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Effects of Clearcutting, Patch Cutting, and Low-density Shelterwoods on Breeding Birds and Tree Regeneration in New Hampshire Northern Hardwoods

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Abstract

Clearcutting is an effective regeneration practice for northern hardwoods in New England. However, in esthetically sensitive areas forest managers sometimes use methods that soften the visual impact, such as smaller clearcuts (patch cuts) or low-density shelterwoods. It is unclear if these methods produce the same effects as clearcuts on tree regeneration and breeding bird habitat. A comparison of a 15-acre clearcut, four patch cuts varying in size from 2.9 to 5.5 acres, and a 34-acre low-density shelterwood showed that the patches regenerated some early successional tree species, similar to the clearcut, however, the smaller 3-acre patches also produced a higher component of beech and less pin cherry. The shelterwood produced high proportions of beech and striped maple. Early successional, generalists, and mid-/later successional birds were present in all three treatment areas although the clearcut and patches had higher proportions and more observations of early successional bird species.

Cover Photo

Bartlett Experimental Forest, White Mountain National Forest, NH. Photo by Ken Dudzik, U.S. Forest Service.

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Clearcutting is an effective harvest method in northern hardwood stands in New England, especially in stands that are uniformly mature or of poor quality. The subsequent regeneration usually contains a wide mix of desirable tree species including early successional species such as paper birch, aspen, and pin cherry[1] (Marquis 1967). In addition, research has shown that clearcutting provides the early successional habitat utilized by a variety of breeding birds and other vertebrates (Annand and Thompson 1997, DeGraaf et al. 2006, King et al. 2001, Titterington et al. 1979). This type of habitat is decreasing in the eastern United States due to several factors such as forest maturation, habitat loss from development, the disruption of natural disturbance regimes, and the reduction of even-age management (Askins 2001, DeGraaf and Yamasaki 2003). As one would expect, the decline in early successional habitat has led to a strong decline in populations of the birds associated with it (Askins 2001, DeGraaf et al. 2006, Hunter et al. 2001, Schlossberg and King 2007, Thompson and DeGraaf 2001, Witham and Hunter 1992). Schlossberg and King (2007) report that 78 percent of scrub-shrub habitat in New England is regenerating forest created by logging, but despite the benefits of clearcutting as a management tool, its use still draws criticism from the public due to its appearance and perceived detrimental effects on wildlife and forest health. There are two likely alternatives. First is the use of low-density shelterwoods (Miller et al. 2006), which allows abundant sunlight to reach the forest floor but softens the visual impact. The second is the use of patch harvests, which are simply small clearcuts that are perhaps less objectionable to the public. Neither approach has been thoroughly examined in New England with regard to forest regeneration and bird use.

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[1] Scientific names of tree species are reported in Table 1.

METHODS

Vegetation

Between 1998 and 2000, these three harvesting methods—clearcutting, patch cut, and low-density shelterwood—were applied on the Bartlett Experimental Forest, a 5,500-acre tract within the White Mountain National Forest, New Hampshire.

The clearcut was approximately 15 acres in size with a small central reserve of ½ acre. The area, which had been previously partially harvested in the mid 1950s, supported mature northern hardwoods with up to 50 percent beech. About two-thirds of the area was completely harvested; a residual of about 40 ft^2 of basal area (ranging from 20 to 80 ft^2, 20-factor prism) remained on the other one-third to provide a feathering transition into the uncut stand. Harvesting took place in late fall of 1999/early winter of 2000 using a whole-tree system with a feller-buncher and grapple-skidder; slash was returned to the site along skid trails—a so-called conventional harvest (Fig. 1).

The four patch harvests were small clearcuts (Fig. 2): the two smaller patches were 2.9 and 3.4 acres in size. The larger patches were 5.1 and 5.5 acres. Whole-tree removals were done on one small (2.9 acres) and one large patch (5.5 acres); conventional harvests similar to the clearcut occurred on the other two patches. Harvesting occurred in the late fall of 1998. The stands where patch cuts were located contained sawtimber-sized trees up to about 100 years old as well as a few old aspen trees which produced a component of aspen root suckers in the regeneration.

The nearby shelterwood harvest totaled 34 acres (Fig. 3). About 20 acres was pure northern hardwoods with little hemlock influence; this section was used for the regeneration surveys. Harvesting occurred in the winter of 2000, and stand conditions were similar to the clearcut. The residual basal area was about 40 ft^2, ranging from about 20 to 80 ft^2. Following the harvest, beech saplings up to 4 inches in diameter were removed by chain saw to minimize effects on the subsequent regeneration. No additional after-harvest timber stand improvement was applied.

The size of both clearcut and shelterwood harvest areas are representative of current practices on the surrounding White Mountain National Forest, where maximum size of temporary openings created by even-age management is limited to 30 acres, but on average is less than 20 acres. Clearcut harvests on nonindustrial private forest land in New Hampshire are often smaller.

