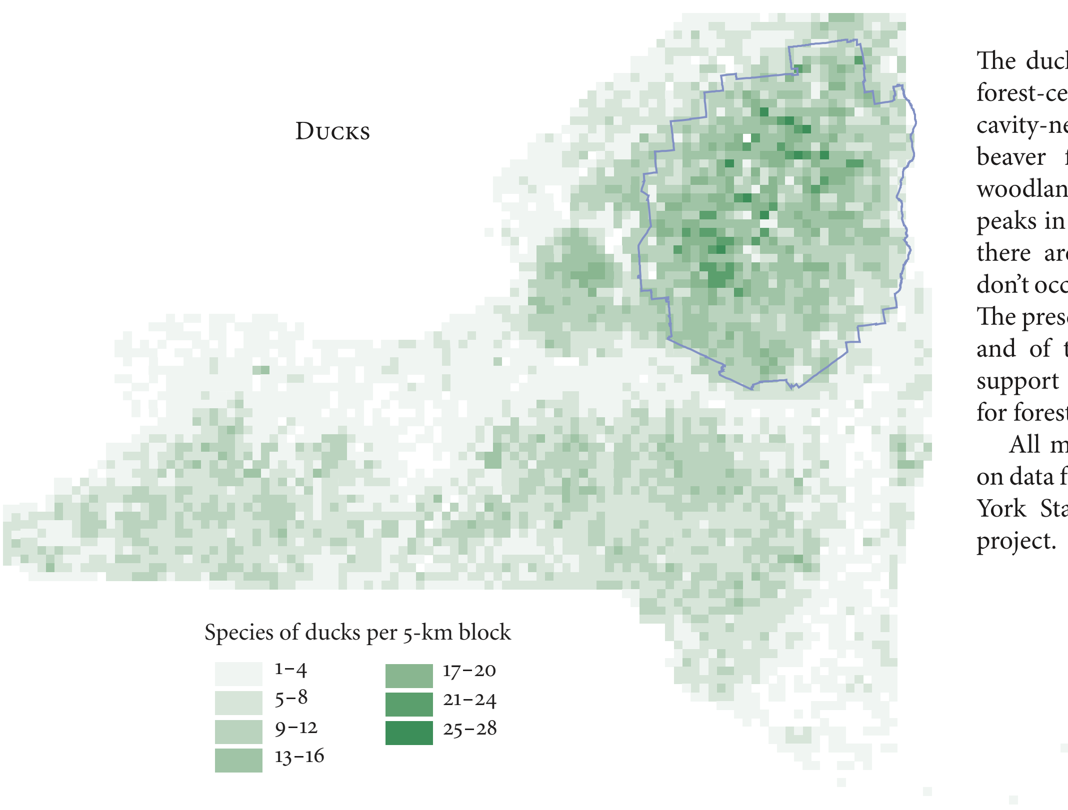
This completes the discussion of what the Northern Forest Region contains and what is worth protecting. With this in hand, we turn to forestry. After development has been prevented, forestry is the major remaining land-use. How much effect does it have on biodiversity, and what plants and animals does it most affect?

PATTERNS OF BIRD DIVERSITY IN NEW YORK STATE



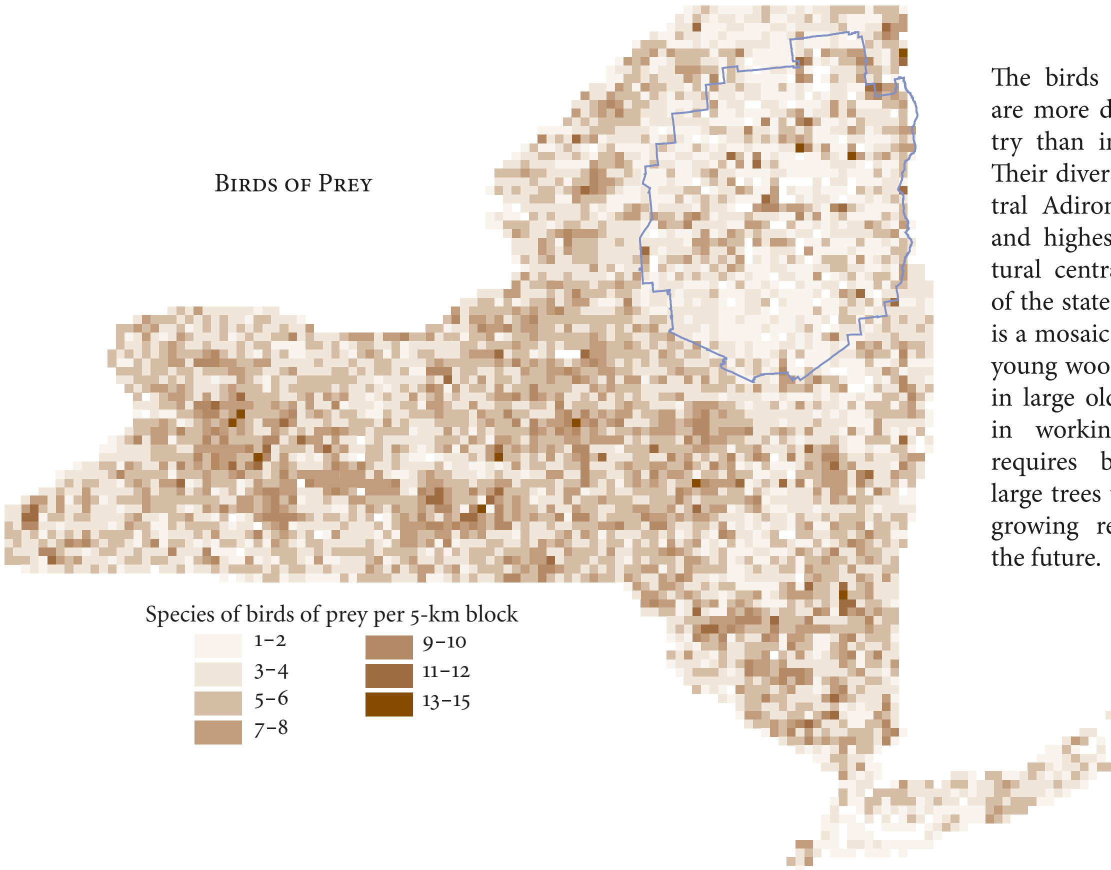
Birds are the most diverse vertebrate group in northern forests. Their overall patterns of diversity give some sense of their ecological requirements, and also of where there may be high-diversity habitats that need protection.

The warblers are a woodland and woodland-gap group, with many forest-interior species. They are known to be sensitive to forest fragmentation and nest predation, and do not do well in agricultural and suburban landscapes. Their New York State diversity clearly reflects the distribution of forests: they are most diverse in the Adirondacks and Tug Hill—both in the NFR—and also diverse in the well wooded southern tier.

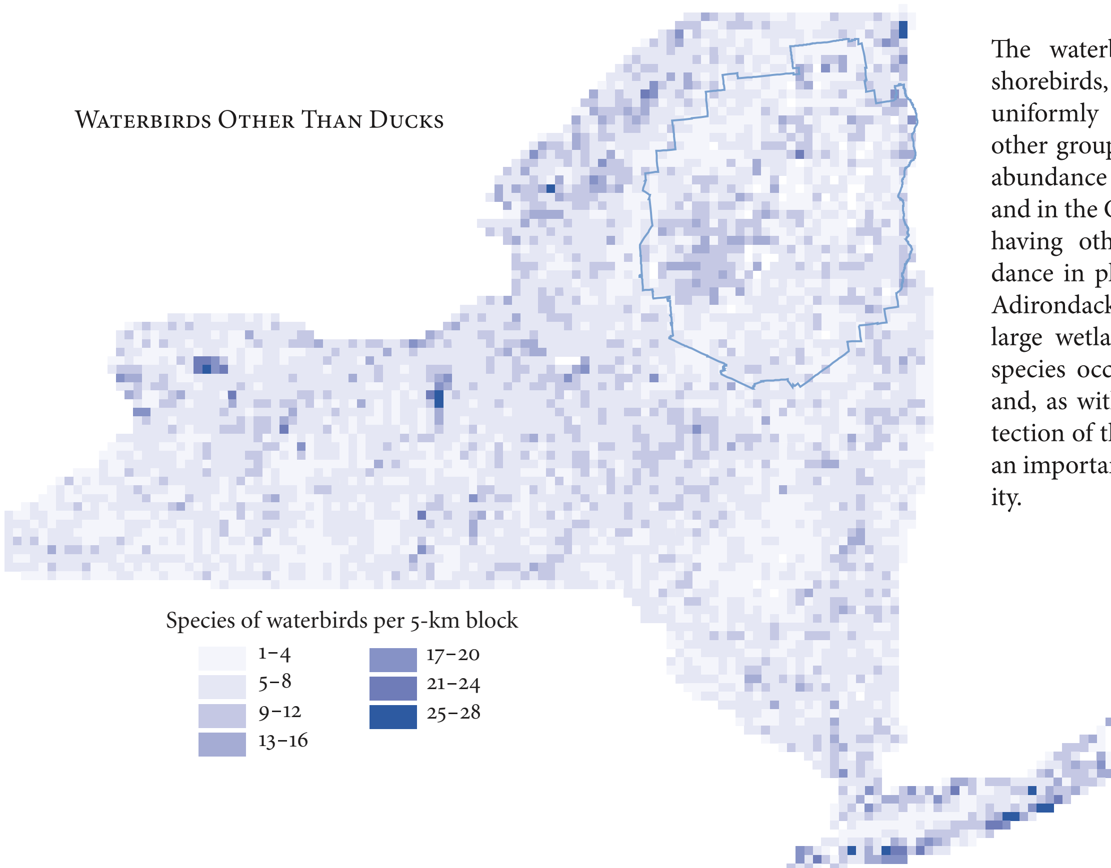


The ducks as a whole are also a forest-centered group, with many cavity-nesting species that use beaver flows and other small woodland ponds. Their diversity peaks in the Adirondacks, where there are northern species that don't occur elsewhere in the state. The preservation of these species, and of the small wetlands that support them, is a high priority for forest management.

All maps by J. Jenkins, based on data from the 2000-2005 New York State Breeding Bird Atlas project.



The birds of prey, in contrast, are more diverse in open country than in continuous forests. Their diversity is low in the central Adirondacks and Catskills, and highest in the postagricultural central and western parts of the state, where the landscape is a mosaic of forests, farms, and young woods. Many species nest in large old trees; their survival in working forest landscapes requires both preserving the large trees that already exist and growing replacement trees for the future.



The waterbirds (gulls, herons, shorebirds, rails, etc.) are more uniformly distributed than any other group, reaching their peak abundance along the seacoast and in the Champlain Valley, and having other centers of abundance in places like the western Adirondacks where there are large wetland complexes. Many species occur in small wetlands and, as with the ducks, the protection of these small wetlands is an important management priority.

To protect the plants and animals of logged forests, we need to know how they respond to logging. If they are highly sensitive, we need to manage logging carefully or create no-cut reserves. If they are only moderately sensitive, then we have latitude to manage in a variety of ways, but management decisions are still important. And if they are tolerant of logging or recover quickly when it is over, then it doesn't matter what we do.

In this section I attempt a short review of a large subject. For sources and notes see p. 94. More detailed reviews by myself and two of my collaborators can be found in *Forestry & Biodiversity in the Northern Forest Region: A Literature Review*, J. Jenkins, with attached reviews by Michale Glennon and Charles Cogbill. Be aware many plant and animal groups have not been adequately studied and that significant parts of the literature that does exist are unclear or contradictory. The synthesis I present here is my own, applies only to the NFR, and would be qualified or disputed by other researchers.

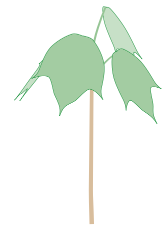
What are the ecological effects of logging?

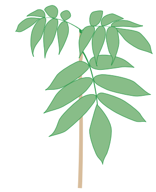
In the short term, logging opens the canopy, disturbs soil, and decreases the size and density of the forest. It also creates a permanent network of roads, which can cover up to 25% of the forest area. These roads open the canopy, create large amounts of forest edge, and alter the soils and hydrology. The result is forests that are lower, more disturbed, and more patchy than undisturbed ones.

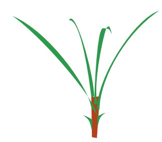
Over longer terms, logging removes biomass that would have died and rotted in place. The result is a forest with less organic matter—fewer snags and logs, more exposed inorganic soil—and hence with less substrate for mosses, fungi, and insects and a lower ability to retain water and nutrients.

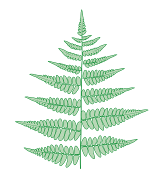
Both the short- and long-term effects are consequential. In states like Maine where the harvests equal or exceed the net growth for many species, the long-term removal of timber, like the long-term withdrawal of water from many western rivers, has had great ecological consequences. Heavily harvested stands inevitably have less structural complexity, less dead and rotting wood, fewer hollow trees, thinner and less organic soils, and more surface runoff than lightly harvested ones. If the amount of biomass removed is a significant fraction of total growth, then no matter how good the owner's intentions are or how skilled the foresters and operators, there is no way that a harvested stand will have the same structure and ecology as an old-growth one.

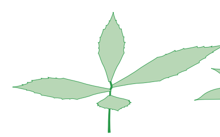
SMALL-GAP SPECIES

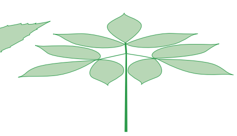

Striped Maple


Red Elderberry

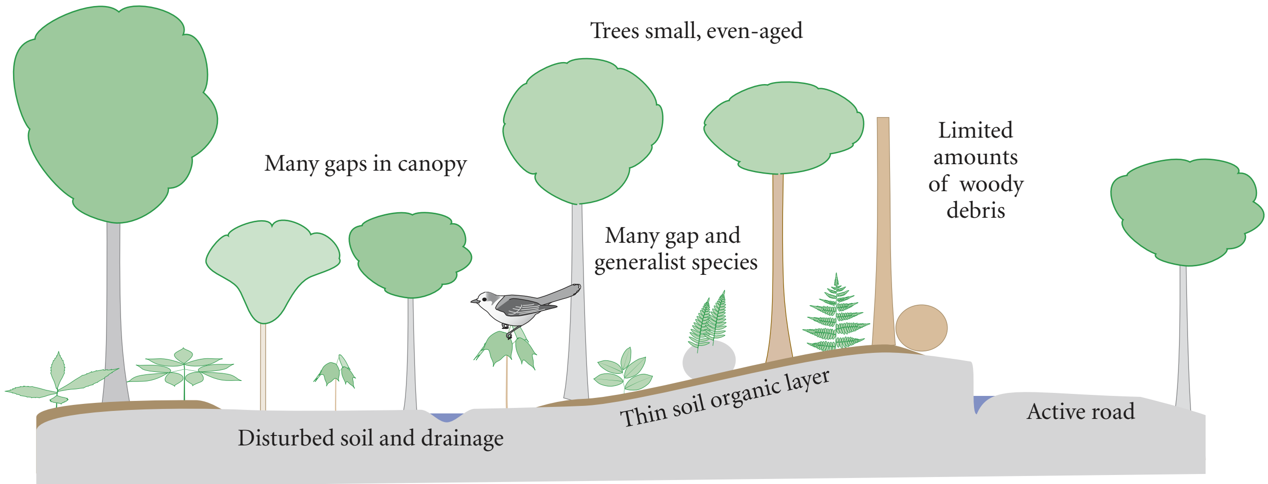

Carex communis


Marginal Woodfern


Acuminate Aster


Wild Sarsaparilla

Many forest herbs and shrubs are gap species, surviving in shade but growing and flowering best in partial sun. These species do very well in the openings that selective logging creates and are often common in logged forests. They do less well in the full sun of clear cuts but are common and prolific enough that they are usually able to survive in forest remnants and recolonize regenerating cuts.



