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Protection of Habitat for State-Listed Rare Flora and Fauna in Massachusetts During Timber Harvesting

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ABSTRACT: A state Forest Practices Act and Endangered Species Act combine to protect habitat of state-listed rare flora and fauna during timber harvesting in Massachusetts. In a three-year period, 10.5% of 2041 reviewed harvest operations co-occurred with rare species habitats. Over 60% of these co-occurrences were evaluated by biologists to have no impact on the species or its habitat. For 35% of co-occurrences, additional mitigating measures were recommended by biologists to be included in the harvest plan. The primary species that triggered rare species habitat review were reptiles and amphibians (e.g., *Clemmys insculpta*, *Ambystoma jeffersonianum*), in spite of the fact that habitat of all rare flora and fauna were considered. The rate of co-occurrence is higher than previously documented when only rare wetland fauna were afforded regulatory protection. Recommended mitigating measures primarily focus on restricted timing of operations to frozen conditions and buffers along aquatic habitats. Based on the low rate of co-occurrence, the small portion of co-occurrences that are deemed to have possible impacts and the inexpensive nature of mitigating measures, it does not appear that this level of regulatory protection of rarity represents an obstacle to timber harvesting.

Index Terms: regulation, rare habitat, timber harvesting

INTRODUCTION

Although it is the nation's third most densely populated state (Alerich 2000), Massachusetts is heavily forested. Approximately 62% of Massachusetts is covered by forest, making it the eighth most wooded state by percent of land use (Alerich 2000). This condition is not unlike that of many other northeastern states, with relatively fertile post-glacial soils, temperate climates, and moderate precipitation (Cogbill et al. 2002, Hall et al. 2002, Foster et al. 2004). Approximately 100-150 years ago, forests—through natural succession—commonly followed agricultural abandonment or intensive harvest for fuel wood or other products. Even primary forests that had never been cleared sustained some level of harvest. Forests tend to be relatively complicated mixtures of one or two age classes, composed of varying amounts of red oak (*Quercus rubra* L.), red maple (*Acer rubrum* L.), Eastern hemlock (*Tsuga canadensis* (L.) Carr.), white pine (*Pinus strobus* L.), black birch (*Betula lenta* L.), and other species (e.g., *Fraxinus* spp., other *Quercus* spp.). Private families, individuals, and non-profit organizations own over 75% of all forestland in Massachusetts (Alerich 2000). It is estimated that there are over 200,000 individual owners, with an average ownership size of 4.8 hectares (Birch 1996).

Because so much of the Massachusetts forest is in private, non-industrial ownership, many rare species' habitats and unique natural communities fall on private lands. Nationally, it is estimated that over 90% of

federally listed taxa under the Endangered Species Act have at least some of their habitat on non-federal lands (USGAO 1994). Non-federal lands provide over 60% of the total habitat for approximately 73% of these listed species (USGAO 1994). With a paucity of public lands, it is logical that a meaningful percentage of rare species resides on private lands. Consequently, the future of this rarity depends on actions taken by owners of these lands, as well as the effectiveness of public policy designed to protect these critical elements of diversity.

In Massachusetts, the Forest Cutting Practices Act (FCPA; Massachusetts General Laws chapter 132, Sections 40-49) regulates commercial timber harvesting. The Natural Heritage and Endangered Species Program of the Massachusetts Division of Fisheries and Wildlife maintains a statewide atlas of priority habitats of rare flora and fauna as part of their responsibility to oversee provisions of the Massachusetts Endangered Species Act (MESA, Massachusetts General Laws Chapter 131A, Sections 1-6). This affords an opportunity to review proposed harvesting occurrence statewide and to assess the extent to which they co-occur with rare species habitats. Between 1990 and 1994, only the habitats of rare wetland fauna were protected under the regulatory authority of the Massachusetts Wetlands Protection Act (MGL c.131, Section 40A). Kittredge (1996) determined that out of more than 3300 harvest events, rare wetland faunal habitat was involved 5% of the time. Since that time, Forest Cutting Plans have also

been reviewed under the authority of the MESA, and both rare flora and fauna are now protected regardless of their location in uplands or wetlands. Our objectives were to determine the extent to which rare habitat intersects with commercial timber harvesting in Massachusetts, the degree to which it represents an adverse impact, and the mitigating measures recommended to protect rare species habitat. In addition, we compared the change in these from the earlier study (Kittredge 1996). How much more timber harvesting intersects with rare species habitats when flora and non-wetland circumstances are included?

