Monitoring Songbird Response to Forest Stand Improvement 2016 Final Report

Kate Slankard and Gary Sprandel
Kentucky Department of Fish and Wildlife Resources
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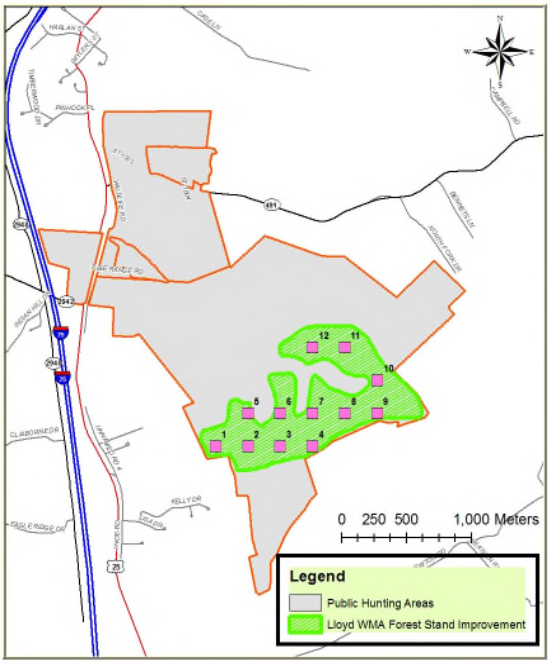
In 2009, the Kentucky Department of Fish and Wildlife Resources (KDFWR) created an internal initiative to increase forest management on Wildlife Management Areas (WMAs). Prior to this initiative, habitat manipulations on WMAs generally focused on open vegetation types, but growing interest in improving degraded forests led to a concerted effort to plan for forest stand improvement (FSI) on state lands. Soon after, WMA managers created and began implementation of forest plans that encouraged historical conditions, focusing on the restoration of oak-hickory dominant forests. Most areas accomplished FSI without the involvement of commercial timber sales, and overall treatments were fairly conservative when it came to timber removal. Nonetheless, KDFWR's Avian Monitoring Program initiated point count surveys on several Kentucky WMAs in order to investigate songbird response to FSI.

The objectives of this project were to estimate abundance of priority songbird species on WMAs and to compare songbird abundance before and after localized management for FSI. Considerable challenges were met at a number of areas when it came time for implementation and some areas were not able to complete planned FSI at the time of this report. In this summary, we present the pre-treatment and post-treatment results from six WMAs at which FSI occurred during 2010-2014. In addition, we present abundance estimates for seven WMAs where FSI did not occur.

METHODS

The point count methodology used for this project was developed in 2009 by the Central Hardwoods Joint Venture (CHJV) in order to validate Habitat Suitability Index (HSI) models for priority landbirds (CHJV 2009, Tirpak et al 2009). Since HSI models for most species were validated successfully with one season of data, the CHJV did not continue their survey and several survey transects were discontinued in Kentucky after 2009. However, surveys were continued on selected Kentucky WMAs which were slated for FSI and the same protocol used throughout the project (2009-2016).



Survey transect at Curtis Gates Lloyd WMA

Our study design involved surveying the same areas for songbirds before and after forest treatments. Public lands where FSI was planned within the Central Hardwoods (CH) and Appalachian Mountains (AM) BCRs were selected as survey areas. WMA managers provided GIS layers for planned FSI and later recorded implementation using GIS. Random grids of potential survey points (250 m apart) were generated for each potential treatment area and points that fell within planned treatment areas were selected for survey transects. Survey transects consisted of 10-12 points that one observer could walk to in a single morning.

Focal Species
Acadian Flycatcher*
Bell's Vireo*
Black-throated Green Warbler*
Black-&-white Warbler
Blue-gray Gnatcatcher
Blue-winged Warbler*
Brown Thrasher
Carolina Chickadee
Cerulean Warbler*
Eastern Wood-Pewee
Field Sparrow
Great Crested Flycatcher
Hooded Warbler
Kentucky Warbler*
Louisiana Waterthrush*
Northern Bobwhite*
Northern Parula
Orchard Oriole
Pileated Woodpecker
Prairie Warbler*
Prothonotary Warbler*
Red-headed Woodpecker*
White-eyed Vireo
Wood Thrush*
Worm-eating Warbler*
Yellow-breasted Chat
Yellow-throated Vireo

*SGCN

Surveys were conducted between 15 May and 15 June to target breeding songbirds when they are most vocal. Most surveys were conducted annually between 2009 and 2016, in order to collect 2-3 years of data prior to treatment and 2-3 years of data post-treatment. Surveys commenced just before local sunrise (i.e. as soon as it was light enough to see about 200 m) and ended no later than 10:00 AM. Most transects were surveyed by the same observer each year; however, several different observers conducted transects throughout the state.

Surveys focused on 30 priority songbirds in the CH BCR, including 13 Species of Greatest Conservation Need (SGCN), listed in Kentucky's State Wildlife Action Plan (KDFWR 2013). All detections of focal species were recorded, except for fly overs. If the bird did not land in the plot, it was not recorded. Observers recorded the first observation of each bird at each point within the 5-minute survey period. Time interval was recorded as the minute (1-5) in which a bird was first detected. The distance band was also recorded at the first detection. Distance bands reflected easily separable thresholds (0-25 m, 25-50 m, 50-100 m & >100 m).

Point counts were not conducted during moderate-heavy precipitation, dense fog, or strong winds, as these conditions impact bird activity and the ability to detect birds. Counts were also conducted only when ambient air temperature was ≥ 50° F and wind speeds were <19 mph (Beaufort Scale Class ≤ 4).

Habitat measurements were collected at each point count location, during the count, by a second individual or by the bird observer later that afternoon or on a separate day, soon after the survey. If a second individual conducted habitat measurements during the point count, they were asked to make every effort to avoid distracting the bird observer or doing anything to affect bird behavior. They did not help count or point out birds.