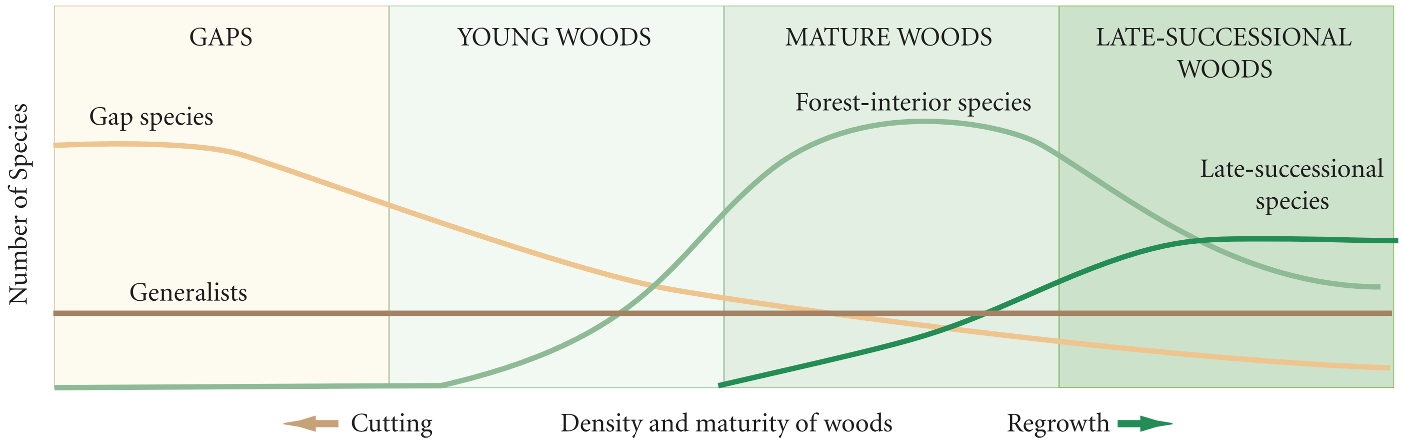
A heavily cut forest, showing the patchy canopy, disturbed forest floor, gaps and edges generated by cutting and roads, and many gap species. Much of the NFR in New England consists of forest of this type. See p. 69 for a contrasting illustration of a late-successional forest.

How do individual species respond to the effects of logging?

This depends on the needs of the species. We can, at least as a hypothesis, imagine four responses. These are shown schematically in the diagram on p. 48. The most specialized group includes late-successional species that need deep undisturbed soils, large rotting logs or snags, or continuous shade and moisture. While this group as a whole does not tolerate heavy cutting, we would expect that all the species could survive light cuts and that some may prosper in them. Light selective cuts, if made in a way that minimizes soil damage, may be ecologically indistinguishable from the gaps made by natural treefall, and treefall, after all, occurs naturally in all forests.

The second group is the forest-interior and small-gap species. These need shade or diffuse sun and are most common in continuous forests with 50% or more canopy but do not need late-successional forests. They are more tolerant of disturbance than the late-successional species and their relation to it more complex. Some avoid gaps and edges entirely. Some, like several forest birds, may breed in forest interiors but feed in gaps. Some, like the vernal pool amphibians, will be quite content to breed in open ponds but need the humidity of forest interiors after they leave the water. And some, like a number of forest plants, may need both habitats, reaching their largest populations in continuous forest but flowering most abundantly in gaps.

The third and fourth groups, the gap species and generalists, are the most tolerant of disturbance and hence the most widely distributed in our landscape. The gap species require open habitats, do best in large openings and thickets, and disappear when a gap closes and the canopy returns. The generalists—the crows and toads and goldenrods of the NFR—use many different habitats, The Distribution of Three Ecological Groups and Their Response to Cutting



A generalized picture of the distribution of the main ecological groups in forests of different age and size. The gap species prefer large gaps and permanent openings, the forest-interior species prefer shade or small gaps, and the generalists go anywhere. The late-successional species are a disturbance-intolerant group. They need forests with much rotting woody debris and a complex structure. No such species have been conclusively identified in the NFR. The most likely candidates include lichens, other fungi, and invertebrates.

though of course they may, like the toad or the crow, use particular habitats for breeding or nesting.

How many species are there in each group?

This is not well enough known to give exact numbers. But still, the literature is consistent enough to allow us to make some useful generalizations.

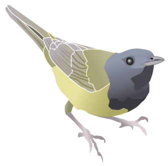
Amphibians. Most amphibians require water to breed and, with the exception of the versatile American toad, all require moist habitats after the breeding season. Some, like the leopard and pickerel frogs, are largely restricted to waterbodies and wetlands. The remainder are mostly forest-interior or late-successional species. This is particularly true of the forest floor salamanders (red-backed, juvenile red-spotted newt, northern dusky) and the amphibians of vernal pools (wood frogs, peepers, spotted salamander group). Most studies show that these either avoid gaps and edges entirely or are more common in interiors than near gaps.

Reptiles. With the exception of the wood turtle, the terrestrial reptiles tend to use open habitats, and snakes in particular seem to be more common in open habitats. But the reptiles on the whole are a southern group and generally rare in the NFR.

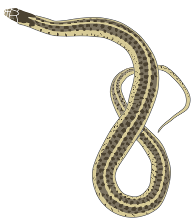
Birds. Birds are exceptionally versatile and include forest-interior, gap, and generalist species. In the Northeast, there seem to be no obligate late-successional species. This may be because there are too few late-successional woods for late-successional birds to have survived in, or because there are no important differences, from a bird's point of view, between mature woods and late-successional woods.

The Major Ecological Groups of Northern Forest Species

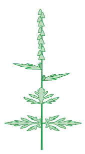
Gap Species



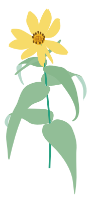
Mourning Warbler



Garter Snake

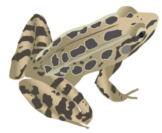


Ragweed

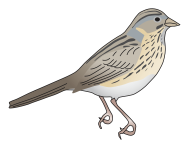


Woodland Sunflower

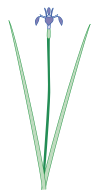
Wetland Species



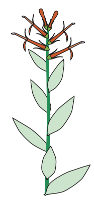
Pickerel Frog



Lincoln's Sparrow

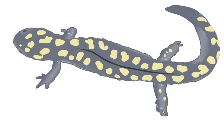


Blueflag Iris

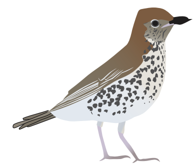


Cardinal Flower

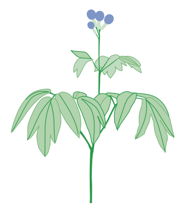
Forest-Interior Species



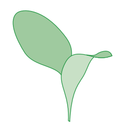
Spotted Salamander



Wood Thrush



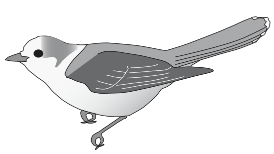
Blue Cohosh



Wild Leek

Generalists

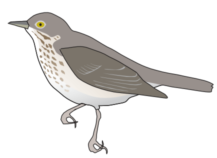
American Toad



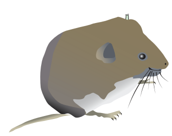
Gray Jay

Least Shrew

Species of Special Habitats

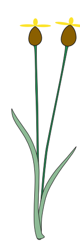


Bicknell's Thrush



Rock Vole

Douglas's Knotweed



Yellow-eyed Grass

Common examples of the five main ecological groups in the NFR. More information on some of these species will be found scattered through this publication. No late-successional species are listed, because we are still unsure who they are.

The proportions of the different groups differ depending on the habitat, but in several studies the numbers of generalists, gap species, and forest-interior species have been roughly equal.

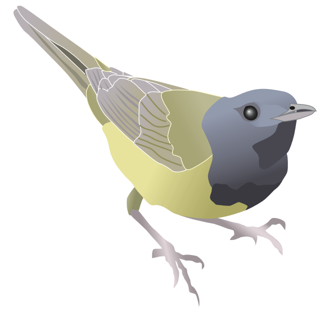
Mammals. The distribution of mammals among forest types is less well known and may, judging from the number of studies that contradict each other, be more variable. It seems fair to say that many mammals, from shrews to bears, use a variety of habitats and are to some extent generalists. Our most specialized species may be the pine martin, which seems to be a forest-interior species; the snowshoe hare, which likes young dense vegetation; and the Canada lynx, which depends on snowshoe hares and so needs habitats where hares are abundant.

Unlike the Pacific Northwest, where there is a guild of forest-interior mammals which are dependent on the late-successional structure of old-growth forests, so far as we know there are no true late-successional mammals in the NFR.

Higher plants. As with birds, there are clear gap species and forest-interior species but few or no species that are restricted to late-successional conditions. Unlike birds, there seem to be fewer generalists, but there are also fewer studies that have made a careful analysis of different groups of plants.

Mosses and liverworts. There have been few published studies of mosses in forests of different ages. Those that are available, as well as my own observations, suggest that there are definitely gap and forest-interior mosses, and that a few mosses, particularly *Neckera pennata,* that are most commonly found on big old trees. Interestingly however, *Neckera* does not seem to require late-successional forests and in fact can grow quite well on relict big trees in younger forests and even when transplanted to smaller trees in young forests. This suggests that it may be a "slow-returning" species (p. 51) that propagates effectively within stands but is slow to colonize new forests. If this proves true, then *Neckera* may be our best-studied example of a species that profits from leaving large trees when a stand is harvested.

Lichens. Studies in Great Britain and the Pacific Northwest have identified groups of late-successional lichens that are strongly associated with old forests and either are intolerant of the conditions in younger forests or slow to recolonize them after disturbance. Similar assertions have been made for the NFR, but the evidence is still incomplete. Several papers show that certain groups of lichens—particularly some of the stubble lichens and jelly lichens—are regularly found in old-growth forests in the NFR. But so far as I know, there no papers showing that these species are restricted to these forests.



The mourning warbler is a classic gap species, nesting in raspberry thickets and young shrubby openings. It colonizes openings rapidly and leaves as soon as a canopy of young trees forms.

Could there be late-successional species in groups like fungi and invertebrates that have not been studied?

Definitely. Late-successional forests are distinguished by their thick soils and large amounts of decaying wood. Fungi and invertebrates are the agents of much of this decay, and it is likely that some species are characteristic of or restricted to old moldy forests.

The common toad is a generalist species. Adults are more tolerant of dryness and sun than our other amphibians and can be found in both open and shaded habitats. They breed in waters of all sorts, from backwaters in rivers to woodland pools to small wet depressions in open meadows, and can use pools that are too shallow and temporary for other amphibians.

How do the ecological groups respond when a forest is logged?

By changing their abundance and diversity. Sometimes the changes are gradual, sometimes more abrupt. When a mature forest is selectively cut, most forest-interior species persist, and some benefit from the increased light and actually become more abundant. At the same time, new species appear, often quickly, in the gaps. The process mostly involves an acquisition of new species rather than the replacement of interior species with gap species. As a result, the total diversity of the forest usually increases.* The increase is significant but not dramatic. An increase in diversity of 10 or 20% might be expected; a doubling would not be.

Clear-cuts are different. When a mature forest is clear-cut, the interior species are replaced with gap species and generalists. Some forest-interior species can survive in openings, especially if the openings are small or revegetate quickly. Many others can not, and few can survive if the cut is large or if it remains open for many years.

How does the total diversity of large gaps and open areas compare with that of mature woods?

Often quite favorably, because gaps are rich in resources, and the gaps species are, by necessity, mobile, disturbance tolerant, and good at finding these resources. Many studies have found that bird diversity in gaps is equal to or greater than that in the forests they replace. Clear-cutting, whatever its other faults or merits, does not usually reduce overall diversity.

How fast do forest-interior species return after logging?

There has been nowhere near enough research on this point and, in particular, almost no studies following individual plots for long periods. A rough answer is that birds are mobile and return quickly; once a forest has the structure that they need, the birds seem to come. Amphibians and plants seem to return much more slowly. Some plants, in particular, disperse very slowly and may recolonize a disturbed forest only after a long time has passed, or if there are remnant forests nearby. These species have been called indicators of ecological continuity. I prefer to call them slow-returning spe-

*One study by researchers at Harvard Forest, which has not yet been published, found that the increase in plant diversity after cutting depends on soil fertility: fertile forests responded more strongly than infertile ones, perhaps simply because they had more species to respond with.

cies, recognizing that, like other species, they are occasionally capable of crossing gaps and dispersing into successional habitats.*

How much is known about these slow-returning plants in the NFR?

Very little. A single paper suggests that several lichen groups are slow to return after logging, and another identifies several old-growth indicators in the spruce forests of the New Brunswick coast. Work at Harvard Forest, in Massachusetts, has identified a few oak forest plants (wintergreen, pipissewa) that are slow to return to postagricultural forests. Studies of the moss *Neckera pennata* (p. 50), which is only rarely found on small trees, suggest that it is a poor colonist and has trouble reaching young stands. My own field observations suggest that some of the common rich woods species reestablish slowly after heavy cutting. This is corroborated by several papers from the southern Appalachians and some unpublished work in central New York by Greg McGee, but not by any published work in the NFR.*

What influence does the slow return of some forest-interior species have on forest biodiversity?

It makes forest biodiversity sensitive to forest history. The boreal forest, where natural disturbance is frequent, in some sense never really get old and never has many true interior species. The eastern deciduous forest and the Acadian coniferous forest, where disturbance is rare, will likely have them, particularly if the site is fertile and has never been heavily logged. And forests that has been repeatedly clear-cut, whatever their natural disturbance regimes and whatever they started with, are unlikely to have them now.

What are the implications of our current knowledge of forest biodiversity for forest-management?

There are four.

First that logging, by controlling forest ages and the mix of gaps and continuous-canopy stands, also controls the overall diversity of the forest. A forest without openings, or a dissected forest that is all edges and openings, will be less diverse than one that has openings and a continuous interior. A manager who wants to maximize diversity will be sure to have some of each. And a manager who wants to ensure that all the ecological groups are reasonably abundant will try to balance the acreage in each group.

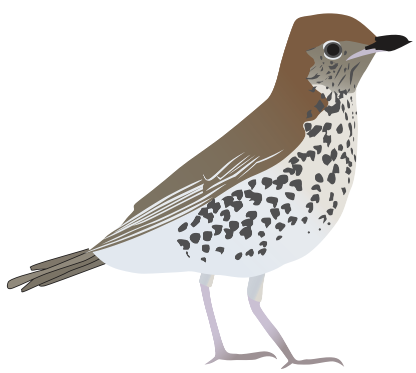
The spotted salamander is a true forest-interior species, breeding in vernal pools and spending the rest of the year in moist, continuous forests, usually within a few hundred meters of its breeding pool.

* There are several reasons that a plant species may be slow to return after disturbance, and the group of slow-returning species is correspondingly heterogeneous. Some species require specialized habitats like large trees or deep humus that are not found in young woods. Maidenhair fern and wild ginger may be examples of this group. Others are poorly dispersed and therefore slow to colonize new habitats, but not particularly choosy about what habitats they colonize once they can get there. Bloodroot, large-flowered trillium, and several of the woodland violets seem to be examples of this group. See Norden and Appelqvist, 2001. "Conceptual problems of ecological continuity and its bioindicators" for a good discussion of the differences between these groups and their significance for conservation.

Second, because of the slow return of some species, forest-interior plants are most abundant in forests where major disturbances happen only rarely. In the forests with repeated disturbance there are few forest-interior plants and their protection is not an issue. In forests, especially fertile ones, with little disturbance, forest-interior species are likely to be present. Such forests are uncommon, and their continued protection is critical.

Third, again because of the slow return of many plant species, the restoration of forest-interior floras in stands that have been logged repeatedly may be slow. In the best situations, on fertile sites in which forest-interior species persist upslope or around outcrops, the return of forest-interior may begin in 25 years. In the worst situations, after multiple disturbances on infertile sites with no nearby source populations, it may not happen at all.

And fourth, the apparent scarcity of late late-successional species in the Northeast may be because fungi and invertebrates, the groups most directly tied to the decay processes that create late-successional attributes, have not yet been systematically compared across a range of forest ages.



The wood thrush is a forest-interior species and intolerant of fragmentation and edges. It is one of the first eastern species for which the effects of fragmentation were documented. It is still common in mature, continuous forests but has declined greatly in dissected and isolated forests.

Beech salvage, western Adirondacks.

Clear-cut, Connecticut Lakes, New Hampshire.

Dissected landscape, eastern Maine.

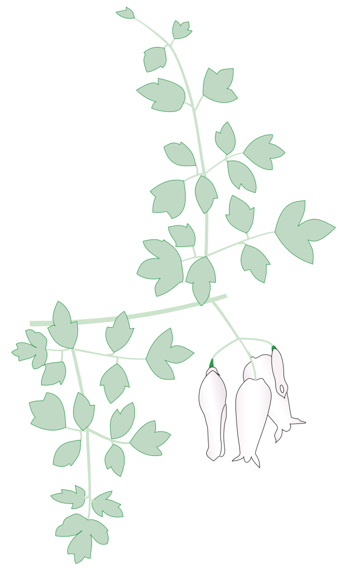
Hardwoods dissected by harvest roads, West Branch of the Penobscot.

IV PROTECTING THE EXISTING BIODIVERSITY IN WORKING FORESTS

In this section I consider how the existing biodiversity of working forests—the species and communities that are in them today—can best be protected. This is, fortunately, a relatively easy problem with a straightforward solution. In the next section I consider the more difficult problem of whether working forests can or should be made older and more natural.

To protect existing biodiversity, we need to do three things. We have to figure out what biodiversity we actually have, determine what threatens it, and then select a type of protection that matches the species and the threat.

I start with a summary of what there is to protect.