BACKGROUND

Many New England species depend on forested habitats for their existence, and a portion of these species are rare. Some species are relatively tolerant of disturbance, and indeed, depend on early successional forest habitat that results from natural and artificial disturbances (e.g., chestnut-sided warbler (*Dendroica pensylvanica*), New England cottontail (*Sylvilagus transitionalis*)) (DeGraaf and Yamasaki 2001). Other species, rare or not, are more or less intolerant of disturbance, and show preference for late seral forest conditions (e.g., black-throated blue warbler (*Dendroica caerulescens*)) (DeGraaf and Yamasaki 2001). Disturbance varies considerably in its spatial extent, severity, periodicity, and effect on successional trajectories. In many parts of the eastern United States, the predominant natural disturbance is wind-based (Foster et al. 2004), resulting in varying degrees of damage to the residual stand. Since many species (some of which are rare and some of which are intolerant to varying degrees of any form of disturbance) depend on forest, timber harvest can represent a potential disruptive and harmful activity. For some state-listed rare species, the harm can result from the habitat change that follows tree removal and the creation of different conditions. For others, the harm can result from the process of harvest itself, and not the resulting conditions.

Timber harvest and rare species protection have been a source of conflict between

interest groups, private landowners, and public agencies. Noted examples of these are the conflicts between northern spotted owl (*Strix occidentalis*) and the production of Douglas fir (*Pseudotsuga menziesii*) in the Pacific Northwest (e.g., Sample and LeMaster 1992, Franklin 1993) and red-cockaded woodpecker (*Picoides borealis*) and the production of pine (e.g., *Pinus palustris*, *P. taeda*) in the southeastern United States (e.g., Drake and Jones 2002, Zhang 2004). Private landowners have apparently preemptively harvested their southern pine timber before management options were restricted due to red-cockaded woodpecker habitat identification (Zhang 2004). Johnson et al. (1997), however, studied private forest owners in Oregon and Washington, and found that their future harvest decisions were relatively uninfluenced by potential regulation resulting from rare species. They concluded that there are a number of factors that influence landowner decision-making, such as tract size, timber value, and ownership goals. There are other examples in the literature of timber harvest impacts on rare species (e.g., Kaye and Kirkland 1999, Wahbe and Bunnell 2001, Madarish and Schuler 2002), but there are few studies that review the interaction between habitat protection programs and timber harvesting in parts of North America other than the Pacific Northwest or the Southeast.

Massachusetts Forest Cutting Practices Act

Massachusetts General Laws Chapter 132, Sections 40-49 establish the legal framework for forest cutting practice regulations on all forestlands in the Commonwealth (MGL c. 132). Enforcement and jurisdiction of the regulations are the responsibility of the Bureau of Forestry within the state's Department of Conservation and Recreation. On the ground, harvest is reviewed and approved by a network of the Bureau of Forestry's Service Foresters assigned to one of 14 major watersheds in the state.

Any harvest greater than 87 m³ (25 Mbf) on land that will remain in forestland use requires approval of a Forest Cutting Plan (FCP) filed with the Bureau of Forestry.

This is a relatively small volume by commercial standards, and could represent as little as one or two hectares (Kittredge et al. 1996). The FCP must describe the location of the proposed harvest with both locus map and a specific harvest map identifying spatial details about the operation, such as: (1) roads and trails; (2) landings or staging areas where logs are concentrated; (3) wetlands, intermittent and perennial streams, and vernal pools; and (4) steep slopes. FCPs also have stand delineations and descriptions of the proposed silvicultural treatment. Importantly, FCPs describe the erosion control measures or best management practices (BMPs) that will be used to minimize non-point source water pollution (Kittredge and Parker 1995). The regulations are quite specific about BMPs, and stipulate, for example, that filter strips must be 15.2 m in width along all perennial streams, as well as intermittent ones down gradient from a wetland. No more than 50% of the basal area of timber may be removed from a filter strip, and no machinery may operate in filter strips except to cross a stream. Stream crossings must be approved in terms of location, number, and method (e.g., ford vs. bridge). Bridges can only be temporarily used during the operation, unless a more stringent review procedure is used. No more than 50% of the basal area of timber may be harvested from a wetland, and this can only occur when the conditions are dry, frozen, or otherwise stable. The regulations further require an aesthetic buffer strip of 15.2 m in width along public roads within which no more than 50% of the basal area may be harvested. Slash or logging debris is also regulated in terms of its height and location with respect to streams, boundaries, and roads. Other BMPs, such as water bars on trails and roads (which divert water from the disturbed soil surface) and application of hay mulch or seed to stabilize soil, may also be required. These regulations apply to all harvests above the threshold volume, regardless of ownership. Furthermore, loggers are required to have a license, and annual renewal of the license depends on a modest level of required continuing education designed to provide reinforcement of and exposure to the regulations and BMP. Overall, compared to other states, these regulations represent