Habitat measurements (Husch et al 2003) focused on the conditions within 15 m of the point and included the following:

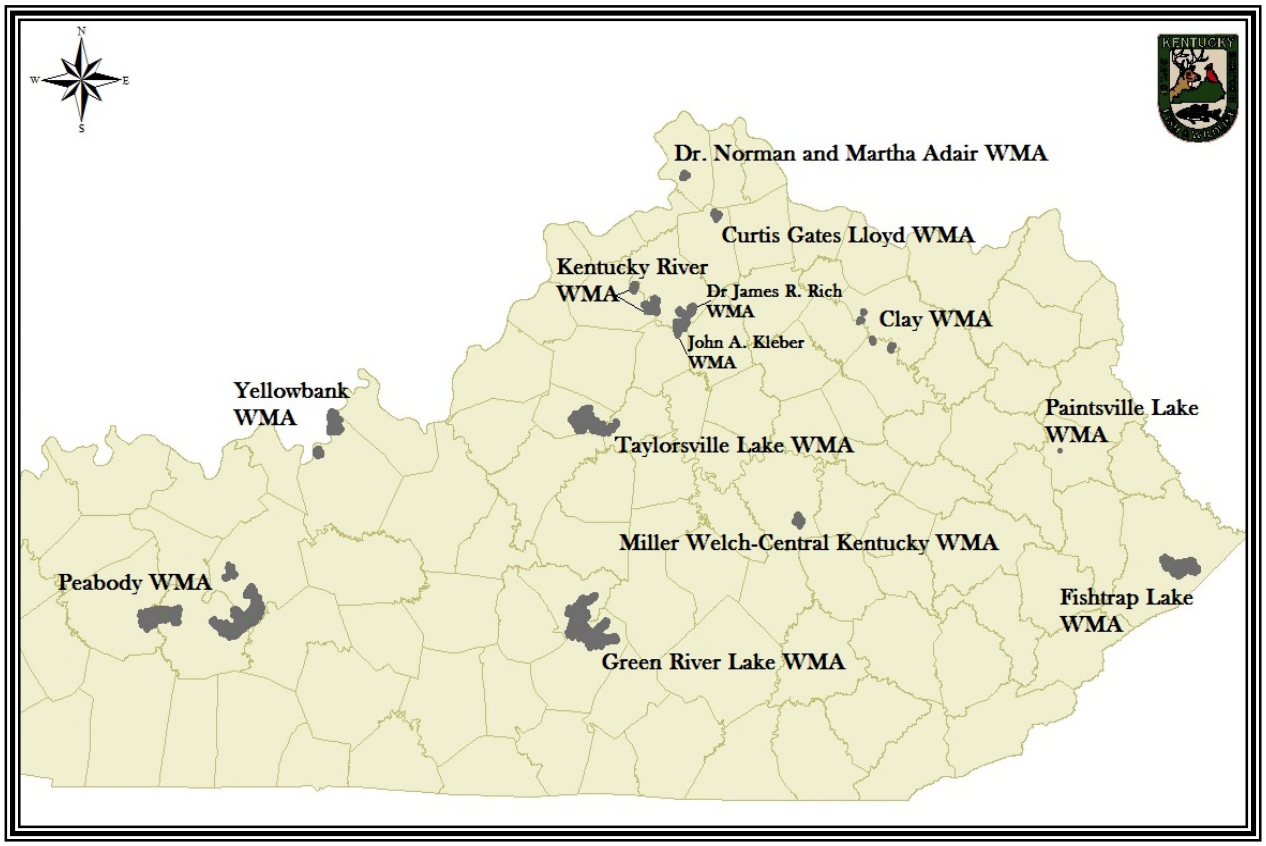
- Forest type – An objective choice of the following categories, based on the dominant vegetation type:
    - Upland deciduous: forests with > 75% coverage by tree species that shed their foliage.
    - Evergreen: forests with > 75% coverage by tree species that are green all year.
    - Mixed deciduous & evergreen: forests where neither deciduous nor evergreen trees dominate.
    - Bottomland hardwood: forests on the floodplain of a large river.
    - Riparian: all other stream-side forests.
    - Shrubland/Old field: sites dominated by a mix of herbaceous and shrubby cover including regenerating forest stands.
    - Grassland: natural or exotic with >80% grass cover.
- Dominant stand size class - An objective choice of the following categories to best describe the dominant stand size class of trees, evaluating dominance based on basal area and canopy cover:
    - Seedling – stands dominated by trees between 1 and 2.9 inches diameter at breast height (DBH).
    - Sapling– stands dominated by trees between 3.0 and 4.9 inches DBH.
    - Poletimber – stands dominated by trees between 5.0 and 10.9 inches DBH.
    - Sawtimber – stands dominated by trees >11 inches DBH.
- Basal area – measured using a 10-factor prism, reported in ft^2/ac.
- Snag density – measured using a 10-factor prism, reported in ft^2/ac.
- Canopy cover – measured using a densitometer.
- Small stem density – a count of small trees (less than 1 inch DBH).
- Dominant tree species present
- Small stem species present
- Vines species present
- Herbaceous layer/Ground cover- percent cover
- Herbaceous layer/Ground cover- average height.

A tree mulcher was used for management of alder stands at Green River Lake WMA

WMA managers tracked implementation of forest plans via GIS and provided feedback on progress, timing and location of treatments. Practices varied from thinning and girdling to invasive

species removal and treatments generally spanned 60-250 acres. Treatments did not occur during the songbird survey season. Forest management was not accomplished at some areas for various reasons and these transects were later dropped from the survey. Nonetheless, we report data for these areas as a basis for comparison (Table 1).