In the late summers of 2007 (clearcut and shelterwood) and 2008 (patches), regeneration surveys (Leak 2007) were conducted. On milacre plots spaced about 1 by 1.5 chains apart, the dominant (tallest) stem was recorded by species and height. If the tallest stem was noncommercial, the tallest commercial species also was recorded. Basal area per acre of the residual shelterwood overstory and portions of the clearcut with remaining overstory also were measured with a 20-factor prism.

Breeding Bird Surveys

Breeding bird surveys were conducted yearly in the three treatment areas during the month of June from 1998 through 2009 using 50-m radius point counts (Ralph et al. 1995). We used the point count method since it has proven to be effective and efficient as well as comparable to other northeastern studies (Chandler 2007, DeGraaf et al. 1998, Hagan et al. 1997). One year of preharvest data was collected in all three treatment areas in 1998. Only three of the four patch cuts were used for the breeding bird portion of the study. The 3.4-acre patch cut was excluded because of its long, narrow shape that resulted in a 50-m radius survey area that extended well into the surrounding forest. The survey areas in the remaining three patch cuts only included the cut areas.

Three point-count stations were established along a line placed centrally through the 34-acre low density shelterwood and were located approximately 200 m apart. To avoid stand edge and to limit the survey area to the openings themselves, only one point-count station was established in the approximate center of the 15-acre clearcut and in all three of the patch cuts. All birds seen or heard within 50 m of survey points were recorded during a 10-minute period. The 50-m survey area did not extend into the residual area or the feathered edge of the clearcut. Although the number of points differed

Figure 1.—Clearcut seven growing seasons post-harvest, Bartlett Experimental Forest. Photo by Christine Costello, U.S. Forest Service.

Figure 2.—Two bull moose foraging in a conventionally harvested patch cut five growing seasons post-harvest, Bartlett Experimental Forest. Photo by Mariko Yamasaki, U.S. Forest Service.

Figure 3.—Deferred shelterwood one growing season post-harvest, Bartlett Experimental Forest. Photo by Mariko Yamasaki, U.S. Forest Service.

between the three treatments because of differences in size and the desire to avoid edge bias, we are confident that the data analysis and chi-square tests provide valid comparisons without resorting to discarding valuable data.

Six experienced observers participated in the study, however one observer was responsible for 79 percent of surveys conducted. Additionally, when a new observer was added to the study, surveys were conducted by pairs of observers—the lead observer and the new observer—until observer variability was determined to be minimal. Each stand was surveyed three or four times a season between 0500 and 0930 hrs and the order in which stations were resurveyed was reversed to compensate for time-of-day bias associated with singing behavior. Surveys were not conducted in rainy or windy weather.

Due to circumstances outside of our control, harvests took place over the course of 3 consecutive years (1998-2000), therefore, the number of years of post-harvest data differed between treatments. We collected 11 years of post-harvest data from the patch cuts, 10 years from the clearcut and 9 years from the shelterwood. To account for this difference we included only 9 years of post-harvest data for each treatment.

We grouped bird species into three categories based on habitat: early successional, generalist, and mid-/later successional. These designations were based on a combination of our New England experience and the literature (DeGraaf and Yamasaki 2001, Dettmers 2003, Schlossberg and King 2007). The magnolia warbler[2] was eliminated from analysis due to its strong tie to advance softwood regeneration, which was only present brook-side within the shelterwood cut. We used chi-square procedures to test for independence in species richness and numbers of observations for each of the habitat categories. Bird species occurring infrequently (<2 observations per plot over the 9 years) were dropped from post-harvest analysis. Since only 1 year of preharvest data was reported, all bird observations were included in this part of the analysis. Counts of both species and numbers of observations were analyzed using chi-square procedures, appropriately adjusted to account for differences in numbers of survey points.

[2] Scientific names of bird species are reported in the appendix.

RESULTS

Tree Regeneration

Clearcutting (without a residual overstory) resulted in typical early successional regeneration with a predominance of paper birch and pin cherry coupled with a mix of other species (Tables 1 and 2). Aspen regeneration was absent because of the lack of aspen in the harvested late-successional stand. The patches also regenerated to early successional species, especially the larger (~5-acre) patches, although species proportions are quite variable. However, the larger patches produced noticeably higher proportions of yellow birch than the clearcut; the smaller two patches produced more beech and less pin cherry. The shelterwood harvest resulted in a later-successional species mix with high proportions of beech and striped maple and smaller proportions of other species; quite possibly, a snow-free harvest would have resulted in higher proportions of yellow birch. The clearcut with a residual overstory resulted in regeneration very similar to the shelterwood. This result supports the theory that even a light overstory, averaging about 40 ft^2 of basal area, will encourage more shade-tolerant regeneration. Possibly significant, the whole-tree harvests in the patches produced far more aspen regeneration, perhaps due to the removal of the slash and the higher intensity of ground-level sunlight.

Breeding Bird Surveys

During 1998 preharvest surveys, we recorded 19 species and 77 observations within the three pretreatment areas (Table 3). All observations fell within the generalist or mid-/later successional habitat category with generalists accounting for the bulk of the observations in all three areas. No early successional bird species were observed. The brown creeper was the only bird recorded in preharvest surveys and not recorded in post-harvest surveys although its presence was extremely rare with only one observation in the preharvest shelterwood stand.