some of the most stringent harvest practice rules in the eastern United States (Irland and Connors 1994).

Massachusetts Endangered Species Act

There are 186 vertebrate and invertebrate animal species, and 262 native plant species listed as Endangered, Threatened, or of Special Concern according to the Massachusetts Natural Heritage and Endangered Species Program (MNHESP 2004). The *Massachusetts Endangered Species Act* (M.G.L.c.131A) and its implementing regulations (321 CMR 10.00) prohibit the "taking" of any rare plant or animal species listed as Endangered, Threatened, or of Special Concern. "Taking" is defined under the Act as to harass, harm, pursue, hunt, shoot, hound, kill, trap, capture, collect, process, disrupt the nesting, breeding, feeding or migratory activity of an animal or to collect, pick, kill, transplant, cut, or process a plant. MNHESP maintains a Natural Heritage Atlas of the state, with Priority Habitats of state-listed rare species habitat delineated on topographic maps. These maps are based on a database containing over 13,000 recent and historical records of rare species occurrences. MNHESP annually reviews over 1500 proposed projects of all kinds for potential impact on listed species habitat and provides guidance on how to avoid potential taking as defined in the regulations. In addition to significant development projects (e.g., new mall, subdivision, golf course, highway construction, etc.), MNHESP also reviews FCPs for potential impact to state-listed rare species and their habitat.

As a regular part of the FCP review and approval process, the Bureau of Forestry Service Foresters consults MNHESP's Natural Heritage Atlas. Proposed harvest locations identified on the locus map of the FCP are compared with the relevant page in the Atlas. If a proposed harvest co-occurs with the habitat of rare species, the FCP is transmitted to the MNHESP for office review (i.e., no actual field visit involved) by their staff. Bureau of Forestry approval of the FCP is delayed until MNHESP evaluates the FCP for potential impact. The atlas

only identifies a rare species habitat, but does not reveal the species or other biological information. MNHESP biologists consult their database to determine the species that may be involved, and assess the potential impacts to the habitat based on the details in the FCP (e.g., silvicultural system, volume to be removed, time of year, location of roads and landings) and the natural history of the species. Proposed harvesting is evaluated as having "no impact," "possible impact," or "definite impact" to state-listed rare species or their habitat. Based on the species involved and proposed harvest activities, biologists recommend mitigating measures to minimize impact to habitat of listed species. A memo identifying the species involved, potential impact, and mitigating measures is sent from MNHESP to the Service Forester, who has final regulatory authority under the Forest Cutting Practices Act and may amend FCPs to ensure compliance with the MESA regulations. Adherence to the mitigating measures recommended by MNHESP implies that, if followed, a taking will not occur and a violation of MESA will be avoided. Potential exists for an unlawful taking if the mitigating measures are ignored. If the mitigating measures are ignored, the forester can no longer claim an exemption to a formal review by MNHESP.

We reviewed MNHESP records of all FCPs submitted in fiscal years 1999, 2000, and 2001 whose harvest activity was determined to occur on land that had rare species habitat. Each FCP had a copy of the memo from MNHESP identifying the species, assessed impact level, and recommended mitigating measures. Data were recorded from each of these FCPs and appended with memos on species, impact, mitigating measures, and date.

RESULTS AND DISCUSSION

Co-occurrence

Proposed timber harvest operations covering 34,577 ha over a three-year period resulted in 215 co-occurrences with rare species habitat. MNHESP polygons of rarity co-occurred with 10.5% of all FCPs

submitted from 1999 through 2001 (Table 1). This co-occurrence rate increased from the earlier sample period (i.e., 5.3% from 1990 through 1994), and further suggests an increasing trend (i.e., 7.8% in 1999, 10.5% in 2000, and 13.5% in 2001).