We used the program, *AbundanceR* to calculate species relative abundance, with confidence intervals (Mordecai 2012). This program accounts for detection probability using time-removal methods (Alldredge 2007) and computes abundance as birds per survey point. Data for unmanaged areas was pooled for all of the years an area was surveyed to produce abundance estimates. For managed area abundance estimates, each survey date was classified as "before" or "after" management, based on reports from areas managers. Data from all years before and after treatment were pooled and comparisons were made between these two groups. We removed species with less than 10 detections for this analysis. Confidence intervals (95% and 90%) were used to determine significant differences in abundance before and after treatments. Differences with p values less than 0.1 are referred to as "probable" and differences with p values less than 0.05 are deemed "significant" in the following results. There were several species ($n \geq 10$) that *AbundanceR* could not produce abundance estimates for, due to sample size. These were left out of the comparison analysis. When possible, annual species specific abundances were also produced for managed sites, but are reported below only when relevant to discussion of post-treatment findings.



WMAs where FSI songbird surveys occurred in 2009-2016

RESULTS

Results for managed areas are broken down by WMA and presented below. Abundance estimates for areas which were not managed are also presented in Table 1.

- ***Dr. Norman and Martha Adair WMA***

Dominant Forest Type: Upland deciduous forest
Forest Characteristics: Dominant size classes for this area were recorded as mostly poletimber (49%), and saplings (33%), with some sawtimber (18%).
Management Practices: Oak-hickory restoration. Thinning and girdling of non-desirable species (maple and ash). Mean basal area was reduced by treatments from (75 ft^2/ac) to (34 ft^2/ac).
Timing of Treatment: January-March 2013
Years Bird Surveys Were Conducted: 2009-2015
Bird Response: Kentucky Warbler showed a significant increase in abundance after management. The data suggested a higher abundance post-treatment for Great Crested Flycatcher, but this difference was not significant (Table 2).

Great Crested Flycatchers are associated with open woodlands, with more large and fewer small trees and lower shrub density (Reidy et al 2014). Consequently, their probable increase after the management at Adair is not surprising. Kentucky Warblers prefer a basal area of 20 ft^2/ac – 40 ft^2/ac (Wood et al 2013); thus, reducing the basal area at Adair improved habitat conditions for this species. Interestingly, there was no significant difference in the abundance Wood Thrush (a mature forest bird) before or after treatments, despite the reduction in basal area.

- ***Clay WMA***

Dominant Forest Type: Upland deciduous forest, with some areas of mixed evergreen forest and shrubland.
Forest Characteristics: Dominant size classes for this area were recorded as sawtimber (58%) and poletimber (42%).
Management Practices: Open woodland restoration. Removal of eastern red cedar. Mean basal area was slightly lower after treatment (67 ft^2/ac), in comparison to before (77 ft^2/ac). Snag density increased after treatment from 0.35 ft^2/ac to 0.73 ft^2/ac.
Timing of Treatment: Summer 2011
Years Bird Surveys Were Conducted: 2010-2015
Bird Response: Management resulted in a significant increase in Prairie Warbler abundance. Great Crested Flycatchers were not detected at all pre-treatment, but did occur post-treatment (Table 3).

Great Crested Flycatchers are associated with open woodlands (Reidy et al 2014), so their probable increase after these restoration efforts is not surprising. Prairie Warblers are often associated with eastern red cedar in Kentucky (Palmer-Ball 1996); however the cedar at this site was quite thick prior to management. As expected, Prairie Warbler responded positively to the thinning of red cedar at this area, probably due to the more open structure.

- ***Fishtrap Lake WMA***

Dominant Forest Type: Riparian forest
Forest Characteristics: A mature stand of sawtimber-sized hardwoods, with a small amount of evergreen.
Management Practices: Invasive species removal. Treatment of Japanese knotweed, formerly the dominant understory plant. Mean percent ground cover of grass was 24% pre-treatment and 45% post-treatment.
Timing of Treatment: Summer 2011
Years Bird Surveys Were Conducted: 2010-2015
Bird Response: Post-management surveys suggested a higher abundance for Acadian Flycatcher and Pileated Woodpecker, but these differences were not significant. On the contrary, a lower abundance post-management was found for Cerulean Warbler. Moreover, a lower post-treatment abundance was suggested, but not significant for Northern Parula and White-eyed Vireo (Table 4).

Conditions before treatment at Fishtrap WMA. Knotweed was the dominant understory plant.

Conditions after treatment at Fishtrap WMA. Knotweed removal opened up the understory.

Although Acadian Flycatchers nest in the mid-story, they are often found in areas where the understory is quite sparse (Bakermans and Rodewald 2006). Japanese knotweed can form dense thickets in the understory which could possibly lead to avoidance by Acadian Flycatchers. Hence, the probable increase seen in this species may have been caused by opening up the understory. The probable increase in Pileated Woodpeckers was not expected at this site and we do not assume the knotweed removal caused this increase. We

surmise other natural events may have led to this (e.g. storm damage or local insect infestations such as the emerald ash borer). Even more puzzling, an increase in snag density was not observed by our vegetation monitoring.

The treatment of the understory at this site was not expected to affect abundance for Cerulean Warbler and their decrease was unanticipated. This could have been due to natural succession in forest openings, which this species requires. Moreover, surveys in 2013-2014 were run late in the survey period (June 14 and 13 respectively); meanwhile the surveys in 2010-2011 were run on June 6. We hypothesize the singing rate of this species slowed later in the survey period, resulting in a false decline in our results. Robbins et al, 2009 suggested that song rates of Cerulean Warblers likely decrease rapidly after June 4 in the Missouri Ozarks. Surveys for this species in our area should probably have a narrower survey window, ending earlier in June. The probable decline in White-eyed Vireos was less surprising since they prefer a dense understory (Palmer-Ball 1996). We did not anticipate the probable decrease post-treatment for Northern Parula, but sample size was small and borderline for analysis for this species.