Allegheny vine is an uncommon species of gaps in moist fertile woods. It is an annual herb that appears in an opening for a few years and then disappears. It occurs naturally in treefall gaps and on open talus slopes, and also along roads and openings created by management. Species like this are too erratic to protect with special management areas and can be best protected by a mixture of natural disturbance and patch cutting.

What elements of biodiversity most need protecting in the working forests in the NFR?

As discussed in the previous sections, most ownerships will have significant birds and wetlands, significant breeding habitats for amphibians, and structural features like nest and mast trees that are important for wildlife. These will probably be dispersed through the ownership and will need a general protection policy. In addition, some ownerships may have mature forests, rare species, or rare communities. These will often be very local, and will need to be protected with special management areas.

What threatens these elements on conservation easements?

Regionally and globally, acid rain and climate change, which are beyond the reach of easements.

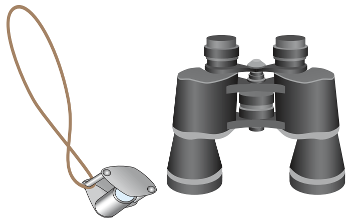
Much more locally, harvesting that decreases the amount of mature forest and forest-interior species or that alters waterbodies or special communities. Regulating this is very much the business of easements.*

What tools are available for protecting biodiversity?

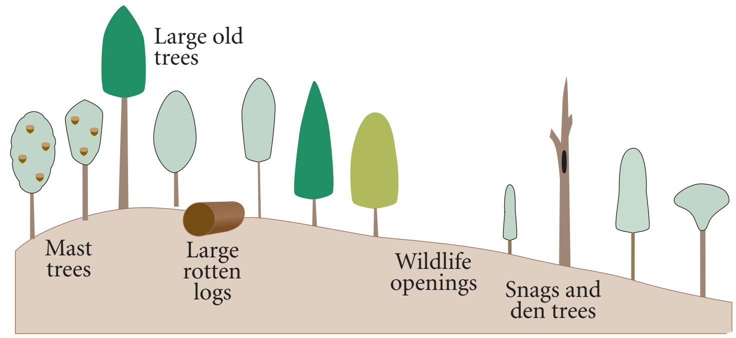
The available tools divide into two groups. What I call the standard toolkit consists of eight tools for conducting inventories, limiting harvests, managing stands, and managing landscapes. The tools in the standard toolkit are used, though to different extents and with different degrees of success, by all conservation practitioners. What I call the deluxe toolkit contains tools for recreating late-successional structure, imitating natural disturbance, and generating landscape patterns (p. 61). These tools, though much talked about, have thus far been little used or evaluated. Some may, with more experience, prove valuable and become standard tools. Others may prove to have little effect and eventually be discarded.

*Here and in what follows I assume that development rights have been largely or completely extinguished by the easement and that further development is not an issue. On lands without conservation easements, residential development is a clear threat to biodiversity. See Glennon and Kretser, 2005. *Impacts to Wildlife from Low Density Exurban Development*, for a recent review.

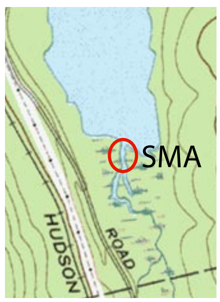
The Standard Toolkit for Preserving Extant Biodiversity



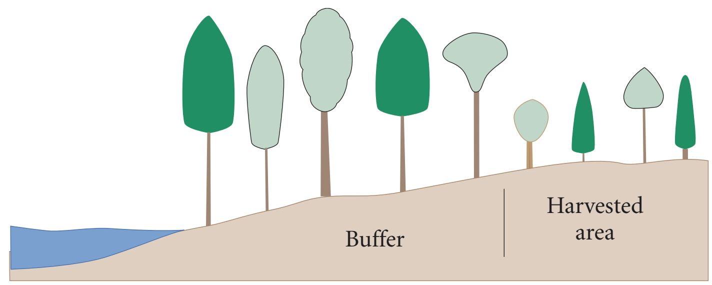
Biological survey. Conducting a survey to locate species and communities of special interest.



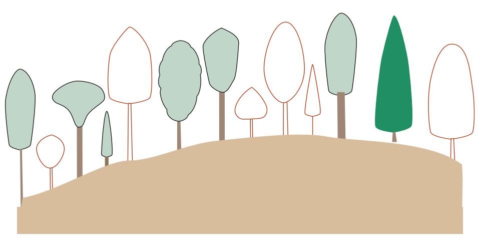
Habitat management for wildlife. Protecting features needed by species of particular interest.



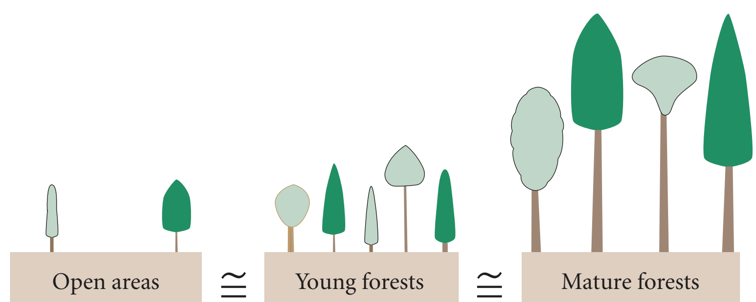
Red-lining. Creating reserves and special management areas (SMAs) to protect species and communities that do not tolerate logging.



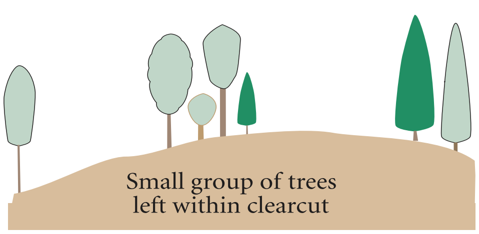
Buffer strips. Providing strips of uncut or selectively cut forest between waterbodies and more intensively cut areas to provide habitat for wildlife and forest-interior species and protect water quality.



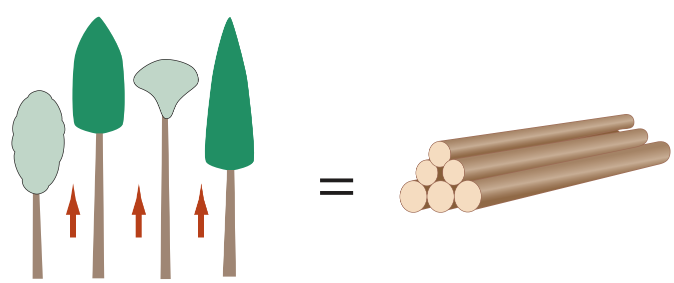
Selective cutting. Harvesting trees singly or in small groups to maintain habitat for forest-interior species.



Balancing size classes across the ownership. Keeping comparable amounts of land in openings, young forests, and older forests to provide habitats for as many types of animals and plants as possible.



Green tree retention. Leaving living trees within forests to carry forest-interior species ("legacies") from the previous forest to the new one.



Balancing growth and harvest. Keeping the harvest of each size class less than growth to ensure that the amount of mature timber does not decrease.

The tools in the standard toolkit are discussed fully here; those in the deluxe toolkit, which seem to me more appropriate to restoring biodiversity than maintaining it, are introduced below.

How are the tools in the standard toolkit used, and how effective are they?

I give a brief summary here, and diagram their use on the opposite page.

Biological inventories are most useful for locating rare species and communities, for characterizing the current level of diversity of an ownership, and for determining how well the different ecological groups of plants and birds are represented. They are effective when they are carefully done, but this takes time and requires surveyors with expertise in different biological groups. For a large ownership with potentially important habitat, a team of half a dozen surveyors and an investment on the order of $1 to $2 per acre may be required.

Red-lining, which is the creation of special management areas is which harvesting is restricted or forbidden, is the principal tool for protecting communities and species that cannot tolerate logging. It is both efficient and effective: for the biologist it represents secure protection, for the forester a sharply defined area in which operations are restricted, and for the fee owner an assessable loss of value that can be included in the price of the easement.

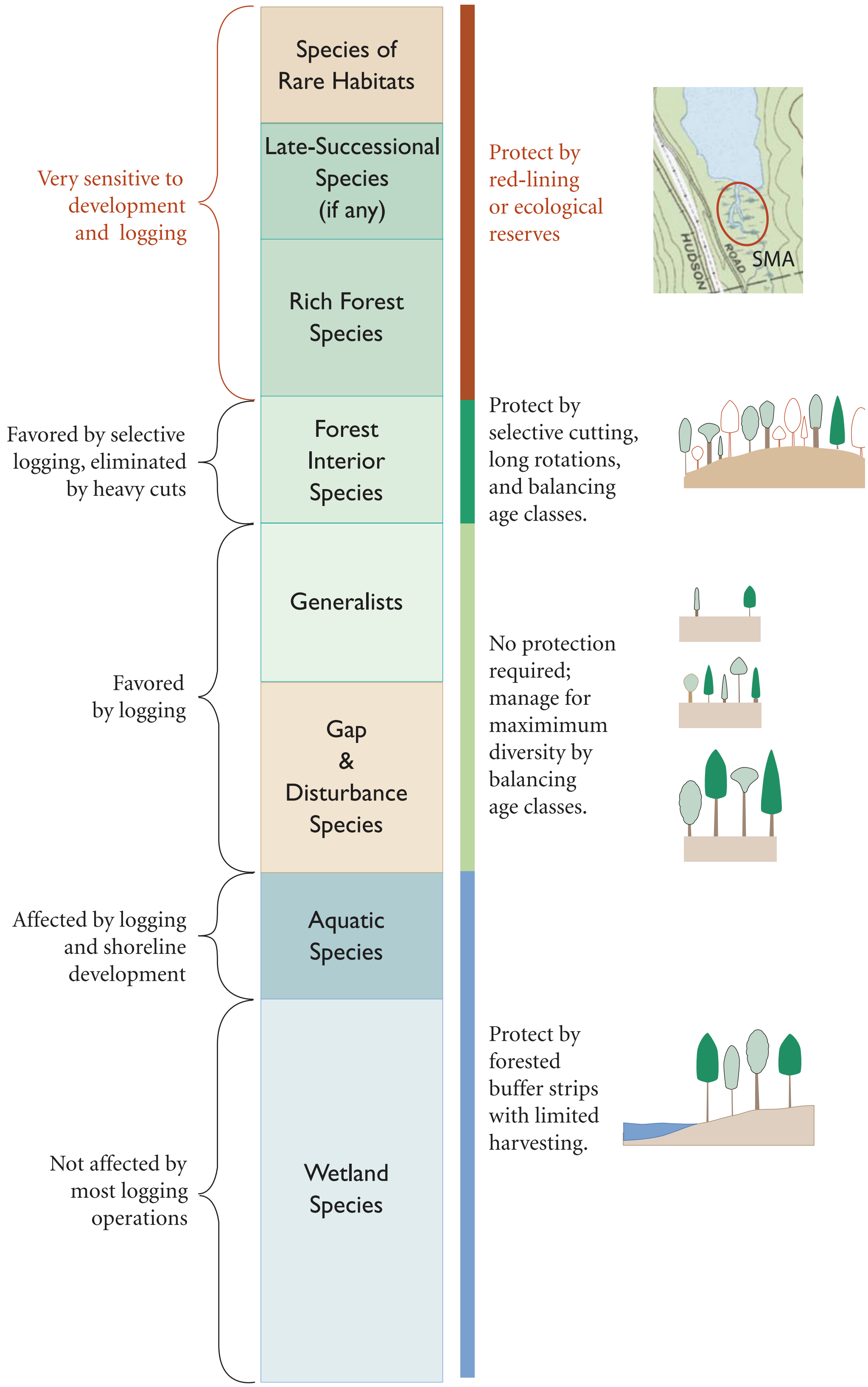
Forested buffer strips are the preferred way of minimizing the effects of harvesting on streams and wetlands and a way to create travel corridors and high-quality habitat for animals that feed near water. They may be either full no-cut zones or, more commonly, zones in which only selection cuts are allowed. Their effectiveness, so far as it has been measured, varies with the species involved. The literature on edge effects is large and confused, but it seems that many species respond to edges within 25 meters of their breeding sites, and few to edges 100 meters or more away. The proper width of buffers, if there is one, likely lies in between.

Selective cutting, which is to say harvesting trees singly without creating large openings in the canopy, is a proven method of protecting forest-interior species in commercial settings. In every study I am aware of that has compared selectively cut and undisturbed forests in the NFR, the selectively cut woods have equalled or exceeded the undisturbed ones in the diversity of forest-interior species of birds, amphibians, and higher plants, and have often had additional gap species as well.

Leatherwood is an uncommon shrub of rocky fertile woods, often associated with high-diversity herb communities and easily damaged soils. When it occurs by itself it can be protected by selective cutting but when it occurs in rich woods communities it is probably best managed in an ecological reserve.

Opposite page, matching protection to ecology. Once identified by a biological survey, the different ecological groups need different types of protection. The most specialized and intolerant species, in the top three groups, need spaces of their own where logging can't reach them. The forest-interior species (fourth group) can coexist with logging but need forests that are selectively cut on long rotations. The generalists and gap species (fifth and sixth groups) do not need to be protected, but will achieve their maximum diversity only if provided with similarly diverse forests. And the aquatic and wetland species, at bottom, are not at direct risk from logging but still need to be protected from its indirect effects by vegetated buffer strips.

Using The Standard Toolkit To Match Protection To Ecological Groups



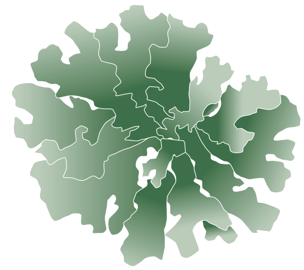
Balancing the growth and harvest of large trees is a related technique that ensures that mature forests—by far the scarcest age class on most ownerships—are not gradually depleted and converted to younger stands. It is effective only when large trees are treated separately from the rest of the forest; otherwise a manager could replace mature forest with young regeneration and still keep growth and harvest balanced across the ownership.

Balancing age classes across the ownership is a yet more generalized tool that attempts to balance the abundance of gap and interior species by equalizing the amount of area in openings, small trees, and larger trees. It is well supported by studies showing that the abundance of the different ecological groups is closely related to the abundance of different ages of forests. But I regard its effectiveness as unproven because it is a slow technique, and it can be hard to tell whether a manager is achieving a balance or not. It is a stated goal of many management plans and many managers. But just how effectively it can be done, and to what extent attempts to do it will be limited by commercial pressure to harvest trees as soon as they are merchantable, I am unable to say.

Green tree retention is a technique that was developed in the western United States. The idea is to mitigate the effects of clear-cutting old forests by leaving unharvested patches—"lifeboats," the biologists like to say—that are supposed to carry some of the forest-interior species over to the regenerating forest. I am not sure how relevant the idea is in our landscape, where the heaviest cuts are in young forests that have neither interiors nor interior species and where, because of regulations on clear-cutting, most cuts have at least some residual trees anyway.*

Habitat management for wildlife consists of a variety of techniques—creating openings, leaving mast trees, leaving snags and logs, protecting vernal pools—that try to meet the needs of species of particular interest.** The potential effectiveness of these techniques is clear, and there is a large and useful literature that identifies the habitat requirements of individual species. Their actual effectiveness depends on what there is to apply them to and how carefully they are applied. Both considerations are important. A manager cannot have large dead trees to protect unless he first grows large live ones. And no protection of vernal pools or mast trees will work unless the trees and pools have been mapped and marked.

I stress these last points because many young and beat-up forests don't offer much for the manager to work with, and won't for a long time unless their management changes. And although most



Lichens occur in all successional stages. Late-successional species have been identified in Britain, Europe, and the Pacific Northwest. They likely occur in the NFR, but the evidence is still equivocal. See p. 50.

*The Manomet Center for Conservation Science in Bangor, Maine, is currently conducting a study to determine the biodiversity effects of patch retention. No results are available yet.

**Interestingly, while the logic of improving wildlife habitat is clear, the evidence that doing this actually increases wildlife populations is thinner. One study found, for example, that woods with more snags for woodpeckers actually had fewer woodpeckers (Gunn and Hagan, 2000). Clearly, we have much to learn about what animals really need. Supplying resources that are in limited supply may be critical. Supplying ones that are not limiting may have no effect at all.

easements require in a general way that managers improve wildlife habitat, few set explicit benchmarks for how they are to do it.

What are the tools in the deluxe toolkit, and how effective are they?

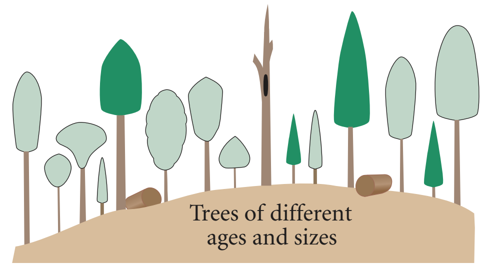
There are three tools. Generating late-successional structure is a stand-level tool that uses specialized and somewhat restricted kinds of harvesting to create uneven-aged forests resembling undisturbed stands. I discuss it more on p. 68. Imitating natural disturbance and creating landscape patterns are larger-scale techniques based on the premise that the more closely logging practices imitate natural disturbance patterns, the more likely native species will be to survive. They are examples of what, on p. 7, I have called ecomimetic forestry.