Table 1.—Percentage of milacres with a dominant stem of any species on clearcut, shelterwood, and patch cuts, Bartlett Experimental Forest, NH. (NR = no residual basal area; WR = with residual basal area; WTH = whole-tree harvest; CH = conventional harvest)

	Clearcut		Shelterwood	Patch cuts			
Species	NR	WR	WR	5.5 acres WTH	5.1 acres CH	2.9 acres WTH	3.4 acres CH
Beech *Fagus grandifolia*	4	48	42	--	3	15	41
Yellow birch *Betula alleghaniensis*	9	7	17	13	45	5	24
Sugar maple *Acer saccharum*	3	2	4	--	--	--	--
Red maple *A. rubrum*	1	--	4	3	--	5	--
Paper birch *B. papyrifera*	23	5	2	3	24	25	23
White ash *Fraxinus americana*	7	2	2	--	--	--	--
Red spruce *Picea rubens*	--	--	1	--	--	--	--
Eastern hemlock *Tsuga canadensis*	--	--	--	--	--	--	6
Striped maple *A. pensylvanicum*	4	31	20	--	--	--	6
Pin cherry *Prunus pensylvanica*	46	2	5	51	24	10	--
Aspen *Populus* spp.	--	--	--	30	--	40	--
Other	3	3	3	--	4	--	--
Number of plots	63	42	130	27	29	20	17

Table 2.—Percentage of milacres with a tallest commercial species on clearcut, shelterwood, and patch cuts, Bartlett Experimental Forest, NH. (NR = no residual basal area; WR = with residual basal area; WTH = whole-tree harvest; CH = conventional harvest)

	Clearcut	Clearcut	Shelterwood	Patch cuts			
Species	NR	WR	WR	5.5 acres WTH	5.1 acres CH	2.9 acres WTH	3.4 acres CH
Beech	14	68	54	--	3	20	41
Yellow birch	17	12	22	47	52	10	24
Sugar maple	7	2	5	--	3	--	--
Red maple	7	5	10	3	3	5	--
Paper birch	37	8	2	20	35	25	23
White ash	12	5	5	--	--	--	--
Red spruce	--	--	1	--	--	--	--
Eastern hemlock	--	--	--	--	--	--	6
Aspen	--	--	--	30	4	40	6
Other	6	--	1	--	--	--	--
Number of plots	63	42	130	27	29	20	17

Table 3.—Breeding bird species detected during preharvest surveys in a clearcut (15 acres), three patch cuts (3-5 acres) and a low-density shelterwood cut (34 acres) by habitat group on the Bartlett Experimental Forest, NH. (Total = number of observations; Ave. = average number; and RA = relative abundance)

	Clearcut		Patch Cuts			Shelterwood			All stands	
Habitat Group	Total	RA	Total	Ave.	RA	Total	Ave.	RA	Total	RA
Generalist (GEN)										
American redstart	1	0.1	2	0.7	0.1	2	0.7	0.1	5	0.1
Black-capped chickadee	--	--	2	0.7	0.1	--	--	--	2	<0.1
Blue jay	--	--	--	--	--	1	0.3	<0.1	1	<0.1
Least flycatcher	1	0.1	11	3.7	0.3	--	--	--	12	0.2
Red-eyed vireo	4	0.3	7	2.3	0.2	9	3	0.3	20	0.3
Swainson's thrush	--	--	--	--	--	3	1	0.1	3	<0.1
White-breasted nuthatch	1	0.1	1	0.3	<0.1	--	--	--	2	<0.1
Winter wren	--	--	1	0.3	<0.1	3	1	0.1	4	0.1
Yellow-bellied sapsucker	--	--	--	--	--	1	0.3	<0.1	1	<0.1
Yellow-rumped warbler	--	--	--	--	--	1	0.3	<0.1	1	<0.1
Total No. GEN Observations	7	0.5	24	8	0.8	20	6.7	0.6	51	0.7
Total No. GEN Species	4		6	3		7	3.7		10	
Mid-/Later Successional (M/LS)										
Blue-headed vireo	--	--	1	0.3	<0.1	--	--	--	1	<0.1
Blackburnian warbler	--	--	--	--	--	1	0.3	<0.1	1	<0.1
Brown creeper	--	--	--	--	--	1	0.3	<0.1	1	<0.1
Black-throated blue warbler	2	0.2	1	0.3	<0.1	4	1.3	0.1	7	0.1
Black-throated green warbler	1	0.1	--	--	--	1	0.3	<0.1	2	<0.1
Hermit thrush	--	--	1	0.3	<0.1	1	0.3	<0.1	2	<0.1
Ovenbird	3	0.2	2	0.7	0.1	3	1	0.1	8	0.1
Scarlet tanager	--	--	2	0.7	0.1	1	0.3	<0.1	3	<0.1
Veery	--	--	1	0.3	<0.1	--	--	--	1	<0.1
Total No. M/LS Observations	6	0.5	8	2.7	0.3	12	4	0.4	26	0.3
Total No. M/LS Species	3		6	2.3		7	2.7		9	
Grand Total Observations	13		32	10.7		32	10.7		77	
Grand Total Species	7		12	5.3		14	6.3		19	