- ***Green River Lake WMA- Casey Creek***

Dominant Forest Type: Bottomland hardwood forest, with occasional evergreens.
Forest Characteristics: Dominant size classes for this area were recorded as mostly poletimber (80%) with some sawtimber (20%).
Management Practices: Oak-hickory restoration and midstory removal. Mean basal area was reduced after treatment (108 ft^2/ac), in comparison to before (127 ft^2/ac). Snag density increased after treatment from 1.3 ft^2/ac to 2.0 ft^2/ac.
Timing of Treatment: Winter 2010-2011
Years Bird Surveys Were Conducted: 2009-2015
Bird Response: Post-treatment surveys suggested a higher abundance in Northern Parula than pre-treatment, but this difference was not significant. However, abundance for White-eyed Vireo was significantly lower post-treatment (Table 5).

White-eyed Vireos need areas of dense trees and shrubs for nesting and foraging (Palmer-Ball 1996). Thus, the mid-story thinning at this site likely caused them to decrease. The probable increase for Northern Parula post-treatment is somewhat surprising, since it is generally regarded as a mature forest species (Palmer-Ball 1996) and other studies have associated this species with dense deciduous forests. Nevertheless, in Louisiana, this species was also found to be associated with managed bottomland hardwood forests (Norris et al 2009).

- ***Green River Lake WMA- Green River Lake***

Dominant Forest Type: Bottomland hardwood forest
Forest Characteristics: Dominant size classes for this area were recorded as mostly poletimber (80%), with some sapling (8%), and sawtimber (12%).
Management Practices: Oak-hickory restoration. Heavy thinning (midstory removal), invasive species removal, oak planting, and alder rejuvenation (thinning thick stands of alder). Pre and post treatment vegetation data showed a basal area of 100 ft^2/ac.
Timing of Treatment: Winter 2010-2011
Years Bird Surveys Were Conducted: 2009-2015
Bird Response: More species demonstrated response to management at this site than any others. Post-treatment surveys measured a significantly higher abundance in Northern Parula and Yellow-breasted Chat than pre-treatment surveys, as also suggested a higher abundance for Blue-gray Gnatcatcher. Conversely, abundance for Acadian Flycatcher, Yellow-throated Vireo, White-eyed Vireo and were significantly lower post-treatment (Table 6).

Yellow-breasted Chats responded well to alder rejuvenation, likely benefitting from lower, dense, shrubby regrowth. Blue-gray Gnatcatchers probably benefitted from canopy gaps and a more open mid-story created by thinning (Palmer-Ball 1996). The increase in Northern Parula post-treatment was significant at this site and consistent with the other site at this WMA (see discussion above). Acadian Flycatchers usually forage and nest in the mid-story (Bakermans and Rodewald 2006), hence removal of the midstory no doubt drove their decline. White-eyed Vireos declined in the three years after the thinning. However, then a rebound was observed in this species when breaking the data down annually (Figure 1), and it appears the decline was only temporary. The decline seen in Yellow-throated Vireo was surprising to us since they are often associated with open upland woods in Kentucky (Palmer-Ball 1996). On the other hand, in Louisiana this species also experienced a decline after thinning bottomland hardwood forests (Norris et al 2009), suggesting that habitat management for this species depends on forest type.

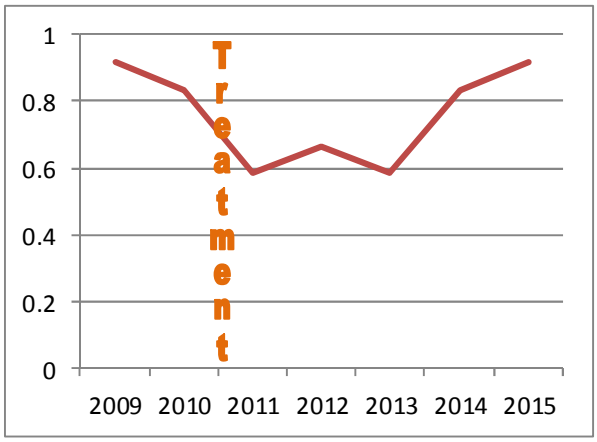


Figure 1. White-eyed Vireo annual abundance at the Green River Lake WMA transect near Green River Lake.

- ***Curtis Gates Lloyd WMA***

Dominant Forest Type: Upland deciduous forest
Forest Characteristics: Dominant size classes for this area were recorded as mostly sawtimber (75%), with some poletimber (25%).

Management Practices: Edge feathering and invasive species (honeysuckle) removal. Treatments did not reduce basal area, which averaged 91 ft^2/ac throughout the course of the study.
Timing of Treatment: Winter 2010-2011
Years Bird Surveys Were Conducted: 2009-2014
Bird Response: The abundance of Acadian Flycatchers and Northern Parulas was significantly higher post-treatment, than pre-treatment. The data suggested a higher abundance of Eastern Wood-Pewee post-treatment, but these findings were not significant (Table 7).

Girdling of undesirable species occurred at several WMAs

The increase in abundance for Acadian Flycatcher is consistent with Bakermans and Rodewald, 2006, which found that Acadian Flycatchers have lower densities and productivity when honeysuckle is abundant. The significant increase for Northern Parula paralleled findings at Green River WMA, although notably at Lloyd, basal area of the forest interior was not significantly reduced. Northern Parulas are known to occur at the forest edge and it's likely that forest-edge related treatments were responsible for the increase of this species at Lloyd. Eastern Wood-Pewees are associated with open woodlands with more large and fewer small trees and lower shrub density (Reidy et al 2014), so their probable increase to the management at Lloyd is not surprising.