Harvest is likely to decline statewide, however, as more forest is converted to some form of development. Breunig (2003) showed that between 16 and 31 ha/day in Massachusetts were lost to various forms of development between 1985 and 1999. Likewise, Alerich (2000) showed that Worcester County in central Massachusetts lost 7.9% of its forest between 1985 and 1998. Land use conversion was not as great on a statewide basis, and Alerich estimated an overall loss of 3% for this period. Kittredge et al. (2003) estimated that in a 1680-km² portion of the central Massachusetts landscape between 1984 and 2000, approximately 1.5% of all forest experienced a harvest activity annually. Harvest events appeared to occur randomly with respect to one another and with respect to biophysical features such as cover type, slope, aspect, elevation, distance to roads, and surficial geology. If harvest appears to occur randomly statewide with respect to these factors, it might co-occur with rarity on a limited basis. The overall likelihood of co-occurrence may decline. It is likely, however, that this observed decline in the extent of harvesting is regionalized, in that harvest continues to occur at its customary rate in rural areas but is declining dramatically in areas influenced by sprawl (Breunig 2003) that radiates from urbanized areas. Likelihood of co-occurrence in the future will also be a function of growing knowledge about the location of rare habitats and communities. As more are delineated, the likelihood may increase, but as harvest declines in some areas due to development or to parceling, the rates of co-occurrence may also decline.

The increase in the proportion of submitted FCPs that co-occur with rare species habitat has several impacts. It potentially adds delay to logging operations that need to wait for results of MNHESP analysis. FCPs can spend as much as 10 business days at the Bureau of Forestry, and between 10 and 15 business days at MNHESP, resulting in a

Table 1. Number of forest cutting plans with rare species co-occurrences (FY90-94^a and FY99-01).

Fiscal Year	Total Number Cutting Plans	Area Covered by Plans (ha)	Volume Harvested (m³)	Number of Plans with Co-occurrences	Proportion of Total Plans (%)
1990	610	9,759	273,603	23	3.8
1991	639	10,729	275,054	37	5.8
1992	670	10,912	298,325	47	7.0
1993	657	10,767	276,714	36	5.5
1994	753	11,888	306,024	32	4.2
TOTAL (FY90-94)	3,329	54,055	1,429,720	175	5.3
1999	693	12,647	166,897	54	7.8
2000	703	11,526	160,272	74	10.5
2001	645	10,404	141,496	87	13.5
TOTAL (FY99-01)	2,041	34,577	468,665	215	10.5

^a From Kittredge (1996).

Table 2. Number of forest cutting plans with rare species co-occurrences by impact (FY 90-94^a and FY99-01).

Fiscal Year	Number of Plans with Co-occurrences	Impact^b							
		1		2		3		N/A	
		No.	(%)	No.	(%)	No.	(%)	No.	(%)
1990	23	15	(65.2)	8	(34.8)	0	(0)	0	(0)
1991	37	28	(75.7)	9	(24.3)	0	(0)	0	(0)
1992	47	29	(61.7)	18	(38.3)	0	(0)	0	(0)
1993	36	16	(44.4)	20	(55.6)	0	(0)	0	(0)
1994	32	15	(46.9)	15	(46.9)	2	(6.2)	0	(0)
TOTAL (FY90-94)	175	103	(58.9)	70	(40.0)	2	(1.1)	0	(0)
1999	54	27	(50.0)	20	(37.0)	0	(0)	7	(13.0)
2000	74	54	(73.0)	15	(20.3)	5	(6.8)	0	(0)
2001	87	54	(62.1)	23	(26.4)	6	(7.0)	4	(4.6)
TOTAL (FY99-01)	215	135	(62.8)	58	(27.0)	11	(5.1)	11	(5.1)

^a From Kittredge (1996).