Thirty-five bird species and 1195 observations were included in the post-harvest analysis (Table 4). We recorded 19 species (210 observations) in the clearcut stand, an average of 14.7 species (144.7 observations) per patch cut, and an average of 24.7 species (183.7 observations) per survey point in the shelterwood stand during the 9-year study period. Numbers of observations were highly significantly greater in the clearcut and shelterwood than in the patch cuts, as were the numbers of species appreciably greater but not significantly so. It appears that the shelterwood and clearcut have some advantage in total species richness over the patch cuts (Table 5).

Gray catbird was observed exclusively in the clearcut; least flycatcher was observed exclusively in the patch cuts; and 11 species were observed exclusively within the low-density shelterwood cut (i.e., winter wren, blackburnian warbler, Canada warbler, black-throated green warbler, yellow-bellied sapsucker, blue-headed vireo, yellow-rumped warbler, hairy woodpecker, white-breasted nuthatch, northern flicker, and scarlet tanager).

Table 4.—Breeding bird species with more than two observations in a clearcut (15 acres), three patch cuts (3-5 acres), and a low-density shelterwood cut (34 acres) by habitat group and first appearance 1-9 years post-harvest, Bartlett Experimental Forest, New Hampshire. (CC = clearcut, Ave. = average number in patch cuts and shelterwood, and SW = shelterwood; ES = early successional, GEN = generalist, and M/LS = mid-/later successional)

	First appearance by growing season			Clearcut		Patch cuts			Shelterwood		
Habitat Group	CC	Patch cuts	SW	Total	RA	Total	Ave.	RA	Total	Ave.	RA
Early Successional (ES)											
Alder flycatcher	5	4	n/a	8	3.8	17	5.7	3.9	--	--	--
American goldfinch	n/a	3	2	--	--	5	1.7	1.2	3	1	0.5
Black-and-white warbler	3	4	2	9	4.3	--	--	--	24	8	4.4
Cedar waxwing	5	3	2	5	2.4	26	8.7	6.0	15	5	2.7
Common yellowthroat	3	3	3	14	6.7	53	17.7	12.2	19	6.3	3.4
Chestnut-sided warbler	2	3	3	58	28	139	46.3	32	101	33.7	18.3
Dark-eyed junco	1	n/a	1	14	6.7	--	--	--	14	4.7	2.5
Grey catbird	5	n/a	n/a	8	3.8	--	--	--	--	--	--
Indigo bunting	3	2	n/a	14	6.7	35	11.7	8.1	--	--	--
Mourning warbler	1	3	4	15	7.1	9	3	2.1	17	5.7	3.1
Ruby-throated hummingbird	3	4	n/a	5	2.4	15	5	3.5	--	--	--
White-throated sparrow	5	4	1	3	1.4	3	1	0.7	11	3.7	2.0
Total no. ES observations				153	72.8	302	100.7	69.6	204	68	37.0
Total no. of ES species				11		9	7.7		8	7.3	
Generalists (GEN)											
American redstart	3	2	4	24	11	39	13	8.9	32	10.7	5.8
Black-capped chickadee	7	4	1	2	1	11	3.7	2.5	9	3	1.6
Blue jay	n/a	n/a	2	--	--	--	--	--	6	2	1.1
Canada warbler	n/a	n/a	6	--	--	--	--	--	20	6.7	3.6
Least flycatcher	n/a	3	n/a	--	--	4	1.3	0.9	--	--	--
Northern flicker	n/a	n/a	1	--	--	--	---	--	5	1.7	0.9
Rose-breasted grosbeak	4	n/a	3	4	1.9	--	--	--	2	0.7	0.4
Red-eyed vireo	7	3	1	3	1.4	17	5.7	3.9	37	12.3	6.7
Swainson's thrush	7	5	1	4	1.9	25	8.3	5.8	19	6.3	3.4
White breasted nuthatch	n/a	n/a	1	--	--	--	--	--	7	2.3	1.3
Winter wren	n/a	n/a	1	--	--	--	--	--	22	7.3	4.0
Yellow-bellied sapsucker	n/a	n/a	2	--	--	--	--	--	12	4	2.2
Yellow-rumped warbler	n/a	n/a	1	--	--	--	--	--	6	2	1.1
Total no. GEN observations				37	17.6	96	32	22.1	177	59	32.1
Total no. GEN species				5		5	4.3		12	9.7	
Mid-/Later Successional (M/LS)											
Blue-headed vireo	n/a	n/a	1	--	--	--	--	--	8	2.7	1.5
Blackburnian warbler	--	n/a	1	--	--	--	--	--	20	6.7	3.6
Black-throated blue warbler	5	3	1	4	1.9	11	3.7	2.5	78	26	14.2
Black-throated green warbler	n/a	n/a	1	--	--	--	--	--	15	5	2.7
Eastern wood-pewee	n/a	3	1	--	--	2	0.7	0.5	2	0.7	0.4
Hairy woodpecker	n/a	3	3	--	--	--	--	--	7	2.3	1.3
Hermit thrush	n/a	2	1	--	--	5	1.7	1.2	2	0.7	0.4
Ovenbird	2	n/a	1	2	1	--	--	--	16	5.3	2.9
Scarlet tanager	n/a	n/a	6	--	--	--	--	--	2	0.7	0.4
Veery	4	5	6	14	6.7	18	6	4.2	20	6.7	3.6
Total no. M/LS observations				20	9.5	36	12	8.3	170	56.7	30.9
Total no. M/LS species				3		4	2.7		10	7.7	
Total no. observations				210		434	144.7		551	183.7	
Total no. species				19		18	14.7		30	24.7	