Although the deluxe tools are advocated in textbooks and referred to in publications on sustainability, their use in large eastern forests is as yet limited. Landscape-scale planning and natural disturbance forestry have rarely been tried in the Northeast; so far as I know, there is currently no literature on how successful they have been. For anyone wanting to think further about them, I give a brief summary here, with a warning that the literature is vague and to some extent unsatisfying.

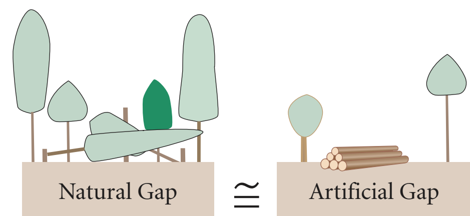
Imitating natural disturbance assumes that the species of the presettlement forests evolved under a particular disturbance regime and that by cutting in a way that mimics this regime we will ensure their survival. Unfortunately, there is no reason to believe that the premise is true or the conclusion workable. The species that occur in the forests of the NFR did not necessarily evolve here, certainly encountered different disturbance regimes in different parts of their ranges, and equally certainly have survived many dramatic changes in disturbance regimes in their evolutionary histories.

Furthermore, it is far from clear that forestry can imitate natural disturbance in more than a superficial way. In the first place, forestry is unlike natural disturbance in that it removes trees rather than killing them in place. In the second, forestry adds to natural disturbance rather than supplementing it: a management system that imitated natural disturbance exactly would double the total rate at which the forest was being disturbed. And third, the pattern of natural disturbance of much of the NFR is a mixture of scattered single-tree gaps and rare stand-replacing disturbances over large areas. This pattern doesn't resemble any current forestry practices. No commercial ownerships thin 1% of their trees over the whole ownership every year, and no ownerships plan, or would be allowed to plan, to wait a hundred years and then clear-cut 100,000 acres to simulate a windstorm.

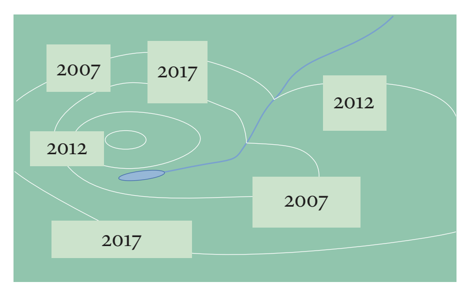
THE DELUXE TOOLKIT: TOOLS FOR MAKING FORESTS MORE NATURAL



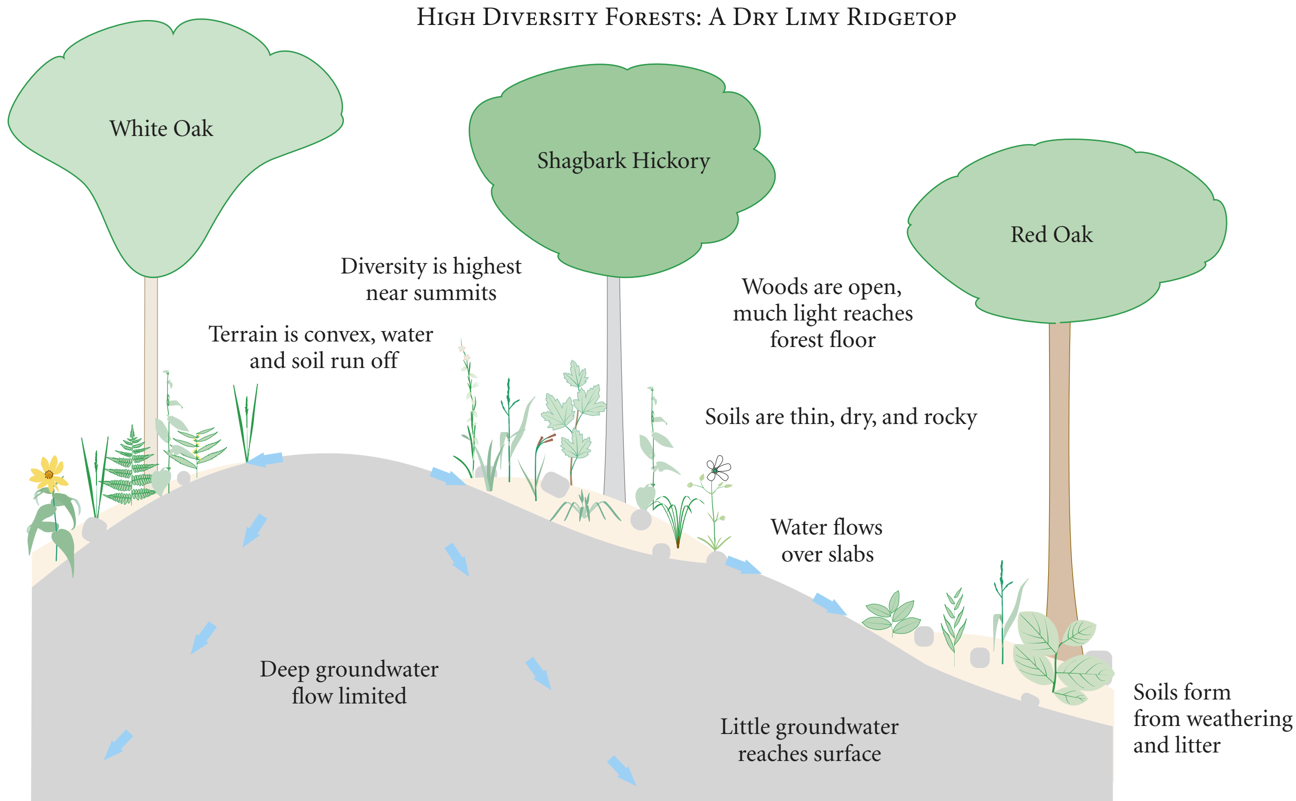
Generating late-successional structure. Selective cutting and long rotations are used to generate structurally diverse stands with large old trees and much dead wood.



Imitating natural disturbance. Cuts are about the same size as and occur at about the same intervals as the natural openings created by windstorms or fires.



Creating landscape patterns: Cuts are arranged in some large-scale pattern thought desirable.



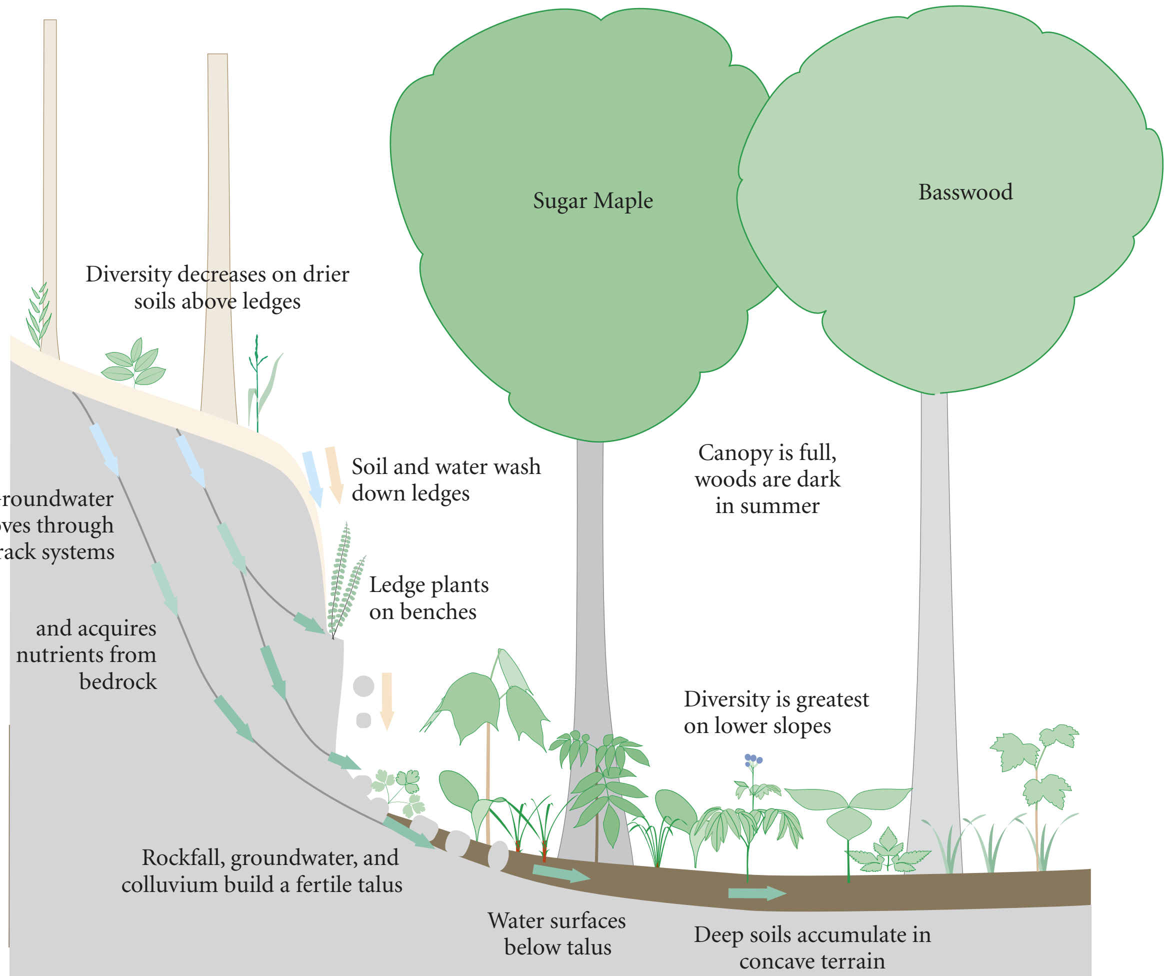
A dry, fertile hill with an open, gladelike, high diversity forest. Such forests are rare and, because of their high diversity, thin soils, and slowly growing trees, may not tolerate logging well. They are important conservation targets and are probably best protected in red-lined ecological reserves. From Jenkins, J., 2006, *The West Champlain Hills*.

*Creating desirable landscape patterns** is often recommended as a way of maintaining the continuity of the forest and perhaps other features of spatial pattern thought important. The idea developed from the field of landscape ecology. Its strength, if it turns out to be true, is that it will supply rules for managing large-scale forest landscapes. Its major weakness is that it has little scientific support. Researchers who have looked for, say, the influence of landscape patterns on bird distributions find that the abundance of species at a sample point is mostly influenced by the mix of habitats within a few hundred meters of the point, and that features more than a kilometer away have little influence at all.

Another weakness of large-scale approaches is that they are hard to accomplish in practice. Managers have to work within the patterns created by topography, roads, and previous cuts. In their eyes, keeping real forests growing and real logs on the landings is more important than achieving theoretical desirable arrangements of stands and corridors.

A final note. All the published discussions of the deluxe tools that I have seen are highly general. None tell you how to apply them to real forests or what species will benefit from them or what species are at risk if we don't use them. This generality is, to me, a warning, that these are still conceptual tools and not as yet, at

* This is different from the balancing of size classes discussed on p. 60. That balancing refers to *equalizing* the total amounts of different age groups to produce a forest that is as diverse as possible. This refers to *arranging* the different types of forests and openings in some pattern that is thought to be ecologically desirable.



A moist cove with a shaded, high-diversity forest. Such forests are frequent in Vermont and eastern New York but rare in the rest of the NFR. They tolerate careful selective logging well, and indeed some of our showiest wildflower displays are in rich moist forests that have been selectively logged. They are good candidates for protection in special management areas. From Jenkins, J., 2006, *The West Champlain Hills*.

least in the Northeast, supported by research, case histories, or practice.

What kind of monitoring should biodiversity protection involve?

Here, as with the deluxe tools, there is a major divide between theory and practice. Theory, ignoring costs and practicality, says monitor everything you want to protect. Practice, limited by costs and the training of the workforce, says monitor little except the trees themselves.

Clearly, theory wants too much and practice doesn't want enough. Just where a realistic middle ground lies is tricky. I would argue that the way to build an effective monitoring program is to monitor as little as possible and at as long intervals as possible but then to monitor carefully when you do. This might involve three approaches:

Use red-lining instead of monitoring for special communities and species. If you have, say, 5 acres of special old forest, it may be cheaper to make a one-time payment to make it a permanent no-harvest zone than to monitor it repeatedly to see whether it is tolerating harvest.

Substitute baseline data for annual monitoring. If, for example, you want to know whether climate change will change your open bogs, pay for good air photos and some transect data up front, wait ten years or until you start to see changes, and then resurvey them.

Require monitoring for any management that requires progress toward a long-term goal, especially when this goal is quantitative. If, for example, the management plan requires increasing the number of large rotten logs or the percentage of the ownership in mature forest, have the managers count the logs and acres of mature forest every few years. Otherwise you will have no idea whether you are making progress or not.

The last point is particularly important for indicators of forest quality or sustainability that require changes in forest practice. It is much easier, and in fact common in management plans, to promise to make these changes. It is much harder, and in my experience quite rare, to produce hard evidence that the changes are working.

What might a model program for protecting biodiversity in a working forest look like?

If we think about an ownership of moderate size, say 100,000 acres, where there was a reasonable possibility of finding rare species and communities, it might include the following elements:

A general biological survey, in the first two years after acquisition, to map communities, develop species lists for major groups, and establish some baseline information for examples of each major community.

A rare species and special community survey, in the same time period, to locate elements that need explicit protection.

A biodiversity management plan, prepared by the surveyors in consultation with the owners, managers, and easement holders, that describes the biodiversity of the property and makes recommendations for its protection.

A plan for protecting wetlands and waterbodies (including vernal pools) using forested buffers, no-cut zones, and harvesting restriction.

Woodland sunflower is a dry-rich woods species of glades on open summits in the oak-hickory zone. It may or may not tolerate heavy logging. On the one hand, it is a wind-dispersed gap species with unspecialized pollinators and therefore should be tolerant. On the other it grows in what I perceive to be a fragile habitat and doesn't seem to seed into clearings in adjacent woodlands. I take a precautionary approach and think of it as a sensitive species that may tolerate only mild disturbance.

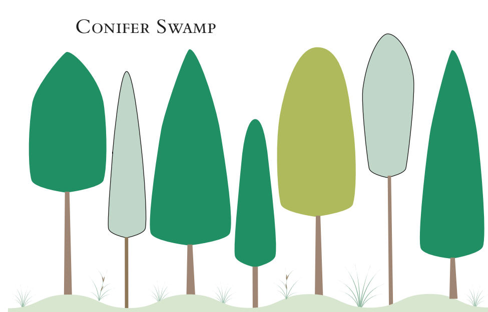
A plan for protecting mature and late-successional forests, involving some mix of reserves and selective forestry on long rotations.

A plan for protecting special management areas containing rare species and special communities. My recommendation is that most of these be red-lined and treated as no-cut areas.

A general commitment to forest sustainability, including the provision that the harvest of sawtimber not exceed some designated fraction of the growth, and a requirement for periodic reports showing this requirement is being met.

A description and map of the current distribution of forest sizes and ages, and a plan, including five-year projections, benchmarks, and a monitoring program, for either maintaining current distribution or shifting it to a more balanced one.

A plan for improving wildlife habitat, including a plan and benchmarks for increasing the number of large logs and snags, and a monitoring program to determine whether these benchmarks are being met.



Conifer swamps and other wooded swamps are only rarely protected in most easements but perhaps should be. They have wetland soils and mossy understories that are easily damaged by harvesting, and they support many boreal and forest-interior species of birds. Since all of these birds are vulnerable to climate change and several are already declining, is seems reasonable that, as a minimum, their breeding habitat be protected from other disturbance.

A late-successional forest is one that resembles, in composition, structure, and ecological processes, the undisturbed forests of the region. It does not need to *be* undisturbed, but it does need to show strong similarities to the forests that are.

As noted several places above, late-successional forests are rare on commercial ownerships. Typical commercial forests are small, young, and patchy and much dissected by roads. Logging removes trees that would otherwise die and decay, and as a result logged forests have thinner soils, less woody debris, and less decay.

But as also noted above, typical working forests are neither impoverished nor dysfunctional. They recycle nutrients, neutralize acid rain, and store carbon at rates often exceeding those of old-growth. They contain almost all the vertebrates and higher plants of natural forests, and may have higher overall diversities. And they contain intact waterbodies and wetlands that are unpolluted and biologically diverse.