^b Impact: 1 = no impact, 2 = possible impact, 3 = definite impact, N/A = impact rating not available.

potential delay of three to five weeks (J.J. Scanlon, Forester, Massachusetts Division of Fisheries and Wildlife, pers. comm.) This delay can be costly both in terms of economic impact (to the logger) and potential environmental impact. Loggers may have had to borrow money or pay in advance for the standing timber and, thus, they have an interest in converting the timber to logs and selling them in a timely manner. The loggers have high fixed costs due to expensive machinery loans and interest (e.g., some Massachusetts loggers have monthly debt service of between \$3000 and \$6000). Delays in harvest can be problematic in the winter as spring approaches, because frozen conditions and snow cover that afford ground protection—especially for amphibians, reptiles, and certain plants—can be lost. From the perspective of a private landowner selling standing timber, some of these mitigating measures may represent a cost or have a negative effect on timber value. Timing measures that may limit logging options or requirements to re-route skid trails or stream crossings may make timber less attractive to a logger, resulting in a lower offered price. Kilgore and Blinn (2003), for example, documented a difference in offered price for timber sales in Minnesota requiring additional environmental protections (e.g., erosion control measures, filter strips, retention of standing dead trees) vs. identical sales where such protections were not required. They estimated a 10.1% discount or impact to offered timber price when additional protecting measures were required. Mitigating measures that reduce the potential amount of timber sold (e.g., 15 m no-harvest buffer) represent forgone potential income to a landowner. The increase in FCPs to review also has an impact on MNHESP, which has a limited staff as well as other rare species and development issues competing for attention. It is estimated that MNHESP dedicates a portion of one staff person to FCP review (approximately 0.1 ft, J.J. Scanlon, Forester, Massachusetts Division of Fisheries and Wildlife, pers. comm.). From an administrative standpoint, providing this level of review for every timber sale is costly.

Potential impacts

A slightly higher proportion of plans were evaluated as having either no impact or definite impact during 1999-2001 (Table 2), and a smaller proportion of plans were evaluated as having possible impact. Overall, there has not been a meaningful shift in terms of assessed potential impacts. Of those plans that co-occur between 1990 and 1994 and between 1999 and 2001 (i.e., 390 co-occurring plans in eight years), an average of 59.9% are assessed to have no impact, 35.5% to have a possible impact, and 2.5% to have a definite impact (an average of 2.2% of plans did not have an impact rating available). Put in perspective, in spite of the fact that many more taxa were involved in the protection process once all rare flora and upland faunal habitat were included, from a total of 2041 plans covering 34,577 ha over three years (1999-2001), 11 forest cutting plans (i.e., 0.5% of all

submitted plans) were deemed by NHESP to have a definite impact on delineated rare habitat. Although deemed to potentially have a definite impact, these plans were approved with mitigating measures. There were no cases of an inability to harvest due to this review procedure.

Species involved

Interestingly, 14 of the 109 different species and communities had total occurrences of seven or more over the three year period, and the remaining 95 occurred fewer than seven times each (Tables 3, 4). Of these 89 species, only 59 appeared to co-occur one time in three years, which is a testimony to their relative rarity. Three different uniquely designated natural community types co-occurred 12 times (i.e., vernal pools, tupelo-pin oak (*Nyssa silvatica* – *Quercus palustris*) associa-

Table 3. Co-occurrences of harvesting and state listed species habitat, by taxonomic groups.

	Number of taxa	Total number of co-occurrences (and percent) in 1999, 2000, and 2001
Reptiles	7	138 (32)
Amphibians	6	83 (19)
Plants	51	75 (18)
Birds	12	40 (9)
Fish	4	14 (3)
Communities	3	12 (3)
Mammals	2	8 (2)
Invertebrates:		
Dragonflies	11	23 (5)
Mussels	5	21 (5)
Butterflies and moths	4	7 (2)
Crustaceans	2	3 (1)
Sponges	1	1 (<1)
Flatworms	1	1 (<1)
TOTAL	109	426 (100)

Note: the total number of co-occurrences exceeds the total number of forest cutting plans that co-occur, because some co-occurrences involve more than one species.

Table 4. Listed species with 7 or more co-occurrences with harvesting, 1999 – 2001 (SC = Special Concern, T = Threatened, and E = Endangered; * occurred in the review of FY90-94).