Table. 5.—Number of breeding bird species and observations in the clearcut, shelterwood, and patch cuts during pre- and post- harvest surveys, Bartlett Experimental Forest, NH. Shelterwood numbers are the average of three plots. Species with less than two observations per plot over the 9 years of post-harvest surveys were eliminated from analysis. Preharvest numbers are from data collected in 1998 only and all observations were included. (CC = clearcut; Ave. patch = average patch; and SW = shelterwood; ES = early successional; GEN = generalist; and M/LS = mid-/later successional)

Timing	Species group	CC	Ave. patch	SW	Chi square results D.F. =2; $\chi^2_{(0.05)}$ =5.99		CC	Ave. patch	SW	Chi square results D.F. =2; $\chi^2_{(0.001)}$ =13.86	
		Number of species			χ^2	Signif.	Number of observations			χ^2	Signif.
Pre-cut	ES	--	--	--	n/a	n/a	--	--	--		
	GEN	4	3	3.7	n/a	n/a	7	8	6.7		
	M/LS	3	2.3	2.7	n/a	n/a	6	2.7	4		
	Total	7	5.3	6.7	n/a	n/a	13	10.7	10.7		
Post-cut	ES	11	7.7	7.3	0.5	no	153	100.7	68	59.65	yes
	GEN	5	4.3	9.7	4.45	no	37	32	59	26.15	yes
	M/LS	3	2.7	7.7	5.05	no	20	12	56.7	68.32	yes
	Total	19	14.7	24.7	3.97	no	210	144.7	183.7	23.7	yes

The clearcut, patch cuts, and shelterwood averaged 11, 7.7, and 7.3 early successional species, respectively (nonsignificant), and 153, 100.7, and 68 observations (highly significant). In terms of abundance, the clearcut and patch cuts are clearly most effective in attracting early successional breeding birds, although differences in species richness are not distinct. Early successional species accounted for about 70 percent of the observations in the clearcut and patches, but only 37 percent of the observations in the shelterwood.

For the generalist habitat group, the clearcut, patch cuts and shelterwood averaged 5, 4.3 and 9.7 species, respectively (nonsignificant) and 37, 32 and 59 observations, respectively (highly significant). Although differences in species richness were nonsignificant, the trends in species richness and abundance strongly indicate that the shelterwood is more favorable to the generalist group of species than the clearcut or patch cuts.

For the mid-/later successional habitat group, the clearcut, patch cuts, and shelterwood averaged 3, 2.7 and 7.7 species respectively (nearly significant, see Table 5) and 20, 12, and 56.7 observations (highly significant). As expected the shelterwood is clearly more favorable to mid-/later successional species than the other harvest methods.

Although observations were low, early successional birds began to occupy the clearcut in the first growing season and were the majority component of species and observations for all 9 years post-harvest (Fig. 4A and 4B). Peak abundance for early successional birds occurred 3 years post-harvest; peak richness occurred 5 years post-harvest. Patch cuts were also dominated by early successional birds for all 9 years post-harvest, although birds did not begin to occupy the patches until 2 years post-harvest. Peak richness of early successional birds in patches occurred at 5 and 6 years post-harvest; peak abundance occurred at 4 years post-harvest (Fig. 4C and 4D).

The shelterwood cut was occupied by birds from all three habitat categories beginning 1 year post-harvest, including low numbers of early successional birds (Fig. 4E and 4F). Richness and abundance of early successional birds and all habitat categories combined, occurred 6 years post-harvest in the shelterwood treatment.