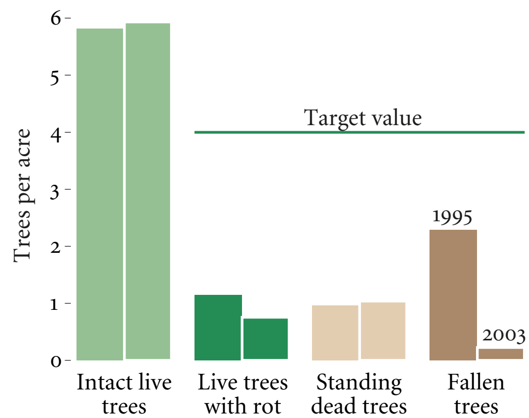
That working forests can be both highly unnatural and highly functional is philosophically confusing and has engendered a fascinating debate on what forests are for and what they should look like. On the one side are the preservationists who, with good reason, complain that you can walk for miles in the North Maine Woods—one of the great temperate forests of the world—and rarely see a tree much bigger than fifteen inches at breast height. On the other side are the foresters who point out that they are using native species, natural regeneration, and natural nutrient cycling to supply an essential product and at the same time protecting wetlands, rivers, and perhaps 95% of the native biodiversity as well. And who then ask, also with good reason, why they should be expected to grow large trees in continuous forests as well?

The large issues in this debate extend beyond what I can discuss here. But because easements can in principle be used to increase the naturalness of working forests, I can't ignore the matter altogether. I will limit myself to three questions: how much natural forest do we have, whether we need more, and if so what is the best way to produce it.*

Where are the relatively undisturbed forests and how much of them do we have?

Within private ownerships the least undisturbed forests are at higher elevations, on steep slopes, and in bands along rivers and lakes. The total amount is unknown but is, in my experience, probably less than 5% on many ownerships.

On public and nonprofit lands the natural forests are in reserves. The total amount of reserved land in the Adirondacks is large (2.9 million acres or 47% of the park, of which 0.5 million acres is esti-

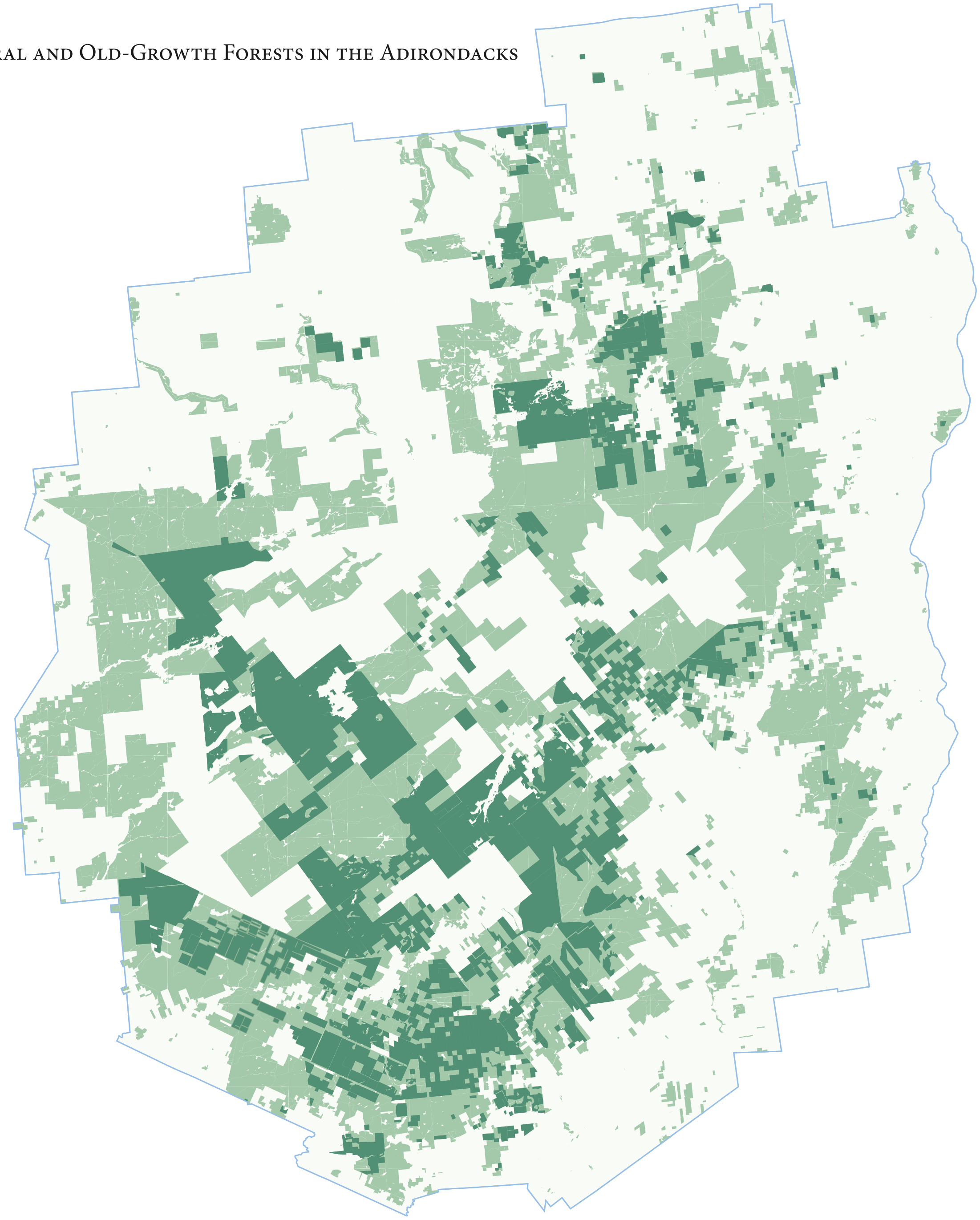


Actual and target values for the density of living and dead trees 15 inches in diameter or more in Maine. Data from Maine Forest Service, Forest Policy Division, 2005. The large change in the density of fallen trees is unlikely (where would they go?) and suggests that one of the bars is in error.

Large living and dead trees provide wildlife habitat, support moss and lichen species that are rare on smaller trees, and create more complex forests with more woody debris. The Maine Forest Sustainability Standards set a target of 16 such trees per acre, with 4 per acre in each of the categories shown above. Only the numbers of intact live trees attain the target; the numbers of rotten trees, standing dead trees, and fallen trees are currently a quarter of the target value or less. Further, except for the anomalous decrease in fallen trees, there has been little change in eight years. Commercial foresters have not been increasing the numbers of large living trees, and so the numbers of large dead ones haven't changed either.

*I use *natural* here to mean forests that resemble undisturbed forests in their age-structure, freedom from disturbance, ability to store carbon in dead wood, and ability to provide habitat for forest-interior species. It is not used normatively, and does not deny that natural processes occur in managed forests. But it does point to an important distinction: the large-scale removal of biomass that occurs in managed forests has no analog in natural ones.

Natural and Old-Growth Forests in the Adirondacks



Forest Preserve lands acquired before 1900; many are likely to have old-growth hardwoods, some may have old-growth spruce and fir.

Forest Preserve lands acquired after 1900; most have second-growth hardwoods and spruce less than 150 years old.

Maturing and old-growth forests in the Adirondack Park, from Jenkins, J., 2004, *The Adirondack Atlas*, Syracuse University Press. The Adirondack Forest Preserve, containing about 2.9 million acres of land, is protected by the state constitution and may not be sold or harvested. It is by far the largest reserve of natural forests in the NFR. About 1.0 million acres was acquired before 1800 and has never been logged. Another 0.3 million acres was acquired between 1890 and has been at most been lightly logged for softwoods.

mated to be virgin forest) and much lower elsewhere. The map at the right shows the protected areas of Maine, which total only a few percent of the forest area.

Why are late-successional forests desirable?

Late-successional forests are valuable for their beauty, naturalness, wildness, historical and cultural values, and potential for scientific research. In addition they are often described as biologically superior to working forests. Sometimes this claim is made explicitly—late-successional forests have been said to be healthier, more diverse, more stable, better functioning, more hospitable to rare species and so on. Other times it is made implicitly. The "index of biotic integrity," a measure of the extent to which a forest has late-successional character, suggests by its name that old forests are more whole and thus better than younger ones.*

It would take another report the size of this one to review these arguments, and I am not sure that any conclusions I reached would or should persuade readers in what is, ultimately, a matter of values and world view. For what it is worth, I have a strong preservationist strain. I argue that one of the great things a society can do is to protect and improve its wild places and I would certainly support a program to increase the amount of late-successional forest in the NFR. And while I do not believe that undisturbed forests have thus far been shown to have any intrinsic biological superiority, I do however caution that the sustainability of our current forestry systems is only a hypothesis. Should this hypothesis prove wrong—should, for example, managed forests prove unable to support the same biodiversity as unmanaged ones—we will have to turn back to undisturbed forests to find what true sustainability looks like.

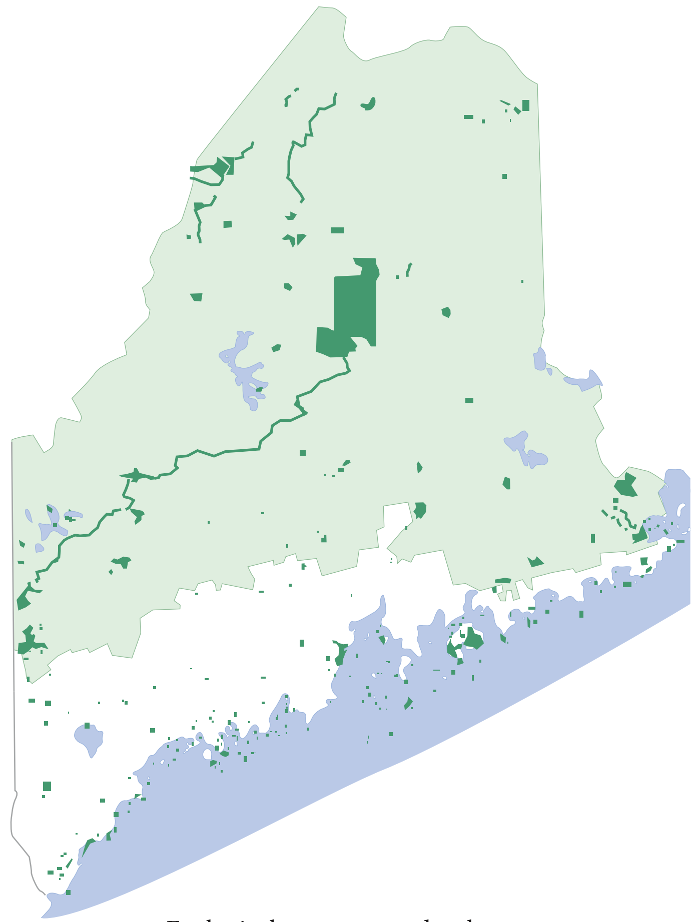
How can managed forests be made to resemble natural late-successional ones?

Managed forests can develop late-successional structure if some trees are allowed to grow old and die and rot naturally. This requires either limiting harvesting or stopping it altogether.

What is required to do this?

Approached silviculturally, some system of management that uses long rotations, encourages the development of a more natural age and size distribution, and leaves much coarse debris in the forest.

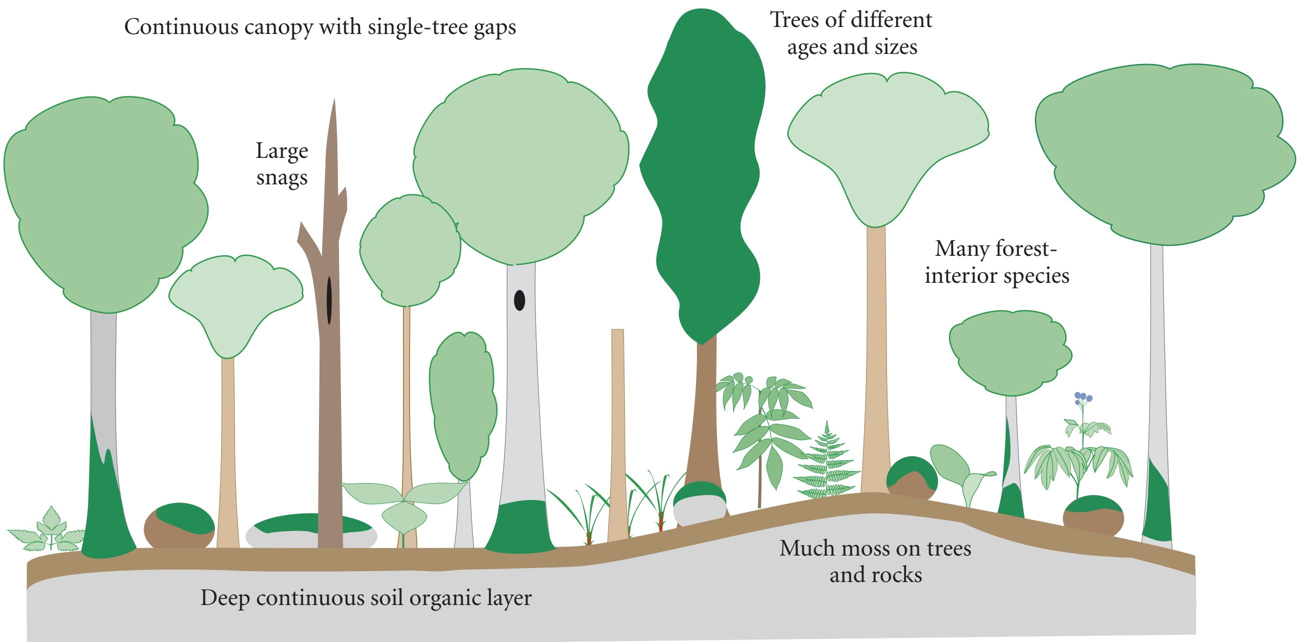
Late-successional Forests in Maine



Ecological reserves and other no-harvest areas in Maine, from GIS data supplied by the Appalachian Mountain Club. The Northern Forest Region is shown in light green. Unharvested land is rare in Maine, New Hampshire, and Vermont. With the exception of Baxter State Park, most of the areas shown are a few thousand acres or less.

*This assertion is circular. Since late-successional forests are used to define biotic integrity, the only meaning the integrity of late-successional forests has is that they resemble themselves.

A Late-successional Forest



Such systems are being practiced experimentally and on nonprofit ownerships, but nowhere seem to be part of the standard practice of large-scale commercial forestry. I call the techniques involved *artisanal* forestry.

Approached through no-cut reserves, a system like that in the Adirondacks in which the trees are left unharvested, and it is assumed that given enough time the stand will develop a late-successional structure of its own accord.

How long will this take?

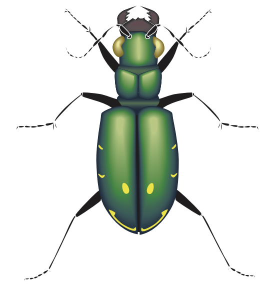
It depends on the age of the stand that you start with. There is evidence that stands that develop after clear-cutting will be similar to undisturbed stands in some, but not all, features of their biology in a hundred years. Thus if you start with a typical commercial stand of 50-year-old trees and manipulate the age structure through selective cutting you may have a moderately natural stand in 50 years. But considering that for a truly natural stand you need big dead trees on the ground as well as big living trees in the canopy, and considering further that natural old-growth in the NFR often contains trees over 200 years old, it will probably take another 100 years, or 150 years in all, for your restored old-growth stand to become indistinguishable from a natural one.

Attributes of a natural forest with late-successional structure. Structurally, undisturbed forests tend to have continuous canopies and contain mixtures of living and dead trees of different sizes and ages, thus making them more complex than harvested forests. Ecologically, their dead wood decays in place and produces organic soils with much rotten woody debris. Biologically, they tend to have much moss cover and many forest-interior species, and may have late-successional specialists dependent on large trees or coarse woody debris. Contrast the illustration of a heavily cut forest on p. 47.

What are the economics of growing late-successional forests?

They are daunting in a commercial setting, because you must defer harvesting and use complicated selection methods when you do harvest. Today most trees are harvested almost as soon as they are commercially harvestable, which is to say at somewhere around 10 inches in diameter and 60 to 80 years in age. To grow a forest of bigger older trees, you must decide to leave trees that could be harvested now unharvested for another 60 years or more, and further decide that a significant number of them, including the biggest ones, won't be harvested at all. Because of the discount rate—the low ability of future income to offset present costs—this represents a major loss of income and so is rarely done in commercial settings. While researching this report I heard some interesting discussions of "purchasing rotation length" (paying an owner to produce older trees) but have not seen estimates of how much this would cost and do not know of instances where it has been done.

The economics may be different in a noncommercial context. Some nonprofits are currently practicing a kind of low-profit forestry aimed at producing older forests and larger trees. And in some cases it may be cheaper for nonprofits to purchase a reserve and grow old trees themselves than to pay someone else to do it for them. Commercial forestry, after all, is based on harvesting trees efficiently; if your goal is an inefficient harvest or none at all, it may not make sense to dry to do this commercially.