Common name	Scientific name	Type	Status	3-year total number of co-occurrences (percent of total number of co-occurrences [n=215])
Wood turtle	<i>Clemmys insculpta</i>	Reptile	SC *	79 (37)
Spotted turtle	<i>Clemmys guttata</i>	Reptile	SC *	38 (18)
Four-toed salamander	<i>Hemidactylum scutatum</i>	Amphibian	SC *	25 (12)
Jefferson salamander	<i>Ambystoma jeffersonianum</i>	Amphibian	SC *	23 (11)
Marbled salamander	<i>Ambystoma opacum</i>	Amphibian	T *	16 (7)
Bald eagle	<i>Haliaeetus leucocephalus</i>	Bird	E *	13 (6)
Spring salamander	<i>Gyrinophilus porphyriticus</i>	Amphibian	SC *	13 (6)
Triangle floater	<i>Alasmidonta undulata</i>	Mussel	SC	8 (4)
Creeper	<i>Strophitus undulates</i>	Mussel	SC	8 (4)
Eastern box turtle	<i>Terrapene Carolina</i>	Reptile	SC *	7 (3)
Ginseng	<i>Panax quinquefolius</i>	Plant	SC	7 (3)
Certified vernal pool		Community		7 (3)
American bittern	<i>Botaurus lentiginosus</i>	Bird	E *	7 (3)
Common loon	<i>Gavia immer</i>	Bird	SC *	7 (3)

tion, and a calcareous sloping fen). These natural communities themselves are not protected through regulation unless they are the specific habitat for a state-listed rare species.

By far the dominant rare species whose habitat co-occurred with proposed harvest was wood turtle (*Clemmys insculpta*), which over the three-year period represented 37% of all occurrences. The five most frequently occurring rare species were either reptiles (wood turtle or spotted turtle; *Clemmys guttata*) or amphibians (three salamander species; Table 4), which depend on some form of wetland for habitat for at least a portion of the year. Although the policy for rare species habitat protection and timber harvest changed to more expansively include flora and upland species whose habitat is not limited to wetland conditions, the majority of species which co-occur with proposed harvest and result in rare species review and additional mitigating measures are still wetland fauna. This could be because MNHESP has more information on rare wetland habitats—an artifact of their earlier level of protection.

Indeed, 10 of the 14 most frequently occurring taxa and communities (Table 4) were also those identified in the previous study during the time that only considered habitats of rare wetland fauna. Only three new taxa made it into the list of the 14 most cited during FY1999-2001, and ironically, two of these (*Alasmidonta undulata* and *Strophitus undulatus*) are freshwater mussels that require aquatic habitats. In spite of considering all known rare flora in Massachusetts, only one species was included in the list of the 14 most co-occurring taxa (*Panax quinquefolius*), and it co-occurred with proposed harvest seven times in three years.

On the statewide list of rare plants, 60% are considered endangered, 25% threatened, and 15% of special concern. Those listed plants that co-occur with proposed harvesting are somewhat less rare, in that 35% were considered endangered, 35% threatened, and 30% of special concern. The degree of rarity of fauna on the statewide list much more closely mirrored the proportions encountered via forest cutting plans. On the statewide list, 33% of fauna

are considered endangered, 22% threatened, and 45% are of special concern. In comparison, of the rare fauna encountered via the cutting plan review process, 38% were considered endangered, 11% were considered threatened, and 51% were of special concern. Harvesting in Massachusetts seems to have encountered rare faunal habitat at a rate that roughly reflects the proportion of endangered, threatened, and special concern species distributed statewide, whereas a much smaller proportion of endangered plants are encountered through the harvest permit process than exist on the landscape.

Mitigating measures

Of the 215 co-occurring FCPs that were reviewed by MNHESP, 139 (i.e., 65%) had no mitigating measures associated with them, other than to adhere to the regulations required of all harvests (Table 5a). Thus, even if a proposed timber sale co-occurred with rare habitat, almost two-thirds of the time it did not have additional mitigating measures assigned to it. The remaining FCPs (i.e., 76 plans, or 35%)

Table 5a. Recommended mitigating measures by impact, sorted by activity (FY 1999, 2000, 2001). Measures listed in FY1990-1994 are indicated with a *; others are new and were not cited in that period.