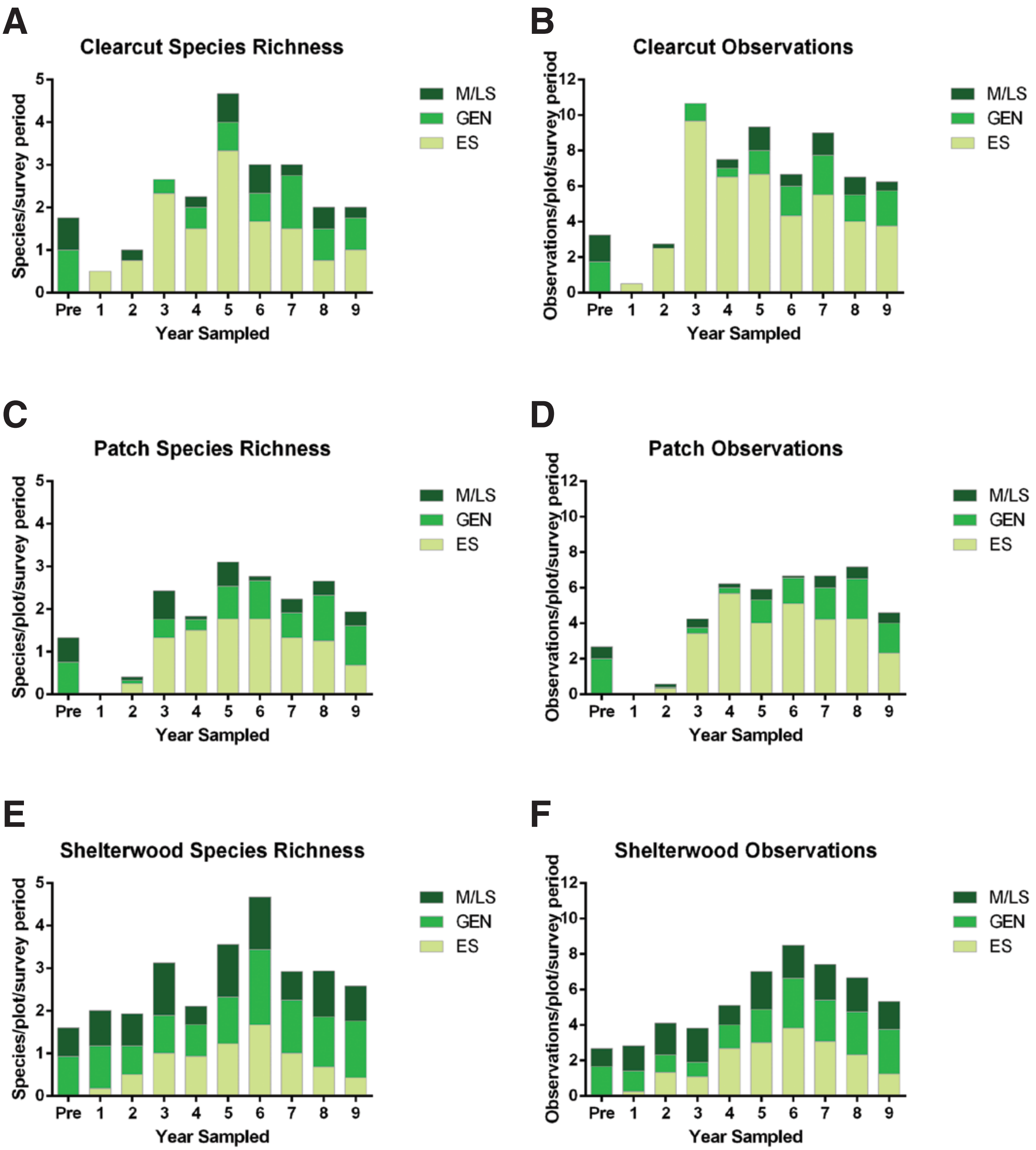

Figure 4.—Species richness and number of observations per survey period by habitat group (ES = early successional; GEN = generalist; and M/LS = mid-/later successional); and stand age for a 15-acre clearcut (A and B); three patch cuts (C and D); and 34-acre low-density shelterwood (E and F) on the Bartlett Experimental Forest, NH

DISCUSSION AND MANAGEMENT IMPLICATIONS

Clearcutting, patch harvests, and low-density shelterwoods are viable harvest systems in northern hardwoods of New England; however they produce different results in terms of tree regeneration and bird habitat. Winter-harvested shelterwoods with as little as 40 ft^2 residual basal area will favor tolerant and intermediately tolerant species such as beech, striped maple, and yellow birch. Clearcutting, on the other hand, results in true early-successional vegetation such as pin cherry, paper birch, and *Rubus* spp. together with a component of yellow birch, white ash, and other species. Aspen would also regenerate well if present on the site prior to harvest. Larger patch cuts, 5 acres or more, also produce true early-successional regeneration.

Our research also shows that regenerating clearcuts, patch cuts, and shelterwoods create ephemeral, early successional or brushy bird habitat not present in preharvest stands. However, treatment areas that have been cleanly cut of all stems (clearcut and patch cuts) create conditions where the greater proportion of the breeding bird community is composed of early successional birds than do stands that maintain some residual basal area as was seen in our low-density shelterwood. Additionally, three early successional birds (i.e., indigo bunting, alder flycatcher, and ruby-throated hummingbird) were absent from our low-density shelterwood, but present in both the clearcut and patch cuts. Ruby-throated hummingbird appeared to be attracted to the abundant *Rubus* spp. flowers within these areas (C. Costello, personal observation). Indigo buntings and alder flycatchers were found to prefer clearcuts over shelterwood cuts in another study conducted in the White Mountain region (King and DeGraaf 2000). This same study also determined that 56 percent canopy closure was enough to exclude some species of shrubland birds from shelterwoods.