- ***Yellowbank WMA***

Dominant Forest Type: Upland deciduous forest.
Forest Characteristics: A mature stand of sawtimber-sized hardwoods.
Management Practices: Oak-hickory restoration, including girdling of non-desirable species. Mean basal area was similar before and after treatments (96.5 ft^2/ac).
Timing of Treatment: Winter 2013-2014
Years Bird Surveys Were Conducted: 2009-2016
Bird Response: Post-treatment surveys documented a significantly higher abundance of Blue-gray Gnatcatcher, Northern Parula, and Wood Thrush than pre-treatment surveys (Table 8).

Blue-gray Gnatcatchers likely benefitted from canopy gaps created by girdling non-desirable species (Palmer-Ball 1996). Northern Parula again benefitted from management at this site, even though no timber was cut and girdling was the primary method used. Similarly, Moorman and Guynn, 2001 found that group selection harvests increased abundance of Northern Parula and that these areas were likely important for post-fledging habitat.

Interestingly, Wood Thrush increased post-treatment at this site, which contradicts a common sentiment that this species often does not benefit from forest management. However, studies indicate that this species requires a dense understory of saplings and shrubs (Rosenberg et al 2003) and we assume that the treatments which occurred at Yellowbank WMA resulted in a better developed shrub/sapling layer in some areas. Likewise, Crawford et al. (1981) found that selective removal of mature trees scattered throughout a stand creates favorable conditions for the species.

DISCUSSION

Although forest treatments for this project were generally conservative and basal area was often not drastically reduced, at least a few changes in focal species abundance were observed at each managed area. Increases and decreases in some of the focal species were expected. For instance, a relatively aggressive reduction in basal area at Adair WMA resulted in an anticipated significant increase in Kentucky Warbler. Similarly, thinning and restoration of open woodland conditions at Clay WMA resulted in a significant increase in Prairie Warbler. Conversely, some unanticipated changes in abundance were observed for the mature forest species, Northern Parula, which increased in abundance at most areas with FSI. In addition, the positive response of Acadian Flycatcher at Lloyd WMA and Fishtrap Lake WMA, in both cases after the removal of invasive species, was not only consistent with other studies but confirms that this management tactic should be a priority for this SGCN in Kentucky.

Habitat change inevitably results in tradeoffs in songbird species composition, with a decrease in species that preferred pre-treatment habitat conditions. Forest treatments in our case were implemented in hopes to restore historical forest conditions (oak and hickory dominant forests) and benefit SGCN. Several treatments resulted in a decrease in White-eyed Vireos. This was not surprising as many treatments involved reducing the midstory and understory, which is crucial for this species. Although this species is not a SGCN, at first glance, this may seem concerning. However, this species has been found to have a positive trend of 2.33% (95% CI 0.05, 4.20), with high credibility in 2003-2013 Kentucky Breeding Bird Survey data (Sauer et al 2014). Recognizing that we cannot benefit all species with a single practice, in general, forest treatments resulted in significant increases in SGCN including Kentucky Warbler, Prairie Warbler, Wood Thrush and Acadian Flycatcher (increased at two sites, declined at one site). Declines in SGCN included Acadian Flycatcher at one of the Green River WMA sites and Cerulean Warbler at Fishtrap WMA. Again, the decline of Cerulean Warbler at Fishtrap WMA was likely not attributable to the understory treatment. Thus, more often than not, forest treatments benefitted SGCN.

On the other hand, several forest-dependent SGCN were not detected with sufficient sample size to evaluate the effects of treatments or did not respond to forest treatment when detected (Black-throated Green Warbler, Black-and-White Warbler, Louisiana Waterthrush and Worm-

eating Warbler). While most of these are mature forest birds which may benefit most from no management, more study is needed to determine if they may respond positively to habitat manipulations of some sort.

Due to differences in observers and survey effort, we were apprehensive to look for differences in abundance between managed sites (Tables 2-8) and unmanaged sites (Table 1). Although we discuss some comparisons below, we recommend caution in their interpretation. Kentucky Warblers were significantly more abundant post-treatment at Adair WMA than at any of the unmanaged sites. Wood Thrushes were also significantly more abundant at Yellowbank WMA, post-treatment than at any of the unmanaged sites. Acadian Flycatcher abundance was highest at Yellowbank WMA, though not significantly more so than post-treatment Lloyd WMA or Fishtrap WMA, where we recorded response to management for this species. On the contrary, Prairie Warbler abundance was highest at an unmanaged site. Their abundance at the Rich WMA (young forest), was 1.12 birds per survey (95% CI 1.04, 1.34), and significantly higher than Clay WMA, where they had significantly increased post-treatment.

There are several methods for obtaining abundance estimates from bird point count data and our analysis used time-removal methods to account for detectability of species. However, we also collected distance band data for each detection. Further analysis using distance-sampling methods or combining distance sampling and time-removal methods may fine tune results (Farnsworth et al 2005).

The survey period for this project was rather short, in terms of forest change and most areas were surveyed 3-4 years after treatments. It may be worthwhile to repeat surveys, for a 2-3 year sampling period, 10-15 years post-treatment to evaluate long term effects on bird communities and vegetation composition. This project also encompassed relatively few FSI practices and as the opportunity arises to evaluate additional practices or replicate the aforementioned practices in other areas of the state, additional bird monitoring will lead to a better understanding of the effects of FSI on SGCN.

ACKNOWLEDGMENTS

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Table 1. Abundance (birds per survey point) of focal species at unmanaged sites.