Mitigating Measure	Impact				Total
	1	2	3	N/A	
Forest cutting plans with no mitigating measures recommended *	134	0	1	5	139
Timing					
harvest only when ground is snow-covered	0	0	1	0	1
harvest only in winter *	0	2	0	0	2
harvest only when ground is frozen *	0	4	3	1	8
harvest only when ground is dry *	0	0	2	0	2
harvest only between September 1 and March 31	0	3	0	0	3
harvest only between November 1 and March 15	0	20	1	0	21
harvest only between November 1 and April 30	0	2	1	0	3
harvest only between September 1 and May 1	0	1	0	0	1
no harvest from March 15 through May 15 to protect migrating salamanders	0	1	0	0	1
Filter Strip^a or Buffer					
no-harvest buffer of 15 to 30 m along shoreline, streambank, or wetland *	0	5	0	0	5
mark filter strip or buffer in the field	0	0	2	0	2
15 m no-harvest buffer *	0	2	0	0	2
no roads or skid trails within 61 m of vernal pool	1	1	1	0	3
no harvesting within 152 m of vernal pool	0	1	0	0	1
use variable width filter strip according to slope	0	3	2	0	5
8 m no-harvest buffer along stream	0	1	0	0	1
maintain forested conditions within 61 m of stream *	0	2	0	0	2
mark trees to be harvested within filter strip	0	3	2	1	6
no harvesting within 6 m of top of stream bank	0	2	0	0	2

^a Per Massachusetts timber harvest regulations, filter strips are an area along all water bodies, wetlands, and certified vernal pools with a minimum width of 15 m (wider for slopes) in which no more than 50% of the basal area may be removed, and then a 5-year waiting period must pass before any more harvest may occur in the filter strip.

^b Vernal pool guidelines consist of the following: no machinery in pools, no landings or skid trails in pools, avoid ruts deeper than 15 cm within 60 m of a pool, no tops or slash in pools, maintain shaded condition within 15 m of pools, no exposed mineral soil within 15 m of a pool.

required additional mitigating measures beyond those required by the statewide regulations. Overall, 76 plans out of a total of 2041 plans over the three year period (3.7 % of all submitted plans in this period) required additional mitigating

measures beyond those required as a matter of course by the Forest Cutting Practices Act. Of the 76 FCPs that required additional mitigating measures, 42 involved timing, 29 involved additional filter or buffer strip considerations, 24 involved specific addi-

tional limitations on stream crossings, and 59 involved other measures (see Table 5a, b; e.g., survey for vernal pools in advance of harvest, no harvest of trees that support the stream bank). Most of the mitigating measures recommended by MNHESP

Table 5b. Recommended mitigating measures by impact, sorted by activity (FY 1999, 2000, 2001). Measures listed in FY1990-1994 are indicated with a *; others are new and were not cited in that period.

Mitigating Measure	Impact				Total
	1	2	3	N/A	
Stream Crossing					
prevent siltation*	0	3	0	0	3
use portable or temporary bridge for stream crossing *	0	9	2	1	12
cross stream or wetland when dry *	0	1	0	1	2
re-route skid trails to avoid stream crossings *	0	3	2	0	5
protect stream crossing with hay bales	0	2	0	0	2
Other Measures					
follow vernal pool guidelines ^b *	1	19	3	0	23
do not cut certain/specific trees *	0	1	0	0	1
smooth ruts *	0	0	2	0	2
no felling of trees into streams	0	1	0	0	1
survey for vernal pools in the cutting area	0	8	1	0	9
follow BMP's	0	1	0	0	1
locate landing away from stream/wetland/rare species habitat	0	2	0	0	2
do not harvest more than 50% of basal area on entire site	0	1	0	0	1
do not reduce canopy cover by more than 10%	0	0	2	0	2
do not reduce canopy cover by more than 20%	0	4	0	0	4
no harvesting of trees which support stream bank	0	3	2	0	5
no harvesting on slope	0	2	0	0	2
mark off rare species habitat in field and conduct no activity therein	0	2	2	0	4
no harvesting in wetland *	0	0	1	0	1
maintain predominantly forested condition (light selective cutting only)	0	1	0	0	1

^a Per Massachusetts timber harvest regulations, filter strips are an area along all water bodies, wetlands, and certified vernal pools with a minimum width of 15 m (wider for slopes) in which no more than 50% of the basal area may be removed, and then a 5-year waiting period must pass before any more harvest may occur in the filter strip.

^b Vernal pool guidelines consist of the following: no machinery in pools, no landings or skid trails in pools, avoid ruts deeper than 15 cm within 60 m of a pool, no tops or slash in pools, maintain shaded condition within 15 m of pools, no exposed mineral soil within 15 m of a pool.

involve aquatic habitat, water quality, or frozen wintertime conditions—again a reflection of the dominance of reptile and amphibian habitat.