Although the residual basal area in shelterwood cuts can limit the amount of early successional habitat in these areas, it does increase the vegetative structure (e.g., raptor and flycatcher hunting sites, cavity trees, mast trees, and softwood inclusions) of the regenerating stand (DeGraaf et al. 2006) thereby allowing for the maintenance of some generalist and mid-/later successional bird species in the immediate years following harvesting, a time period when species richness is very low in clearcuts and patch cuts. With the exception of the Canada warbler and winter wren, all birds exclusive to the low-density shelterwood cut were mid- to upper-canopy foragers or bark foragers and their presence can be explained by the residual basal area in this stand. The Canada warbler appears on some early successional bird lists (Schlossberg and King 2007), however, we did not include it in our early successional habitat category because our experience has shown that although it is associated with very dense understories, there is also a strong tie to moist woodlands with some degree of canopy closure (DeGraaf and Yamasaki 2001). Another study in New Hampshire concluded that the Canada warbler does well in two-age or deferment harvests that leave mature trees throughout intensive cuts (Hallworth et al. 2008). Shelterwood stands may provide highly productive habitat for this bird. Winter wrens are often found near water and their presence in the shelterwood is most likely explained by the brook that ran through the cut.

This study also illustrates the ephemeral nature of early successional habitat whether created by clearcuts, patch cuts, or shelterwood cuts. Richness and abundance of birds in this habitat category peaked between 3 and 6 years post-harvest and, although still present 9 years post-harvest, data from this study and others show decreasing observations of early successional birds with age of cut (DeGraaf 1987, McDermott and Wood 2009). These observations demonstrate the need to keep the time period between regeneration cuts short enough to maintain the presence of early successional bird species regardless of the system used.

Our experience has shown that resource managers sometimes resort to shelterwood harvests simply because the residual basal area makes it more aesthetically pleasing and not for timber or wildlife reasons. However, care is needed to avoid compromising intolerant regeneration objectives (e.g., tree species, fruit/berry production, and stem density) when choosing this system. Patch cuts may be chosen for similar reasons, however size of opening could play a role in occupancy of forest openings by early successional birds. This topic has received a considerable amount of attention in the last two decades although research results are somewhat conflicting. For example, Rudnicky and Hunter (1993) examined clearcuts in Maine that ranged from 2 to 112 ha (5 to 277 acres) and found that frequency of occurrence for many species increased with clearcut size up to 20 ha (49 acres). In contrast, Askins et al. (2007) did not find a relationship between abundance of shrubland specialists and size of harvest openings ranging from 0.5 to 21 ha (1.2 to 52 acres) in Connecticut. Similarly, Lehnen and Rodewald (2009) found weak support for area sensitivity in shrubland birds in 4 to 16 ha (9.8 to 39.5 acres) clearcuts in Ohio.

Studies conducted in much smaller forest openings created by single tree and group selection up to 2 acres generally agree that these areas are not sufficient to satisfy the requirements of the diverse array of early successional shrubland birds (Annand and Thompson 1997, Costello et al. 2000, Moorman and Guynn 2001, Robinson and Robinson 1999). In the northeast, some shrubland birds have territory sizes of up to 3 acres, so openings need to be at least this large if the objective is to provide for the range of species within this habitat group (Chandler et. al. 2009). With the exception of the gray catbird and dark eyed junco, species composition and species richness of early successional birds was similar in our 15-acre clearcut and 3- to 5-acre patch cuts, however, abundance was significantly higher in the clearcut.

Recent research has concluded that the value of young regenerating forests goes well beyond providing nesting habitat for early successional birds and that these areas are also used disproportionately during the post-breeding and migration period by birds that nest in mature forests (Chandler 2007, Chandler et al. 2012, King et al. 2011, Rodewald and Brittingham 2004, Stoleson 2013) including boreal species (Stoleson 2010). Common explanations given for high bird use in young regenerating stands during these two critical time periods are increased areas of cover and/or high insect and fruit abundance associated with these areas (Anders et al. 1998, King et al. 2006, McDermott and Wood 2010, Rodewald and Brittingham 2004, Vitz and Rodewald 2007). Additionally, Stoleson (2010) found that capture rates increased almost linearly with increasing clearcut size, suggesting that larger cuts may provide a greater benefit.

Although research on post-breeding use of shelterwood stands is limited, one study determined that high amounts of residual canopy depressed use of harvested stands by early successional species during this time period (McDermott and Wood 2011). Additionally, if fruit abundance is one of the driving factors contributing to high post-breeding bird use in patch cuts and clearcuts, shelterwoods may not provide the same benefit. Our regeneration studies found much less pin cherry in our low-density shelterwood than in our larger patches and clearcut. Personal observations also noted much less *Rubus* spp. regenerating in the low-density shelterwood.