	Dr. James R. Rich WMA	Dr. James R. Rich WMA	Kleber WMA	Kleber WMA	KY River WMA	Miller-Welch Central KY WMA	Miller-Welch Central KY WMA	Paintsville Lake WMA	Peabody WMA - Ken	Peabody WMA - Homestead	Taylorsville WMA
Vegetation Type	Young Forest	Mature Forest	Young Forest	Mature Forest	Young Forest	Young Forest	Mature Forest	Mature Forest	Grassland Shrubland	Grassland Shrubland	Mature Forest
Acadian Flycatcher*		0.06	**	0.07	0.10			0.46			0.38
Bell's Vireo									1.21	0.52	
Black-and-white Warbler	**	**	**					0.07			0.04
Blue-gray gnatcatcher	0.31	**	0.31	0.62	0.20	**		0.14		**	0.34
Blue-winged Warbler	**		**	0.11	**	0.09		0.28			
Brown Thrasher	0.38	0.06	0.38	0.11	**	**		0.03	0.37	**	0.06
Carolina Chickadee	**	0.10	**	0.05	**	**	**	0.07			**
Cerulean Warbler								**			**
Eastern Wood-Pewee	**	0.14	**	0.23	0.59	**	0.53	0.07			0.06
Field Sparrow	0.63	0.23	0.63	0.27	0.79	1.23	**	0.14	1.76	1.66	0.37
Great Crested Flycatcher	**	0.33	**	0.14		**	**				**
Hooded Warbler			**	0.23				1.01			
Kentucky Warbler*	**	0.34	**	**	**			0.24			0.17
Louisiana Waterthrush	**										
Northern Bobwhite	0.20		0.20		**				1.21	0.62	**
Northern Parula	0.17	0.10	0.17	0.07	**			**		0.52	0.58
Orchard Oriole					**				**		0.01
Pileated Woodpecker	0.11	**	0.11	**	**	**	0.09	**			0.11
Prairie Warbler*	1.06	0.46	1.06	0.62		0.53	0.54	0.17	0.19	**	0.43
Prothonotary Warbler									0.09		0.05
Red-headed Woodpecker						0.09			**		
White-eyed Vireo	0.31	**	0.31	0.11	**	**	**	0.38	0.38	0.42	0.46
Wood Thrush*	0.08	0.22	0.08	0.07	0.20		**	**			**
Worm-eating Warbler		**		**			0.26	0.24			0.01
Yellow-breasted Chat	0.50	0.29	0.50	0.14	2.86	0.18		0.70	1.11	0.62	**
Yellow-throated Vireo		**	**	**				0.24		**	**
Focal Species Detected	**17**	**17**	**19**	**18**	**15**	**12**	**9**	**19**	**10**	**10**	**21**
Years Data Collected	2009-2013	2009-2013	2009-2014	2010-2014	2009	2009	2009	2010-2013	2009	2009	2009-2016

*Species of Great Conservation Need.

**Species was detected at the transect, but sample size was not sufficient for an abundance estimate.

Table 2. Abundance of focal species, including lower confidence interval (LCI) and upper confidence interval (UCI) before and after management at Dr. Norman and Martha Adair WMA.

Group	Species	Abundance per survey	90% LCI	90% UCI	95% LCI	95% UCI	P value	Response (if P<0.10)
Before	Blue-gray Gnatcatcher	0.13	0.12	0.27	0.12	0.34		
After	Blue-gray Gnatcatcher	0.18	0.15	0.35	0.15	0.44	P>0.10	
Before	Carolina Chickadee	0.06	0.06	0.17	0.06	0.25		
After	Carolina Chickadee	0.13	0.11	0.29	0.11	0.39	P>0.10	
Before	Eastern Wood-Pewee	0.45	0.41	0.64	0.41	0.73		
After	Eastern Wood-Pewee	0.57	0.51	0.80	0.50	0.89	P>0.10	
Before	Great Crested Flycatcher	0.14	0.12	0.28	0.12	0.35		
After	Great Crested Flycatcher	0.34	0.28	0.53	0.28	0.61	P=0.10	Probable Increase
Before	**Kentucky Warbler***	0.30	0.27	0.47	0.26	0.54		
After	**Kentucky Warbler***	0.68	0.60	0.91	0.59	1.00	P=0.05	Significant Increase
Before	Northern Parula	0.06	0.06	0.17	0.06	0.25		
After	Northern Parula	0.17	0.15	0.35	0.15	0.44	P>0.10	
Before	Pileated Woodpecker	0.07	0.06	0.18	0.06	0.26		
After	Pileated Woodpecker	0.13	0.11	0.29	0.11	0.39	P>0.10	
Before	**Wood Thrush***	0.90	0.83	1.14	0.82	1.23		
After	**Wood Thrush***	0.92	0.82	1.19	0.82	1.28	P>0.10	
Before	Yellow-breasted Chat	0.33	0.30	0.50	0.29	0.58		
After	Yellow-breasted Chat	0.40	0.35	0.61	0.35	0.69	P>0.10	

*Species of Great Conservation Need.

Table 3. Abundance of focal species, including lower confidence interval (LCI) and upper confidence interval (UCI) before and after management at Clay WMA.