On several occasions, the MNHESP recom-

mended filter or buffer strip widths along water bodies that exceeded those required of all operations under the statewide forest practice regulations, both in terms of distance or width, as well as operational limitations (e.g., harvest no trees, locate no

roads or trails within a certain distance). In some cases, these were relatively nominal (e.g., no harvest within 6 m of the top of a stream bank, no harvest buffer of 8 or 15 m along a stream); but in a few isolated circumstances, these mitigating measures

were more demanding (e.g., no harvest within 152 m of a vernal pool).

Mitigating measures also became more explicit in terms of residual forest conditions. Whereas before they requested “little or no cutting within 15 m of a stream” or “selective rather than regeneration cutting between 5 and 90 m of a stream,” measures now stipulate, in a few instances, not reducing the basal area or canopy cover by more than 10, 20, or 50%. Whereas before measures included “follow vernal pool guidelines,” now they include, in a few instances, “survey for vernal pools in the cutting area.” In the previous period, MNHESP advised to harvest only when the ground was frozen, or in winter, but measures now stipulate calendar dates, generally in fall, winter, and spring. Limiting harvest to between November 1 and March 15 was frequently cited as an important measure. In general, measures appear to have become more temporally and spatially explicit.

There does not appear to be an expansion or evolution of protective coverage through amplified mitigating measures between 1999 and 2001. Measures have become more explicit in terms of temporal and residual stand conditions, but not apparently more limiting in terms of the harvest operation. Only in a very few circumstances is harvesting forbidden in a significant way through the mitigating measures (e.g., one circumstance in three years caused a recommendation of a 152-m radius of no harvest around a vernal pool, resulting in a loss of 7.3 ha of timber). Mitigating measures becoming more explicit is an advantage for logging operators and foresters, since they need to guess less about implications for harvest operations and can plan accordingly.

CONCLUSIONS

This system of MNHESP review and impact assessment, interacting with review and oversight of the statewide Forest Cutting Practices Act, does not apparently represent a serious impediment to commercial timber harvest in Massachusetts. In virtually no case was harvest prohibited.

Roughly 90% of the time there was no co-occurrence with rarity, and proposed harvest was reviewed by foresters to ensure compliance with regulations, but MNHESP was not involved. Out of 2041 plans submitted statewide during this three-year period, 76 plans (i.e., 3.7% of all submitted cutting plans) required additional mitigating measures.

Unlike other parts of North America, the potential for conflict between owners, loggers, and biologists over rarity is unlikely, because the value of timber is relatively modest when compared to other regions. For example, between 1999 and 2002, average values of standing Douglas fir on National Forests in the “west-side” region of the Pacific Northwest have ranged from between \$200 to over \$700/thousand board feet (Haynes 2004). The average standing timber price of loblolly pine (*Pinus taeda* L.) in Mississippi in early 2004 ranged from \$378 to \$423/thousand board feet, depending on regions within the state (Daniels 2004). In contrast, the median price of eastern white pine in southern New England (i.e., Connecticut, Rhode Island, and Massachusetts) in early 2004 ranged from \$70 to \$100/thousand board feet (Kittredge 2004). Prevalent species such as eastern hemlock and red maple had median timber prices of between \$30 and \$50/thousand board feet. Red oak had median values ranging from \$300 to \$350/thousand board feet. In general, timber values are low, as are timber volumes per hectare, compared to other parts of North America where the interaction between rare species protection and commercial harvest is more contentious. The apparently prevailing rare species habitat issues in Massachusetts involve reptiles and amphibians with comparatively minor limitations to operation (such as restrictions on timing or harvest buffers). In contrast, habitat protection of red-cockaded woodpeckers can involve much greater limitations on operation within 0.8 km of identified nesting habitat (Zhang 2004) and much higher timber values and volumes per hectare.

The interaction between the Massachusetts Natural Heritage and Endangered Species Program and the Bureau of Forestry, in conjunction with a forest practices regulatory

system and strong spatial data of delineated rare species habitats, results in a responsive program that protects the public interest in biodiversity and rare species, while generating mitigating measures that are, in large part, compatible with commercial timber harvesting in Massachusetts. This serves as an effective model that can be considered for other places—not only in Massachusetts where many taxa do not require large protected areas (e.g., northern spotted owls, red-cockaded woodpeckers)—but also in different localities that have different interactions between their rare species, their habitats, and the type and intensity of harvesting. Even when flora, fauna, and rare communities are considered, this level of protection does not appear to impair the effective operation of commercial harvesting.

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