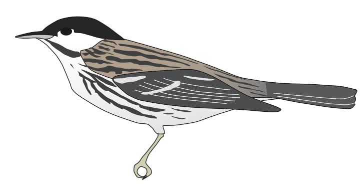
The beetles (here a tiger beetle, *Cicindella*) have many species associated with forest floors and decaying wood. Work in Finland (Berglund and Jonsson 2005) has suggested that many species are limited to older forests and have become extinct in the southern part of the country, where the forests have been heavily cut. This could be true in the our area as well, but thus far there have been no comparable studies.

Summary: why should late-successional forests be restored and how should it be done?

The main arguments are that late-successional forests have scientific and cultural value, may contain species not found in younger forests, and may function as refuges for late-successional species that are uncommon in commercial forests. All of these arguements seem valid and I would agree that the eastern parts of the NFR, where the amounts of late-successional forest are quite low, need more.

Late-successional forests can be created from working forests in two ways: either by stopping harvesting altogether (as has been done in the Adirondacks and in other reserves) or by using specialized types of long-rotation forestry designed to create late-successional structure. Neither way is fast. It will take at least 50 years for uneven age structure to begin to develop, and probably 150 years before the forests resemble natural old growth.

Because of the time required, it will likely be expensive to create late-successional conditions in commercial forests and easier and



The blackpoll warbler is a northern species that feeds in the crowns of conifers. It does not need continuous canopies or forest interiors; it is common in narrow bands of conifers at the edges of wetlands and in stunted or patchy conifers in the alpine and subalpine zones of the high mountains.

probably cheaper to create them, whether by artisanal forestry or by reserves, on public and nonprofit ownerships.

This completes my survey of what biodiversity elements need protection and which tools are best suited to protecting them. I turn next to real easements and the forests they govern and ask whether the protections offered by the easements are sufficient on paper and effective in the woods.

Wet subalpine cliffs, Mount Colden, Adirondacks.

Dry alpine cliffs and tundra, the Tableland, Mount Katahdin.

Large open bog, Massawepie Mire, western Adirondacks.

Floating bog mats, Upper Fishing Brook, central Adirondacks

Open stream valley with alluvial conifer thickets, Massawepie Outlet, Adirondacks.

Large alder wetland in a lowland black spruce basin, Connecticut Lakes, New Hampshire.

Bog stream with levees and adjacent raised bogs, Katahdin Forest, Maine.

Open river corridor along a small stream, Katahdin Forest, Maine.

Remnant beech stand on small ridge, West Branch Easement, Maine.

Old-growth hemlock near lakeshore, Grand Lake Stream, Maine.

Mature spruce and maple north of Rainbow Lake, in reserve near Katahdin Forest, Maine.

Mature northern hardwoods on Clear Pond Mountain, eastern Adirondacks.

VI BIODIVERSITY CONSERVATION IN WORKING FOREST EASEMENTS

How are working forest conservation easements structured?

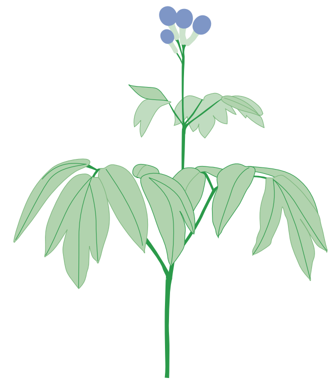
The more complicated ones, like the Connecticut Lakes easement outlined on the next page, create what is in effect a limited partnership between the fee holder (owner of the land) and the easement holder. They state goals and purposes to which both parties are bound; create a general framework for the use of the property; give each party rights and obligations; divide management responsibilities between the two parties; provide for notification, consent, and dispute resolution; and set conditions on the transfer of the property or the easement to other owners.

How is biodiversity conservation incorporated into these easements?

In several ways. The six recent easements that I have looked at all contain a general statement of conservation goals. The Connecticut Lakes easement, for example, says that its purpose is to "conserve open spaces, natural resources, and scenic values," to "sustain traditional forest uses including Forest Management Activities," to "conserve waterfront, streams, riparian areas, and the quality of groundwater and surface water," to "conserve biological diversity, fish and wildlife habitats, rare plants and animals, rare and exemplary communities and cultural resources," and to "retain the Property as an economically viable and sustainable tract of land…for the production of timber, pulpwood, and other forest products." This is further elaborated in the section on stewardship goals, which among other things requires the "monitoring and control of fire, disease, and insect outbreaks" and, of great potential importance, the "maintenance and protection of biological diversity and integrity through the promotion of a forest that reflects a diversity of stand ages and naturally occurring forest types in a majority of the forest."

Where the easements differ is in how carefully they provide for the accomplishment of the goals. In a minority of the easements, specific mechanisms for accomplishing biodiversity goals are created. The Connecticut Lakes easement, for example, creates a system of special management areas for protecting rare species and exemplary communities and, uniquely among the easements I have seen, allows the easement holder to add up to 3,000 acres of additional management areas of its choice in the future. The Downeast Lakes Land Trust, also uniquely among the easements I have examined, creates both a no-harvest ecological reserve and a late-successional management area.

The majority of the easements are less explicit. Commonly all the details of biodiversity protection are left to the forest management plan. The West Branch easement, for example, requires that



Blue cohosh is a forest-interior species of fertile moist hardwood forests. It is typical of a group of "rich-mesic" species that are common in small gaps in primary woods but absent or much less common in secondary woods. These species clearly tolerate selective logging but may not—we are not fully sure—tolerate clearcutting.

Right, the section and subsection headings of the Connecticut Lakes Easement, with green circles indicating the sections containing language that bears directly on biodiversity management. The full easement is 44 pages, with 24 sections and 70 subsections; 14 subsections (green circles) are relevant to biodiversity.

Unlike older easements, which simply extinguished development rights, this easement is in effect a contract providing for the joint management of the property by the fee holder (Lyme Timber) and the easement holder (the State of New Hampshire). Its provisions run from critical (forest management activities, public access) to minor (hobby mineral collection) to arcane (encumbrances, estoppel). Peter Stein of Lyme Timber said it took approximately a hundred meetings to work out the details of this easement.

GRANT OF CONSERVATION VEASEMENT

PREAMBLE

● PURPOSES

USE LIMITATIONS
- ● Prohibited and Permitted Uses
- ● Forest Management Activities
- ● Stewardship Goals
- ● Standards for Forest Management Activities
- ● Stewardship Plan
- Approval of Stewardship Plan
- ● Annual Operation Plan
- ● Special Management Areas
- ● Additional Forest Management Restriction
- Subdivision
- Structures
- Excavation
- Signage
- Hazardous Materials
- ● Off-Road Vehicle Use

RESERVED RIGHTS
- Fee Owner's Recreational Rights
- Outdoor Conservation Education
- Construction of Recreational Improvements and Charging Fees for Commercial Recreational Use
- Fee Owner's Right to Grant Access on and across the Property to Others
- ● Motorized Vehicle Use
- Structures, Improvements, Trails
- Signage
- Withdrawal of Forest Product Processing and/or Manufacturing Facility
- Archaeological Activities
- Licensed Sites (recreational leases)
- ● Water Resources Extraction
- Use of Hazardous Substances
- Notice

NOTIFICATION OF TRANSFER: TAXES

AFFIRMATIVE RIGHTS AND RESPONSIBILITIES OF THE EASEMENT HOLDER
- Public Access
- ● Public Access and Recreational Use Management Plan
- Review and Approval Process for Public Access and Recreational Use Management Plan
- Maintenance and Management of Designated Roads
- Five-Year Road Management Plan
- Road Management Agreement
- Operations Plans; Annual Meetings
- No Independent Right
- Access to the Property
- Temporary Limitations on Access
- Licensed Sites
- Storage and Removal of Rubbish, Garbage, Debris, and Waste Materials Left on the Property by the Public
- Gravel Rights
- Recreational Improvements
- Snowmobile Trail Maintenance and Management
- Hobby Mineral Collection
- Access by Easement Holder
- Collection of Data
- Signage
- ● Water Resources Extraction
- Third-Party Certification
- Third-Party Liability; Statutory Protections from Liability

CONSENT OR APPROVAL PRIOR TO UNDERTAKING CERTAIN ACTIONS
- Notice
- Response
- Failure to Seek Consent or Discontinue Use or Activity

BREACH OF EASEMENT
- Notice of Breach
- Response
- Right to Cure
- Breach Caused by Others
- Non-Waiver Provision
- Existing Rights of Parties
- Third-Party Claims

DISPUTES
- Non-Binding Arbitration
- Selecting Arbitrators
- Scheduling a Hearing
- Written Decision

NOTICES
- Delivering Notice
- Notice after Transfer
- Notice Regarding Transfer to Connecticut Lakes Realty Trust

CONDEMNATION
- Expenses Paid from Damages
- Damages Divided Proportionately
- Use of Easement Holder's Share of Damages

ADDITIONAL EASEMENT AND RIGHTS

ASSIGNMENT

SUBSEQUENT TRANSFERS

LIMITATION ON AMENDMENT

SALE OR CONVEYANCE

EASEMENT CONVERSION

BASELINE DOCUMENTATION

FUTURE ENCUMBRANCES

ESTOPPEL CERTIFICATES

BINDING EFFECT

STATE LAW CONTROLLING

HEADINGS

● = Relevant to biodiversity protection

the forest management plan "describe the Grantor's actions to conserve or enhance biological diversity at the stand and landscape levels" but places no further conditions on what those actions might be and what actions might be deemed sufficient or insufficient to conserve diversity.

While all the easements rely on the forest management plan to provide the details of biodiversity conservation, they differ greatly in just how explicit those details must be and who decides whether the plan is adequate. The Connecticut Lakes easement, which is exceptionally detailed, requires that the stewardship plan contain, among other things, management objectives for "wildlife, rare, threatened, or endangered animal species including, but not limited to, riparian areas, high elevation zones, low elevation spruce-fir forests, known deer wintering areas, early successional habitats, and mast stands." It also requires "objectives including forest structure and composition goals for the entire property" and an explicit plan for special management areas. Further, it requires that the plan be approved by the easement holder. No other easement requires this level of management detail and only two others, Tug Hill and Pond of Safety, require that the management plan be reviewed by the easement holder.

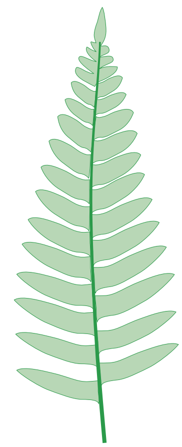
What biodiversity provisions do working forest easements commonly contain?

The main biodiversity provisions of the six easements I examined are summarized in the chart at right. All require sustainable management, endangered species protection, wildlife habitat protection, and some protection for riparian areas and lakeshores. Otherwise, the protections vary considerably. Only three have language about creating a diversity of age classes. Only two have explicit provisions for creating special management areas, and only a single easement requires certification and sets up old-growth and ecological reserve areas. And most surprising, only one easement requires that the forest management plan describe the overall structure and composition of the forest, and only two require that the forest management plan describe the actual steps taken (as opposed to those intended to be taken) to achieve specific biodiversity goals.

Compared to the recommendations on p. 64, where do these easements fall short?

In two ways: what they leave out altogether and what they include but implement weakly.

In the first category, omissions, I note that the easements I have examined:

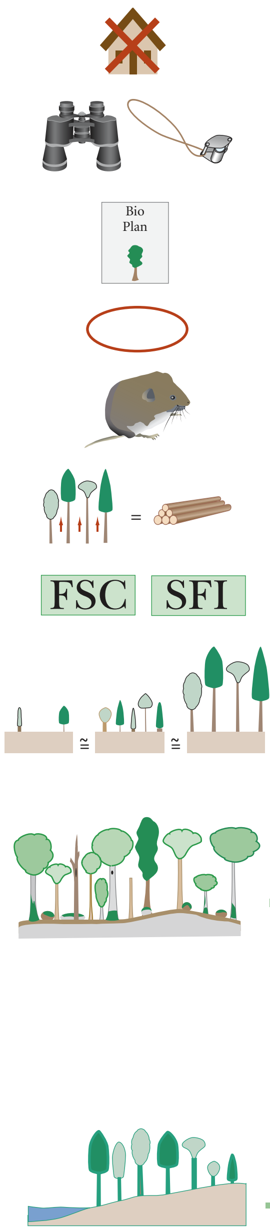


Common polypody is a forest-interior fern commonly found on shaded boulders in woods. It is common in older forests but is neither a late-successional species nor a slow-returning species. It might be classified as a second-generation colonist, absent for the first 50 years after abandonment when a forest is still in aspen and birch but often well established in suitably rocky woods after a hundred years.

Right, the implementation of biodiversity protection on six working forest easements, in the Forest Stewardship Council (FSC) and Sustainable Forestry Initiative (SFI) standards (Northeast Region Working Group, 2004; Sustainable Forestry Initiative, 2005).

Note that although the FSC standards require explicit proof of compliance with or progress toward almost all the biodiversity goals I regard as important, the SFI standards are weaker and require less proof. And also that most easements, except the remarkably thorough Downeast Lakes Land Trust easement, omit important goals and leave others to the management plan or to state best management practices. And finally that two properties, the Connecticut Lakes and the West Branch, are in fact certified even though the easement doesn't require it.

Biodiversity Protections in Easements and Certification Systems



	Tug Hill	Pond of Safety	Connecticut Lakes	West Branch	Katahdin Forest	Downeast Lakes	FSC Standards	SFI Standards
Prevent development	●	●	●	●	●	●		
Mandated survey							S	S
Biological Management Plan								
Special Management areas			●			●	S	
Protect threatened and endangered species and special communities	G	G	G	G	G	G	S	S
Manage sustainably	G	G	G	G	G	G	S	S
Require forest certification						●		
Balance age groups	G		G			G	S	
Protect old-growth						●	S	S
Generate late-succesional forest						●	S	
Generate coarse woody debris						●	S	
Protect wetlands	G	G	G		G	G	S	S
Protect riparian areas	B	B	B	B	B	B	S	S
Protect lake shores	B		B	B	B		S	S
Protect vernal pools	?		?	?	?	?	?	S
Manage for wildlife habitat	G	G	G	G	G	G	S	S
Monitor progress on goals			●			●	S	

● Explicitly provided for in easement
G Mentioned in easement goals
B State best management practices to be followed
S Part of FSC or SFI certification standards

Do not explicitly require a biological survey. Many have had excellent surveys, but these were not required by the easements.

Only rarely require a formal system of special management areas.

Only rarely protect old-growth forests.

Do not explicitly protect vernal pools.*

Often fail to require that forest management aim at a balanced distribution of age classes.

Only rarely provide for generating woods with late-successional structure.

In the second category, weak implementation, I note that the easements I have examined:

Rarely involve biologists in the preparation of management plans and never require a stand-alone biodiversity management plan.

Only rarely require that managers report on the overall structure and composition of the forests.

Rarely provide explicit benchmarks for sustainablity, age class balance, or other management goals.

Only rarely require managers report on progress toward those goals.

Often do not require that the management plans be approved by the easement holder.

Could forest certification improve biodiversity management?

Yes it could, but only if the managers follow the certification standards. The current Forest Stewardship Council Standards for the Northeast Region include extremely detailed requirements for monitoring and protecting biodiversity. All of the types of biodiversity protection in the chart on p. 81 except vernal pool protection and a biological management plan are required for FSC certification. The Sustainable Forestry Initiative standards also provide a number of important protections but do not require explicit benchmarks for progress toward conservation goals and do not provide for special management areas, balancing age classes, managing for coarse woody debris, or generating late-successional forests.

How might future easements be improved?

In the following section I will give more detailed recommendations. In a quick summary, I would fix the omissions by requiring a biological survey and a system of special management areas, and by building

*Several states (at least Maine, New Hampshire, and Massachusetts) include vernal pool protection in their best management practices for logging. But unless an easement requires that the state BMPs be followed—and many don't, or do for streams or lakes but not ponds—this will not guarantee protection.

explicit sustainability conditions and explicit protections for missing biodiversity elements into the easements. I would improve the implementation by requiring explicit benchmarks for sustainability, by requiring that the easement holder approve the management plan and, in a major change from the way things have thus far been done, requiring a biodiversity management plan to be prepared by the biologists who do the survey.

How effective do the current easements seem to be at protecting biodiversity?

I have to answer this partially and tentatively. I have done recent fieldwork on four working forest easements and previous fieldwork on two others, which is sufficient to form some opinions but not sufficient to make a full review.

My overall impression is that where protections have been implemented, they are working well. The most obvious problems are that some features important for biodiversity have been left unprotected and that there is often no way of measuring progress towards long-term goals like forest structure.

On all the properties I visited, wetlands and streams seemed in good condition, buffer strips were present and being respected, old trees were being left for wildlife, and special management areas for wildlife had been identified and flagged.