Group	Species	Abundance per survey	90% LCI	90% UCI	95% LCI	95% UCI	P-value	Response (if P<0.10)
before	**Acadian Flycatcher***	0.48	0.45	0.79	0.45	1.01		
after	**Acadian Flycatcher***	0.41	0.40	0.61	0.40	0.76	P>0.10	
before	Blue-gray Gnatcatcher	0.48	0.45	0.79	0.45	1.01		
after	Blue-gray Gnatcatcher	0.54	0.53	0.77	0.53	0.93	P>0.10	
before	Eastern Wood-Pewee	0.27	0.25	0.52	0.25	0.71		
after	Eastern Wood-Pewee	0.44	0.43	0.64	0.43	0.80	P>0.10	
before	Great Crested Flycatcher	0.05	0.05	0.18	0.05	0.31		
after	Great Crested Flycatcher	0.21	0.20	0.35	0.20	0.47	P=0.10	Probable Increase
before	**Kentucky Warbler***	0.27	0.25	0.52	0.25	0.71		
after	**Kentucky Warbler***	0.41	0.40	0.61	0.40	0.76	P>0.10	
before	**Louisiana Waterthrush***	0.05	0.05	0.18	0.05	0.31		
after	**Louisiana Waterthrush***	0.08	0.08	0.16	0.08	0.25	P>0.10	
before	Northern Parula	0.21	0.20	0.44	0.20	0.62		
after	Northern Parula	0.31	0.30	0.48	0.30	0.62	P>0.10	
before	**Prairie Warbler***	0.05	0.05	0.18	0.05	0.31		
after	**Prairie Warbler***	0.41	0.40	0.61	0.40	0.76	P=0.05	Significant Increase
before	**Wood Thrush***	0.37	0.35	0.66	0.35	0.86		
after	**Wood Thrush***	0.23	0.23	0.38	0.23	0.51	P>0.10	
before	Yellow-breasted Chat	0.32	0.30	0.59	0.30	0.78		
after	Yellow-breasted Chat	0.46	0.45	0.68	0.45	0.83	P>0.10	

*Species of Great Conservation Need.

Table 4. Abundance of focal species, including lower confidence interval (LCI) and upper confidence interval (UCI) before and after management at Fishtrap Lake WMA.

Group	Species	Abundance per survey	90% LCI	90% UCI	95% LCI	95% UCI	P-value	Response (if P<0.10)
before	**Acadian Flycatcher***	0.59	0.55	0.86	0.55	1.00		
after	**Acadian Flycatcher***	0.98	0.93	1.18	0.92	1.26	P=0.10 *	Probable Increase
before	Black-and-white Warbler	0.15	0.14	0.32	0.14	0.45		
after	Black-and-white Warbler	0.08	0.07	0.16	0.07	0.23	P>0.10	
before	Blue-gray Gnatcatcher	0.10	0.09	0.25	0.09	0.37		
after	Blue-gray Gnatcatcher	0.05	0.05	0.13	0.05	0.19	P>0.10	
before	**Cerulean Warbler***	0.39	0.37	0.63	0.37	0.77		
after	**Cerulean Warbler***	0.18	0.16	0.29	0.16	0.36	P=0.05	Significant Decrease
before	Hooded Warbler	0.69	0.64	0.97	0.64	1.11		
after	Hooded Warbler	0.78	0.73	0.96	0.73	1.04	P>0.10	
before	**Louisiana Waterthrush***	0.44	0.41	0.69	0.41	0.83		
after	**Louisiana Waterthrush***	0.35	0.33	0.50	0.33	0.57	P>0.10	
before	Northern Parula	0.29	0.27	0.51	0.27	0.65		
after	Northern Parula	0.13	0.12	0.23	0.12	0.30	P=0.10	Probable Decrease
before	Pileated Woodpecker	0.20	0.18	0.39	0.18	0.52		
after	Pileated Woodpecker	0.48	0.45	0.64	0.45	0.71	P=0.10	Probable Increase
before	**Swainson's Warbler***	0.10	0.09	0.25	0.09	0.37		
after	**Swainson's Warbler***	0.05	0.05	0.13	0.05	0.19	P>0.10	
before	White-eyed Vireo	0.29	0.27	0.51	0.27	0.65		
after	White-eyed Vireo	0.15	0.14	0.26	0.14	0.33	P=0.10	Probable Decrease
before	**Wood Thrush***	0.79	0.74	1.08	0.73	1.22		
after	**Wood Thrush***	1.00	0.95	1.20	0.95	1.28	P>0.10	
before	Yellow-throated Vireo	0.15	0.14	0.32	0.14	0.45		
after	Yellow-throated Vireo	0.18	0.16	0.29	0.16	0.36	P>0.10	

*Species of Great Conservation Need.

Table 5. Abundance of focal species, including lower confidence interval (LCI) and upper confidence interval (UCI) before and after management at the Green River Lake WMA- Casey Creek site.

Group	Species	Abundance per survey	90% LCI	90% UCI	95% LCI	95% UCI	P-value	Response (if P<0.10)
before	**Acadian Flycatcher***	0.72	0.66	0.87	0.65	0.93		
after	**Acadian Flycatcher***	0.63	0.62	0.73	0.62	0.78	P>0.10	
before	Blue-gray Gnatcatcher	0.43	0.39	0.58	0.39	0.64		
after	Blue-gray Gnatcatcher	0.48	0.47	0.57	0.47	0.62	P>0.10	
before	Eastern Wood-Pewee	0.19	0.17	0.34	0.17	0.42		
after	Eastern Wood-Pewee	0.15	0.15	0.22	0.15	0.27	P>0.10	
before	Great Crested Flycatcher	0.14	0.13	0.29	0.13	0.38		
after	Great Crested Flycatcher	0.09	0.08	0.14	0.08	0.19	P>0.10	
before	**Kentucky Warbler***	0.38	0.35	0.54	0.34	0.60		
after	**Kentucky Warbler***	0.27	0.27	0.35	0.27	0.41	P>0.10	
before	Northern Parula	0.10	0.08	0.24	0.08	0.34		
after	Northern Parula	0.26	0.25	0.33	0.25	0.39	P=0.10	Probable Increase
before	**Prothonotary Warbler***	0.14	0.13	0.29	0.13	0.38		
after	**Prothonotary Warbler***	0.10	0.10	0.16	0.10	0.21	P>0.10	
before	White-eyed Vireo	0.77	0.70	0.92	0.70	0.97		
after	White-eyed Vireo	0.41	0.40	0.50	0.40	0.55	P=0.05	Significant Decrease
before	Yellow-breasted Chat	0.43	0.39	0.58	0.39	0.64		
after	Yellow-breasted Chat	0.48	0.47	0.57	0.47	0.62	P>0.10	

*Species of Great Conservation Need.