These recent studies that indicate a shift in habitat use among some late successional bird species from mature forests to regenerating stands during the post-breeding and migration periods illustrate the need to expand our understanding of the significance of early successional habitat to this group of birds during these critical time periods. Further studies are necessary to the determine the relationship between such factors as size of opening and degree of residual basal area, and their influence on the quality of early successional habitat for both early successional species and mature forest species so effective management practices can be implemented. Given the diverse range of habitats used by forest birds, we continue to recommend a variety of silvicultural techniques to maintain avian species diversity across forested landscapes in New England (DeGraaf et al. 2006).

It is important to recognize certain limitations of this research. First, this is a case study and caution is advised when interpreting the data due the lack of replication. However, the inclusion of preharvest data and relatively long-term post-harvest data is rare and valuable because of high annual variation in bird populations.

Second, this study measured bird species richness and abundance, not productivity. Measurements of productivity are preferable to presence of singing males because reproduction and habitat quality can only be inferred from the former (Van Horne 1983, Vickery et al. 1992). Finally, this study was conducted during one phase of the breeding season and current research is demonstrating the need to consider all phases due to shifts in habitat use post-breeding.

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APPENDIX

Breeding bird species by habitat group (early successional, generalist, and mid-/later successional) observed on the study areas on the Bartlett Experimental Forest, NH, including all species tallied during the study (DeGraaf and Yamasaki 2001, Dettmers 2003, Schlossberg and King 2007)

Species	Scientific name	Early successional	Generalist	Mid-/later successional
Ruby-throated hummingbird	*Archilochus colubris*	X		
Yellow-bellied sapsucker	*Sphyrapicus varius*		X	
Hairy woodpecker	*Picoides villosus*			X
Northern flicker	*Colaptes auratus*		X	
Eastern wood-pewee	*Contopus virens*			X
Alder flycatcher	*Empidonax alnorum*	X		
Least flycatcher	*Empidonax minimus*		X	
Blue-headed vireo	*Vireo solitarius*			X
Red-eyed vireo	*Vireo olivaceus*		X	
Blue jay	*Cyanocitta cristata*		X	
Black-capped chickadee	*Poecile atricapillus*		X	
White-breasted nuthatch	*Sitta carolinensis*		X	
Brown creeper	*Certhia americana*			X
Winter wren	*Troglodytes hiemalis*		X	
Veery	*Catharus fuscescens*			X
Swainson's thrush	*Catharus ustulatus*		X	
Hermit thrush	*Catharus guttatus*			X
Gray catbird	*Dumetella carolinensis*	X		
Cedar waxwing	*Bombycilla cedrorum*	X		
Ovenbird	*Seiurus aurocapilla*			X
Black-and-white warbler	*Mniotilta varia*	X		
Mourning warbler	*Geothlypis philadelphia*	X		
Common yellowthroat	*Geothlypis trichas*	X		
American redstart	*Setophaga ruticilla*		X	
Magnolia warbler	*Setophaga magnolia*	X		
Blackburnian warbler	*Setophaga fusca*			X
Chestnut-sided warbler	*Setophaga pensylvanica*	X		
Black-throated blue warbler	*Setophaga caerulescens*			X
Yellow-rumped warbler	*Setophaga coronata*		X	
Black-throated green warbler	*Setophaga virens*			X
Canada warbler	*Cardellina canadensis*		X	
White-throated sparrow	*Zonotrichia albicollis*	X		
Dark-eyed junco	*Junco hyemalis*	X		
Scarlet tanager	*Piranga olivacea*			X
Rose-breasted grosbeak	*Pheucticus ludovicianus*		X	
Indigo bunting	*Passerina cyanea*	X		
American goldfinch	*Spinus tristis*	X		
Total species		12	14	11

Yamasaki, Mariko; Costello, Christine A.; Leak, William B. 2014. **Effects of clearcutting, patch cutting, and low-density shelterwoods on breeding birds and tree regeneration in New Hampshire northern hardwoods.** Res. Pap. NRS-26. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 15 p.

Clearcutting is an effective regeneration practice for northern hardwoods in New England. However, in esthetically sensitive areas forest managers sometimes use methods that soften the visual impact, such as smaller clearcuts (patch cuts) or low-density shelterwoods. It is unclear if these methods produce the same effects as clearcuts on tree regeneration and breeding bird habitat. A comparison of a 15-acre clearcut, four patch cuts varying in size from 2.9 to 5.5 acres, and a 34-acre low-density shelterwood showed that the patches regenerated some early successional tree species, similar to the clearcut, however, the smaller 3-acre patches also produced a higher component of beech and less pin cherry. The shelterwood produced high proportions of beech and striped maple. Early successional, generalists, and mid-/later successional birds were present in all three treatment areas although the clearcut and patches had higher proportions and more observations of early successional bird species.

KEY WORDS: northern hardwoods, songbirds, early successional, clearcut, shelterwood, patch cuts

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