On the two easements (Downeast Lakes and Connecticut Lakes) that have extensive systems of reserves and special management areas, I was impressed by the quality of some of the older forests that had been placed in ecological reserves or no-cut areas. I felt that the reserve and special management area systems were a great asset to these properties, and wish that more easements had similar reserves. I was also impressed by the way artisanal harvesting was being used to create uneven-aged forests in the late-successional reserve on the Downeast Lakes Property.

On none of the easements that I visited did I find rare species in areas subject to harvest.

On most of the easements I visited, I found older, more intact, or biologically richer forests that seemed to merit some sort of protection as special or exemplary communities. In most cases, however, the easement did not provide for the protection of better-than-average examples of common forest communities, and so these forests were unprotected.

Progress towards more balanced age distributions with more mature forests is required on three easements and suggested by language requiring sustainability on most others. This kind of progress is hard to evaluate in the field. I saw little evidence that it is happening but cannot prove that it is not.

The large (>1,000 acres) easements in the Northern Forest Region in 2007, from data compiled by the Appalachian Mountain Club and Adirondack Nature Conservancy. A few of the large Adirondack easements (Brandon, Bay Pond, Nehasane, Adirondack Mountain Reserve, Paul Smith's College) are lands belonging to clubs or families or nonprofits. Most of the rest are on commercial timberlands owned by investment groups. Many of these are former industrial lands. The Forestland Group owns the former Champion lands, and Lyme Timber the former Domtar and International Paper lands.


Pingree
Pingree
Pingree
Pingree
West
Branch
Katahdin Forest
Penobscot River
Katahdin
Forest
Sunrise
Connecticut
Lakes
Pingree
Pierce Pond
Robbins
Downeast
Lakes
Machias
Essex
Timber
Bunnell
Mt. Blue
Pingree
Pond of
Safety
Davis
Andorra
Forest

VII SYNTHESIS: A BLUEPRINT FOR HIGH-LEVEL BIODIVERSITY PROTECTION

Imagine that we are concerned with protecting biodiversity on a property of around 100,000 acres somewhere in the NFR. And imagine further that this is an exceptional property: high timber value, high development value, high beauty and recreation value, and high numbers of rare species and communities. Three-tquarters of the property will likely go to a timber investment firm, the remaining quarter to the state or a nonprofit. The easement will be complex and will likely include a timber management plan, a recreation plan, and a wildlife management plan. We wish to build in high-level biodiversity protection for the whole property, protecting the special communities from timber management on the privately owned part and from recreational use, which we expect to increase, on the publicly owned part. How do we do this?

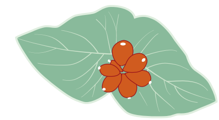
If this property was smaller, less distinguished, or harder-used, doing nothing would be an option. We could argue that the plants and animals were mostly common species that had proved themselves tolerant of commercial forestry, and that the combination of a simple no-development easement and existing state requirements for wetland and stream protection would suffice to protect existing biodiversity. We might be wrong about this, especially if the biomass market takes off and there is a large demand for cheap wood from young trees. But we might also be right, and by keeping the protection simple we would have resources—money, certainly, but also staff time—that we could use to protect other more valuable properties.

Our example, however, is a property of exceptional value. Doing nothing is not an option, and simply passing it to the state and saying "You work out the easement" is not a good option. We are the preservation and biodiversity specialists, and we want to be involved through the whole process, to ensure the highest levels of protection. And we want to ensure that these protections apply to the publicly owned parts of the property as well—something that the easement will not guarantee. How do we do this?

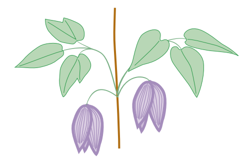
My answer, based on a year and a half of studying the problem and many years looking at biodiversity in commercial settings, is that there are five things we have to do and a sixth that we may want to do. All but one are standard protection tools that are in wide use. There is no novelty in recommending them; the novelty here comes from insisting that they all be used together, and that they be used in such a way that there is a public record of what is to be protected and what progress has been made toward protecting it.

The five things I think you must do to protect biodiversity at a high level are:

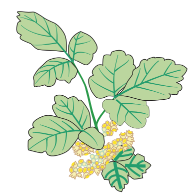
RICH-WOODS INDICATORS



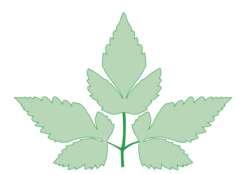
Limber Honeysuckle



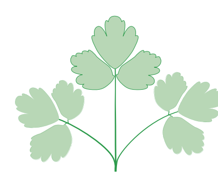
Purple Clematis



Fragrant Sumac



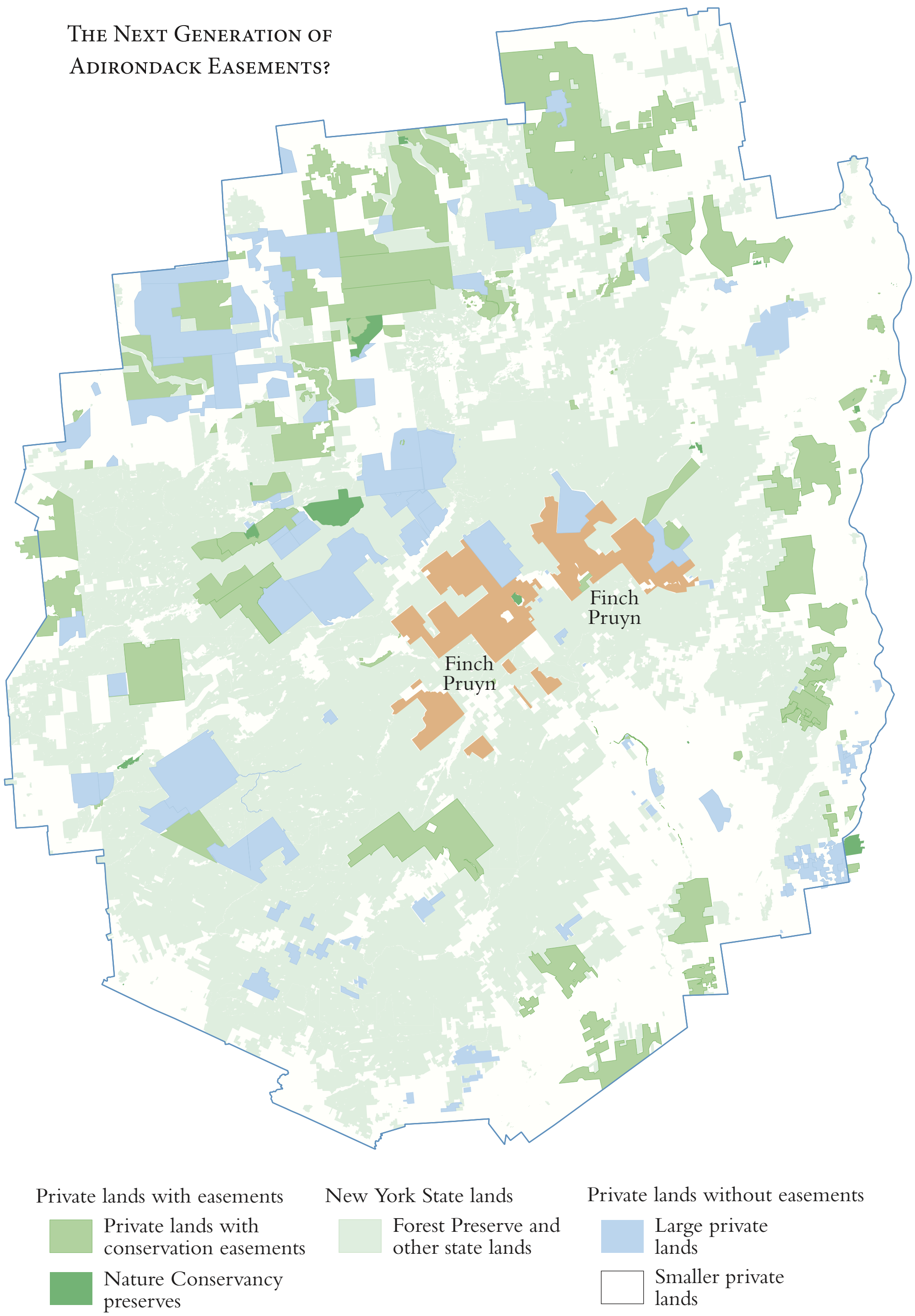
Sweet Cicely



Columbine

Five species (among many others) associated with calcium-rich soils. The first three are uncommon, the last two common. The presence of any of them indicates that high-diversity forest communities may be present and may need special protection.

The Next Generation of Adirondack Easements?



The Adirondacks now contain about 760,000 acres of working forest conservation easements (medium green) and a similar acreage of large private forests without easements (blue, orange). One of these, the 160,000-acre Finch Pruyn tract, contains some of the most valuable lands in the Adirondacks. The Finch lands were recently bought by Atlas paper, a holding company, and then resold to the Nature Conservancy. The State of New York has recently agreed to buy 57,000 acres of the Finch lands outright and buy and hold working forest easements on another 74,000 acres.

1 *Make a complete survey and use it to create a biological baseline and a biodiversity management plan for the entire property. Require that the plan be used as a guide for the future management of both the public and private sections of the property.*

There are two innovations here: requiring a survey and using it to generate a biological management plan. Although many of the working forests currently under easements have had surveys, none of the easements require them. In many cases they just say that "known localities for rare species and communities will be protected." This is grossly inadequate; most large ownerships have never been systematically surveyed, and most, as our brief field visits showed, have important biological features that have never been mapped.

All the easements that I have seen incorporate biodiversity planning into the forest management plan; none require a separate biological management plan. My strong (and of course biased) feeling is that this isn't enough. The existing management plans are, and should be, forestry documents. They are not the place to present detailed biological information, and their authors, whose primary responsibility is to keep the property productive, are not the ones to argue forcefully for types of protection that may conflict with production.

The logical alternative is a separate biodiversity plan, prepared by the survey biologists in consultation with the easement holder. The biologists have seen the species at risk and likely know the most about what is needed to protect them. The easement holder is the legal representative of the public's interest interest in biodiversity protection and has a fiduciary responsibility to make sure that the protection works. Because the easement holder and the biologists are the ones most knowledgeable about biodiversity and most responsible for protecting it, it is only reasonable that they are the ones who should design the protection plan.

Specifically, I recommend that all large easements (and any small ones with exceptional biological features) should have a dedicated biodiversity plan. The plan should be prepared by the survey biologists and easement holder, after consultation with the fee owner, and forest managers. It would have two functions: it would present a detailed survey of the current biodiversity to be used as a baseline for assessing the future condition of the property and it would identify the elements needing special protection and recommend protection for them.

The plan could either be designed as a regulatory document that would be referenced in the easement and bind both parties, or as an advisory document that stated an expert opinion and left it to the easement and forest management plan to put those protections into effect. This might vary with the easement. My tendency is to

Right hand page, the framework of biodiversity management recommended in the text for a property with exceptional biological value. The elements shown in red on the diagram are rare or lacking in current easements.

A biological survey of the entire property provides baseline information on the general biological condition and identifies the species and communities of particular conservation interest.

A biological management plan is prepared by the survey biologists in consultation with the owners and easement holders. It recommends conservation measures for the species and communities of interest and describes the monitoring that will be necessary to determine whether these measures are working.

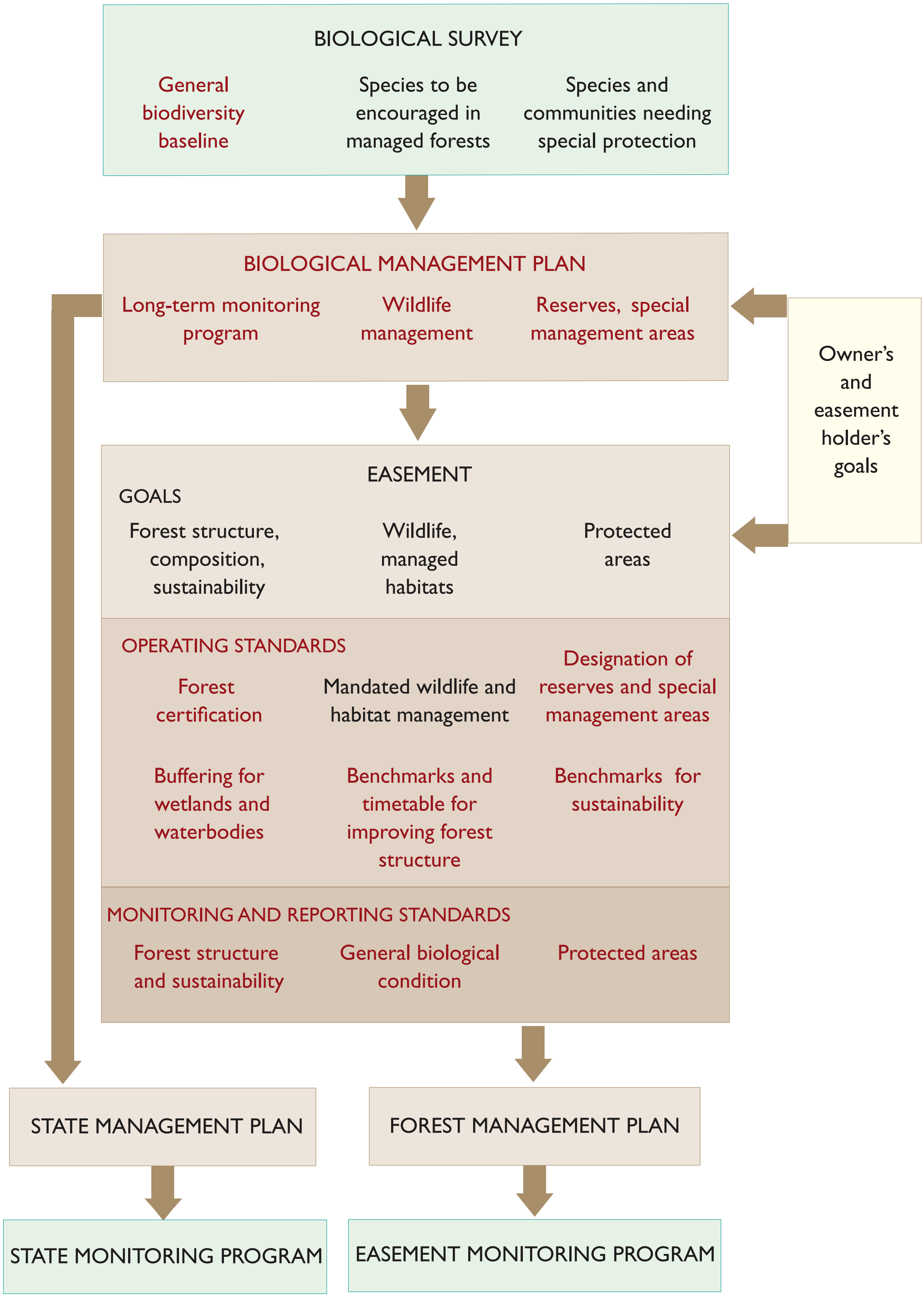
The recommendations of the biological management plan are incorporated in the goals of the easement.

The easement contains explicit operating standards that the managers must meet.

The easement requires periodic monitoring and reporting, which will describe the overall state of the property and determine whether the biological goals are being met.

The forest management plan is responsible for meeting the biological goals in the easement. It prescribes a monitoring program to show that the goals are being met.

Because the biological management plan covers the whole property, it also provides a public standard by which the management and monitoring plans of any parts transferred to the state may be judged.


BIOLOGICAL SURVEY
General biodiversity baseline
Species to be encouraged in managed forests
Species and communities needing special protection
BIOLOGICAL MANAGEMENT PLAN
Long-term monitoring program
Wildlife management
Reserves, special management areas
Owner's and easement holder's goals
EASEMENT
GOALS
Forest structure, composition, sustainability
Wildlife, managed habitats
Protected areas
OPERATING STANDARDS
Forest certification
Mandated wildlife and habitat management
Designation of reserves and special management areas
Buffering for wetlands and waterbodies
Benchmarks and timetable for improving forest structure
Benchmarks for sustainability
MONITORING AND REPORTING STANDARDS
Forest structure and sustainability
General biological condition
Protected areas
STATE MANAGEMENT PLAN
FOREST MANAGEMENT PLAN
STATE MONITORING PROGRAM
EASEMENT MONITORING PROGRAM

prefer the latter: let the biologists be independent voices, ombudsmen for biodiversity if you like, and let the parties to the easement, who have the long-term responsibilities for management, be responsible for the actual protection.

The kind of survey and planning proposed here will neither be quick nor cheap. I would think that a year's time and somewhere around 0.5% of the value of the property would be a minimum; particularly valuable ownerships might require twice this. I recommend that the cost of the biological management plan be included as a transaction cost, like a boundary survey or timber cruise, in the overall price of the sale and easement, and that it be regarded, again like a survey or an appraisal, as anessential part of the transaction. When you buy a conservation easement, you are assuming that property contains something worth conserving and that the easement will protect it. Without a biological survey and biological management plan, you have no proof of either.