Table 6. Abundance of focal species, including lower confidence interval (LCI) and upper confidence interval (UCI) before and after management at the Green River Lake WMA- Green River Lake site.

Group	Species	Abundance per survey	90% LCI	90% UCI	95% LCI	95% UCI	P-value	Response (if P<0.10)
before	**Acadian Flycatcher***	0.64	0.63	0.79	0.63	0.88		
after	**Acadian Flycatcher***	0.34	0.33	0.40	0.33	0.44	P=0.05	Significant Decrease
before	Blue-gray Gnatcatcher	0.56	0.54	0.71	0.54	0.79		
after	Blue-gray Gnatcatcher	0.73	0.71	0.78	0.71	0.80	P=0.10	Probable Increase
before	Carolina Chickadee	0.06	0.04	0.23	0.04	0.34		
after	Carolina Chickadee	0.02	0.02	0.09	0.02	0.14	P>0.10	
before	**Kentucky Warbler***	0.72	0.71	0.86	0.71	0.96		
after	**Kentucky Warbler***	0.78	0.77	0.84	0.77	0.87	P>0.10	
before	Northern Parula	0.17	0.17	0.19	0.17	0.24		
after	Northern Parula	0.33	0.33	0.36	0.33	0.39	P=0.05	Significant Increase
before	Pileated Woodpecker	1.76	1.51	2.06	1.47	2.12		
after	Pileated Woodpecker	2.12	1.98	2.27	1.95	2.30	P>0.10	
before	White-eyed Vireo	0.91	0.88	1.05	0.88	1.11		
after	White-eyed Vireo	0.75	0.73	0.80	0.73	0.82	P=0.05	Significant Decrease
before	Yellow-breasted Chat	0.68	0.64	0.81	0.64	0.86		
after	Yellow-breasted Chat	1.04	1.01	1.09	1.00	1.10	P=0.05	Significant Increase
before	Yellow-throated Vireo	0.26	0.25	0.39	0.25	0.50		
after	Yellow-throated Vireo	0.14	0.13	0.20	0.13	0.23	P=0.05	Significant Decrease

*Species of Great Conservation Need.

Table 7. Abundance of focal species, including lower confidence interval (LCI) and upper confidence interval (UCI) before and after management at the Curtis Gates Lloyd WMA.

Group	Species	Abundance per survey	90% LCI	90% UCI	95% LCI	95% UCI	P-value	Response (if P<0.10)
before	**Acadian Flycatcher***	0.30	0.29	0.50	0.29	0.70		
after	**Acadian Flycatcher***	0.84	0.82	1.08	0.81	1.24	P=0.05	Significant Increase
before	Blue-gray Gnatcatcher	0.64	0.63	0.95	0.63	1.21		
after	Blue-gray Gnatcatcher	0.77	0.75	1.01	0.75	1.16	P>0.10	
before	Carolina Chickadee	0.09	0.08	0.19	0.08	0.31		
after	Carolina Chickadee	0.06	0.06	0.13	0.06	0.21	P>0.10	
before	Eastern Wood-Pewee	0.26	0.25	0.44	0.25	0.63		
after	Eastern Wood-Pewee	0.62	0.61	0.84	0.61	0.98	P=0.10	Probable Increase
before	Field Sparrow	0.04	0.04	0.11	0.04	0.20		
after	Field Sparrow	0.06	0.06	0.13	0.06	0.21	P>0.10	
before	Great Crested Flycatcher	0.04	0.04	0.11	0.04	0.20		
after	Great Crested Flycatcher	0.02	0.02	0.06	0.02	0.11	P>0.10	
before	Northern Parula	0.04	0.04	0.11	0.04	0.20		
after	Northern Parula	0.30	0.29	0.45	0.29	0.57	P=0.05	Significant Increase
before	**Wood Thrush***	0.98	0.96	1.36	0.96	1.66		
after	**Wood Thrush***	0.82	0.79	1.06	0.79	1.21	P>0.10	

*Species of Great Conservation Need.

Table 8. Abundance of focal species, including lower confidence interval (LCI) and upper confidence interval (UCI) before and after management at the Yellowbank WMA.

Group	Species	Abundance per survey	90% LCI	90% UCI	95% LCI	95% UCI	P-value	Response (if P<0.10)
before	**Acadian Flycatcher***	1.22	1.11	1.35	1.09	1.38		
after	**Acadian Flycatcher***	1.31	1.20	1.50	1.18	1.55	P>0.10	
before	Blue-gray Gnatcatcher	1.77	1.64	1.94	1.62	1.98		
after	Blue-gray Gnatcatcher	2.56	2.40	2.80	2.38	2.86	P=0.05	Significant Increase
before	Eastern Wood-Pewee	1.17	1.06	1.31	1.04	1.34		
after	Eastern Wood-Pewee	1.13	1.02	1.31	1.00	1.36	P>0.10	
before	Hooded Warbler	0.11	0.08	0.19	0.08	0.21		
after	Hooded Warbler	0.07	0.06	0.19	0.06	0.24	P>0.10	
before	Northern Parula	0.49	0.42	0.59	0.41	0.61		
after	Northern Parula	0.82	0.73	0.98	0.72	1.02	P=0.05	Significant Increase
before	**Worm-eating Warbler***	0.07	0.05	0.14	0.05	0.17		
after	**Worm-eating Warbler***	0.03	0.03	0.13	0.03	0.20	P>0.10	
before	**Wood Thrush***	1.20	1.09	1.34	1.08	1.37		
after	**Wood Thrush***	1.54	1.42	1.73	1.40	1.78	P=0.05	Significant Increase

*Species of Great Conservation Need.