A good biological management plan might also be a solution to the important and increasingly discussed problem of how to protect a public property from increased use. Most large NFR transactions transfer some lands to public ownership. These lands, which often contain important biological features, are not usually covered by conservation easements and will often be subject to increased recreational use. They usually do not get biological surveys, and their management plans, in my experience, often deal inadequately with biological resources and with conflicts between biodiversity and recreational use.

My proposed solution is do a biological management plan before the lands are transferred to the public owner, and then make sure that the plan and its recommendations become part of the public record. The recommendations might be referenced in the deed and become legally binding or might only be advisory. Either way, any management plan for the public lands would have to consider biodiversity protection. It would, at a minimum, have to acknowledge the significant species and communities that had been found and, at a maximum, follow the biologist's recommendations for their protection.

2 *Write basic requirements for forest structure and sustainable harvesting into the easement and require an annual report showing that these are being attained.*

All of the easements that I have examined require that timber be produced sustainably, and many have some language about maintaining and improving the age structure or diversity of the forests. Yet few set explicit benchmarks for structure or sustainability or require that the management plan report on progress toward them.

My suspicion, after visiting ownerships and talking with foresters and easement holders, is that this is an area where good intentions alone are not going to work, and where there need to be concrete benchmarks and reporting requirements. The reason is that the age distribution in most forests is anything but balanced (p. 17), and that some current harvesting rates, especially for softwood sawtimber, are unsustainable. There are, in other words, strong pressures toward growing a lot of small trees and harvesting them before they get very old. If we want foresters to resist these pressures—as many of them would like to do—we need to give them explicit targets: a clear definition of how sustainability will be measured and clear guidelines for what the eventual age-distribution of the forest should be and how fast it should be achieved.

3 *Create a system of special management areas, based on the biological management plan. Red-line these areas as no-cut zones whenever possible. Make sure that these areas are mapped and, where appropriate, marked in the field, and that the biological management plan shows where they are, why they are being protected, and what they contain.*

Most current easements do not create systems of permanent protected areas. Instead they instruct the managers to plan and monitor forestry activities to ensure that species and communities are not being harmed.

This kind of protection involves continuing management costs. The foresters must plan their harvests around the needs of the protected species, the contractors must follow their directions, and the easement holder must monitor the cuts to see that the protection is working. Needless to say, all this takes time and information and doesn't always happen. It is probably a good approach for the temporary protection of casually occurring species—some nesting owls, say, or a few lady's-slippers—in ordinary commercial woods. But for the rarities that are associated with special communities and require permanent protection, I strongly recommend red-lined no-cut areas.

The premise of red-lining is that it is simpler and cheaper to segregate the most important rare species and communities in special management areas than to manage them within working forests. The costs are borne up front by the easement holder and the areas are permanently flagged and marked on the compartment maps. Operations are simpler because you don't need special harvesting techniques. Monitoring is simpler because all you have to determine is whether the machinery stayed on the right side of the flagged line and not whether some silvicultural prescription is actually protecting what it is supposed to protect.

The Connecticut Lakes easement includes an innovative prescription allowing the easement holder the right to designate, on a no-questions-asked basis, additional special management areas if something new is discovered that needs protecting. This is the biodiversity equivalent of a prepaid phone card, and effective for the same reasons: it lets you pay up front but reserve some of the decisions about what to protect for when you need them. Given changes in biology and the limitations of surveys, this seems like an essential tool for any large, biologically rich property.

4 *Put explicit rules for buffering waterbodies and wetlands in the easement. Make sure vernal pools are included in these rules.*

My concern here is not that waterbodies and wetlands are unprotected, but rather that the protections are not uniform and not explicit.

The easements I examined differed greatly in the degree of protection they gave to rivers and lakes, and in whether wetlands are protected at all. Most of them referenced state best management practices, which may change over time. One easement cited a set of state guidelines which apparently no longer exist. And none of them explicitly protect vernal pools, which are commonly found within actively harvested areas and can be damaged by logging.

My recommendation would be to choose levels of protection for streams, lakes, wetlands, and vernal pools, perhaps based on state guidelines, and then write this level of protection directly into the easement. This way there is no doubt about what the easement requires, and no possibility of it changing.

5 *Provide a reserve or special management system to protect existing old forests and to increase the amount of mature or late-successional forests. Again, make sure that the* biological management plan *shows where these areas are and what they currently contain. Choose a set of indicators of successional status, measure them at five-year intervals, and use them to determine whether your management is working.*

There are two issues here: the protection of existing mature forests, and the creation of new ones from younger stands. Both are based on the observation that mature forests are uncommon and old-growth ones rare on most ownerships in the NFR. Since many forest-interior animals and plants are dependent on mature forests, these animals and plants are scarce on many ownerships, and the conservation of older forests and forest species as thus a conservation priority.

Conserving them requires three steps. The first is to acknowledge that existing old-growth and late-successional forests are one of our rarest and most endangered communities and should be protected as we would any other rare community, with no-cut zones and special management areas.

The second is to acknowledge that mature forests, while not as rare as old growth, are still scarce in most of the NFR and should be harvested sustainably, with no diminution in their acreage or timber volume.

The third is to institute some sort of management that will create more mature and late-successional forest. Increasing the amount of mature forest falls is a common management goal and part of the balancing of age classes discussed on p. 60. Increasing the amount of late-successional forest requires either long rotations and special harvesting plans or ecological reserves. It is not currently a part of normal practice on any commercial ownership I have seen, but is being used on nonprofit ownerships.

My recommendation is that increasing the amounts of mature forest and balancing the age classes be considered a basic component of sustainable management and be incorporated in all easements. The development of late-successional forests, on the other hand, seems to me a meritorious option that some owners will want to pay for and others won't. I would consider it a desirable component of all easements outside the Adirondacks. But I would leave it to the individual easement owner to chose how much they wish to develop, and whether they wish to develop it through artisanal forestry, ecological reserves, or a combination of the two.

6 *Require forest certification and use the certification audits to monitor compliance with the easement.*

With the exception of the biodiversity management plan and the protection of vernal pools, all of the biodiversity provisions that I have recommended are required by the Forest Stewardship Council's certification standards, which give detailed benchmarks for compliance and documentation.* On a high-value property where the easement holder wished a rigorous third-party assessment of sustainability and good management, I would recommend requiring FSC certification. I would still require a biological management plan, which is not included in the certification standards. And I would still put explicit requirements for sustainability, special management areas, waterbodies, and so on, in the easement, both to guide the certifiers and to make the requirements legally binding in a way that certification is not.

*Many of the biodiversity provisions are also included in the Sustainable Forestry Initiative standards, but several important ones are missing. Further, the SFI standards do not require benchmarks for compliance and documentation (p. 81). Thus the FSC standards seem definitely better for biodiversity protection.

NOTES

A set of extended notes on many of the papers mentioned here (Jenkins 2007) is available from the Open Space Institute or Wildlife Conservation Society Adirondack Program. See the back cover for contact information.

I The Northern Forest Region

Much of this chapter is derived from the author's own fieldwork, which spans 40 years and has included most parts of the Northern Forest Region. The fieldwork has focused on higher plants, bryophytes, and birds, but has also included some work on mammals, lichens, and higher fungi.

p. 12 "used for timber production for 150 to 200 years" The large-scale commercial logging of the NFR began in the 1810s with the development of river drives in Maine and the Adirondacks. This logging was necessarily selective; the drivers were only interested in softwoods and, at least for the first 50 years, in logs 14" in diameter or more. See McMartin 1994.

"except in parts of the Adirondacks." The rules of the Adirondack Park Agency require permits for clear-cuts above a certain size. A few ownerships still clear-cut, but most do some form of partial harvesting.

p. 13 "severe spruce budworm outbreaks." Dates from Marcia McTeague, Katahdin Forest Management, Millinocket, Me.

"Sugar maple … is regenerating poorly in the western Adirondacks" See Jenkins 1998. There is now a substantial literature suggesting that soil cation depletion caused by acid rain has affected sugar maple health and regeneration: see Jenkins et al. 2007.

p. 16 "The wetlands, free-flowing rivers, and ponds are all in good condition." Based on my own experience. In perhaps half a million acres of biological work on commercial ownerships in the NFR, I have only rarely seen examples of development or forest operations adversely affecting a wetland. I have, however, seen many examples where development was occurring on the shores of lakes or ponds, and many examples of forest operations that came right to the edge of wetlands.

II Biodiversity in the Northern Forest Region

I have found few large-scale analyses of biodiversity in the NFR and so have provided my own here. The object is to provide an estimate of the diversity of northern forests and the wetlands and successional openings regularly associated with them, excluding species of nonforest habitats like seacoasts, developed areas, and agricultural lands. Such an estimate is smaller, and more relevant to questions of forest management, than an estimate of all the species in the NFR.

p. 36 "My estimates at right." These estimates are of the species that regularly occur in northern hardwood and conifer forests and in the wetlands, clearings, cliffs, and other special habitats within them. The plant estimates are taken from floras and from my own surveys; the animal estimates are taken from state atlases. I do not include alien species, species restricted to developed or agricultural habitats, highly rare species, and species of the oak zone with a limited presence in the NFR.

"Finnish biologists have estimated" Hanski 2000. It should be possible to make comparable estimates for the total diversity of the NFR, but so far as I know it has not been done.

p. 41 "can proxy measurements, either of forest structure or of selected indicator species, be used to predict overall species diversity?" For a useful review, which concludes that "the relationships between potential indicator species and total biodiversity are not well established" see Lindenmayer, Margules, and Botkin 2000. For other discussions of indicators, see Noss 1999; Stork et al. 1997; and Whitman and Hagan 2003.

III Effects of Logging on Forest Biodiversity

The literature here is large but, as noted on p. 58, of uneven quality and relevance. Only a few general reviews seem to be available. The most useful I have found are Carey and Harrington 2001; deMaynadier and Hunter 1995; Hunter 1990; and Welsh and Droege 2001.

p. 46 "significant parts of the literature that does exist are unclear or contradictory" For an interesting analysis of the literature on logging and birds, see Sallabanks, Arnett, and Marzluff 2000. They found that many studies have methodological problems—poor replication, lack of before-and-after information, and little or no analysis of causes. My experience has been that this is also true of the amphibian, mammal, and plant literature. An additional problem, common to many studies, is that they report changes in total diversity, which is relatively insensitive to changes in forest structure, but not the changes in the diversities of the different ecological groups discussed on pp. 47-48, which are much more informative.

p. 47 "late successional species" In contrast to the western and northwestern United States, where late-successional species have been found in a number of groups, late-successional species are either rare or poorly known in the NFR. There are probably several reasons for this: the structural differences between early-successional and late-successional forests are much larger in the west than the east, the eastern forests have been repeatedly glaciated and so may not have not had the time to evolve late-successional specialists, and the eastern forests are more disturbed by fire and windstorm than the forests of the Pacific coast.

p. 48 "Amphibians" The papers I found most relevant were: Ash 1997; DeGraaf and Yamasaki 2002; deMaynadier and Hunter 1998; Harpole and Haas 1999; Hartley, Burger, and Beyea 2003; Lowe and Bolger 2002; Marsh and Beckman 2004; McKenny, Keeton, and Donovan 2006; Morneault et al. 2004; Patrick, Hunter, and Calhoun 2006; Petranka, Eldridge, and Haley 1993; and Ross et al. 2000.

"Birds" The papers I found most relevant were: Pekins, Leak, and Neefus 2000; Germaine, Vessey, and Capen 1997; Gram et al. 2003; Gunn, and Hagan 2000; Hagen and Groves 1999; Hartley, Burger, and Beyea 2003; Keller, Richmond, and Smith 2003; and Welsh and Healy 1993.

p. 50 "Mammals" The papers I found most relevant were: Clough 1987; Fredericksen et al. 2000; Fuller and Harrison 2003; Glennon and Porter 2006; Homyack, Harrison, and Krohn 2003; Martell 1983; Robinson et al. 2005; and Sekgororoane and Dilworth, 1995.

"Higher plants" The papers on understory vegetation that I found most useful were: Duffy and Meir 1992; Goebel, Hix, and Olivero 1999; Halpern, Spies, and Kemball 1995; Kemball, Wang, and Dang 2005; Noola and Vasseur 2004; Reich et al. 2001; and Roberts and Zhu 2002.

"Mosses and liverworts" There is a considerable literature from Europe and the British Isles which I do not review here. The eastern North American literature is sparser. Three useful recent studies on *Neckera pennata* and other forest-interior bryophytes are McGee and Kimmerer 2002, 2004; and Schluter and Reed 2001. A floristic study showing a definite though weak differentiation of the bryophyte flora of late-successional woods is Cooper-Ellis 1998.

"Lichens" Here again the British and European is much richer than the literature from eastern North America, and suggests that there may be late-successional species in our forests that have not been identified. The major paper on continuity indicators and late-successional species is Selva 1994, which, though often cited, is methodologically weak. It only looked at older forests and had no control plots in younger forests.

p. 52 "slow returning plants in the NFR" For a general discussion of the difficulties of defining continuity and late-successional indicators see Norden and Appelqvist 2001. For references on mosses and lichens, see the notes for p. 50. For general evidence on the slow rate of spread of forest herbs see Cain, Damman, and Muir 1998. For evidence of slow-returning plants in the United States see Bratton 1994; Duffy and Meier 1992; Halpern and Spies 1995; Meier, Bratton, and Duffy 1995; Scheller and Mladenoff 2002; and Roberts and Zhu 2002. One of the very few studies that identifies the reasons that a species is restricted to forest interiors is Jules and Rathcke 1999.

The small number of citations for this chapter and their somewhat contradictory findings suggest how much we still have to learn about plants and logging.

IV Protecting the Existing Biodiversity in Working Forests

p. 56 "The Standard Toolkit" The name is my own. The eight tools I illustrate here are widely discussed, under a variety of names, in the literature of biodiversity, wildlife management, and conservation forestry. See, among others, Calhoun and deMaynadier 2004; DeGraaf, Yamasaki, Leak, and Lanier 1992; DeGraaf, Yamasaki, Leak, and Lester 2006; Flatebo, Foss, and Pelletier 1999; Hansen, Spies, Swanson, and Ohman 1991; Hunter 1990; Mitchell, Breisch, and Buhlmann 2006; New Hampshire Forest Sustainability Standards Work Team 1997; and Woodley and Forbes 1997.

p. 58 "What are the tools in the standard toolkit used for, and how effective are they?" The discussion in this section and the graphic on p. 59 is a synthesis of the literature, comments from biologists and managers, and my own field observations.

"The literature on edge effects" See, for example, Cockle and Richardson 2003; Darveau et al. 2001; DeGraaf and Yamasaki 2002; deMaynadier and Hunter 1998; Hagan 2000; and Wilkerson et al. 2006.

p. 61 "While all three of these tools are advocated in textbooks and referred to in many guideline for sustainable forestry" See, for example, Seymour and Hunter in Hunter 1990 on emulating natural disturbance and uneven-aged management; Lindenmayer and Franklin 2002 on all three techniques; Curtis in Kohm and Franklin 1997 on late-successional structure; and Diaz and Bell, also in

Kohm and Franklin 1997, on large-scale spatial pattern. Also see Flatebo and Pelletier 1999; Woodley and Forbes 1997; and Northeast Region Working Group 2004 for sustainable forestry guidelines that recommend these tools.

p. 62 *"features more than a kilometer away have little influence at all."* See for example, Drapeau et al. 2000 and Lichstein et al. 2002.

p. 64 "a model program for protecting biodiversity" The recommendations here are my own but they are broadly similar to those suggested in Seymour and Hunter in Hunter, 1999 and Lindenmayer and Franklin 2002.

V Restoration Forestry: Can Working Forests be Made to Resemble Natural Late-Successional Ones?

p. 68 "Why are late-successional forests desirable?" Discussions of the value and practicality of creating forests with late-successional structure may be found, among others, in Curtis in Kohm and Franklin 1997; Flatebo, Foss, and Pelletie 1999; Frelich and Puettmann in Hunter 1999; Hagan and Whitman 2004; Moore 2004; Norton in Hunter 1999; Perschel 2006; Whitman and Hagan 2004; and Woodley and Forbes 1997.

VI Biodiversity Conservation in Working Forest Easements

The analysis here is original.

p. 82 "Could forest certification improve biodiversity management?" The FSC and SFI standards are: Northeast Region Working Group 2004; and Sustainable Forestry Initiative, 2005.

p. 97 "recent fieldwork on four working forest easements" In this study I spent a week each doing fieldwork on the Connecticut Lakes, Downeast Lakes, Katahdin Forest, and West Branch easements. I have also done biological inventories of four large working forests in the Adirondacks (Champion, Domtar, International Paper in part, and Finch-Pruyn) which are now or will soon be under conservation easements.

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